UNIVERSITÀ DELLA CALABRIA
Dipartimento di FISICA

ANNUAL REPORT 2008

ACADEMIC YEAR 2007-2008

Scientific publications in 2008

Table of Contents

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Introduzione

Nonostante sia ormai stato realizzato oltre 5 anni fa, l'esercizio di valutazione CIVR relativo agli anni 2001-2003, resta per il momento l'unico ed è quindi ancora da esso che bisogna partire per avere un'idea della collocazione del dipartimento di Fisica nell'ambito della ricerca nazionale. In occasione di quell'esercizio di valutazione, i risultati ottenuti dal Dipartimento di Fisica dell'Università della Calabria, presente nelle aree *02-Fisica* e *15c-Scienze e Tecnologie dei Nano/Microsistemi*, sono stati tutto sommato lusinghieri. L'area Fisica ha ottenuto sugli 8 lavori presentati, con grado di proprietà di 0.73, una valutazione media di 0.90 (4 lavori sono stati valutati eccellenti e 4 buoni) superiore alla valutazione media dell'area, l'area Scienze e Tecnologie dei Nano/Microsistemi ha ottenuto una valutazione media di 0.90, nettamente superiore alla valutazione media nazionale. Negli anni seguenti (2004-2008) il dipartimento di Fisica è ulteriormente cresciuto, sia come numero di professori e ricercatori (ormai oltre 50) che come numero di dottorandi ed assegnisti (circa 40), ed ormai stabilmente produce oltre 100 lavori l'anno su riviste internazionali. Inoltre negli ultimi tre anni è considerevolmente aumentata la percentuale di lavori su riviste particolarmente prestigiose (Nature, Phys. Rev. Lett., Ap. J.).

Oggi il Dipartimento di Fisica dell'Università della Calabria, che ha iniziato le sue attività circa 36 anni fa, rappresenta una consistente realtà nel panorama della ricerca nazionale ed internazionale, con settori che, anche dal punto di vista della massa critica di ricercatori, hanno ormai raggiunto una notevole visibilità. All'interno dell'area fisica gruppi di ricerca di assoluto rilievo internazionale sia dal punto di vista quantitativo che qualitativo, sono presenti nei campi della fisica molecolare ed in particolare dei cristalli liquidi, della fisica dei plasmi con particolare riguardo allo studio della corona solare e del mezzo interplanetario, della fisica delle alte energie, della fisica delle superfici. Ognuno di questi gruppi ha al suo attivo progetti che hanno ottenuto chiari riconoscimenti, sia nazionali che internazionali. In entrambe le tornate del bando ministeriale COFINLAB, destinato al finanziamento di centri di ricerca di eccellenza, il Dipartimento di Fisica è stato presente con successo: nella prima tornata è, infatti, stato finanziato il *Centro di Eccellenza per il Calcolo ad Alte Prestazioni*, cui ha contribuito in maniera determinante il gruppo di plasmi astrofisici, nella seconda tornata è invece stato finanziato il *Centro di eccellenza per la Preparazione ed il Trattamento di Materiali a struttura organizzata su scala nanometrica per applicazioni in fotonica, optoelettronica, trasformazioni e separazioni* nella realizzazione del quale ha un ruolo primario il gruppo di fisica molecolare. Il gruppo di fisica delle Alte Energie è inoltre direttamente coinvolto nel progetto internazionale ATLAS, che ha finito di realizzare nel 2006 uno strumento da installare all'interno del *Large Hadron Collider* per rivelare il bosone di Higgs. Nell'ambito di questo progetto, nei laboratori del Dipartimento di Fisica sono stati prodotti 35.000 dei tubi a deriva necessari alla costruzione delle camere di precisione di uno spettrometro a muoni.

Tra i risultati più significativi ottenuti dalla ricerca in area fisica negli ultimi anni debbono essere ricordati:

- *nell'ambito dell'astrofisica del plasma*: la costruzione di uno dei modelli più efficaci nel descrivere la turbolenza MHD nelle strutture della corona solare e la sua relazione con i brillamenti solari; l'analisi delle inversioni del campo geomagnetico, che ha mostrato il persistere di una memoria degli eventi e la costruzione di modelli semplificati per riprodurre le inversioni stesse; la messa in evidenza in una serie di fenomeni astrofisici di processi diffusivi con statistiche non gaussiane (distribuzioni di Levy) analoghe a quelle rilevate nell'analisi degli indici economici; l'analisi della turbolenza MHD nel vento solare, che ha messo in evidenza l'esistenza di una legge di scala di tipo Yaglom per le correlazioni del terzo ordine e la costruzione di modelli numerici basati su codici cinetici per spiegare la costruzione di piccole scale al di sotto della lunghezza di pelle degli ioni.
- *nell'ambito della fisica sperimentale delle alte energie*: il completamento della costruzione di parte del già ricordato spettrometro a muoni di ATLAS e l'inizio dei test realizzati utilizzando raggi cosmici.
- *nell'ambito della fisica teorica delle alte energie*: lo studio delle propietà conformazionali del nucleo BFKL nella teoria supersimmetrica di Yang-Mills; lo studio delle dimensioni anomale ad alto spin degli oparatori di twist nella teoria super simmetrica di Yanf-Mills; la continuazione analitica della linea criticadal potenziale chimico immaginario a quello reale nelle teorie SU(N) a temperatura e densità finite.
- *nell'ambito della fisica molecolare e dei cristalli liquidi*: lo sviluppo di nuovi dispositivi laser; la messa a punto di una nuova tecnologia per la realizzazione di reticoli di diffrazione (policryps) dalle svariate applicazioni tecnologiche, in particolare nel campo della olografia; lo studio delle interazioni

superficiali della materia soffice a dimensioni nanometriche; la messa a punto di alcune applicazioni biomediche (microscopia a scansione in chirurgia oftalmologica e studio della biolubrificazione di bordo delle articolazioni); l'inizio di una nuova attività nel campo dei metamateriali.

- *nell'ambito della fisica dei solidi e delle superfici*: lo studio sperimentale del confinamento quantico di elettroni sulla superficie di un metallo; l'analisi di nanotubi di carbonio sintetizzati in scariche ad arco; la costruzione di un modello teorico per descrivere lo shake-up elettronico che avviene nei nanotubi durante il processo di fotoemissione.
- *nell'ambito della biofisica*: lo sudio della dinamica librazionale del peptide antimicrobico alameticina in membrane lipidiche, collegata al trasporto di ioni attraverso il canale ionico formato dal peptide nelle membrane; lo studio del carattere entropico nella riduzione della stabilità termodinamica dell'umecianina in condizioni alcaline; la dimostrazione della formazioni di fibrille in proteine indotte da ioni metallici.
- *nel campo della fisica quantistica*: l'analisi delle proprietà critiche dell'*entanglement* e della fase di Berry in prossimità della transizione di fase superradiante; l'individuazione di un qubit di decoerenza ridotta in un accoppiamento di impurità di fase intermedia in una rete di giunzioni di Josephson.
- *nell'ambito della geofisica*: la gestione ormai trentennale della rete sismica regionale, di particolare rilievo in una regione ad elevato rischio sismico come la Calabria.

Gli anni che ci si prospettano dovrebbero essere quelli del consolidamento dei risultati raggiunti e della capacità di utilizzare le competenze sviluppate nella prospettiva di applicarle anche a tematiche direttamente legate allo sviluppo del territorio. È però importante per il dipartimento di Fisica, che le strutture di governo dell'Ateneo ne sostengano lo sforzo, realizzando una politica di incentivazione della ricerca di qualità e di riconoscimento del ruolo che la stessa svolge nel miglioramento anche della didattica. Saranno quindi necessarie scelte politiche che, da un lato attribuiscano direttamente alle aree di ricerca non solo le risorse finanziarie ma anche e soprattutto quelle di personale, in maniera che ogni area sia completamente responsabile dell'utilizzo delle stesse, dall'altro prevedano sistemi di valutazione interna e meccanismi di feedback che tengano conto dei risultati della ricerca e della didattica realizzati da ognuna della aree dell'Ateneo, nella distribuzione delle risorse.

Purtroppo le disposizioni di legge degli ultimi anni, in particolare il sostanziale blocco del turn-over nelle università, impediranno di fatto qualsiasi assunzione a tempo indeterminato di giovani ricercatori, mentre la comsiderevole riduzione dei fondi nazionali per la ricerca (PRIN) renderà estremamente difficile anche offrire ad essi contratti a termine. Il risultato complessivo rischia di essere disastroso. E' quindi auspicabile che ci sia un responsabile ripensamento su questi temi.

Arcavacata di Rende, 21 dicembre 2009

Il Direttore del Dipartimento di Fisica
(prof. Pierluigi VELTRI)

Introduction

The CIVR evaluation exercise, which has analyzed the Italian research produced during the years from 2001 to 2003 remains the unique exercise of this kind performed up to date, so that to have an idea of the ranking of the Pysics Departmente of the University of Calabria in the framework of Italian research, one has to start from these results also if they are somewhat dated. In that evaluation the results obtained by the Physics Department of the University of Calabria, were extremely good. The Physics Department, whose research products have been evaluated in the areas 2- Physics and 15c-Science and Tecnology of Nano/Microsystems has obtained in the Physics area, over the 8 works presented with a property grade 0.73, an average evalution of 0.90 (i.e., 4 papers were judged to be excellent and 4 papers were judged to be good), which is above the average evaluation of the Physics area in Italy. Also the evaluation of the Science and Tecnology of Nano/Microsystems area of the University of Calabria, was 0.90, well above the average evaluation of the area in Italy. In the following three years (2004-2006), the Physics Department has grown further, both as number of professors and researchers (by now beyond 50) and as number of doctoral students and postdoctoral fellows (by now beyond 40), and stably produces more than 100 papers per year on ISI referred international journals. Moreover, in the last three years the share of papers on particularly prestigious journals (Nature, Phys. Rev. Lett., Astrophys. J., J. Geophys. Res.) has also grown.

Nowadays, the Physics Department of the University of Calabria, which started operating about 36 years ago, represents a strong physics center in the community of national and international research, with research sectors which, even from the point of view of the number of researchers, have gained a large visibility. In this connection, research groups of high international reputation and high quality production are presents in the fields of molecular physics, especially for liquid crystals, of plasma physics, with special emphasis on solar corona and interplanetary space, of high energy physics, and of solid state and surface physics. Each of these research groups has developed research projects which have received important international recognition. In both of the ministerial calls COFINLAB, aimed at financing research centers of excellence, the Physics Department has presented successful proposals: indeed, in the first call, the *Center of Excellence for High Performance Computing* (HPCC), in which the group of Astrophysical Plasmas is heavily involved, has been funded. In the second call, the *Center of Excellence for Preparation and Treatment of Materials with Structure Organized on a Nanometric Scale for Applications to Photonics, Optoelectronics, Transformations and Separations*, in which the group of Liquid Crystals is primarily involved, has been funded. The group of High Energy Physics is directly involved in the international project ATLAS, which has completed in 2006 the realization of an instrument to be placed inside the *Large Hadron Collider,* with the objective to reveal the Higgs boson. In connection with this project, about 35000 drift tubes necessary for the construction of the precision chambers of a muon spectrometer have been produced in the laboratories of the Department of Physics.

Among the most important results obtained in the last three years by the research in the Physics Area let us recall:

- *in the field of plasma astrophysics*: the realization of one of the most effective model to describe MHD turbulence in solar corona magnetic structures and its relation with solar flares; the analysis of geomagnetic field polarity reversals, which has revealed some kind of "memory" of previous events; the investigation in a series of astrophysical phenomena of Brownian diffusive processes, whose statistics is represented by Levy distribution in analogy with the behaviour of some market indices; the analysis of MHD turbulence in Solar Wind, which has shown the existence of a Yaglom scaling law for thirs order correlations and the realization of numerical models based on kinetic codes to explain how scales smaller than the ion skin depth can be formed inside the solar wind plasma turbulence.
- *in the field of high energy experimental physics:* the end in 2006 of the production of derive tubes, and their installation inside the spectrometer of Atlas and the start up of the tests using cosmic rays.
- *in the field of high energy theoretical physics*: the study of the conformal properties of the BFKL kernel in supersymmetric Yang-Mills theory; the study of high-spin anomalous dimensions of twist operators in supersymmetric Yang-Mills theory; the analytic continuation of the critical line from imaginary to real chemical potential in SU(N) theories at finite temperature and density.
- *in the field of molecular and liquid crystals physics;* the development of new conception laser devices; the definition of a new technology to product diffraction gratings (policryps) with a wide range of technological applications, in particular in the field of holography; the study of surface interactions of soft matter at nanometer scale; the build up of some biomedical applications (SEM microscopy in

ophthalmic surgery and the study of bio-lubrication of articulation edge); the start of a new line of research in the field of metamaterials.

- *in the field of solid state and surface physics:* the experimental study of electron quantum confinement on a metal surface; the analysis of carbon nanotubes produced in arc discharges; the build up of a model to describe the electronic shake-up which occurs in nanotubes during photoemission processes;
- *in the field of biophysics:* the librational dynamics of the antimicrobic peptide alamethicin in lipid membranes related to the ion transport through the peptide-induced ion channels in the membranes; the entropic character of the reduced thermodynamic stability of a phytocyanin in alkaline conditions; the fibril formation in proteins induced by metal ions.
- *in the field of quantum physics:* the analysis of critical properties of entanglement and of Berry phase near the super radiant transition; the theoretical study of conductivity through a superconductive interferometric ring, which has allowed a better understanding of some quantum mechanics peculiar effects like Berry phase and Bohm-Aharonov interference; the individuation of a reduced decoherence qubit at an intermediate coupling impurity phase in a Josephson Junction network
- *in the field of geophysics:* the manegement of the regional sismic network, the activity related covering now more than thirty years.

Next years should be those where the excellent results obtained must be definitely consolidated. Moreover we should be able to use the skills developped to apply them to research items directly related to the economic development of our region. It is however important that researchers in the Physics Department will be supported by academic authorities of Calabria University, in that they should set up a policy which takes into account the preminent role of a qualified research also from the point of view of an increase of the teaching quality. It will be necessary to make each Research Area directly responsible of the resources, in term of money, equipment and personnel, which have been attributed to it. To realize this aim it will be necessary to set up an internal efficient evaluation process, whose result should be the basis for the following resource distribution among the Research Areas of the Calabria University.

Unluckely, the recent research budget cuts by Italian government (*Nature* **455**, 835-836), will practically not allow to any new young researcher to be employed on a permanent job. Moreover the considerable reduction of the budget devoted to the national research projects (PRIN) will also give to these young researcher a poor chance to obtain contracts, also for a limited time period. In these conditions the only possibility remaining for them is to look for a job abroad, thus strongly reducing the productivity of the Physics department research groups.

Arcavacata di Rende, December 21, 2009

The head of the Physics Department
(Prof. Pierluigi VELTRI)

DEPARTMENTAL ADMINISTRATION

Head of Department:
Pierluigi VELTRI

Executive Board:
Giovanni FALCONE, Luigi SPORTELLI, Giancarlo SUSINNO, Alessandro PAPA, Cesare UMETON, Luigi PAPAGNO, Nicola SCARAMUZZA, Vincenzo FORMOSO

Department Council:
14 Full Professors
20 Associate Professors
20 Senior Researchers
4 Representatives of PhD students
9 Representatives of the Technical and Administrative Staff

Administative Secretary:
Giocondo PERRI

RESEARCH PERMANENT STAFF

Full Professors

1. Riccardo BARBERI	*FIS/07*
2. Roberto BARTOLINO	*FIS/07*
3. Lev BLINOV	*FIS/03*
4. Vincenzo CARBONE	*FIS/07*
5. Elio COLAVITA	*FIS/07*
6. Giovanni FALCONE	*FIS/01*
7. Roberto FIORE	*FIS/02*
8. Ignazio GUERRA	*GEO/10*
9. Antonino OLIVA	*FIS/01*
10. Luigi PAPAGNO	*FIS/01*
11. Luigi SPORTELLI	*FIS/07*
12. Giancarlo SUSINNO	*FIS/01*
13. Cesare UMETON	*FIS/01*
14. Pierluigi VELTRI	*FIS/03*

Associate Professors

1. Raffaele AGOSTINO	*FIS/01*
2. Orazio BARRA	*FIS/01*
3. Rosina BARTUCCI	*FIS/07*
4. Assunta BONANNO	*FIS/01*
5. Lorenzo CAPUTI	*FIS/01*
6. Enzo CAZZANELLI	*FIS/03*
7. Gabriella CIPPARRONE	*FIS/03*
8. Gennaro CHIARELLO	*FIS/07*
9. Giovanni CROSETTI	*FIS/01*
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12. Alessandro PAPA	*FIS/02*
13. Francesco PIPERNO	*FIS/03*
14. Nicola SCARAMUZZA	*FIS/07*
15. Marco SCHIOPPA	*FIS/01*
16. Enrico TASSI	*FIS/01*
17. Carlo VERSACE	*FIS/01*
18. Galileo VIOLINI	*FIS/02*
19. Fang XU	*FIS/01*
20.Gaetano ZIMBARDO	*FIS/06*

Senior Researchers

1. Michele CAMARCA	*FIS/01*
2. Marcella CAPUA	*FIS/01*
3. Roberto CAPUTO	*FIS/03*
4. Tommaso CARUSO	*FIS/07*
5. Anna CUPOLILLO	*FIS/01*
6. Maria DE SANTO	*FIS/07*
7. Vincenzo FORMOSO	*FIS/01*
8. Domenico GIULIANO	*FIS/02*
9. Antonella GRECO	*FIS/07*
10. Rita GUZZI	*FIS/07*
11. Fabio LEPRETI	*FIS/03*
12. Anna MASTOBERARDINO	*FIS/01*
13. Daniela PACILE'	*FIS/01*
14. Pasquale PAGLIUSI	*FIS/07*
15. Francesco PLASTINA	*FIS/01*
16. Leonardo PRIMAVERA	*FIS/05*
17. Pierfrancesco RICCARDI	*FIS/01*
18. Marco ROSSI	*FIS/02*
19. Antonello SINDONA	*FIS/01*
20. Giuseppe STRANGI	*FIS/07*

Post-Doctoral Research Fellows

1. Cristina ADORISIO
2. Francesco CAPORALE
3. Giovanni CARBONE
4. Marco CASTRIOTA
5. Mario COMMISSO
6. Antonio DE LUCA
7. Luciano DE SIO
8. Samah FERJANI
9. Enrico MACCALLINI
10. Salvatore MARINO
11. Giuseppina NIGRO
12. Marco ONOFRI
13. Antonio POLICICCHIO
14. Clementina PROVENZANO
15. Daniela SALVATORE
16. Peppino SAPIA
17. Sergio SERVIDIO
18. Francesco VALENTINI
19. Alessandro VELTRI
20. Bruno ZAPPONE

Phd Students in Physics

1. Rossella FALCONE	*(XXI Cycle)*
2. Mario GRAVINA	*(XXI Cycle)*
3. Stefano MALETTA s.b.	*(XXI Cycle)*
4. Maria MINNITI	*(XXI Cycle)*
5. Silvia PERRI	*(XXI Cycle)*
6. Antonio POLITANO	*(XXI Cycle)*
7. Francesco FRANCICA	*(XXII Cycle)*
8. Raffaele MARINO	*(XXII Cycle)*
9. Valentino PINGITORE	*(XXII Cycle)*
10. Massimo VENTURELLI	*(XXII Cycle)*
11. Georgios KALANTZOPOULOS	*(XXII Cycle)*
12. Giacomo BOZZO	(*XXIII Cicle*)
13. Sandro DONATO	(*XXIII Cicle*)
14. Davide Remo GROSSO	(*XXIII Cicle*)
15. Gabriele INFUSINO	(*XXIII Cicle*)
16. Melissa INFUSINO	(*XXIII Cicle*)
17. Gianfranco MORELLO	(*XXIII Cicle*)
18. Roberta VASTA	(*XXIII Cicle*)

Phd Students in Science and Tecnology of Mesophases and Molecular Materails

1. Maria RIVERA VELASQUEZ	*(XXI Cycle)*
2. Tania RUGIERO	*(XXI Cycle)*
3. Gaetano NICASTRO	*(XXI Cycle)*
4. Stefano D'ELIA	*(XXI Cycle)*
5. Houda SELLAME	*(XXI Cycle)*
6. Mario Ariosto MATRANGA	*(XXI Cycle)*
7. Emanuela BRUNO	*(XXII Cycle)*
8. Said HOUMADI	*(XXII Cycle)*
9. Salvatore ARLIA	*(XXII Cycle)*
10. Lara SELVAGGI	*(XXII Cycle)*
11. Francesco CARBONE	(*XXIII Cycle*)
12. Ridha HAMDI	(*XXIII Cycle*)
13. Leticia Jimenez	(*XXIII Cycle*)

TECHNICAL AND ADMINISTRATIVE STAFF

Administration

1. Giocondo PERRI (*Administrative Secretary*)
2. Gaspare PECORA (*Vice-Administrative Secretary*)
3. Lidia MAIDA
4. Anna Eduardina PASTORE

Secretary

5. Luigina DE ROSE
6. Luigi PARISE

Teaching Laboratories

7. Mario LOMBARDI
8. Giovanni VIAPIANA (*Person in charge*)

Computer Staff

9. Nicola GUARRACINO (*Person in charge*)
10. Fedele STABILE

Research Laboratories

Molecular Physics and Biophysics

11. Bruno DE NARDO (*Person in charge*)
12. Carmine PRETE

Ion-Matter Interaction and Surface Electronic Spectroscopy

13. Eugenio LI PRETI (*Person in charge*)
14. Vito FABIO

Elementary Particles

15. Francesco SCIOMMARELLA
16. Francesco PELLEGRINO

Geophysics

17. Gerolamo LATORRE

The Physics Department hosts a INFM Section with the following staff:
Sonia VIVONA (*Administrative Official - INFM*)
Antonio BOZZARELLO (*Administrative Collaborator*)

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CAMARCA Michele	6172-6178
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CARBONE Vincenzo	6131-6033
CARUSO Tommaso	6095
CAZZANELLI Enzo	6114-6142
CHIARELLO Gennaro	6157-6174
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CROSETTI Giovanni	6021
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DE NARDO Bruno	6111-6106
DE ROSE Luigina	6001
DE SANTO Maria Penelope	6150
FORMOSO Vincenzo	6161
GIULIANO Domenico	6025
GRECO Antonella	6132
GUARRACINO Nicola	6030
GUERRA Ignazio	3166
GUZZI Rita	6077-6073
LA ROTONDA Laura	6014-6102
LAMANNA Ernesto	6020-6103
LATORRE Gerolamo	3664
LI PRETI Eugenio	6179-6165
LOMBARDI Mario	6083
MAIDA Lidia	6006
MALARA Francesco	6135-6033
MASTROBERARDINO Anna	6031
OLIVA Antonino	6167-6178
PAGLIUSI Pasquale	6148
PAPA Alessandro	6015
PAPAGNO Luigi	6158-6174
PARISE Luigi	6002
PECORA Gaspare	6005
PELLEGRINO Francesco	6102-6098
PERRI Giocondo	6004
PIPERNO Franco	6058
PLASTINA Francesco	6046
PRETE Carmine	6142
PRIMAVERA Leonardo	6138
RICCARDI Pierfrancesco	6171-6178
ROSSI Marco	6020
SCARAMUZZA Nicola	6113-6151
SCHIOPPA Marco	6017-6104
SCIOMMARELLA Francesco	6011
SINDONA Antonello	6059
SPORTELLI Luigi	6076-6073
STABILE Fedele	6027
STRANGI Giuseppe	6120
SUSINNO Giancarlo	6016-6104
UMETON Cesare	6117-6152
VELTRI Pierluigi	6136-6033
VERSACE Carlo	6116-6147
VIAPIANA Giovanni	6053
VIOLINI Galileo	6024
VIVONA Sonia	6007
XU Fang	6168-6178
ZIMBARDO Gaetano	6134-6033

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Medical Physics Lab.	*6068*
Astrophysical Plasmas Computer Lab.	*6033*
Ion-Matter Interaction Lab.	*6178*
Electronic Spectroscopy Lab.	*6174*
Biophysics Lab.	*6073*
Molecular Physics Lab.	*6151*
Particle Physics Lab.	*6104*
Mechanical Workshop	*6006*

SEMINARS (2008)

Jan 23, 2008
Georges Durand (*CNRS-Université Paris Sud, Orsay*)
Shape Polarity in Excluded Volume Interactions

Feb 1, 2008
S. Bellucci (*Lab. Naz. Frascati - INFN*),
Electronic screening and correlated superconductivity in carbon nanotubes

Feb 1, 2008
G. Isidori (*Lab. Naz. Frascati - INFN*)
Effetti oltre il Modello Standard nella fisica del sapore

Feb 13, 2008
Francisco Vera Saz (*Instituto de Ciencia de Materiales de Aragon, Universidad de Zaragoza*)
Chiral Induction in Columnar Supramolecular Aggregates

Feb 13, 2008
D. Espriu (*Univ. Barcellona*)
Spontaneous parity breaking in dense nuclear matter

Feb 19, 2008
Jacob Israelachvili (*Univ. California*)
Adhesion, friction and lubrication forces in everyday life

Feb 27, 2008
Luigi Amico (*DMFSI - Catania*)
Entanglement in many body systems

Feb 28,/2008
Luigi Amico (*DMFCI - Catania*)
Scaling of entanglement at a quantum phase transition

Mar 11, 2008
I.C. KHOO (*PennState University, USA*)
Liquid Crystals Optical Metamaterials

Mar 18, 2008
Daniela Pacile' (*Dip. Fisica, Univ. Calabria*)
On the Physics of Graphene

Apr 9, 2008
Emmanuelle Lacaze (*Institut de NanoSciences de Paris*)
Photoinduced Reorganization of Doped Chiral Liquid Crystals

Apr 2, 2008
Pantellis Trikalitis *(Chemistry Department-University of Crete*)
Advanced Porous Materials: Synthetis and Applications

Apr 8, 2008
Tullio Caronna (*Politecnico di Milano*)
Gli Eliceni: Molecole con Grandi Potenzialità Applicative, Sintesi e Propretà

Apr 21, 2008
V.V. Grecu
Use of Electron Paramagnetic Resonance in determining molecular structure and properties

Apr 22, 2008
Claudia Schmidt
Rheo-NMR Spectroscopy of Surfactant Mesophases

Apr 22, 2008
M. Dreucci (*Lab. Naz. Frascati - INFN*)
La fisica dei K neutri con l'esperimento Kloe a Daphne

May 7, 2008
Ibis Ricardez-Vargas
Optical Tweezers: multi-particle manipulation using interference patterns

May 7, 2008
C. Rosenblatt
Rayleigh-Taylor Instability Experiments by Magnetic Levitation: Precise and Arbitrary Control of the Initial Interface Shape

May 28, 2008
Pasquale Sodano (*Università di Perugia*)
On the Exotic Phases and Entanglement Properties of Inhomogeneous Condensed Matter systems and devices

May 28, 2008
R.L. Zaffino (*Parigi*)
Studio del modello di Kitaev con rottura spontanea della simmetria di inversione temporale

Jun 5, 2008
Marco Rossi (*Dipartimento di Fisica, Università della Calabria ed I.N.F.N.,Gr. Coll. di Cosenza*)
Some applications of integrable systems techniques

Jun 11, 2008
Derek Marsh, (*MPI for Biophysical Chemistry, Goettingen,Germany*)
Energetics of the Hydrophobic Matching in Lipid-Protein Interactions

Jun 12, 2008
Stefano Miscetti (*LNF*)
Programma di fisica e stato dell'esperimento KLOE2

Jun 19, 2008
Nathalie BELLEC (*Université de Rennes 1*)
Ligands based on tetrathiafulvalenes and analogues: synthesis and coordination

Jun 20, 2008
Sergio Servidio (*University Delaware, USA*)
Suppression of nonlinearity in MHD turbulence

Jul 8, 2008
Jean-Louis Pinçon (*LPCE/CNRS, Orléans, France*)
The k-filtering technique Applied to Cluster Wave-Field Measurements

Jul 18, 2008
Ernesto Lamanna (*Università Magna Graecia, Catanzaro*)
Realizzazione di un sistema per la produzione di neutroni epitermici

Sept 18, 2008
Giancarlo Ruocco (*Centro di Ricerca SOFT-INFM-CNR, Dipartimento di Fisica, Università di Roma "La Sapienza")*
Aging and flow in complex fluids

Oct 6, 2008
Shohei Naemura (*School of Chemistry, University of Southampton)*
A Group Theory Based Study of Polymorphism of Nematic Liquid Crystals

Oct 14, 2008
Elisabetta Narducci (*CNR*)
Presentazione Progetti ERC

Oct 15, 2008
Peter Sigmund (*Department of Physics & Chemistry, University of Southern Denmark, Odense, Denmark*)
Stopping of heavy ions and associated electron spectra

Oct 21, 2008
Stefania Stucci
Analisi dati ad HERA - Risultati di una scuola estiva

Oct 23, 2008
Derek Marsh (*MPI for Biophysical Chemistry, Goettingen,Germany*)
Transmembrane Polarity Profiles by Spin-Echo and High-Field EPR

Oct 29, 2008
Oleg Borisenko (*ITP Kiev*)
Theoretical studies of the phase transition to quark-gluon plasma

Oct 12, 2008
Dmitry Yu Ivanov (*Sobolev Institute of Mathematics, Novosibirsk*)
Proton dissociation into three jets

Nov 26, 2008
M. Paternostro (*Queen's College* (*Belfast*)
Flusso di informazioni in catene di spin

Nov 26, 2008
Sandra Savaglio (*Max Planck Institute, Monaco, Germania*)
Exploring the Universe using Gamma-Ray Bursts

Dec 10, 2008
Andrea Trombettoni (*Scuola Superiore di Studi Avanzati (SISSA) - Trieste*)
Bose Gases on Disordered Lattices

Dec 10, 2008
Volker Bothmer
Highlights from the STEREO mission

Dec 15, 2008
F. Gliozzi (*Univ. di Torino*)
Entanglement entropy on the lattice

LAUREA THESIS' IN 2008

July 22 *(a.y. 2007-08)*
Salvatore LORENZO
Effetto tunnel quantistico per barriere nano- e subnano- metriche
Relatore***:*** Giuseppe Antonio NISTICO'

Dec 9 *(a.y. 2007-08)*
Ugo CATALDI ***(****a.y. 2007-08****)***
Fisisorbimento di idrogeno in materiali nanoporosi
Relatore: Raffaele Giuseppe AGOSTINO

1st LEVEL DEGREE THESIS' IN 2008

May 7 (*a.y. 2007-08*)
Orsola Silvana CAPOLUPO
Introduzione al metodo sperimentale on-line
Relatore: Riccardo BARBERI

Eugenio CALABRESE (*a.y. 2007-08*)
Dipendenza dalla temperatura nella scintillazione di cristalli di PbWO4
Relatore: Laura LA ROTONDA

July 22 (*a.y. 2007-08*)
Loris D'ALESSI (*a.y. 2007-08*)
Caos in sistemi hamiltoniani
Relatore: Vincenzo *CARBONE*

Gilda STELLATO (*a.y. 2007-08*)
Controllo qualitativo di dati GPS
Relatore: Ignazio GUERRA

Sept 30 (*a.y. 2007-08*)
Gaetano DE VITA (*a.y. 2007-08*)
Analisi dati da satelliti artificiali
Relatore: Gaetano ZIMBARDO

Domenico GIAMPA' (*a.y. 2007-08*)
La radiointerferometria. Principi generali ed applicazioni nella ricerca astronomica
Relatore: Vincenzo CARBONE

Gaetano COZZA (*a.y. 2007-08*)
Laser a cristalli liquidi
Relatore: Maria Penelope DE SANTO

Michele CARRIERO (*a.y. 2007-08*)
Apparato innovativo per l'acquisizione di isoterme di adsorbimento gas
Relatore: Raffaele Giuseppe AGOSTINO

Antonia MORABITO (*a.y. 2007-08*)
Produzione di bosoni z° ad lhc
Relatore: Enrico TASSI

Maria Caterina TONE
Preparazione e caratterizzazione di film di Langmuir-Blodgett
Relatore: Maria Penelope DE SANTO

Antonio MANDARINO (*a.y. 2007-08*)
Gli errori quantistici e le disuguaglianze di Bell.
Relatore: Francesco PIPERNO

Cristian, Natale GENCARELLI (*a.y. 2007-08*)
Analisi temperature
Relatore: Vincenzo CARBONE

Valerio SCARFONE (*a.y. 2007-08*)
Produzione dei bosoni w in interazioni protone-protone ad LHC
Relatore: Enrico TASSI

Francesco Demetrio MINUTO (*a.y. 2007-08*)
Adsorbimento di idrogeno su silicalite-1.
Relatore: Raffaele Giuseppe AGOSTINO

Dec 12
Amino Adelmo LAVORINI (*a.y. 2007-08*)
Supersimmetria in meccanica quantistica
Relatore: Alessandro PAPA

Carla ESPOSITO (*a.y. 2007-08*)
Ottimizzazione di un apparato per l'acquisizione di isoterme di adsorbimento di idrogeno su materiali solidi
Relatore: Raffaele Giuseppe AGOSTINO

Alessandra TURANO (*a.y. 2007-08*)
Anomalie nelle fluttuazioni climatiche degli U.S.A. a scale secolari: analisi della mappa delle temperature
Relatore: Vincenzo CARBONE

Valeria RANIA (*a.y. 2007-08*)
Garanzia della qualità nelle attività di diagnostica medica: controllo di qualità di un apparecchio radiologico
Relatore: Loredana ANDRONICO

Paolo MUTO (*a.y. 2007-08*)
Caratterizzazione morfologica e strutturale di materiali nanostrutturati per adsorbimento di gas
Relatore Raffaele Giuseppe AGOSTINO

Gaetana ANAMIATI (*a.y. 2007-08*)
Invarianza di Gauge in meccanica quantistica
Relatore: Alessandro PAPA

2nd LEVEL DEGREE THESIS' IN 2008

May 7
Serena DALENA (*a.y. 2007-08*)
Influenza della turbolenza magnetica sulla dinamica degli ioni di ossigeno ed idrogeno nella coda magnatica terrestre
Relatore: Gaetano ZIMBARDO

Teresa GRANATA (*a.y. 2007-08*)
Proprietà statistiche del campo di velocità in un flusso turbolento di Taylor-Green
Relatore: Vincenzo CARBONE

July 23
Ernesto PECORA (*a.y. 2007-08*)
Misure di spettroscopia di energia di perdita degli elettroni ad alta risoluzione di film sottili di Ag depositato su Cu (111)
Relatore: Vincenzo FORMOSO

Roberta RASO (*a.y. 2007-08*)
Studio delle proprietà elettroniche di un singolo strato di grafite cresciuto epitassialmente su una superficie di Ni(111).
Relatore: Luigi PAPAGNO

Elio MASCIARI (*a.y. 2007-08*)
Analisi delle proprietà elettriche in nanostrutture di carbonio SWNT drogati con alcalini
Relatore: Assunta BONANNO

Giuseppe PUCCI (*a.y. 2007-08*)
Domain self-adaptation induced by Faraday instability
Relatore: Riccardo BARBERI

Dec 12
Giuseppe NISTICO' (*a.y. 2007-08*)
Study and observations of coronal hole jets with the stereo spacecraft
Relatore: Gaetano ZIMBARDO

PhD THESIS' in 2008

(*21° Cycle*)
Rossella FALCONE
Study of a SU(N) Gauge Theory of the Lattice
Supervisore: Alessandro PAPA

Mario GRAVINA
Critical Aspects of Quantum Filed Theories on the Lattice
Supervisore: Alessandro PAPA

Stefano MALETTA
Meccanismi di scambio di carica nell'interazione ione-superficie
Supervisore: Antonello SINDONA

Silvia PERRI
Complex Phenomena in Astrophysical Plasmas
Supervisore: Vincenzo CARBONE

Antonio POLITANO
Electronic and vibrational properties of adsorbed layers on metallic substrates
Supervisore: Gennaro CHIARELLO

Maria Fernanda RIVERA VELASQUEZ
Remediacion de un sitio contaminado (Pertusola): modelacion del transporte subterraneo y analisis de riesgo sanitario
Supervisore: Ignazio GUERRA

1. ASTROPHYSICS

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Introduction

The research in Astrophysics in the Physics Department of University of Calabria is mainly devoted to study plasma physics. Most of interplanetary matter and of the solar atmosphere is actually formed by plasma. For that reason, most of data obtained in space missions, or by solar observatories, can be interpreted within the framework of plasma physics. Such data have allowed for the construction of models describing astrophysical phenomena, and they have represented a powerful tool of investigation which has often given new perspectives for the comprehension of phenomena in fundamental physics. This has allowed to use the space as a huge laboratory where measurements not accessible in a terrestrial laboratory can be performed. On the other hand, using analogue techniques both on space and on laboratory measures allows for a comparison of the basic physical phenomena that take place on completely different scales, and for a comprehension of such phenomena which are relevant both in the domain of controlled thermonuclear fusion and in the perspective of industrial applications.

The group of Astrophysical Plasmas of Calabria University has been involved in such kind of problems, in collaboration with other groups of Italian universities (Pisa, Rome “La Sapienza”, Potenza) and with Italian Institutions (IFSI - CNR of Frascati, Osservatorio Astrofisico di Arcetri, Osservatorio Astronomico di Capodimonte, Consorzio RFX of Padova) and foreign Institutions (Naval Research Laboratory, Baltimora (USA); Bartol Research Institute, Newark, Delaware (USA); Observatoire de Paris-Meudon (France); Physics Dept., University of California at San Diego (USA); Russian Academy of Sciences, Moscow (Russia); Observatoire de la Cote d'Azur, Nice (France); Dept. of Physycs and Technology, University of Tromsoe (Norway); National Solar Observatory, New Mexico (USA); Kipenheuer Institute für Sonnenphysics, Freiburg (Germany); Departemento de Fisica, Universitad de Buenos Aires (Argentina); Abastumani Observatory, Tbilisi (Georgia); Goddard Space Flight Center, NASA (USA); Institute for Astro- and Particles Physics, University of Innsbruck (Austria); Space Research Institute, Moscow (Russia); Nodia Geophysics Institute, Tbilisi University (Georgia); Goettingen University (Germany)). The specific research themes under study during the year 2008 are described in the following.

1.1 MAGNETOHYDRODYNAMIC TURBULENCE AND KINETIC EFFECTS IN THE INTERPLANETARY SPACE

Solar wind heating by turbulent dissipation

The solar wind is a plasma in a state of fully developed turbulence that can be described by incompressible Magnetohydrodynamics (MHD), at least at large scales. The first models for the solar wind assumed an adiabatic expansion of the plasma emanated from the external corona, such that the temperature decreases proportional to the distance to the power -4/3. In contrast, in-situ measures by spacecrafts have shown that the temperature diminishes slower than what is predicted, i.e., it proportional to the distance to the power -1 or less. This implies that a mechanism of heating is necessary to explain these observations; this is probably represented by the turbulent energy cascade to small scales. The Yaglom law relates the statistics of the third-order mixed momenta of velocity and magnetic field fluctuations to the characteristic scale of fluctuations through the transfer rate of turbulent energy to small scales. Then, such a law can be used to obtain a realistic estimation of the energy transfer rate. Assuming the the turbulence is in a stationary state, this represents also an estimation of the energy dissipated at small scales. After verifying the Yaglom law can be observed in some periods of polar solar wind turbulence, using data of Ulysses spacecraft we have derived the dissipation rate and we have compared it with that required to explain the heating of solar wind. We have found that 60% of heating is due to the turbulent energy cascade. Of course, the assumption of incompressibility that is not strictly verified could represent a source of this partial discrepancy.

Dispersive effects in solar wind turbulence

Dissipative processes at small scales in the solar wind that can dissipate energy are not known; this represents one of the most debated subjects. Actually, the mean free path is of the order of the Sun-Earth distance, so viscosity should play no role in energy dissipation. Observations show that at scales of the order of the proton Larmor radius the spectrum of magnetic fluctuations becomes steeper, going from a slope -5/3, typical of a Kolmogorov turbulence, to a slope -7/3. The origin of this steepening is still under debate. Using data of Cluster spacecraft, first we have tried to understand if this effect is due to dissipative processes. We have derived the scaling laws of distribution functions of magnetic fluctuations, finding that they strongly depend on the scale; this indicates the presence of intermittency, i.e., fluctuations are not globally self-similar. Then, we have assumed that the steepening of the spectrum is due to a turbulence deriving from dispersive effects that are present at those scales. A simple phenomenology of the Hall effect in a compressible turbulence is able to describe the observed spectral slope. This has allowed us to understand that dispersive effects dominate the small-scale domain, instead of dissipative effects. Using direct Hall-MHD numerical simulations we have found that an Alfvenic turbulence at large scales, with highly correlated velocity and magnetic field fluctuations and small density fluctuations, is replaced at small scales by a magnetosonic turbulence where density fluctuations are anticorrelated with magnetic field fluctuations are anticorrelated and correlated with the velocity field. Moreover, we have performed Hall MHD simulations with no dissipation to study the dynamics of invariants and the statistical mechanics of fluctuations. We have found that the system asymptotically covers all the phase space in an ergodic manner, and, similar to what observed in the solar wind, the equilibrium spectra obtained by the Gibbs ensemble technique predict that electric field fluctuations dominate magnetic field fluctuations at small scales.

Intermittent structures and magnetic discontinuities in MHD turbulence and solar wind

We re-examine the statistics of rapid spatial variations of the magnetic field in simulations of Hall magnetohydrodynamic (HMHD) turbulence, using analysis of intermittency properties of the turbulence, and also using methods often employed to identify discontinuities in the solar wind (as in the earlier work of Tsurutani & Smith 1979). The hypothesis is that the statistics of intermittent events might be related to the statistics of classical MHD discontinuities. Indeed, those methods give similar distributions of events, often identifying the same structures. This suggests that observed discontinuities might not be static solutions to the MHD equations, but instead may be related to the intermittent structures that appear spontaneously in MHD turbulence. Then, we further examine the link between intermittency and MHD discontinuities, directly comparing statistical analysis from solar wind data and 3D and 2D simulations of MHD turbulence. The comparison between ACE solar wind data and simulations of magnetohydrodynamic turbulence shows a good agreement in the Waiting-Time analysis of magnetic field discontinuities. This result adds to evidence that solar wind magnetic structures may emerge fast and locally from nonlinear dynamics that can be properly described in the framework of MHD theory.

Short-scale termination of solar wind turbulence

In interplanetary plasmas, due to the absence of collisional viscosity, fundamental questions about how energy is

transfered from large to small scales and how it is eventually dissipated are still open. Since astrophysical plasmas are known to be highly turbulent, the understanding of the role of turbulence in such collisionless systems would be of key relevance for the explanation of the energy transport and heating problem in space. The fast technological development of supercomputers gives nowadays the possibility of using kinetic Eulerian Vlasov codes that solve the Vlasov-Maxwell equations in multi-dimensional phase space. The use of these "zero-noise" codes is crucial in the analysis of the development of turbulent spectra at typical kinetic scales, where the energy level of the fluctuations is typically very low. To study the system dynamics at frequencies of the order of the ion cyclotron frequency, we built up a hybrid-Vlasov model, in collaboration with Prof. A. Mangeney (Observatory of Paris-Meudon) and Prof. F. Califano (Università di Pisa). Within this model, the ion dynamics is described through the Vlasov equation and the electrons are treated as a fluid. A generalized Ohm equation, that retains Hall effect and electron inertia terms, is considered. Faraday equation, Ampere equation (the displacement current is neglected) and an equation of state for the electron pressure close the system. Quasi-neutrality is assumed. The above equations are solved through a numerical hybrid-Vlasov code in a multi-dimensional phase space (typically 1-D or 2-D in physical space and 3-D in velocity space), discretized on a uniform Cartesian grid. Our numerical analysis showed that the electrostatic turbulence in space plasmas with plasma beta of the order of unity (typical value for the solar wind)consists of longitudinal waves with dispersion relations of the acoustic form and it is associated with the generation of ion-beam distributions. Beside the ion-acoustic branch, which is in agreement with solar wind data from Helios 1 and 2 spacecraft, the kappa-omega spectrum of the numerical signals indicates the presence of a new branch of kinetic waves propagating at velocity close to the ion thermal speed. These waves are driven by kinetic effects of particle trapping and are stable against Landau damping due to the formation of trapping plateaus in the ion velocity distributions. We found that these novel kinetic fluctuations are nonlinear Bernstein-Green-Kruskal-like (BGK) solutions of the hybrid Vlasov-Maxwell equations, driven by particle trapping phenomena. In fact, taking into account particle trapping allows for the existence of fluctuations with phase speed in the bulk of the ion velocity distribution, which represent a privileged way for electrostatic turbulence to develop towards short scales.

Kinetic acoustic-like fluctuations driven by particle trapping effects

The novel kinetic electrostatic fluctuations recovered in the hybrid-Vlasov simulations of turbulence in solar wind plasmas turn out to be analogous (at low frequency) to the so-called electron acoustic waves (EAWs), which are acoustic-like fluctuations at phase speed close to the electron thermal speed. An EAW is a nonlinear wave with a carefully tailored trapped particle velocity distribution. Within linear theory an EAW would be heavily Landau damped, since the wave phase velocity is comparable to the thermal speed. However, the EAW is a Bernstein-Greene-Kruskal (BGK) nonlinear mode with electrons trapped in the wave troughs. Because of the trapped electrons, the velocity distribution is effectively flattened at the wave phase speed, and this turns off Landau damping. We proved the existence of these kinetic oscillations, predicted within kinetic theory, both numerically through PIC and Vlasov simulations and experimentally in a pure ion plasma apparatus, in collaboration with the nonneutral plasma laboratory at University of California at San Diego, lead by Prof. T. O'Neil. These kind of machines (Penning-Malmberg traps) are extremely useful for the study of fundamental physics in the kinetic regime, since the confining time of the nonneutral plasmas is of the order of several days. For example, it is possible to investigate the energy exchange between waves and particles in Landau damping phenomena both in linear and nonlinear regimes or the nature of the instabilities driven by nonthermal distributions of particle velocities as well as plasma heating processes. This kind of analysis is relevant in the interpretation of physical phenomena also observed in space plasmas.

1.2 OBSERVATIONS AND TURBULENCE MODELS IN THE SOLAR ATMOSPHERE

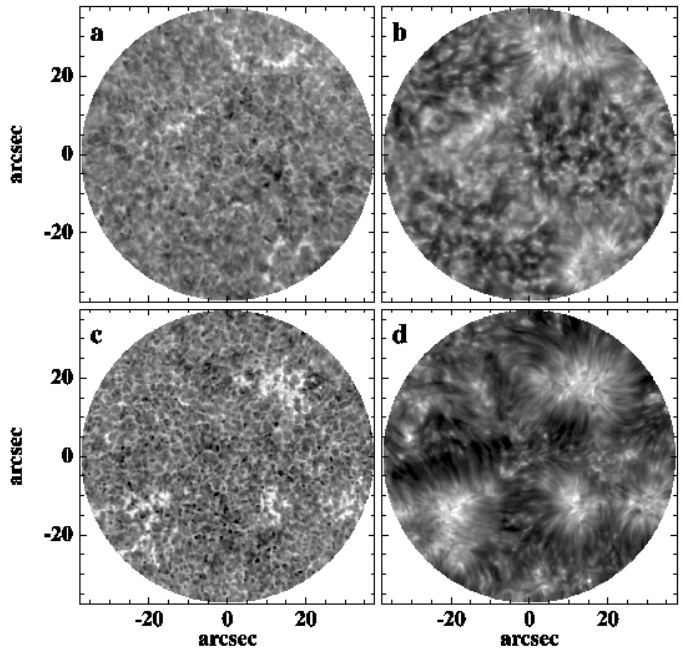

Fig. 1.1*: Narrowband images of the solar atmosphere obtained by analysis of the spectral line CAII 854.2 nm*

High-resolution studied of the lower solar atmosphere

Convective and magnetic processes occurring at the solar surface of spatial scales of several hundred kilometers represent fundamental "building blocks" for the development of the solar atmosphere as a whole, as well as being crucial for our understanding of magnetohydrodynamical processes in general. This is the motivation that has led our research group, in collaboration with the Osservatorio Astrofisico di Arcetri, to concentrate on multiwavelength observations and interpretation of small scale phenomena, both in the quiet and active Sun. In particular we focalized our attention on the study of the oscillatory properties of the quiet solar chromosphere in relation to the underlying photosphere, with particular regard to the effects of the magnetic topology. For this scope we use the Interferometric Bidimensional Spectrometer (IBIS) which has been built at Arcetri and is presently installed at the Dunn Solar Telescope of the US National Solar Observatory.Spectrally resolved, high-resolution imaging of the Ca II 854.2 nm line (Fig. 1.1) has provided new insights into the nature of the quiet Sun chromosphere. We show that waves with frequencies above the acoustic cut-off propagate from the photosphere to upper layers only in restricted areas of the quiet Sun. A large fraction of the quiet chromosphere is in fact occupied by “magnetic shadows”, surrounding network regions, that we identify as originating from fibril-like structures observed in intensity images. Moreover the well-known 3-minute chromospheric oscillations are due almost entirely to acoustic shocks, whose presence is highly dependent on the local magnetic topology. Mid-chromospheric shocks occur within the general chromospheric dynamics pattern of acoustic waves propagating from the photosphere. In particular, they appear as a response to underlying powerful photospheric motions at periodicities nearing the acoustic cut-off, consistent with 1-D hydrodynamical modeling. However, their spatial distribution is highly dependent on the local magnetic topology, both at the network and internetwork scale. Large portions of the internetwork regions undergo very few shocks, since they are “shadowed” by the horizontal component of the magnetic field. The latter is betrayed by the presence of chromospheric fibrils, slanted structures with distinct dynamical properties.

Solar activity analyzed by POD

The magnetic solar cycle consists of two components: the well-known main cycle with period around 11 yr, and a high-frequency component with period close to 2 yr, whose origin is not yet understood. We analyzing the green coronal emission line at 530.3 nm to investigate the spatio-temporal behavior of the solar cycle. By using the proper orthogonal decomposition (POD) we isolated, for the first time, the 2 yr component from the main 11 yr cycle. The properties of the found quasi-biennial signal suggests that, within the dynamo effect, the high-frequency cycle should be related to some phenomenon that is different from the emergence of solar active regions.

Turbulence in the solar chromosphere

Convective and oscillatory motions occurring in the Sun interior continuously inject energy in the solar atmosphere and perturb its magnetic structure, giving rise to several non-linear dynamical processes and turbulence phenomena. The behaviour of the outer layers of the solar atmosphere (chromosphere and corona) at small spatial and time scales still presents many open questions and is an ongoing subject of study. In particular, the nature of the solar chromosphere and the source of its heating remains one of the main open problems of solar physics. In this framework, the role played by turbulence has not yet been investigated in sufficient detail. We have studied the acoustic properties of the solar chromosphere in the high-frequency regime using a time sequence of velocity measurements in the chromospheric Ca ii 854.2 nm line taken with the Interferometric Bidimensional Spectrometer (IBIS). We concentrate on quiet-Sun behaviour, apply Fourier analysis, and characterize the observations in terms of the probability density functions (PDFs) of velocity increments. We confirm the presence of significant oscillatory fluctuation power above the cutoff frequency and find that it obeys a power-law distribution with frequency up to our 25 mHz Nyquist limit. The chromospheric PDFs are non-Gaussian and asymmetric, and they differ among the network, fibril, and internetwork regions. This suggests that the chromospheric high frequency power is not simply the result of short-period waves propagating upward from the photosphere but rather is the signature of turbulence generated within the chromosphere from shock oscillations near the cut-off frequency. The presence of this pervasive and broad spectrum of motions in the chromosphere is likely to have implications for the excitation of coronal loop oscillations.

Energy balance and cascade in MHD turbulence in the solar corona.

The dynamics of fluctuations in a closed coronal structure is regulated by two phenomena: the resonance excited by motions at the loop basis, that stores energy within the loop; nonlinear couplings, that move energy towards smaller scales. We evaluated the energy balance using both an analytical and a numerical approach, the latter using the so-called hybrid shell model. We derived a scaling law for the input energy flux, that turns out to be independent of nonlinear couplings and is determined by slow (DC) fluctuations. The nonlinear flux is due to interactions between eigenmodes at different perpendicular wavelengths, but with the same parallel wavelength. The energy balance has allowed us to derive an estimation of velocity fluctiations that is in agreement with measures of nonthermal velocity in the solar corona. The fluctuation spectrum is formed by an injection range at large scales, a pre-inertial range where magnetic energy dominates kinetic energy, an inertial range where the turbulence behaves as in an unbounded system, and a dissipative range.

Plasma jets in the solar corona.

We have started a new research activity based on the analysis of UV data from the STEREO dual spacecraft. Preliminary analysis has led to the identification of about 80 plasma jets in the polar corona, which have been organized in a catalogue. This jets show that a substantial activity is going on even in the quiet regions. An assessment of the energetic of jets is under way.

1.3 TRANPORT PROCESSES AND PARTICLE ACCELERATION IN THE HELIOSPHERE

High energy charged particle transport in the solar wind

The propagation of particles in the heliosphere strongly depends both on the magnetic structure and on the turbulence of the solar wind. The presence of magnetic turbulence in the heliosphere has the effect of a non-collisional charged particle diffusion; such a mechanism has a crucial importance for the cosmic ray transport and for the propagation to the Earth of energetic particles generated by solar events through the solar wind. We have shown by numerical simulation that different transport regimes can be obtained, i.e. non Gaussian transport regimes which include superdiffusion parallel to the background magnetic field and subdiffusion perpendicular to the background magnetic field. We have assessed how these anomalous transport regimes depend on the turbulence level, on the turbulence anisotropy, and on the ratio of the Larmor

radius over the correlation length. We have also shown that a new regime, called generalized double diffusion, is possible when the turbulence induces a diffusive or superdiffusive motion parallel to the magnetic field. A representation of such generalized double diffusion by means of fractional derivatives has been proposed.

We have recently developed a new analytical tool to extract the transport properties from the profiles of energetic particles observed in space. This involves the use of the propagator formalism, with the propagator being a Gaussian for normal transport and a power law for anomalous transport. We studied the transport properties of energetic electrons accelerated at corotating interaction regions in the solar wind. It is shown that the particle time profile has a power law behaviour when a non Gaussian propagator, appropriate for superdiffusive transport, is assumed. Looking at shock events detected by Ulysses spacecraft at 5 AU, we found that 42-290 keV electron time profiles are well fitted by a power law corresponding to superdiffusive transport, i.e., $<x^2(t)>$ proportional to t^{α}, with α=1.02 – 1.38. We have carried out a similar analysis for Voyager 2 data at the recently crossed termination shock, and have found that energetic ion transport is also superdiffusive. This shows that particle propagation in the heliosphere can be superdiffusive, and this has implications on the cosmic rays acceleration mechanism known as diffusive shock acceleration, which indeed seems not to be valid at the termination shock.

Turbulent and collisional transport in solar coronal loops

The solar corona plasma is structured by the magnetic field which often assumes a loop-like structure. We have considered the electron transport, for which the Rechester-Rosenbluth transport regime applies. To this end, we have calculated the Kolmogorov entropy in the case of very strong turbulence anisotropy. Indeed, turbulence in coronal loops is expected to be very anisotropic, and this requres to study transport in the percolation regime. We performed the first numerical computation of the Kolmogorov entropy of magnetic field lines extending from the quasilinear up to the percolation regime, using a numerical code where one can change both the turbulence level and the turbulence anisotropy. We find that the proposed percolation scaling of the Kolmogorov entropy is not reproduced, but rather a saturation of is obtained. Also, we find that the Kolmogorov entropy depends solely on the Kubo number. We apply the results to electron transport in solar coronal loops, and show that relevant turbulence levels can be found in coronal loops. Also, a theoretical interpretation of these results in terms of the Hamiltonian formalism is under way.

1.4 MAGNETOSPHERIC PHENOMENA AND NONLINEAR GEOPHYSICS

Magnetotail quasi-neutral sheet equilibrium models

Recent observations by CLUSTER in the magnetotail have unambiguously shown that sometimes the current sheet is bifurcated, i.e., it is divided in two layers, with a corresponding flattening of the magnetic field profile in the central sheet. What is the origin of the double peaked current profile? One of a possible explanation could be the relevant level of turbulence in the distant tail which can be the cause of the double peak, as we investigated in the previous years. On the other hand, one of the most open and challenging questions about current sheets is whether ions or electrons are the major current carriers, and what is their relative contribution. In order to clarify this issue, we have developed a new stationary three-dimensional kinetic-fluid code where ions are represented by particles and electrons by a massless fluid. One of the most interesting results is that, by including the electron effects in a self-consistent way, the equilibrium structure of the current sheet requires the presence of an electrostatic potential and it displays a double peak structure, as recent multi-spacecraft observations have shown, even in those cases where the ion current density does not display any bifurcated structure. A new study has been performed by considering the contribution of ionospheric oxygen to the current sheet. Indeed, during and after disturbed periods, relevant levels of O+ are observed in the magnetotail. We have recently found that oxygen ion can support a double peaked current profile, both in the case when no magnetic turbulence is present in the magnetotai, and when strong turbulence levels are present. Because of its larger Larmor radius, it appears that the interation of oxygen with magnetic turbulence is substantially different from that of hydrogen. A further study, where the influence of the normal electric field on the acceleration of ion beamlets is considered, has been carried out in collaboration with russian collegues. An extensive review of magnetic turbulence in the geospace environment, related to the INTAS 8943 project, coordinated by our group, is under way.

Proton acceleration in the Earth's magnetotail

Ion beams with energies of the order of several tens of keV are frequently observed in the Earth's magnetotail. We

consider two possible acceleration mechanisms, the cross tail electric field Ey (due to the large-scale coupling between solar wind and magnetosphere, along dawn-dusk direction) and the stochastic acceleration due to the electromagnetic fluctuations present in the magnetotail. A 2D test particle simulation has been performed in order to reproduce the interaction between charged particles and electromagnetic fluctuations and the constant dawn-dusk electric field, Ey, in the magnetotail current sheet. Electromagnetic perturbations are generated byrandom oscillating “clouds" moving in the x-y plane (in GSM coordinate system). Protons are accelerated via a stochastic Fermi-like process and, by varying the features of the electromagnetic fluctuations, along with the value of the normal magneticcomponent and other physical parameters, we can explain a range of energetic ion observations.

Nonlinear geophysics and statistics of earthquakes

Often in nature the temporal distribution of inhomogeneous stochastic point processes can be modeled as a realization of renewal Poisson processes with a variable rate. One of the classical examples is the temporal distribution of earthquakes. We show that this process strongly departs from a Poisson statistics for both catalogue and sequence data sets. This indicate the presence of correlations in the system probably related to the stressing perturbation characterizing the seismicity in the area under analysis.

1.5 LABORATORY PLASMAS

Turbulence in laboratory magnetized plasmas

The understanding of turbulence behaviour in magnetized plasmas is of crucial importance for the use of controlled thermonuclear fusion as an energy source, given its central role in driving cross-field energy losses in magnetized plasmas. In particular, the edge region of all kinds of toroidal fusion devices (tokamaks, stellarators, reversed field pinches) is characterized by the presence of strong electrostatic fluctuations which account for most of the particle transport and which are in dynamical equilibrium with the **E**x**B** drift velocity shear. Edge turbulence in fusion devices has been shown to exhibit strong intermittency and formation of coherent structures which play a relevant role in driving energy losses. It has recently been shown that a Yaglom law for electrostatic turbulence, that is, a relation for the third–order mixed moment involving the particle number density as a passive scalar and the **E**x**B** drift velocity, can be deduced from a simple model of electrostatic fluctuations which describes bursty turbulence in plasmas. We have investigated the existence of the Yaglom law for electrostatic turbulence in laboratory magnetized plasmas for the first time. Using measurements of intermittent transport at the edge of the RFX-mod reversed field pinch plasma device, we found that the above scaling relation is nicely verified at intermediate scales of few cm. In this range of scales, that unambiguously represents the inertial range of electrostatic turbulence, we have also analysed the intermittency properties of electrostatic turbulence by measuring anomalous scaling exponents of density and velocity structure functions.

Anisotropy of three-dimensional turbulence in a current sheet

In many astrophysical and laboratory plasmas, magnetohydrodynamic turbulence develops in inhomogeneous systems, where the presence of a background magnetic field has strong effects on the dynamics of such systems and on the properties of the turbulence, which develops spectral anisotropy. We analyzed the anisotropy properties of magnetohydrodynamic turbulence in a sheared magnetic field through a three-dimensional numerical simulation that reproduces the linear and nonlinear stage of a tearing instability. Far from the current sheet, the energy spectrum develops perpendicularly to the local direction of the equilibrium magnetic field. Within the current sheet the spectrum anisotropy is also affected by the structure of unstable modes. With increasing time, the configuration becomes more turbulent, the former effect disappears, and the energy cascade takes place perpendicularly to the local equilibrium magnetic field. The local spectrum becomes increasingly anisotropic while the spatially integrated spectrum tends to isotropize. These properties could be used to identify the nonlinear stage of magnetic reconnection in space and laboratory plasmas and to identify the particle transport regime in different magnetic configurations.

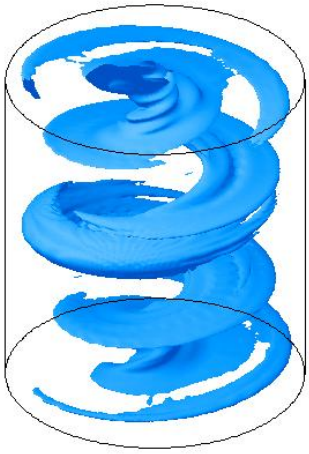

Fig. 1.2: *Density isosurface in a nonlinear compressible simulation of a Reversed Field Pinch machine [Published on the cover of Phys. Rev. Letters* **101**, 255002 (2008)]

Compressible magnetohydrodynamic simulations of the Reversed Field Pinch

A reversed field pinch is a toroidal configuration used to confine plasmas in fusion machines. The poloidal and toroidal components of the magnetic field in an RFP are mostly generated by electric currents flowing in the plasma and they are of the same order of magnitude. The configuration is characterized by a reversal of the toroidal magnetic field close to the wall. Besides the interst of this kind of machines as potential fusion reactors, they are also useful for the study of fundamental issues like plasma relaxation, plasma turbulence and its effects on plasma confinement. We studied the reversed field pinch through the numerical solution of the compressible magnetohydrodynamic equations. Two cases are investigated: In the first case the pressure is derived from an adiabatic condition and in the second case the pressure equation includes heating terms due to resistivity and viscosity. In the adiabatic case, a single helicity state is observed and the reversed field pinch configuration is formed for short time intervals and is finally lost. In the non-adiabatic case, the system reaches a multiple helicity state and the reversal parameter remains negative for a longer time. The results show the importance of compressibility in determining the large scale dynamics of the system.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2008

1. Servidio S., Matthaeus W. H., Carbone V.,
   Statistical properties of ideal three-dimensional Hall magnetohydrodynamics: The spectral structure of the equilibrium ensemble,
   Phys. Plasmas, **15**, 042314 (2008)

2. Valentini F., O'Neil T., Dubin D.,
   Decay instability of electron acoustic waves,
   Communications in nonlinear science and numerical simulations **13**, 215-220 (2008)

3. Carbone V., De Marco R., Valentini F., Veltri P.,
   The approach to statistical equilibrium in collisionless wave-particle interaction,
   Communications in nonlinear science and numerical simulations **13**, 34-39 (2008)

4. De Bartolo R., Greco A., Veltri P.,
   A 3D kinetic-fluid numerical code for stationary equilibrium states in magnetized plasmas,
   Computer Physics Communications **178**, 647-664 (2008)

5. Valentini F., Veltri P.,
   Effect of velocity diffusion on the propagation of nonlinear plasma waves,
   EuroPhysics Letters **81**, 15002- (2008)

6. Vecchio A., Carbone V., Lepreti F., Primavera L., Sorriso-Valvo L., Straus Th., Veltri P.,
   Spatio-Temporal Analysis of Photospheric Turbulent Velocity Fields using the Proper Orthogonal Decomposition,
   Solar Physics **251**, 163-178 (2008)

7. Kossobokov V., Lepreti F., Carbone V.,
   Complexity in sequences of solar flares and earthquakes,
   Pure and Applied Geophysics **165**, 761-775 (2008)

8. Valentini F.,
   Damping of Bernstein-Greene-Kruskal modes in collisional plasmas,
   Physics of Plasmas **15**, 022102-1-022102-10 (2008)

9. Perri S., Zimbardo G.,
   Superdiffusive transport of electrons accelerated at corotating interaction regions,
   J. Geophys. Res. Space Physics **113**, A03107-A03118 (2008)

10. Perri S., Zimbardo G.,
    Observations of anomalous transport of energetic electrons in the heliosphere,
    ASTRA - Astrophysics and Space Sciences Transactions **4**, 27-30 (2008)

11. Alexandrova O., Carbone V., Veltri P., Sorriso-Valvo L.,
    Small-scale energy cascade of the solar wind turbulence,
    The Astrophysical Journal **674**, 1153-1157 (2008)

12. Servidio S., Primavera L., Carbone V., Noullez A., Rypdal K.,

A model for two-dimensional bursty turbulence in magnetized plasmas,
Physics of Plasma **15**, 012301- (2008)

13. Marino R., Sorriso-Valvo L., Carbone V., Noullez A., Bruno R. and Bavassano B.,
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The Astrophysical Journal Letters **677**, L71-L74 (2008)

14. Vecchio A., Carbone V., Sorriso-Valvo L., De Rose C., Guerra I., and Harabaglia P.,
Statistical properties of earthquakes clustering,
Nonlinear Processes in Geophysics **15**, 333-338 (2008)

15. Greco A., Sorriso-Valvo L., Carbone V. and Cidone S.,
Waiting time distributions of the volatility in the Italian MIB30 index: Clustering or Poisson functions?,
Physica A **387**, 4272-4284 (2008)

16. Cauzzi G., Reardon P. K., Uitenbroek H., Cavallini F., Falchi A., Falciani R., Janssen K., Rimmele T., Vecchio A., Woger F.,
The solar chromosphere at high resolution with IBIS. I. New insights from the Ca II 854.2 nm line.,
Astron. & Astrophys. **480**, 515-526 (2008)

17. Vecchio A., Carbone V.,
A Simple Model to Describe Solar Cycle Periodicities below 11 Years,
Solar Physics **249**, 11-16 (2008)

18. Reardon K., Lepreti F., Carbone V., Vecchio A.,
Evidence of Shock-Driven Turbulence in the Solar Chromosphere,
Astrophysical Journal Letters **683**, L207-L210 (2008)

19. Valentini F., Veltri P., Califano F., Mangeney A.,
Cross-scale effects in solar-wind turbulence,
Physical Review Letters **101**, 025006- (2008)

20. Valentini F., De Marco R., Carbone V., Veltri P.,
Linear and nonlinear regimes of bump-on-tail instability through Vlasov and toy model simulations,
EuroPhysics Letters **83**, 55001- (2008)

21. Ferjani S., Sorriso-Valvo L., De Luca A., Barna V., De Marco R., and Strangi G.,
Statistical analysis of random lasing emission properties in nematic liquid crystals,
Physical Review E **78**, 011707-1-011707-6 (2008)

22. Greco A., Chuychai P., Matthaeus W. H., Servidio S., Dmitruk P.,
Intermittent MHD structures and classical discontinuities,
Geophysical research Letters **35**, - (2008)

23. Zimbardo G.; Greco A.; Veltri P.; Voros Z.; Taktakishvili A.L.,
Magnetic turbulence in and around the Earth's magnetosphere,
Astrophysics and Space Sciences Transactions **4**, 35-40 (2008)

24. Vecchio A., Carbone V.,
On the Origin of the Double Magnetic Cycle of the Sun,
The Astrophysical Journal **683**, 536- (2008)

25. Onofri M., Malara F.,
Evolution of anisotropic turbulence in nonlinear magnetic reconnection,

Physical Review E **78**, 016402-016402 (2008)

26. Nigro G., Malara F., Veltri P.,
Resonant behavior and fluctuating energy storage in coronal loops,
Astrophys. J. **685**, 606-621 (2008)

27. Onofri M., Malara F., Veltri P.,
Compressibility effects in the dynamics of the Reversed Field Pinch,
Physical Review Letters **101**, 255002-255002 (2008)

28. Zimbardo G., Pommois P., Veltri P.,
Visualizing Particle Transport Across Magnetic Flux Tubes in Anisotropic Magnetic Turbulence,
IEEE Transactions on Plasma Science **36**, 1114-1115 (2008)

29. Zelenyi L., Artemyev A., Malova H., Milovanov A. V., Zimbardo G.,
Particle transport and acceleration in a time-varying electromagnetic field with a multi-scale structure,
Physics Letters A **372**, 6284-6287 (2008)

30. Zimbardo G., Greco A., Veltri P., Voros Z., Amata E., Taktakishvili A.L., Carbone V., Sorriso-Valvo L., Guerra I.,
Solar-Terrestrial relations: magnetic turbulence in the Earth's magnetosphere and geomagnetic activity,
Earth Moon Planets , 127-129 (2008)

31. Servidio S., Matthaeus W. H., Dmitruk P.,
Depression of Nonlinearity in Decaying Isotropic MHD Turbulence,
Physical Review Letters **100**, 095005-1-095005-4 (2008)

33. Matthaeus W. H., Servidio S., Dmitruk P.,
Comment on ''Kinetic Simulations of Magnetized Turbulence in Astrophysical Plasmas'',
Physical Review Letters **101**, 149501-1-149501-1 (2008)

34. Servidio S., Matthaeus W. H., Carbone V.,
Ergodicity of ideal Galerkin three-dimensional magnetohydrodynamics and Hall magnetohydrodynamics models,
Physical Review E **78**, 046302-1-046302-7 (2008)

A.1.2 Publications on international journals accepted in 2008

1. Perri S., Lepreti F., Carbone V., Vulpiani A.,
Dynamical properties of test particles in stochastic electromagnetic fields,
to appear on Communications in Nonlinear Science and Numerical Simulations.

2. Greco A., Matthaeus W. H., Servidio S., Chuychai P., Dmitruk P.,
Statistical analysis of discontinuities in solar wind ACE data and comparison with intermittent MHD turbulence,
to appear on The Astrophysical Journal.

3. Califano F., Faganello M., Pegoraro F., Valentini F.,
Solar wind interaction with the earth magnetosphere: the role of reconnection in the presence of a large scale sheared flow,
to appear on Nonlinear Processes in Geophysics.

4. Vecchio, A., Cauzzi G., Reardon K. P.,
The solar chromosphere at high resolution with IBIS II. 3-minute acoustic shocks in the quiet internetwork,
to appear on Astron. & Astrophys.

5. Perri S., Greco A., Zimbardo G.,
Stochastic and direct acceleration mechanisms in the Earth's magnetotail,
to appear on Geophysical Research Letters.

6. Zimbardo G., Bitane R., Pommois P., Veltri P.,
Kolmogorov entropy of magnetic field lines in the percolation regime,
to appear on Plasma Physics and Controlled Fusion.

7. Aburjania G. D., Chargazia Kh. Z., Zelenyi L. M., Zimbardo G.,
Model of strong stationary vortex turbulence in space plasmas,
to appear on Nonlinear Processes in Geophysics.

8. Perri S., Zimbardo G.,
Ion superdiffusion at the solar wind termination shock,
to appear on Astropysical Journal Letters.

9. Bruno R., Carbone V., Voros Z., D'Amicis R., Bavassano B., Cattaneo MB, Mura A, Milillo A, Orsini S, Veltri P., Sorriso-Valvo L., Zhang T, Biernat H, Rucker H, Baumjohann W., Jankovicova D., Kovacs P.,
Coordinated Study on Solar Wind Turbulence During the Venus-Express, ACE and Ulysses Alignment of August 2007,
to appear on Earth Moon Planets.

10. Marino R., Sorriso-Valvo L., Carbone V., Noullez A., Bruno R., Bavassano B.,
The Energy Cascade in Solar Wind MHD Turbulence,
to appear on Earth Moon Planets.

11. Perri S., Yordanova E., Carbone V., Veltri P., Sorriso-Valvo L., Bruno R., André M.,
Magnetic turbulence in space plasmas: Scale-dependent effects of anisotropy,
to appear on Journal of Geophysical Research.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2008

1. Perri S., Zimbardo G.,
Levy walks for energetic electrons detected by the Ulysses spacecraft at 5 AU,
in Chaos, Complexity and Transport: Theory and Applications, Proceedings of the CCT '07, C. Chandre, X. Leoncini, and G. Zaslavsky, World Scientific, Singapore, pp. 309-317 (2008)

B.3 Chapters in published books, published books

1. Perri S., Zimbardo G.,
Levy walks for energetic electrons detected by the Ulysses spacecraft at 5 AU,
in Chaos, Complexity and Transport: Theory and Applications, Proceedings of the CCT '07, C. Chandre, X. Leoncini, and G. Zaslavsky, World Scientific, Singapore, pp. 309-317 (2008)

2. Carbone V., Lepreti F., Nigro G., Sorriso-Valvo L., Vecchio A., Veltri P.,
Modeling magnetohydrodynamic turbulence by low-dimensional dynamical systems,
in Anomalous fluctuation phenomena in complex systems: plasmas, fluids, and financial markets, Editors Riccardi C. & Roman H. E., Research Signpost, India, 57-100 (2008)

C INVITED PRESENTATIONS

C1. Invited presentations at international conferences in 2008

1. Sorriso-Valvo L., Carbone V., and Bruno R.,
   Turbulence in space plasmas,
   EGU General Assembly 2008, Vienna, 14/04/2008-18/04/2008

2. Sorriso-Valvo L., Bruno R., Carbone V., Marino R., Noullez A., Veltri P.,
   The inerial range of MHD turbulence in solar wind,
   EGU General Assembly 2008, Vienna, 14/04/2008-18/04/2008

3. M. Onofri, F. Malara, P. Veltri, L. Primavera,
   Three-dimensional numerical simulation of anisotropic turbulence induced by magnetic reconnection,
   EGU General Assembly 2008, Vienna, 14/04/2008-18/04/2008

4. Sorriso-Valvo, L.,
   Turbulence and intermittency in the solar wind,
   Turbulence in geo and astrophysical flows, Villanova i la Geltru (Spain), 29/11/2008-29/11/2008

5. Malara F., Nigro G., Veltri P.,
   Energy balance and cascade in MHD turbulence in the solar corona,
   IAU Symposium 257 - Universal Heliospheric Processes, Ioannina (Greece), September 15-September 19 2008

6. G. Zimbardo,
   Kolmogorov entropy of magnetic field lines and heating of solar coronal loops, 2008
   EGU General Assembly 2008, Vienna, 14/04/2008-18/04/2008

7. G. Zimbardo,
   Superdiffusive and subdiffusive transport of energetic particles in the heliosphere: numerical simulations and experimental evidence,
   37th COSPAR Scientific Assembly, Montreal, Canada, 13 luglio-20 luglio 2008

8. Veltri P.,
   Kinetic Effects in small scale range of Solar Wind Turbulence,
   Solvay Workshop - A tribute to Professor Radu Balescu, Brussels, Belgio, March 6-March 8 2008

9. Veltri P., Valentini F., Califano F., Mangeney A.,
   Kinetic Effects in Small Scale Range of Solar Wind Turbulence,
   Dynamical Processes in Space Plasmas, Israel, May 11-May 19 2008

10. A. Vecchio, G. Cauzzi, K. Reardon,
    Acoustic Shocks in the Quiet Internetwork and the Role of Magnetic Fields,
    12th European Solar Physics Meeting, Freiburg, Germany, 08/09-12/09 2008

D PRESENTATIONS AT CONFERENCES

D1. Presentations at international conferences in 2008

1. Valentini F., Veltri P., Califano F., Mangeney A.,
   Kinetic effects on slab turbulence in solar wind plasmas,
   EGU General Assembly 2008, Vienna, 14/04/2008-18/04/2008

2. Sorriso-Valvo L., Carbone V., Nigro G., Meduri D., Stefani F., Bourgoin M.,
   A statistical analysis of polarity reversals of the geomagnetic field,
   Modelling Geophysical Systems by Means of Statistical Mechanics Methods, Erice, 27 April-2 May 2008

3. Greco A., Perri S., G. Zimbardo,
   Fermi process and steady down-dusk electric field as possible mechanisms for the generation of ion beams in the

Earth magnetotail,
COSPAR Scientific Assembly, Montreal, CANADA, 13 July-19 July 2008

4. Sorriso-Valvo, L.,
An MHD turbulent cascade and turbulent heating of the solar wind,
International Workshop INTAS - MAGNETIC TURBULENCE IN THE GEOSPACE ENVIRONMENT, Arcavacata di Rende (CS, Italy), 29/10/2008-31/10/2008

5. Sorriso-Valvo, L., Marino, R., Carbone, V., Noullez, A., Bruno, R.,
Scaling relations for compressible turbulence in the solar wind,
AGU 2008 Fall Meeting, San Francisco, 15/12-19/12 2008

6. Carbone, V., Perri, S., Yordanova, E., Sorriso-Valvo, L., Veltri, P., Bruno, R., André, M.,
Magnetic turbulence in space plasmas: scale dependent effects of anisotropy,
AGU 2008 Fall Meeting, San Francisco, 15/12-19/12 2008

7. Marino, R., Carbone, V., Sorriso-Valvo, L., Noullez, A., Bruno, R., Veltri, P.,
Solar wind turbulence: cascade, dissipation and heating,
AGU 2008 Fall Meeting, San Francisco, 15/12-19/12 2008

8. Noullez, A., Marino, R., Sorriso-Valvo, L., Bruno, R., Carbone, V.,
Alignment of Velocity and Magnetic Fields in Fast and Slow Solar Wind,
AGU 2008 Fall Meeting, San Francisco, 15/12-19/12 2008

9. Bruno, R., Pietropaolo, E., Servidio, S., Greco, A., Matthaeus, W.H., D'Amicis, R., Sorriso-Valvo, L, Carbone, V., Balogh, A., Bavassano, B.,
Spatial and Temporal Analysis of Magnetic Helicity in the Solar Wind,
AGU 2008 Fall Meeting, San Francisco, 15/12-19/12 2008

10. Valentini F., Veltri P., Califano F., Mangeney A.,
Electrostatic short-scale termination of solar wind turbulence,
International conference INTAS - MAGNETIC TURBULENCE IN THE GEOSPACE ENVIRONMENT, Arcavacata di Rende (CS, Italy), 29/10/2008-31/10/2008

11. M. Onofri, L. Primavera, P. Veltri, F. Malara,
Nonlinear evolution of reconnection instabilities,
International Workshop INTAS - MAGNETIC TURBULENCE IN THE GEOSPACE ENVIRONMENT, Arcavacata di Rende (CS, Italy), 29/10/2008-31/10/2008

12. Greco A., Matthaeus W. H., Servidio S.,
Intermittent structures and magnetic discontinuities in MHD turbulence and solar wind,
International Workshop INTAS - MAGNETIC TURBULENCE IN THE GEOSPACE ENVIRONMENT, Arcavacata di Rende (CS, Italy), 29/10/2008-31/10/2008

13. Greco A., Perri S., G. Zimbardo,
Competition between stochastic and direct acceleration mechanisms in the Earth's magnetotail,
International Workshop INTAS - MAGNETIC TURBULENCE IN THE GEOSPACE ENVIRONMENT, Arcavacata di Rende (CS, Italy), 29/10/2008-31/10/2008

14. Lepreti F., Carbone V., Veltri P., Kossobokov V.,
Statistical properties of solar flares and comparison to other impulsive energy release events,
Workshop "Modelling geophysical systems by means statistical mechanics methods", Erice (TP, Italy), 27-30 April 2008

15. G. Zimbardo,
Magnetic turbulence in the geospace environment: an overview,
International Workshop INTAS - MAGNETIC TURBULENCE IN THE GEOSPACE ENVIRONMENT, Arcavacata di Rende (CS, Italy), 29/10/2008-31/10/2008

16. A. Vecchio, V. Carbone, I. Guerra, P. Harabaglia, B. Rosa,
Quasi-periodic traveling waves of large-scale Earth's global seismicity,
EGU Fall Meeting 2008, S. Francisco, USA, 15/12-19/12 2008

17. S. Perri and G. Zimbardo,
Superdiffusive transport in astrophysical plasmas,
contribution to Multiscale methods for fluid and plasma turbulence: applications to magnetically confined plasmas in fusion devices, Marseille (France), 21-25 April 2008

18. S. Perri, E. Yordanova, V. Carbone, P. Veltri, L. Sorriso-Valvo, R. Bruno, Y. Khotyaintsev and M. Andrè ,
Small-scale anisotropy in the solar wind,
contribution to 35th EPS Plasma Physics Conference, Hersonissos, Creta (Greece), 9-13 June 2008

19. S. Perri and G. Zimbardo,
Superdiffusive transport of energetic particles through the heliosphere,
contribution to 35th EPS Plasma Physics Conference, Hersonissos, Creta (Greece), 9-13 June 2008.

20. S. Perri, E. Yordanova, V. Carbone, L. Sorriso-Valvo, P. Veltri, R. Bruno and M. Andrè,
Analysis of small-scale anisotropy with the high resolution Cluster data,
contribution to 37th COSPAR Scientific Assembly, Montreal (Canada), 13-20 July 2008

21. S. Perri and G. Zimbardo,
Proton and electron superdiffusive transport in the interplanetary space,
contribution to37th COSPAR Scientific Assembly, Montreal (Canada), 13-20 July 2008

22. S. Perri, V. Carbone, E. Yordanova, L. Sorriso-Valvo, R. Bruno, Y. Kothyainsev, P. Veltri and M. Andrè,
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contribution to the International Workshop INTAS - MAGNETIC TURBULENCE IN THE GEOSPACE ENVIRONMENT, Arcavacata di Rende (CS, Italy), 29/10/2008-31/10/2008

2. THEORETICAL PARTICLE PHYSICS AND APPLICATIONS

Professors and Researchers
Roberto Fiore
Domenico Giuliano
Alessandro Papa
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Galileo Violini

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Mario Gravina (XXI cycle)
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O. Borisenko (*Bogolyubov Institute for Theoretical Physics, Kiev, Ucraine*)
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L. Cosmai *(INFN-Bari, Italy)*
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S. Fazio (*Università della Calabria, Italy*)
D. Fioravanti (*Università di Bologna & INFN-Bologna, Italy*)
P. Giudice *(Università di Torino & INFN-Torino, Italy)*
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P. Lucignano *(SISSA-Trieste, Italy)*
V. Magas *(Universidad de Barcelona, Spain)*
R. Orava *(University of Helsinki, Finland)*
E. Predazzi *(Università di Torino & INFN-Torino, Italy)*
A. Prokudin *(Università di Torino & INFN-Torino, Italy)*
A. Sabio Vera *(CERN, Geneva)*
E. Sela (*University of British Columbia, Vancouver, Canada*)
O. Selyugin *(JINR, Dubna, Russia)*
P. Sodano (*Università di Perugia & INFN-Perugia, Italy*)
A. Tagliacozzo (*Università di Napoli, Italy*)
A. Trombettoni *(SISSA-Trieste, Italy)*
V.R. Zoller (*ITEP, Moscow, Russia*)

Introduction

The research activity during the AA 2007-08 included the following subjects:

- phenomenology of hadron collisions and Quantum Chromodynamics (QCD) in the high-energy limit;
- non-perturbative properties of gauge theories discretized on a space-time lattice;
- field theory of correlated devices;
- transport in many-electron correlated systems
- high spin anomalous dimensions in the N=4 supersymmetric Yang-Mills theory
- physics of kaon-nucleon interactions.

A major part of this activity has been carried on in collaboration with other research groups in Italy and abroad. For the part concerning the non-perturbative study of gauge theories on a space-time lattice, a large use has been done of the PC farm "Majorana" of the Istituto Nazionale di Fisica Nucleare (INFN) – Gruppo Collegato di Cosenza, hosted by the Physics Department.

2.1 QCD IN THE REGGE LIMIT AND HADRON PHENOMENOLOGY

2.1.1 QCD in the Regge limit

The dipole (or Moebius) representation of the colour singlet BFKL kernel has been found in the next-to-leading order in supersymmetric Yang--Mills theories and the ambiguities of this form and its conformal properties have been studied.

The use of the BFKL kernel improved by the inclusion of subleading terms generated by renormalization group analysis has been suggested to cure the instabilities in the behaviour of the BFKL Green's function in the next-to-leading approximation. The performance of a RG-improved kernel has been studied in the determination of the amplitude of a physical process, the electroproduction of two light vector mesons, in the BFKL approach in the NLA.

It has been found that a smooth behaviour of the amplitude with the center-of-mass energy can be achieved, setting the renormalization and energy scales appearing in the subleading terms to values much closer to the kinematical scales of the process than in the approaches based on the unimproved kernel.

The total hadronic cross section for the collision of two virtual photons has been studied in the BFKL approach for energies in the range of LEP2 and in the range of future linear colliders. The BFKL resummation has been done at the next-to-leading order in the BFKL Green's function; photon impact factors are taken instead at the leading order, but with the inclusion of the subleading terms required by invariance under changes of the renormalization scale and of the BFKL scale s_0.

2.1.2 Hadron Phenomenology

Due to the weak current non-conservation the diffractive excitation of charm and strangeness dominates the longitudinal structure function $F_L(x,Q^2)$ of neutrino DIS at small Bjorken x. Based on the color dipole BFKL approach quantitative predictions for this effect in the kinematical range of the CCFR/NuTeV experiment have been done.

The non-conservation of charmed-strange current in the neutrino deep inelastic scattering gives rise to sizeable corrections to the longitudinal structure function, F_L, at small values of Bjorken x. These corrections are a higher twist effect enhanced at small-x by the rapidly growing gluon density factor. As a result, the component of F_L induced by the charmed-strange current prevails over the light-quark component and dominates $F_L = F_L^{\{cs\}} + F_L^{\{ud\}}$ at $x \leq 0.01$ and $Q^2 \sim m_c^2$. The color dipole analysis clarifies the physics behind the phenomenon and provides a quantitative estimate of the effect.

A model has been recently proposed for describing Deeply Virtual Compton Scattering amplitude and its comparison to the HERA data has been studied.

A long paper has been written where some important effects in the nearly forward ("soft") region of the future LHC are proposed to be investigated.

J/Psi photo- and electroproduction has been studied in the framework of the analytic S-matrix theory. It has been argued that at low energies the background, which is the low-energy equivalent of the high-energy diffraction, replaces the Pomeron exchange. A previous analysis of on-mass shell J/Psi photoproduction, based on a Dual Model with Mandelstam Analyticity (DAMA) has been extended to the off-shell J/Phi electroproduction.

2.2 LATTICE GAUGE THEORIES

The method of analytic continuation from imaginary to real chemical potentials μ is one of the few available techniques to study QCD at finite temperature and baryon density. One of its most appealing applications is the determination of the critical line for small μ: a direct test of the validity of the method has been performed by studying two-color QCD, where the sign problem is absent. The (pseudo)critical line is found to be analytic around $\mu^2 = 0$, but a very large precision would be needed at imaginary μ to correctly predict the location of the critical line at real μ.

By analytic continuation to real theta of data obtained from numerical simulation at imaginary theta the Haldane conjecture has been studied and it has been shown that the O(3) non-linear sigma model with a theta term in two dimensions becomes massless at θ=3.10(5). A modified cluster algorithm has been introduced to simulate the model with imaginary θ. Two different definitions of the topological charge on the lattice have been used; one of them needs renormalization to match the continuum operator. Our work also offers a successful test for numerical methods based on analytic continuation.

Critical properties of the compact three-dimensional U(1) lattice gauge theory have been explored at finite temperatures on an asymmetric lattice. For vanishing value of the spatial gauge coupling one obtains an effective two-dimensional spin model which describes the interaction between Polyakov loops. This effective spin model has been studied for N_t=1,4,8 on lattices with spatial extension ranging from L=64 to L=256. The results indicate that the finite-temperature U(1) lattice gauge theory belongs to the universality class of the two-dimensional XY model, thus supporting the Svetitsky-Yaffe conjecture.

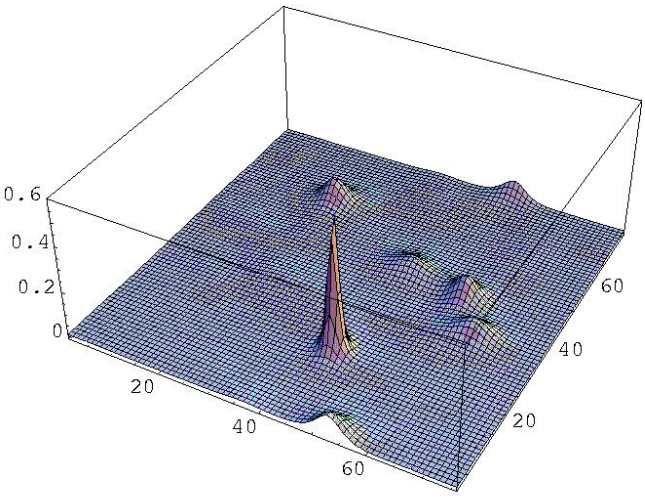

Figure: Action density on a lattice field configuration in the 2d O(3) σ-model after a few

The confinement-deconfinement phase transition has been explored by lattice numerical simulations in non-compact (2+1)-dimensional quantum electrodynamics with massive fermions at finite temperature. The existence of two phases, one with and the other without confinement of fractional charges, is related to the realization of the Z symmetry. The order parameter of this transition can be clearly identified. It has been shown that it is possible to detect the critical temperature for a given value of the fermion mass, by exploiting suitable lattice operators as probes of the Z symmetry. Moreover, the large-distance behaviour of the correlation of these operators permits to distinguish the phase with Coulomb-confinement from the Debye-screened phase. The resulting scenario is compatible with the existence of a Berezinsky-Kosterlitz-Thouless transition.

2.3 FIELD THEORY OF CORRELATED DEVICES

2.3.1 Boundary field theory description of Josephson junction networks

A boundary 1+1-dimensional field theory description of a Y-junction of superconducting Josephson chains has been derived. Within the framework of the corresponding boundary conformal field theory, it has been shown that, for pertinent values of the fabrication and control parameters, a finite coupling fixed point emerges in the phase diagram of a Y-junction of superconducting Josephson chains. The finite coupling fixed point can be either repulsive (phase transition), or attractive (stable phase), depending on the value of the dimensionless flux piercing the central loop of the network. When this is equal to 1/2 of the flux quantum, the finite coupling fixed point corresponds to a phase with restored time-reversal invariance. In this case, it has been shown that phase slips (instantons) have a crucial role in establishing this transition: indeed, a new set

of instantons -the W-instantons- comes into play to destabilize the strongly coupled fixed point. Finally, a detailed description of the Josephson current-phase relationship along the arms of the network, near each one of the allowed fixed points, has been provided.

2.3.2 Frustration of decoherence in one-dimensional Josephson junction networks

The possibility that pertinent impurities in a condensed matter system may help in designing quantum devices with enhanced coherent behaviours has been examined. In particular, it has been shown that, when operated near the attractive finite coupling fixed point arising in its phase diagram, a Y- shaped superconducting Josephson network works as a two-level quantum systems, with reduced entanglement with the environment.

By using boundary conformal field theory techniques, the potential relevance of this result for engineering finite-size superconducting devices with enhanced quantum coherence has been addressed. The result appears to be of practical relevance, as well, as the estimated values of the parameters of the device lie within a range already experimentally accessible.

2.4 TRANSPORT IN MANY-ELECTRON CORRELATED SYSTEMS

2.4.1 AC Josephson effect in a normal electronic chain connected to two superconductors

A boundary model possibly able to reproduce the normal and the AC Josephson current across a normal one-dimensional device connected to two superconductors at a finite biasing voltage V is currently studied.

In particular, a Luttinger liquid model is considerer, for the purpose of describing the current in the case in which the central region is interacting. Possible applications to superfluid He flow across capillars are considered, as well.

2.4.2 Charge sensing and orthogonality catastrophe in a transport experiment

The possibility that charge sensing in a small quantum dot could induce an orthogonality catastrophe in the ground state of the dot itself is currently studied. The phenomenon should be detectable as a power-law dependence of the current across the dot on the applied (DC) bias voltage.

2.5 HIGH SPIN ANOMALOUS DIMENSIONS IN THE N=4 SUPERSYMMETRIC YANG-MILLS THEORY

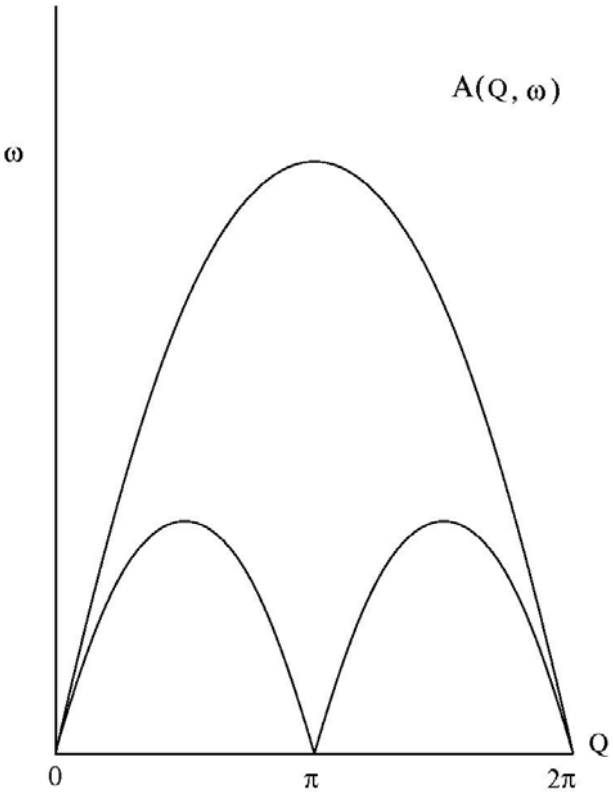

Figure: 2-spinon continuum density of states in a spin-1/2 Heisenberg one-dimensional antiferromagnet.

We studied the high spin behaviour of anomalous dimensions in the planar sl(2) sector of N=4 SYM. In order to do this, we used the mapping of the dilatation operator to the Hamiltonian of a quantum integrable model, completely defined by a set of Bethe equations. In the high spin limit we found that the Bethe equations are completely equivalent to a linear integral equation. This simplification allowed to compute the high spin anomalous dimension at fixed twist and weak coupling (1a), in its leading (logarithmic) and subleading dependence on the spin. Afterwards, the scaling limit in which both the logarithm of the spin and the twist go to infinity, while their ratio is kept constant, was studied. The strong coupling behaviour of the so-called generalised scaling functions that characterise such limit was found in the series of papers (2a), (1b), (2b), and connections to string theory results was successfully established.

At present, we are involved in the computation of subleading terms arising in the previously mentioned scaling limit. These are indeed still given by our linear integral equation.

2.6 PHYSICS OF KAON-NUCLEON INTERACTIONS

We continued the revision of the programs of analysis of low-energy Kaon-Nucleon reactions and had discussions and meetings with the colleagues of KLOE about the way of carrying out a new analysis which uses their results, and of obtaining new data which may be useful for that purpose. This may be favored by the fact that some UNICAL have joined the collaboration and that a Ph D student is starting working on the subject. A further possibility of collaboration is with some Iranian group (Isfahan) after a visit of some from there to LNF. These perspectives should materialize next year. We are also considering the possibility of an ambitious publication on KN physics which essentially would see the participation of the colleagues of the INFN Project PG21.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2008

1. V.S. Fadin, R. Fiore,
The Dipole form of the BFKL kernel in supersymmetric Yang-Mills theories,
Phys. Lett. B661 (2008) 139.

2. F. Caporale, A. Papa and A. Sabio Vera,
Collinear improvement of the BFKL kernel in the electroproduction of two light vector mesons,
Eur. Phys. J. C 53 (2008) 525.

3. F. Caporale, D.Yu. Ivanov and A. Papa,
BFKL *resummation effects in the $\gamma^* \gamma^*$ total hadronic cross section*,
Eur. Phys. J. C 58 (2008) 1.

4. R. Fiore, V.R. Zoller,
Charm of small x neutrino DIS,
JETP Lett. 87 (2008) 524.

5. P. Cea, L. Cosmai, M. D'Elia and A. Papa,
The critical line from imaginary to real baryon chemical potentials in two-color QCD,
Phys. Rev. D 77 (2008) 051501(R).

6. B. Alles and A. Papa,
Mass gap in the 2D O(3) non-linear sigma model with a $\theta=\pi$ term,
Phys. Rev. D 77 (2008) 056008.

7. O. Borisenko, M. Gravina and A. Papa,
Critical behavior of the compact 3d U(1) lattice gauge theory in the limit of zero spatial coupling,
J. Stat. Mech. (2008) P08009.

8. R. Fiore, P. Giudice and A. Papa,
Non-compact QED_3 at finite temperature: the confinement-deconfinement transition,
JHEP11(2008)055.

9. D. Giuliano, P. Sodano,
Frustration of decoherence in Y-shaped superconducting Josephson networks,
New Journal of Physics 10 (2008) 093023.

A.1.2 Publications on international journals accepted in 2008

1. D. Giuliano, P. Sodano,
Y-junction of superconducting Josephson chains,
to appear on Nucl. Phys. B.

2. D. Bombardelli, D. Fioravanti, M. Rossi,
Large spin corrections in N = 4 SYM sl(2): Still a linear integral equation,
to appear on Nucl. Phys. B

3. D. Fioravanti, P. Grinza, M. Rossi,
Strong coupling for planar N=4 SYM theory: an all-order result,
to appear on Nucl. Phys. B

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2008

1. D.Yu. Ivanov and A. Papa,
NLO BFKL at Work: The Electroproduction of Two Light Vector Mesons,
Acta Phys. Polon. B39 (2008) 2391-2417, Proceedings of the "School on QCD, Low-x Physics, Saturation and Diffraction", Copanello (Calabria, Italy) 1-14 July, 2007, presented by A. Papa.

2. F. Caporale, A. Papa and A. Sabio Vera,
Collinear Improvement of the BFKL Kernel in the Electroproduction of Two Light Vector Mesons,
Acta Phys. Polon. B39 (2008) 2571-2575, Proceedings of the "School on QCD, Low-x Physics, Saturation and Diffraction", Copanello (Calabria, Italy) 1-14 July, 2007, presented by F. Caporale.

3. F. Caporale, A. Papa and A. Sabio Vera,
Electroproduction of two light vector mesons from collinearly improved BFKL kernel,
in DIS 2008, Proceedings of the XVI International Workshop on Deep-Inelastic Scattering and Related Topics, London (England) 7-11 April, 2008, editors R. Devenish and J. Ferrando, doi: 10.3360/dis.2008.74, presented by A. Papa

C PRESENTATIONS AT SCHOOL AND CONFERENCES

C.1 Presentations at international schools and conferences in 2008

1. F. Caporale, A. Papa, A. Sabio Vera,
Electroproduction of two light vector mesons from collinearly improved BFKL kernel,
presented by A. Papa at DIS 2008, Proceedings of the XVI International Workshop on Deep-Inelastic Scattering and Related Topics, London (England) 7-11 April, 2008.

2. F. Caporale, D.Yu. Ivanov, A. Papa,
NLO BFKL in $\gamma^*\gamma^*$ collisions,
presented by A. Papa at the Low-x Meeting 2008, Kolimpari (Crete, Greece), July 6-10, 2008, presented by A. Papa

3. F. Caporale, D. Yu. Ivanov, A. Papa,
NLO BFKL in $\gamma^*\gamma^*$ collisions,
presented by F. Caporale at DIFFRACTION 2008, Proceedings of the International Workshop on Diffraction in High Energy Physics, La Londe-les-Maures, France, 9 – 14 September, 2008.

4. R. Fiore, V.R. Zoller,
Full of charm neutrino DIS,
presented by V.R. Zoller at the 43rd Rencontres de Moriond on QCD and Hadronic Interactions, La Thuile, Italy, 8-15 Mar, 2008.

5. R. Fiore, V.R. Zoller,
Current non-conservation effects in vDIS diffraction,
presented by V.R. Zoller at DIFFRACTION 2008, Proceedings of the International Workshop on Diffraction in High Energy Physics, La Londe-les-Maures, France, 9 - 14 September, 2008.

6. S. Fazio, R. Fiore, L.L. Jenkovszky,
Deeply virtual Compton scattering and generalized parton distributions,
presented by L.L. Jenkovszky at DIFFRACTION 2008, Proceedings of the International Workshop on Diffraction in High Energy Physics, La Londe-les-Maures, France, 9 - 14 September, 2008.

7. V.K. Magas, R. Fiore, L.L. Jenkovszky, A. Prokudin,
J/*Psi photo- and electroproduction in a dual model*,

presented by V.K. Magas at DIFFRACTION 2008, Proceedings of the International Workshop on Diffraction in High Energy Physics, La Londe-les-Maures, France, 9 - 14 September, 2008.

8. P. Cea, L. Cosmai, M. D'Elia, A. Papa,
Analytic continuation in two-color QCD: new results on the critical line,
presented by L. Cosmai at "Strong and ElectroWeak Matter", Amsterdam, the Netherlands, 26-29 August, 2008.

9. P. Cea, L. Cosmai, M. D'Elia, A. Papa,
Non-zero baryon density on the lattice with the method of analytic continuation,
presented by A. Papa at the XIII Workshop on Statstical Mechanics and non-perturbative Field Theory, Bari, September 4, 2008.

10. O. Borisenko, M. Gravina, A. Papa,
Critical behavior of compact 3d U(1) theory in the limit of zero spatial coupling,
presented by M. Gravina at the XIII Workshop on Statstical Mechanics and non-perturbative Field Theory, Bari, September 4, 2008.

11. D. Giuliano,
Finite-coupling fixed point and frustration of decoherence in a Y-shaped Josephson junction network,
presented at the XIII Workshop on Statstical Mechanics and non-perturbative Field Theory, Bari, September 4, 2008.

12. D. Giuliano,
Phase diagram of a Y-shaped Josephson junction network and frustration of decoherence,
presented at the Workshop "Exact Results in Low-Dimensional Quantum Systems", held at GGI-Institute, Firenze, November 2008.

ORGANIZATION OF INTERNATIONAL CONFERENCES IN 2008

1. DIFFRACTION 2008,
International Workshop on Diffraction in High Energy Physics
La Londe-les-Maures, France, 9 – 14 September, 2008, organized by R. Fiore and A. Papa (Univ. Calabria), J. Soffer (Temple University, Philadelphia), I. Ivanov (Univ. Liege) et al.., http://www.cs.infn.it/diff2008.

3. EXPERIMENTAL PARTICLE PHYSICS

Experimental particle physics studies the fundamental constituents of matter and the forces that cause their mutual interactions. The researches are made by means of particle accelerators and particle detectors. The first ones rise the energy of beam particles (in the most powerful accelerators the energy can reach some TeV) and allow them to collide against a target that can be fixed or a second beam. The detectors are designed to reconstruct the particles produced as a consequence of the beam-target particle interactions.

The researches on high energies physics to which the physicists of this University take part are:

2. Study of the proton structure in deep inelastic scattering processes with the experiment ZEUS at the lepton- proton accelerator HERA of DESY Laboratory (Hamburg, Germany).
3. Study of proton-proton interactions with the experiment ATLAS at the LHC accelerator of the CERN laboratory (Geneva, Switzerland).
4. Hadronic calorimetry: analysis and develepment of hadronic calorimeters modules based on the Dual Readout Method (DREAM).
5. Study of multi-particle dynamics in inelastic proton-nucleon interactions with extremely high multiplicity at U70 proton accelerator (Protvino, Russia) with the Thermalisation experiment.
6. Study of the electron-positron interactions at the centre of mass energy 1020MeV with KLOE apparatus at DAFNE collider (Frascati, Italy).
7. Project for the realization of a ground-based apparatus to detect the muon content of the showers employing the last generation high precision drift chamber (UNICAL, Italy).

3.1 ZEUS EXPERIMENT AT HERA E-P COLLIDER (HAMBURG-GERMANY)

Physicists: M. Capua
S. Fazio
A. Mastroberardino
M. Schioppa
G. Susinno
E. Tassi

Technicians: F. Pellegrino

International collaboration

ZEUS is a collaboration running a large particle detector at the electron-proton collider HERA at the DESY laboratory in Hamburg. The participating scientists are pushing forward our knowledge of the fundamental particles and forces of nature, gaining unsurpassed insight into the exciting laws of the microcosm.

The ZEUS detector is a sophisticated tool for studying the particle reactions provided by the high-energetic beams of the HERA collider. At the HERA collider two separate magnet systems guide the e and p beams around the 6,3 km long ring and two independent superconducting RF systems accelerate the e and p bunches up to 30GeV and 920GeV energy respectively.

The High Energy Experimental Physics (HEP) group of the UNICAL has been involved in the ZEUS Collaboration, since 1988, in the design, construction, testing, calibration, alignment, running and maintenance of three components of ZEUS experiment: Forward Muon Spectrometer (FMUON), Leading Proton Spectrometer (LPS) and MicroVertex (MVD). Furthermore the UNICAL HEP researchers participate, since 1991 when the detector started operating, to the data taking as well as the physics analyses.

At the maximum beam energies the centre of mass energy is ~314GeV, much larger than previously achieved in such collisions, and allowing to probe the proton structure down to distance scales as low as 10^{-18}m which is a factor 1000 smaller than the proton radius. With this resolving power exciting physics topics can be studied, such as substructure of quarks and electrons, neutral and charged current processes, tests of Quantum Chromodynamics, searches for new currents, studies of diffraction and for new particles. At large momentum transfers (the kinematical limit at HERA is 10^5 GeV^2/c^2) there is a direct interaction of the electron with one of the proton quarks, while the "remnants" of the proton are only slightly involved. For this reason HERA is often addressed as the world's only lepton-quark collider.

New ZEUS results are in progress and the UNICAL Italian members of the Collaboration and INFN, are actively involved; during the 2008 year have contributed to:

- the combination of the ZEUS and H1 inclusive results and determination of the proton parton distribution functions;
- the studies on Deeply Virtual Compton Scattering in diffraction with the complete HERA set of data, and the future application of diffraction at LHC;
- the measurement of the longitudinal component of the diffractive structure function and the future application of diffraction at LHC

The aim of the research program is to capitalize on the experience gained in the study of inclusive and diffractive processes at HERA and apply it to the future measurements at the LHC.

This year the ZEUS Collaboration elected as physics coordinator of the experiment for the year 2009 a member (E.T.) of our group.

3.2 ATLAS EXPERIMENT AT LHC P-P COLLIDER (GENEVA-SWITZERLAND)

Physicists: C. Adorisio
G. Crosetti
M. Capua
S. Fazio
L. La Rotonda
A. Mastroberardino
E. Meoni
G. Morello
A. Policicchio
D. Salvatore
M. Schioppa
G. Susinno
E. Tassi
T. Venturelli

Technicians: F. Pellegrino, V. Romano, P. Turco

International collaboration

Nature has given us more than one elementary particle (6 fermions, 6 quarks and the carriers of the four fundamental interactions), whose masses range in a wide interval of values from the mass-less gauge bosons to the top quark mass, M_t=170 GeV/c^2. With this variety of particles and masses we should have an answer about the mechanism that determines the particle masses. Many experiments with particle accelerators are looking into the mechanism that gives rise to mass.

In 1964 Peter Higgs first proposed a very clever and very elegant solution to this problem: an undetectable field, similar in some ways to the electromagnetic one, permeates the whole of space. As particles move through space they travel through this field, and if they interact with it they acquire what appears to be mass. This is similar to the action of viscous forces felt by particles moving through any thick liquid: the larger the interaction of the particles with the field, the more mass they appear to have. Thus the existence of this field is essential in Higgs hypothesis for the production of the mass of particles. Moreover from quantum theory follows that fields have particles associated with them (i.e. the photon is associated with the electromagnetic field). So the Higgs field should has a particle associated with, the Higgs boson. Finding the Higgs boson is thus the key to discovering whether the Higgs field does exist and whether our best hypothesis for the origin of mass is indeed correct.

The Standard Model of particle physics predicts that the Higgs boson is a hypothetical, massive subatomic neutral particle whose existence would explain the masses of the elementary particles. Up to now, no experiment definitively detected the existence of the Higgs bosons. The Higgs field is perceived the same from every direction (scalar field) and is mostly indistinguishable from empty space. The Higgs boson, itself has a characteristic rest-mass. The best theoretical estimate value for this mass is 117GeV and upper limit of 251 GeV. Particle accelerators have probed energies up to about 115 GeV, and have recorded a small number of events that could be interpreted as resulting from Higgs bosons, but the evidence is yet inconclusive. It is expected that LHC, the multi-TeV p-p collider of CERN, will be able to confirm or

disprove the existence of the Higgs particle. This collider that provide 10 times higher centre of mass energy and 100 times higher p-p collision rates than previous colliders has been commissioned during autumn 2008 and it will be fully operative end 2009. This opens up a new frontier of physics and the LHC experiments (ATLAS, CMS, ALICE, LHCB) will be ready to explore this great potential.

ATLAS is a general purpose detector designed to detect clean signals and perform accurate measurements of: charged leptons, photons, non-interactive particles such as neutrinos through missing energy measurements, hadronic jets, and bottom quarks. The basic design concept to achieve these goals includes three detector systems:

- **Inner tracker** with semi-conductor pixel and strip detectors for very high accuracy measurements of the charged particle trajectories, followed by straw tubes detector giving a bubble chamber like image of the event and independent electron identification. The tracker is confined to a cylinder 6,8m long and 1,1m radius in a 2T magnetic field provided by a superconductive solenoid.
- **Calorimeter** with an inner cylinder in highly granular liquid argon technology with Pb absorber, followed at large radius by an iron-tile scintillator calorimeter providing good resolution in a very cost-effective manner.
- High precision stand-alone **muon spectrometer**. Its conceptual layout is based on the magnetic deflection of muon track in a system of three large superconducting air-core toroid magnets instrumented with separate-function trigger and high-precision tracking chambers.

The researchers of the UNICAL physics department have been actively involved in various aspects of the design, construction and installation of the muon spectrometer detector system since 1994. During this period the hardware projects in which the group participated have employed and trained many undergraduate, graduate and phd students and post doctorate researchers.

In November 2008 a proposal for an **ATLAS Forward Physics** (AFP) program was submitted to the attention of the ATLAS Collaboration. It concerns the possibility to install a new generation of Si3D detectors along the beam pipe at a distance of 220 m and 420 m from the interaction point to measure the four-momentum of protons diffracted at really small angle and escaping the main ATLAS detector through the beam pipe. The installation of these detectors will allow ATLAS collaboration to access the measurement of a wide range of “diffractive” physics interaction including the diffractive production of the Higgs boson. The HEP group is involved in the design and simulation of the AFP apparatus.

During the 2008 year the UNICAL HEP researchers have participated to many ATLAS activities:

- Participation in the maintenance and improvement task force of the muon precision chambers at CERN. This is a small group of physicist specialised to act on the detector curing all the aspects concerning on chamber and distributed systems like gas, read out, alignment, data control, high and low voltage.
- Participation in the study of the drift properties of the muon precision chambers though MonteCarlo studies and test beam performed at CERN. The main purposes of these studies are to achieve a better understanding of the base line MDT gas mixture in terms of spatial resolution, auto calibration and time slewing corrections, and to discover a new gas mixture with low occupancies to be employed with LHC high luminosity.
- hold down and keep developing the low level data acquisition software for the ATLAS sub-detector online monitoring, named **GNAM**. The Cosenza group has developed the GNAM version to monitor the sub-detector performances during the installation and commissioning phase of the ATLAS muon spectrometer. A low level tool is necessary to immediately spot any problem in the detector, such as inefficient or dead channels, that may affect the data taking and the subsequent reconstruction and pattern recognition techniques. Due to the very positive experience of the commissioning phase, the GNAM software has been inserted into the official ATLAS software and will be extensively used during the forthcoming ATLAS data taking.
- Beam test at CERN for the characterisation of several irradiated and not irradiated prototypes of Si 3D detectors to be installed in the AFP apparatus.
- Monte Carlo simulation of the AFP apparatus in GEANT4 and it's implementation into the ATLAS analysis framework ATHENA and translation of the algorithm from GEANT4 standard to the official ATLAS GEANT4-based geometry description language: GEOMODEL.
- Contribution to the B meson physics group studying its **rare semileptonic** decays. The study is an important test of the **Standard Model** and a indirect way to search for **new physics beyond** the Standard Model**.** New analysis algorithms have been developed for the selection of rare decays in to two muons, over the enormous combinatorial background. It has been demonstrated the possibility of study such decay channels efficiently in ATLAS during the first run at low luminosity. For the Collaboration we have the responsibility of the development, integration, testing and maintenance of the second and third level (HLT) trigger for the semileptonic channels.
- Contribution to the Higgs physics group searching the boson in the channel H->ZZ->4 leptons. The Higgs decay in

the four lepton final state is one of the most promising channel for the discovery at LHC. The signal rises to a very distinctive signature consisting of four isolated leptons, but excellent performances in terms of the identification, reconstruction and measurement of **isolated leptons** are required to discover the Higgs in this decay mode, particularly for masses smaller then 180 GeV where the Higgs peak is expected very narrow and the background is expected very large. From 2003 the UNICAL HEP group is involved in the analysis of this channel using the different Atlas Data Challenge productions, which are the official series of massive simulated data planned by the ATLAS Computing in order to test the ATLAS software and to develop a realistic analysis strategy before data tacking. The group has developed in addition to a classical analysis based on a series of subsequent cuts on single variables also **a multivariate analysis** based on likelihood and neural network techniques to optimize the background rejection. At the unexplored energy of LHC, the background is affected by large uncertainties and the Monte-Carlo must be tuned on data during first data taking, since the Higgs discovery must be robust against these uncertainties, the group is involved in the development of the techniques to extract background directly from data with the statistic foreseen for the first year of LHC data tacking.

- Several extensions of the Standard Model (SM) have neutral, weakly couplet unstable particles with macroscopic decay lengths. Among these the Hidden Valley (HV) Scenario predicts a new dinamic accessibile at LHC energies. In the HV model a new sector is weakly couplet to the SM and results in neutral long lived HV particles (πv) that decay to heavy quark pairs and tau pairs. These particles can be produced in Higgs boson decays, SUSY processes and Z decays. Neutral particles with long decay paths and many particle decay final states represent, from an experimental point of view, a challenge both for the trigger and for the reconstruction capabilities of the ATLAS apparatus. Displaced high multiplicity neutral vertices implies unique topological signature, which is not common to any SM process. HV processes are typically almost background free, but with non-pointing tracks and no charged track in the Inner Detector. Current Atlas trigger paths have not been optimized for picking up decays of neutral particles that decay to di-jets thooughout the detector. For the purpose of exploring the challenges to the trigger posed by long-lived particles, the Hidden Valley scenario serves as an excellent setting.

In collaboration with the INFN Rome 1 Group and the Seattle University, Washington, the HEP group is involved in the study of the ATLAS Detector performance for the Higgs decay to two v-pions, where a v-pion is neutral and has a displaced decay mainly to bottom quarks. The HEP group participates in implementing in the ATLAS simulation package the new signature based triggers and is active in the study of the resulting trigger acceptances and of the potential source of significant background, such as the SM QCD processes, at the trigger level. The main goal of this study is to obtain benchmark triggers for processes with non-standard signatures in the ATLAS apparatus. An ATLAS internal note is in preparation which presents the results of a first study of ATLAS detector performance for some Hidden Valley processes with long-lived, neutral states that decay throughout the detector volume to multi heavy-flavor jets, mainly b-bbar.

3.3 DRC (CERN-SWITZERLAND)

Physicists: L. La Rotonda
E. Meoni
A. Policicchio
G. Susinno
T. Venturelli

Technicians: F. Pellegrino, V. Romano

International collaboration

High-precision measurements of hadrons and hadron jets have become increasingly important in experimental particle physics. The energy resolution of a hadron calorimeter is in general much worse than what can be achieved for electromagnetic (e.m.) shower detection. The wide variety of possible interaction processes and the effects associated with excitation of the absorber nuclei are considered responsible for this.

In compensating hadron calorimeters a dominant source of fluctuations that comes from π^0 production in the shower is eliminated by equalizing the calorimeter response to e.m. and purely hadronic shower component.

In recent years, R. Wigmans (Texas Tech) in collaboration other groups have developed an alternative technique: The Dual Readout Method (DREAM).

DREAM calorimeters are based on a simultaneous measurement of different types of signals which provide

complementary information about details of the shower development.

DREAM prototype, that has been successfully tested at CERN in 2004, is a copper absorber structure, equipped with two types of active media. Scintillating fibers measure the total energy deposited by the shower particles, while Quartz fibers measure the Cerenkov light that is only produced by the charged, relativistic shower particles.

Since the latter are almost exclusively found in the e.m. shower component (dominated by π^0 s produced in hadronic showers), a comparison of the two signals makes it possible to measure the energy fraction carried by this component, ϕem, event by event.

Once the effects of the dominant source of fluctuations, *i.e.,* fluctuations in the e.m. energy fraction ϕem, are eliminated, the performance characteristics are determined (and limited) by other types of fluctuations. In the described detector, a prominent role is played by the small number of Cerenkov photoelectrons constituting the signals (8 p.e./GeV).

To avoid this, one could associate to DREAM calorimeter a homogeneous (fully sensitive) detector provided that the light signals can be separated into scintillation and Cerenkov components.

To this last project,with U.S. researchers an Italian collaboration: **DRC** (Bologna - Cagliari - Cosenza - Roma1 - Pavia) is working from 2006.

In a homogeneous calorimeter the two light components can be disentangled by:

(1) Directionality. The Cerenkov light is emitted at a fixed angle with respect to the momentum vector of the particle that generates it, while the scintillation light is isotropically emitted.

(2) Time structure. The Cerenkov light is prompt, whereas scintillation processes have one or several characteristic decay times.

(3) The spectrum. The Cerenkov light is emitted with a characteristic λ^{-2} spectrum, while the scintillation processes have their own characteristic spectra.

(4) Polarization. Contrary to scintillation light, Cerenkov light is polarized.

Very promising results have been obtained in case of a single BGO crystals and a small electromagnetic calorimeter made of lead tungstate (PbWO4) crystals tested in conjunction with the DREAM calorimeter mentioned above, and exposed to high energy particle beams at CERN's Super Proton Synchrotron.

Time structure and spectrum of signals like to be the most interesting characterization of two signals.

The study of new crystals more efficient to discriminate scintillation and Cerenkov light and the development of a faster electronic are going on.

The HEP group participate to the Test Beam and data analysis and is responsible for the Geant simulation and for the on-line and off-line monitoring.

3.4 THERMALIZATION EXPERIMENT AT U70 PROTON ACCELERATOR (PROTVINO-RUSSIA)

Physicists: M. Capua
S. Fazio
R. Fiore

International collaboration

The goal of the project is the study of multi-particle dynamics in inelastic proton-nucleon interactions with extremely high multiplicity (more than 20 charged particles in the final state). The domain of high multiplicity $n_\pi = 30–40$, near the threshold of the reaction $n_\pi \rightarrow 69$, where all particles acquire small relative momentum $\Delta q < 1/R$ (R is the dimension of the particle production region).

The experimental setup consists of a 70 GeV proton beam, accelerated with the U70 synchrotron in Protvino Laboratory (Moscow Region, Russia) scattered off a liquid hydrogen target. The final state is measured by the SVP2 detector which consists of a silicon strip micro-vertex detector, a tracker and a spectrometer using drift tubes ad an electromagnetic calorimeter.

As a consequence of multiboson interference, a number of collective effects may show up:

1. a drastic increase in the partial cross section $\sigma(n)$ of production of n identical particles is expected, compared with commonly accepted extrapolation; the formation of jets consisting of identical particles may occur as a result of the multiboson Bose–Einstein correlation (BEC) effect;
2. a large fluctuation of charged $n(\pi^+,\pi^-)$ and neutral $n(\pi^0)$ components and onset of centauros or chiral

condensate effects are anticipated;

3. an increase in the rate of direct γ as a result of the bremsstrahlung in the partonic cascade and annihilation of $\pi^+\pi^- \rightarrow n\gamma$ in dense and cold pionic gas or condensate is expected.

The UNICAL HEP group joined the Collaboration in spring 2008, two main activities were carried over:

- alignment of the spectrometer installed on the SVD2 detector;
- project and design of the upgrade of the SVD2 detector.

Concerning the SVD2 upgrade a joint project between UNICAL and JINR laboratory (Dubna, Russia) has been proposed in order to designe and build up a new version of the low threshold electromagnetic calorimeter, sensible to the soft photons. The goal is to study the emission of soft direct photons (DP) in pp collisions. Commonly excepted theoretical explanation of the DP phenomenon is the internal bremsstrahlung from the initial and final hadron state. The most interesting are the low transverse and longitudinal momentum DP at pt < 0.1 GeV /c, xF < 0.01.
Preliminary studies show that the yield of photons in this domain (energy range of 1 ÷ 50 MeV in c.m.s.) may exceed theoretical estimates in 5 - 8 times. For the qualitative explanation of this effect the assumption of the formation of cold spot of Quark-Gluon Plasma (QGP) or hadronic gas is made in some of theoretical papers. It is argued that cold spot has relative stability and radiates soft photons. Soft DP signifies existence of a new phenomenon connected to collective behaviour of particles. For example, in accordance with Quantum Chromo-Dynamics (QCD) theory, DP may be emitted in the process of quark-quark and quark-gluon interaction. DP emission intensity depends on system lifetime.
The project has been approved and financed by the Russian Foundation for Basic Research, to cover all the cost of the Russian team. It was well considered and approved by the Italian foundation: Einstein Consortium (Lecce, Italy), who is deputed to approve Italo-Russian experimental and theoretical projects on high energy physics and complex systems. The proposal is now under the attention of the Italian Ministry of Sciences to receive financing to cover the costs of the Italian team.

3.5 KLOE-2 EXPERIMENT AT DAFNE E-E+ COLLIDER (National Laboratory of Frascati)

Physicists: M. Schioppa
G. Morello
Technicians: none
International collaboration

The DAFNE collider accelerates and stores electrons and positrons of 510MeV energy each to produce PHI-mesons via the reaction e^+e^- -> gamma* -> PHI. This meson has 1020 MeV/c2 mass and the photon quantum numbers: $J^{PC} = 1^{--}$. It decays at rest mainly into charged and neutral kaon pairs, branching ratio BR=49.5% and BR=34.3% respectively, but also into RHO-PI and PI+PI-PI0 (BR=15.5%), ETA-GAMMA (BR=1.3%), ETA'-GAMMA (BR=0.00012). The neutral kaon pairs are produced in a well-defined quantum and kinematical state with negative charge parity. The kaons are monochromatic (127MeV/c for charged kaons and 110MeV/c for the neutral one) and are emitted back to back to be detected in an almost background free environment. With the integrated luminosity of 2.5fb-1 (2001-2006) the collider has produced 10^10 PHI-mesons and than about 10^10 kaon pairs. For this reason the DAFNE collider is called a strangeness-producing factory.

DAPHNE has two interaction regions. The experiment KLOE is located in one of them. It is a general purpose detector designed to study all kinds of kaon, PHI, RHO, ETA and ETA' decays emphasising tests of discrete symmetries (CP-, CPT-, T-invariance) and measurements of hadronic cross sections and tests of chiral perturbation theory.

The detector is a huge (4m diameter, 4m long), transparent drift chamber in 0.5Tesla magnetic field produced by a superconductive solenoid, with 55000 stereo wires, in helium based gas mixture, surrounded by a lead-scintillating fiber calorimeter, 15X0 thick, 98% solid angle coverage with a resolution of 54ps/SQRT(E)+50ps (E in GeV) in time and 5.7%/SQRT(E) in energy .

During 2008 the INFN has approved the KLOE-2 proposal at the improved DAFNE luminosity performance, of a two steps roll-in: summer 2009 up to the end of the year, to get the first flavour of the machine; summer 2010 up to the end of the year to get the long data-tacking campaign (20-50fb-1).

The contribution to KLOE-2 project of the UNICAL's researchers has been focused on LET tagger calorimeter performance studies by GEANT4 simulations, cylindrical GEM inner tracker detector gas gain simulations, the absolute

luminosity monitor calorimeter to measure the DAFNE luminosity during the 2007-2008 machine development.

3.6 AIR SHOWER OBSERVATORY WITH SCINTILLATOR DETECTORS ARRAY

Physicists: M. Schioppa
Technicians: none

During the last 20 years the Astroparticle research has considerably contributed to the better understanding of the laws that govern the Universe but it has also leaved many open questions (i.e. the origin, the acceleration mechanism and the elementary composition of the Cosmic Rays) that can be coped only with ground based experimental apparatus that are the only capable to detect those CR coming from galactic and extragalactic exotic astrophysical sources and directly from the Big Bang. Indeed these particles have energy greater than 100TeV (UHE) and interact with the nuclei of the atmosphere generating extensive air showers (EASs). During the last years the ground-based apparatus have reached goals unattainable with the other techniques to explore the Universe. For example it has put in evidence a very large number of gamma-sources from our galaxy and from other galaxy, it has demonstrated the existence of very complex gamma sources, and it has discovered extragalactic gamma source at distance never explored previously.

The researchers of UNICAL physics department, with the precious collaboration of physics students, have designed and realized an EAS observatory made of 3 large scintillator counters placed at the vertex of a equilateral triangle, 20m side. The apparatus detects EAS produced by CR of energy greater than PeV and can measure the direction of the primary CR with a resolution of 5°. During 2008 the apparatus has collected about half million EAS that are used for calibration purpose. The apparatus is particularly suitable also for didactics purpose.

The UNICAL's researchers have presented a PRIN project for the realization of a ground-based apparatus to detect the muon content of the showers employing the last generation high precision drift chamber used in the colliding beam experiment like ATLAS. This apparatus can contribute to the determination of the energy of the primary Cosmic Ray, to the study of the elementary composition of the Cosmic Ray and the reconstruction of the muon tracks, allowing us to increase the angular resolution about the direction of the CR of at least one order of magnitude to respect the existing EAS-arrays.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international scientific journals

A.1.1 Publications on international scientific journals published on 2008

1. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Diffractive Photoproduction of Dijets in ep Collisions at HERA,
Europ. Phys. Journal C 55 (2008) 177-191.

2. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Three- and four-jet final states in photoproduction at HERA,
Nuclear Physics B 792 (2008) 1-47.

3. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Deep Inelastic Inclusive and Diffractive Scattering at Q^2 Values from 25 to 320 GeV^2 with the ZEUS Forward Plug Calorimeter,
Nuclear Physics B 800 (2008) 1-76.

4. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Mulit-jet cross sections in charged current e^+-p scattering at HERA,
Physical Review D 78 (2008) 032004.

5. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Energy dependence of the charged multiplicity in deep inelastic scattering at HERA,
JHEP06 (2008) 061.

6. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Beauty photoproduction using decays into electrons at HERA,
Physical Review D 78 (2008) 072001.

7. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
I*nclusive $K^0_S K^0_S$ resonance production in ep collisions at HERA,*
Physical Review Letters 101 (2008) 112003.

8. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Search for events with an isolated lepton and missing transverse momentum and a measurement of W production at HERA,
DESY-08-089, ZEUS-PUB-08-005, Jul 2008. 17pp. Phys.Lett.B672:106-115,2009.

9. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Measurement of beauty production from dimuon events at HERA,
DESY-08-129, Sep 2008. 41pp. Published in JHEP 0902:032,2009.

10. C. Adorisio, F. Castrovillari, G. Crosetti, L. La Rotonda, E. Lamanna, E. Meoni, A. Policicchio, D. Salvatore, M. Schioppa, G. Susinno and the ATLAS Coll.,
The ATLAS Experiment at the CERN Large Hadron Collider,
Published in JINST 3:S08003,2008.

11. C. Adorisio, G. Avolio, E. Meoni, A. Policicchio, P.F. Zema et al.,
System Test of the ATLAS Muon Spectrometer in the H8 beam at the CERN SPS.,
Nucl.Instrum.Meth.A593, 232 (2008).

12. L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno, T. Venturelli et al.,
Cerenkov light contribution in lead tungstate crystals,

Nucl.Instrum.Meth.A593:530-538,2008.

13. L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno, T. Venturelli et al.,
Separation of Crystal Signals into Scintillation and Cherenkov Components,
Published in Nucl.Instrum.Meth.A595, 359 (2008).

14. A. Policicchio and G. Crosetti,
Study of DiMuon Rare Beauty Decays with ATLAS and CMS,
Eur. Phys. Jour. C55, 173 (2008).

15. L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno, T. Venturelli et al.,
Dual-Readout Calorimetry with Lead Tungstate Crystals,
Nucl. Instrum.Meth. A584, 273 (2008).

16. L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno, T. Venturelli et al.,
Effects of the Temperature Dependence of the Signals from Lead Tungstate Crystals,
Nucl. Instrum. Meth. A593, 530 (2008).

A.1.2 Publications on international journals accepted in 2008

1. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Production of excited charm and charm-strange mesons at HERA,
Accepted by: European Physical Journal C (EPJC-08-11-045).

2. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Angular correlations in three-jet events in ep collisions at HERA,
DESY-08-100 (July 2008) to be published in European Physical Journal D

3. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Measurement of Beauty Photoproduction using Decays into Muons in Dijet Events at HERA,
DESY-08-210 (December 2008) to be published in JHEP.

4. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Measurement of the charm fragmentation function in D photoproduction at HERA,
DESY-08-209 (December 2008) to be published in JHEP.

5. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Measurement of High-Q^2 Neutral Current Deep Inelastic e^- Scattering Cross Sections with a Longitudinally Polarised Electron Beam at HERA,
DESY-08-202 (December 2008) to be published in EPJ C.

6. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Measurement of D^\pm and D^0 Production in Deep Inelastic Scattering Using a Lifetime Tag at HERA,
DESY-08-201 (December 2008) to be published in EPJ C.

7. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Subjet Distributions in Deep Inelastic Scattering at HERA,
DESY-08-178 (December 2008) to be published in EPJ C.

8. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Measurement of Charged Current Deep Inelastic Scattering Cross Sections with a Longitudinally Polarised Electron Beam at HERA,
DESY-08-177 (December 2008) to be published in EPJ C.

9. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Leading Proton Production in Deep Inelastic Scattering at HERA,
DESY-08-176 (December 2008) to be published in JHEP.

10. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Deep Inelastic Scattering with Leading Protons or Large Rapidity Gaps at HERA,
DESY-08-175 (December 2008) accepted by Nuclear Physics B, Ref. No. NPB-D-08-00606R1

11. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
A Measurement of the Q^2, W and t Dependences of Deeply Virtual Compton Scattering at HERA,
DESY-08-132 (December 2008) to be published in JHEP.

12. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration,
Measurement of beauty production from dimuon events at HERA,
DESY-08-129 (September 2008) JHEP02(2009)032.

13. L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno, T. Venturelli et al.,
Neutron Signals for Dual-Readout Calorimetry,
Nucl. Instrum. Meth. A598, 422 (2009).

14. C. Adorisio, G. Avolio, E. Meoni, A. Policicchio, P.F. Zema et al.,
Study of the ATLAS MDT spectrometer using high energy CERN combined test beam data,
Nucl. Instrum. Meth. A598, 400 (2009).

15. L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno, T. Venturelli et al.,
Dual-Readout calorimetry with crystal calorimeters,
Nucl. Instrum.Meth. A 598, 710 (2009).

A.1.3 Public international notes in 2008

1. C. Adorisio, G. Crosetti, M. Capua, S. Fazio, L. La Rotonda, E. Meoni, A. Policicchio, D. Salvatore, M. Schioppa, G. Susinno, E. Tassi, T, Venturelli et. al.
Expected Performance of the ATLAS Experiment : Detector, Trigger and Physics A detailed study is presented of the expected performance of the ATLAS detector,
arXiv:0901.0512 CERN-OPEN-2008-020. - 2008. - 1852 p.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2008

1. S. Fazio,
Exclusive diffractive final states in ep collisions,
Lake Louise Winter Institute: Fundamental Interactions (LLWI 2008), Lake Louise, Alberta, Canada, 18-23 Feb 2008.
e-Print: arXiv:0811.1133

2. S. Fazio and L. Jenkovszky
Exclusive diffraction and Pomeron trajectory in ep collisions
XV Annual Seminar on Non Linear Phenomena in Complex Systems, Minsk (Belarus), PoS NPCS 2008. e-Print: arXiv:0811.1018

3. S. Fazio, R. Fiore (Calabria U. & INFN, Cosenza) , Laszlo L. Jenkovszky (BITP, Kiev & Budapest, RMKI)
Deeply virtual Compton scattering and generalized parton distributions,
Contributed to Diffraction 2008: International Workshop on Diffraction in High Energy Physics, La Londe-les-Maures, France, 9-14 Sep 2008. PoS DIFF 2008. e-Print: arXiv:0812.3125

4. M. Capua, M. Grothe, D.Yu. Ivanov, M.N. Kapishin
Summary from the working group on 'Diffraction and Vector Mesons' at DIS 2008
Proc. of XVI Int. Workshop on Deep-Inelastic Scattering and Related Topics, London, England, April 2008, Published online http://www.sciwipub.com/index.php?doit=dis2008

5. M. Capua on behalf of the H1 and ZEUS Collaborations
DVCS and high-t photons at HERA,
Contributed to Diffraction 2008: International Workshop on Diffraction in High-Energy Physics, La Londe-les-Maures, France September 9-14, 2008

6. M. Schioppa et al.
DAFNE setup and operation with the crab-waist collision scheme,
EPAC08-WEPP036, Jul 2008. 3pp. In the Proceedings of 11th European Particle Accelerator Conference (EPAC 08), Magazzini del Cotone, Genoa, Italy, 23-27 Jun 2008, pp WEPP036. Also in Proceedings of PAC08, Genoa, Italy:2599-2601, 2008.

7. M. Schioppa et al.
Luminosity Measurement at DAFNE for Crab Waist Scheme,
In the Proceedings of 11th European Particle Accelerator Conference (EPAC 08), Magazzini del Cotone, Genoa, Italy, 23-27 Jun 2008, pp TUPC065.

8. E. Meoni on behalf of the ATLAS Coll.,
Searches for the standard model higgs boson with the ATLAS experiment at LHC,
8th International Conference on Particles and Nuclei (PANIC08), Eilal (Israel),9-14 November 2008
ATL-COM-PHYS-2008-290, ATL-PHYS-PROC-2009-025, Jan 2009.

9. C. Adorisio, E. Meoni, A. Policicchio, D. Salvatore, et. al.,
Study of the ATLAS MDT spectrometer using high energy CERN combined test beam data,
ATL-MUON-PUB-2008-005, ATL-COM-MUON-2007-013, Apr 2008. 42pp. Published in Nucl.Instrum.Meth. A598:400-415, 2009.

10. D. Salvatore et al.
Event reconstruction algorithms for the ATLAS trigger
CHEP2007: c/o Elly Driessen, Conference Coordinator: TRIUMF: 4004 WesbrookMall: Vancouver, BC V6T 2A3 CANADA. J.Phys.Conf.Ser.119:022022, 2008.

11. D. Salvatore et al.
Integration of the trigger and data acquisition systems in ATLAS
CHEP2007: c/o Elly Driessen, Conference Coordinator: TRIUMF: 4004 WesbrookMall: Vancouver, BC V6T 2A3 CANADA. J.Phys.Conf.Ser.119:022001, 2008.

12. G. Crosetti, A. Policicchio et al.
B, D and K decays,
Report of Working Group 2 of the CERN Workshop *Flavour in the era of the LHC*, Geneva, Switzerland (2005-2006), Eur. Phys. Jour. C57, 309(2008).

13. L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno, T. Venturelli et al.
Cerenkov Light contribution in lead tungstate crystals,
Prepared for *EPS HEP2007* Manchester, Uk (2007), Journal of Physics: Conference Series 110 (2008) 092034.

14. L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno, T. Venturelli et al.
Assessment of the Cerenkov light produced by a PWO crystal by means of the study of the time structure of the signal
Published by World Scientific (2008).

15. E. Meoni of behalf of the DREAM Collaboration
New Results from the DREAM Project 2008,
IEEE Nuclear Science Symposium, Medical Imaging Conference, Dresden (Germany), 19-25 October 2008.

16. C. Adorisio et al.
Software Validation Infrastructure for the ATLAS High-Level Trigger
XII Advanced Computing and Analysis Techniques in Physics Research, November 3-7 2008 - Erice, Italy
(Ref. internal note: ATL-COM-DAQ-2008-018.- Geneva : CERN, 2008)

PRESENTATIONS AT SCHOOLS AND CONFERENCES

C.1 Invited presentations at international schools and conferences in 2008

1. E. Tassi on behalf of the H1 and ZEUS Collaborations
Electroweak Physics Measurements at HERA,
Les Rencontres de Physique de la Vallée d'Aoste. La Thuile, Aosta Valley, Italy. February 24 - March 1, 2008.

3. S. Fazio
Exclusive photo- and electro-production of vector mesons and real photons at HERA
Invited Seminar given at the BITP (Kiev, Ukraine), July 30, 2008.

4. S. Fazio
Exclusive diffraction and Pomeron trajectory in ep collisions
Presentation given at the XV Annual Seminar on Non Linear Phenomena in Complex Systems, Minsk (Belarus), May 20-23, 2008.

5. C. Adorisio
Studies of Semileptonic Rare B Decays at ATLAS and CMS
presented at: Flavour as a window to New physics at LHC Week IV (May 26-30): Focus Week "B@LHC".

C.2 Invited presentations at national conferences in 2008

1. M. Capua
Risultatidi fisica a ZEUS,
SEZIONE 1: Fisica Nucleare e Subnucleare. Congresso SIF 2008 Genova, 22 – 26 settembre 2008
To be published on Atticon Vol. XCIV section - I - Fisica nucleare e subnucleare.

2. A. Policicchio
Semileptonic rare beauty decays with ATLAS and CMS experiments at LHC,
Prepared for *IFAE 2007*, Neaples, Italy (2007), Springer-Verlag, ISBN 88-470-0746-8 (2008).

3. A. Policicchio et al.
Rare decays at the LHC,
Prepared for V workshop italiano sulla fisica p-p ad LHC, Perugia, Italy (2008), to be published by Nuovo Cimento.

4. A. Policicchio
Rare semileptonic decays at the LHC,
V Incontro sulla Fisica del B, Cagliari, Italy (2008).

5. A. Policicchio
$B_s \to \mu^+\mu^-$ in ATLAS,
V Incontro sulla Fisica del B, Cagliari, Italy (2008).

4. SURFACE ELECTRON SPECTROSCOPY (SPES)

Professors and Researchers	Elio Colavita *(Group Leader)* Gennaro Chiarello Raffaele Giuseppe Agostino Gennaro Chiarello Vincenzo Formoso Tommaso Caruso
Postdoc fellows	Enrico Maccallini Alfonso Policicchio
PhD students	Antonio Marino Georgios Kalantzopoulos Myrsini Antoniou
Technicians	Salvatore Abate (Lycril/CNR) Giovanni Desiderio (Lycril/CNR) Vito Fabio Eugenio Li Preti
Collaborators	P. Milani *(University of Milano, Italy)* P. Rudolf *(Material Science Center, University of Groningen, The Netherlands)* C.E. Bottani (*Politecnico of Milan, Italy*) J. bNagy (*Dept of chemical and material engineering, Univ. of Calabria*) G. Golemme (*Dept of chemical and material engineering, Univ. of Calabria*) A. Goldoni *(Elettra, Trieste, Italy)* S. La Rosa *(Elettra, Trieste, Italy)* S. Scalese *(CNR, Catalina, Italy)* D. Gournis *(University of Ioannina, Greece)* F. Alamgir *(Brookhaven National Laboratory, New York, USA)* G. Froudakis (*University of Crete, Greece*) P. Trikalitis (*University of Crete, Greece*) F. Alamgir *(Georgia Institute of Technology, Atlanta, Georgia, USA)* G. Valenti *(University of Bari, Italy)* A. Politano (*Università autonoma diof Madrid,,,. Cantoblanco. Spain*)-Spagna)

Research subjects:

4.1 CHEMISORPTION ON METAL SURFACES.
4.1.1 Nature of the alkali surface bond at very low coverages:
4.1.2 Alkali coadsorption with CO on Ni(111) and Cu(111) surfaces.
4.1.3 Alkali induced oxidation of metal surfaces and adlayers.
4.1.4 Collective electronic vibrational properties of Ag and Au ultrathin films deposited on metallic substrates.
4.2 SPECTROSCOPIC AND MICROSCOPIC STUDIES OF CARBON/METAL-OXIDE NANOSTRUCURE
4.2.1 Photoemission investigation on nanostructured TiO2 growth by cluster assembling.
4.2.2 Microscopic and spectroscopic characterization on carbon/metal nanocomposites.
4.2.3 Electronic and structural characterization of carbon nanotubes.
4.2.4 Nanostructured titanium oxide films with tailored physical and chemical properties reactivity
4.3 MORPHOLOGICAL AND STRUCTURAL CHARACTERIZATION AND VOLUMETRIC GAS ADSORPTION EVALUATION OF MESO AND MICROPOROUS MATERIALS WITH HIGH SURFACE SPECIFIC AREA
4.3.1 New silicalite carbon nanostructures materials for hydrogen storage
4.3.2 Hydrogen storage capacity at high pressure of organo-silane modified silicalite-1

4.4 SELECTIVE TRANSPORT ACROSS BIOLOGICAL MEMBRANES.
4.4.1 Electron microscopy studies of biological mebranes.

Introduction

Scientific basic research and applied physics have been carried out during the last year. Vibrational studies of alkali atoms and their coadsorption with CO and oxygen on Ni(111) and Cu(111) surfaces allowed to shed more light on some long standing problems as the nature of the alkali surface bond at very low coverages and the role of short and long range interactions in the coadsorption of K and Na with CO molecules and oxygen atoms. Moreover, the role of the temperature on the alkali-promoted CO dissociation was studied with unprecedented details.
The research activity involved also the preparation and the investigation of the electronic properties of ultra-ulrathin films of Ag and Au supported on the Ni(111) and Cu(111) surfaces.

For Ag/N(111) we found that the surface plasmon dispersion is influenced by the electron confinement and by the presence of quantum well states (QWS). Moreover, the dispersion and damping of gold surface plasmon were investigated for the first time.

Carbon and metal-oxide nanostructures spectroscopic studies deal with photoemission investigations on nanostructured TiO_2 grown by a pulsed supersonic cluster beam deposition method. The presence of a certain amount of surface Ti 3d defect states in the band gap of TiO_2 has been found. The Ti local electronic structure was also studied by performing valence band resonant photoemission at the Ti L edge (454-470 eV). Interestingly, the irradiation of carbon/titania nano-composites with the ultraviolet beam (95 eV) focused on a micrometer spot, modifies the film electronic structure. We observed in fact a relevant increase of the photoemission intensity at the Fermi level, suggesting that the films acquire a "metallic" character.

In addition we characterized the electronic, structural and wetting properties of TiO_x thin films growth by Laser Pulsed Deposition (LPD) techniques by XPS-UPS, XRD and contact angle respectively. The samples were grown with different synthesis parameters in order to understand their relationship with the hydrophobic-hydrophillic properties and their evolution by thermal annealing. This work has been realized in collaboration with the group of Prof. Carlo Bottani of the Politecnico di Milano.

The SPES group has been also involved in a collaboration with academic and industrial partnerships of the University of Ioannina and Crete (Greece) and the company INNOVA. The hydrogen and methane storage capacity of different porous material synthesised in the University of Ioannina and Crete was tested. The results have been analyzed by means of particular models (Toth equation) which give indication on the heterogeneity properties of the samples supposed to adsorb gas molecules.

The same setup has been utilized to test the adsorption properties of modified zeolites in collaboration with Prof. Gianni Golemme, Department of chemical and materials engineering, in order to investigate the selectivity of those materials to different gas species. The goal is to understand the behaviour of that material to gas adsorption and to use it in selective membrane for gas purification applications.

A very recent collaboration with Prof. Giovanna Valenti of the University of Bari is in progress with the aim to integrate concepts and techniques from molecular cell biology, with high resolution microscopy (HRTEM) and structural biology by atomic force microscopy.

4.1 CHEMISORPTION ON METAL SURFACES

Nature of the alkali surface bond at very low coverages

HREELS was used to study the nature of the Na/Ni(111) and K/Ni(111) bond at very low coverages. Measurements taken for very clean alkali layers provided, for the first time the expected behaviour of the alkali-substrate stretching energy as a function of the alkali coverages. Moreover, we found that the Na-Ni (K-Ni) bond was dramatically influenced by coadsorbed CO molecules causing a red shift of the alkali-substrate vibrational frequency. We argue, that this effect, never reported before, could be at the base of discrepancies existing between calculated and measured vibrational energies as a function of the alkali coverages.

Alkali coadsorption with CO on Ni(111) and Cu(111) surfaces

The CO adsorption of alkalis (K, Na) and CO on Cu(111) and Ni(111) was investigated at room temperature. We found that CO adsorption is partially dissociative on a potassium-precoverd Cu(1111) surface and fully dissociative for Na /Cu(111). CO molecules occupy adsorption sites directly adjacent to those of alkali adatoms. This conclusion is suggested by the absence of a threshold alkali precoverage for CO dissociation. On the contrary, in the case of alkali+CO/Ni(111) such threshold was found to exist. Moreover, we report experimental eveidences for a very short-range interaction between Na and CO. This result contrasts with recent theoretical prediction overestimating non-local alkali-induced effects. Loss measurements were used to investigate the effects of temperature on the dissociation of CO coadsorbed with Na and K on Ni(111). We found that CO adsorption on alkali-precovered Ni(111) surface is partially dissociative up to 400 K and completely dissociative for higher temperatures. Depending on temperature, an alkali critical precoverage for CO dissociation was found to exist, in agreement with theoretical models. Moreover, we found, that Na and CO desorptions are non-concurrent in contrast with thermal desorption results.

Alkali induced oxidation of metal surfaces and adlayers

We investigated the basic mechanism leading to the oxidation of alkali atoms and of metal surfaces. .Loss measurements revealed for the first time that the coadosorption of K (Na) atoms with oxygen lead to a softening of the Ni-O bond and simultaneously a strengthening of the alkali-Ni bond. The weakening of the O-Ni bond was ascribed to the alkali-induced filling of the O-2pz antibonding. A direct Na-O bond was formed only whenever oxygen was preadsorbed. The strengthening of the alkali-substrate bond was assigned to the existence of a reduced bond distance occurring whenever O and alkalis are coadsorbed. Unexpectedly, we found an enhanced alkali oxidation rate for alkali+CO compared with alkali+oxygen. Such finding was ascribed to the short-range alkali-CO interaction which lowers the barrier for CO dissociation and favours a giant alkali oxidation.

Collective electronic properties of Ag and Au ultra thin films deposited on metallic substrates

We investigated the surface plasmon dispersion of nanoscale Ag film deposited on Ni(111). We found, for the first time that the dispersion curve contains only the quadratic term. The vanishing of the linear term was ascribed to the presence in the film of Ag 5sp-related quantum well states (QWS). Screening effects enhanced by electron confinement in Ag QWS push the position of the centroid of the induced charge of the surface plasmon less inside the interface compared to others Ag systems, rendering null the linear coefficient of the dispersion curve. Moreover, we measured for the first time the dispersion and damping of ultra thin Au films deposited on Cu(111). The measured dispersion of the plasmon mode was positive as in Ag, However, the damping relation of the SP presented a critical wave vector of 0.11 A^{-1}. For higher values of the parallel momentum transfer, the line width of Au surface plasmon considerably increased as a consequence of the opening of a new decay channel via single particle transitions.

4.2 SPECTROSCOPIC AND MICROSCOPIC STUDIES OF CARBON/METAL-OXIDE NANOSTRUCURE

4.2.1 Photoemission investigation on nanostructured TiO_2 growth by cluster assembling

Nanostructured titanium dioxide (ns-TiO2) films were grown by a pulsed supersonic cluster beam deposition method [LGM Lab., prof. P. Milani, Università di Milano]. Transmission electron microscopy demonstrates that film structure can be tailored from nanocrystalline to amorphous by changing the deposition parameters. The ns-TiO2 film electronic structure was studied by photoemission, resonant photoemission and X-ray absorption spectroscopy. The presence of several structural and chemical native defects were shown by the spectroscopic measurements and were connected to the large surface to volume ratio and nanostructure of the deposited clusters. The Ti local electronic structure was primarily studied by performing valence band resonant photoemission and X-ray absoprtion at the Ti L edge (454-470 eV, Material Science beamline at the Elettra synchrotron light source). It was possible to characterize the conduction and valence band of both surface defects and the fully oxygen coordinated Ti atoms and the evolution following thermal treatments and water exposures. The use of resonant photoemission has so permitted to unveil the conduction band of a defective site and, for the first time, its peculiar evolution with annealing and water exposure.

4.2.2 Microscopic and spectroscopic characterization on carbon/metal nanocomposites

We performed the characterization of nanostructured carbon/metal composites deposited by Supersonic Cluster Beam. The electronic properties were determined by electron energy loss (EELS) and Auger spectroscopy experiments. The microscopic studies were performed by scanning electron microscopy (SEM). The SEM microscope was also used in

environmental mode (in-situ pressure up to 20 mbar) to study the condensation of water droplets from vapor phase. These studies were the core or the national project PRIN "*Novel approach to growth and characterization of carbon-based nanostructured and nanocomposite materials with extended interface*" funded by the MIUR in collaboration with prof. P. Milani of the University of Milano.

4.2.3 Electronic and structural characterization of carbon nanotubes

Nanostructured titanium dioxide (ns-TiO_2) films were grown by a pulsed supersonic cluster beam deposition method. Transmission electron microscopy demonstrates that film structure can be tailored from nanocrystalline to amorphous by changing the deposition parameters. The ns-TiO_2 film electronic structure was studied by photoemission, resonant photoemission and X-ray absorption spectroscopy. The presence of several structural and chemical native defects were shown by the spectroscopic measurements and were connected to the large surface to volume ratio and nanostructure of the deposited clusters. The Ti local electronic structure was primarily studied by performing valence band resonant photoemission and X-ray absoprtion at the Ti L edge (454-470 eV, Material Science beamline at the Elettra synchrotron light source), it was possible to characterize the conduction and valence band of both surface defects and the fully oxygen coordinated Ti atoms and the evolution following thermal treatments and water exposures (Ref.6). The use of resonant photoemission has so permitted to unveil the conduction band of a defective site and for the first time its peculiar evolution with annealing and water exposure. The electronic, chemical and structural properties of Carbon NanoTubes (CNTs) synthesized by Silicon Carbide surface decomposition were analyzed by, Scanning Electron Microscopy (SEM), Scanning Tunnelling Microscopy/Spectroscopy (STM/STS), Electron Energy Loss (EEL) and Raman spectroscopy. A clear relationship between the bonding features and the growth condition (temperature and growth time) is obtained. The morphology of the sample investigated by SEM reveals a well-packed and aligned structure of the CNTs. We have begun the characterization of nanostructured carbon/metal composites. The electronic properties were determined by electron energy loss (EELS) and Auger spectroscopy experiments. The microscopic studies were performed by scanning electron microscopy (SEM). The SEM microscope was also used in environmental mode (in-situ pressure up to 20 mbar) to study the condensation of water droplets from vapor phase. These studies were the core or the national project PRIN "*Novel approach to growth and characterization of carbon-based nanostructured and nanocomposite materials with extended interface*" funded by the MIUR in collaboration with prof. P. Milani of the CNTs are observed depending on the local temperature of the sample surface. The longest observed CNTs were 500/600 nm. The STS measurements show I-V diode-like characteristic curve which can be used, for instance, as an electron collector in solar cells applications. As a perspective metallic electrode, gold, will be deposited on top of the CNTs in the future, to collect the electron current and investigated by the same techniques. The data have been presented in the Journal of Physics, 100, 52093 (2008). Recently our group started two collaborations on the synthesis and the characterization of CNTs. The former is with Prof. J. B. Nagy, Department of Chemistry and Materials Engineering, University of Calabria, about the synthesis of CNT by chemical vapour deposition (CVD) technique, supported on zeolites substrates impregnated with Fe and Co catalytic nanoparticles. The characterizations have been obtained by SEM and micro-Raman spectroscopy. The samples show different morphologies due to the synthesis conditions (catalytic nanoparticle size and composition, supporting substrate, gas carrier pressure…). The novelty lies on the synthesis of CNTs into the sepiolite substrate, which is new result in the literature. The goal is also the production of single walled CNT with open ends and well determined diameter for hydrogen storage application. The use of open CNTs should enhance the hydrogen storage capacity because in this way outer and inner surface of CNT will be utilized for H_2 adsorption. Another collaboration on this subject is with Prof. Dimitrios Gournis of University of Ioannina, Greece, about the CNTs growth in Chemical CVD (CCVD). The CCVD is governed by the choice of carbon source, catalyst and growth temperature although in many studies other parameters, such as growth time, have been also proved to be crucial to the resulting carbon materials. SWCNTs, DWCNTs and mixtures of those two have been grown over Fe-Co bimetallic catalysts using various combinations of support material and hydrocarbon gases. We studied samples obtained by the synthesis of SWCNTs in high yields by catalytic decomposition of acetylene over MgO supported Fe-Co bimetallic catalysts without performing any pre-reduction treatment. Transmission electron images were obtained with High Resolution Transmission Electron Microscope (HRTEM) LEO 922. The electronic and chemical structure of the synthesized carbon products were analyzed by Energy Filter Transmission Electron Microscope (EFTEM). The data have been reprodeuced by FEFF program in order to understand the local electronic and structural properties. In addition, as a comparison, valence band measurements have been carried out at ELETTRA synchrotron facility Milano.

4.2.4 Nanostructured titanium oxide films with tailored physical and chemical properties reactivity

Titanium dioxide is widely employed in photocatalysis, electronics and biotechnology. Many TiO_2 properties strongly depend on its nanostructure; hence, for the production of technological devices, it is crucial to develop nanoscale

control of the morphology and structure of the material as well as of its surface properties (wettability). This goal can be achieved by Pulsed Laser Deposition (PLD). TiO_x thin films have been deposited at room temperature by nanosecond PLD in presence of a reactive background gas (Ar/O_2 - 4:1 mixture in the 10÷60 Pa range). Surface morphologies range from smooth and compact to porous and nanostructured as shown by SEM and AFM. The evolution of the structural (by XRD, Raman) and surface chemical properties (by XPS) before and after thermal treatments in air (up to 400°C) have been studied and put in relation with the wetting properties. As-deposited films present an amorphous phase and the presence of a substoichiometric component (Ti_2O_3) is related to the morphology: porous films, due to the large surface to volume ratio, they display a larger amount of surface defects. Post-deposition annealing leads to increased structural order and to a progressive recovery of the TiO_2 stoichiometry. The latter is prevalent for compact films. Water contact angle measurements point out that wettability properties mainly depend on morphology and annealing temperature while the presence of surface defects plays a minor role. Recently we submit a proposal to perform experiments to the ELETTRA Synchrotron, Materials Science beamline and we obtained beamtime to carry out electronic and structural investigation of TiO_x thin films by core level and valence band emission spectra and XANES. In addition in collaboration with the same group we submit an Italian project (FIRB) with title *Oxide Meso and Nanostructured Surfaces for Innovative light HArvesting (OMNIHA)* where our group was involved as local coordinator unit. On this project the electronic, morphological and structural characterization of TiO_x and TCO indium free thin films will be completed with electric measurements to test the photovoltaic efficiency of the materials.

4.3 MORPHOLOGICAL AND STRUCTURAL CHARACTERIZATION AND VOLUMETRIC GAS ADSORPTION EVALUATION OF MESO AND MICROPOROUS MATERIALS WITH HIGH SURFACE SPECIFIC AREA

4.3.1 New silicalite carbon nanostructures materials for hydrogen storage

The SPES group has been involved in 2007 in collaborations with academic and industrial partnerships of the University of Ioannina and Crete (Greece) and the company INNOVA Technology Solutions (Italy). During this collaboration the hydrogen storage capacity of different porous materials synthesised at the University of Ioannina and Crete, has been tested. SEM and XRD measurements were also carried out on those samples by the equipments present in our Department. The materials under investigation are MCM-41 like, which have a hexagonal ordering of the pores. An experimental system (PcT) has been also developed in our group to obtain the hydrogen capacity of the samples up to 80 bar. The layout of the developed PcT system and the measurements obtained with it are discussed in on preparation or submitted articles to international peer reviewed journals in 2008. The samples show different storage capacity depending on the pore size, and substitutional atoms into the materials structure. We observed a dependence of the hydrogen storage capacity with the surface specific area (SSA) of the sample. Usually higher SSA means higher storage capacity. However we observed important stored amount of hydrogen molecules in sample with smaller SSA because of the substitution of peculiar atoms into the sample surface enhancing in this way the physical interaction with H_2. On the same samples preliminary results on CH_4 adsorption have been obtained. In this case, the experimental setup has to be still optimized in the measurements at high pressure values.

4.3.2 Hydrogen storage capacity at high pressure of organo-silane modified silicalite

The same PcT apparatus has been utilized to obtain the adsorption isotherms of modified zeolite by organo-silane molecules. This modification, which is well known in the literature, is external to the zeolite surface. The modification is introduced in order to change the dynamical adsorption properties of the samples by changing the diameter pore size. In this way the diffusion time of hydrogen molecules is different depending on the modification. The next step is the testing of the sample by CH_4 in order to observe if the diffusion time is different. If differences will be observed, that modified zeolites can be utilized as selective membranes. The CNTs growth in CCVD is governed by the choice of carbon source, catalyst and growth temperature although in many studies other parameters, such as growth time, have been also proved to be crucial to the resulting carbon materials. SWCNTs, DWCNTs and mixtures of those two have been grown over Fe-Co bimetallic catalysts using various combinations of support material and hydrocarbon gases. We studied samples obtained by the synthesis of SWCNTs in high yields by catalytic decomposition of acetylene over MgO supported Fe-Co bimetallic catalysts without performing any pre-reduction treatment. Transmission electron images were obtained with High Resolution Transmission Electron Microscope (HRTEM) LEO 922. The electronic and chemical structure of the synthesized carbon products were analyzed by Energy Filter Transmission Electron Microscope (EFTEM).

4.4 SELECTIVE TRANSPORT ACROSS BIOLOGICAL MEMBRANES

4.4.1 Electron microscopy studies of biological mebranes.

Proteins called Aquaporins specifically transport water across biological membranes with high velocity and specificity. Clarifying the structural basis of this remarkable property is one of the main areas of aquaporin research. Electron crystallography at a 3.8 Å resolution showed the structure of AQP1 and gave first insight into water specificity and proton blockage. AQP0 structure is determined to a resolution of 1.9 Å. These studies confirm the structural basis for the mechanism of high speed water permeation without transfer of protons. The physiological roles of aquaporins are known to different degrees of detail. Aquaporins are potential targets for drugs. For instance, blockers of kidney aquaporins will function as diuretics. Specific aquaporin blockers are presently not available. A complete understanding of the mechanisms of transport, substrate specificity and regulation will require the atomic structures of all human AQPs. This project is carried out in collaboration with Prof. Giovanna Valenti of the University of Bari and its success requires innovative integration of concepts and techniques from molecular cell biology; high resolution microscopy (HRTEM), structural biology by atomic force microscopy, computational biology via molecular dynamics simulation and mathematical modelling. Since AQP2 channel fusion to the plasma membrane is expected to modify cell surface architecture, the analysis of those morphological modification by scanning electron microscopes (SEM) is under investigation.

The collaboration between Prof. Giovanna Valenti, well known scientist for the leading research in the cell Physiology of Aquaporirns and the SPES group, expert in microscopic techniques at high resolution, is focused on ambitious scientific goals:

- Achieve a detailed understanding of the structural determinants and modifications of Aquaporins in living cells
- Achieve an understanding of the physiological role of aquaporins in order to assess their importance in health and disease and their use as drug targets.
- Fully understand the structural determinants of transport, specificity and regulation of aquaporins to support rationale drug design and to elucidate the mechanisms of action of novel aquaporin blockers.

International and National Projects

a) Proposal full title: **An innovative approach to the growth and characterization of carbon based materials with extended interface**
Italian PRIN National project
Name of the coordinating person: Prof. Paolo Milani
List of participants:
1 (Coordinator) Università di Milano
2 Physics Dept, Università della Calabria
Period: 2006 - 2008

b) Proposal Full Title: **Novel routes to pillared graphene**
EU Type of funding scheme: Collaborative project
Call: FP7-NMP-2009-SMALL-3
Topic: NMP-2009-2.1-1 Nano-structured materials based on graphene
Name of the coordinating person: George Froudakis
List of participants
1 (coordinator) University of Crete Greece Academic
2 Università della Calabria Italy Academic
3 University of Ioannina Greece Academic
4 Rijksuniversiteit Groningen The Netherlands Academic
5 University of Trieste Italy Academic
6 SCATEC AS Norway SME
Application on 16/02/2009

c) Proposal full title: **Enhanced Multifunctionalities in Photoactive Materials Achieved by Synergetic Scaffolding**
EU Collaborative Project: FP7-NMP-2009-SMALL-3
Work programme topics addressed: NMP-2009-1.2-2 Molecular factory: manufacturing objects with predictable and controllable properties
Name of the coordinating person: Prof. Mauro Ghedini
List of participants:
1 (Coordinator) Università della Calabria ITALY High Education Institution/ University
2 NANOPART BELGIUM SME end-user
3 SOLIS S.p.A. ITALY SME end-user
4 Université de Rennes FRANCE High Education Institution/ University
5 Instituto de Ciencia de Materiales de Madrid SPAIN National Research Council
6 Universitatea din Bucaresti ROMANIA High Education Institution/ University
Application on 16/02/2009

d) Proposal full title: **Electrocatalysts for polymer electrolyte membrane fuel cells: synthesis, characterization, spectroscopic studies of conventional and innovative catalysts and tests from -10 to 120°c.**
Italian PRIN National project
Name of the coordinating person: Prof. Gennaro Chiarello
List of participants:
1 (Coordinator) Physics Dept, Università della Calabria
2 Politecnico di Torino
3 ITAE/CNR Messina
Application on 26/02/2009

e) Proposal full title: **Hybrid polymer-inorganic nanostructured membranes for the separation of hydrogen and helium from gas mixtures**
Italian PRIN National project
Name of the coordinating person: Dr. Giovanni Golemme
List of participants:
1 (Coordinator) Chemical And Materials Engineering Dept, Università della Calabria
2 Physics Dept, Università della Calabria
Application on 26/02/2009

f) Proposal full title: **COmplex and NOvel Supported Clusters on surfaces and Oxide layers: a twofold approach towards bridging the gap between model and real catalysis studies.**
Italian FIRB - PROGRAMMA "FUTURO IN RICERCA" project
Name of the coordinating person: Dr. Tommaso Caruso
List of participants:
1 (Coordinator) Physics Dept, Università della Calabria
2 Politecnico di Milano
3 Università di Milano
Application on 26/02/2009

g) Proposal full title: **Composite membranes with controlled transport properties for separation processes**
Italian FIRB - PROGRAMMA "FUTURO IN RICERCA" project
Name of the coordinating person: Dr. Maria Grazia De Angelis
List of participants:
1 (Coordinator) Università di Bologna
2 Physics Dept, Università della Calabria
3 ITM/CNR Rende (CS)
Application on 26/02/2009

h) Proposal full title: **Oxide Meso and Nanostructured Surfaces for Innovative light HArvesting**

Italian FIRB - PROGRAMMA "FUTURO IN RICERCA" project
Name of the coordinating person: Dr. Andrea Li Bassi
List of participants:
1 (Coordinator) Politecnico di Milano
2 Physics Dept, Università della Calabria
Application on 26/02/2009

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2008

1. Politano A., Agostino R. G., Colavita E., Formoso V., Chiarello G.
Electronic properties of (3/2x3/2)-Na/Cu(111)
Journal of electron spectroscopy and related phenomena, 2008, Vol. 162, n. 1, pp. 25-29

2. Politano A., Formoso V., Chiarello G.
Alkali-promoted CO dissociation on Cu(111) and Ni(111) at room temperature
The Journal of Chemical Physics, 2008, Vol. 129, pp. 164703-1-164703-5

3. Policicchio A., Caruso T., Agostino R. G., Maccallini E., Chiarello G., Colavita E., Formoso V., Castriota M., Cazzanelli E.
Electronic, chemical and structural characterization of CNTs grown by SiC surface decomposition
Journal of Physics: Conference Series, 2008, Vol. 100, pp. 052093-052097

4. Politano A., Agostino R. G., Colavita E., Formoso V., Tenuta L., Chiarello G.,
Vibrational measurements of Na/Ni(111) and (Na+CO)/ Ni(111)
Journal of Material Science, 2008, pp. 3447-3451

5. Maccallini E., Kalantzopoulos G., Tsoufis T., Agostino R. G., Chiarello G., Formoso V., Caruso T., Policicchio A., Gournis D., Colavita E.
Metallic tin-filling effects on Carbon Nanotubes revealed by atomically resolved spectro-microscopies
Journal of nano research, 2008, Vol. 3, pp. 1-6

6. Caruso T., Lenardi C., Agostino R. G., Amati M., Bongiorno G., Mazza T., Policicchio A., Formoso V., Maccallini E., Colavita E., Chiarello G., Finetti P., Sutara F., Skala T., Piseri P., Prince K. C., Milani P.
Electronic structure of cluster assembled nanostructured TiO2 by resonant photoemission at the Ti L2,3 edge
The Journal of Chemical Physics, 2008, Vol. 128, pp. 094704-094711

7. Politano A., Formoso V., Chiarello G.
Dispersion and damping of gold surface plasmon
Plasmonics, 2008, Vol. 3, n. 4, pp. 165-170-6

8. Politano A., Formoso V., Chiarello G.
Alkali adsorption on Ni(111) and their coadsorption with CO and O
Applied Surface Science, 2008, Vol. 254, n. 21, pp. 6854-6859

9. Politano A., Formoso V., Chiarello G.
Mechanisms leading to alkali oxidation on metal surfaces
The Journal of Physical Chemistry C, NuovaSerie, 2008, Vol. 112, pp. 17772-17774.

10. Politano A., Agostino R. G., Colavita E., Formoso V., Chiarello G.
Purely quadratic dispersion of surface plasmon in Ag/Ni(111): the influence of electron confinement
Physica status solidi RRL - Rapid Research Letters, NuovaSerie, 2008, Vol. 2, n. 2, pp. 86-88

11. Politano A., Formoso V., Chiarello G.
Temperature effects on alkali-promoted CO dissociation on Ni(111)
Surface Science, 2008, Vol. 602, pp. 2096-2100

12. Politano A., Agostino R. G., Colavita E., Formoso V., Tenuta L., Chiarello G.
The nature of the alkali-surface bond at low coverages investigated by vibrational measurements

The Journal of Physical Chemistry C, 2008, Vol. 112, pp. 6977-6980

13. Politano A., Formoso V., Agostino R. G., Colavita E., Chiarello G.
Evidences of alkali-induced softening of the oxygen-substrate bond
Journal of Chemical Physics, 2008, n. 128, pp. 074703-1-074703-5

14. Politano A., Agostino R. G., Formoso V., Chiarello G.
Short-range interactions in Na coadsorption with CO and O on Ni(111)
ChemPhysChem, 2008, Vol. 9, pp. 1189-1194

15. D'Elia S., Castriota M., Policicchio A., Scaramuzza N., Versace C. C., Cazzanelli E., Agostino R. G., Vena C., Strangi G., Bartolino R.
Thermally induced modifications of the optic properties of lead zirconate titanate thin films obtained on different substrates by sol-gel synthesis
Journal Applied Physics, 2008, Vol. 104, 123522

A.1.2. Publications on international journals accepted in 2009

1. Politano A., Formoso V., Chiarello G.
Interference effects in the excitation of collective electronic modes in nanoscale thin Ag films
to appear on Superlattices and Microstructures, Nuova Serie, 2009

2. Politano A., Formoso V., Chiarello G.
Effects of O adsorption on the Na+CO/Ni(111) system
to appear on Superlattices and Microstructures, Nuova Serie, 2009

3. Politano A., Formoso V., Colavita E., Chiarello G.
Probing collective electronic excitations in as-deposited and modified Ag thin films grown on Cu(111)
to appear on Physical Review B, 2009

4. Politano A., Formoso V., Chiarello G.
Dispersion and damping of surface plasmon in Ag thin films grown on Cu(111) and Ni(111)
to appear on Superlattices and Microstructures, Nuova Serie, 2009

5. Politano A., Formoso V., Chiarello G.
Electronic properties of metallic bilayers grown on Cu(111): a comparative study
to appear on Surface Science, 2009

6. Politano A., Agostino R. G., Colavita E., Formoso V., Chiarello G.
Collective excitations in nanoscale thin alkali films: Na/Cu(111)
to appear on Journal of Nanoscience and Nanotechnology, Nuova Serie, 2009

7. Politano A., Formoso V., Chiarello G.
Comparative vibrational study on alkali coadsorption with CO and O
to appear on Journal of Physics: Condensed matter, 2009

8. Politano A., Formoso V., Chiarello G.
Damping of the surface plasmon in clean and K-modified Ag thin films
Journal of electron spectroscopy and related phenomena, 2009

9. Politano A., Chiarello G.
Collective electronic excitations in systems exhibiting quantum well states
to appear on Surface Review and Letters, 2009

10. Politano A., Formoso V., Chiarello G.
Chemical reactions at clean and alkali-doped mismatched metal/metal interfaces
to appear on The Journal of Physical Chemistry C, 2009

11. Politano A., Formoso V., Chiarello G.
Annealing effects on the plasmonic excitations of metal/metal interfaces
to appear on Applied Surface Science, 2009

12. Politano A., Formoso V., Chiarello G.
Plasmonic modes confined in nanoscale thin silver films deposited onto metallic substrates
to appear on *The* Journal of Nanoscience and Nanotechnology *Physical Chemistry C*, 2009

D PRESENTATIONS AT CONFERENCES

D.1 Presentations at international conferences in 2008

1. Politano A., Formoso V., Chiarello G.
Probing electronic collective excitations in nanoscale thin silver layers on metallic substrates
Contribution to the 3rd INTERNATIONAL CONFERENCE ON SURFACES, Nanosmat 2008, Barcelona (Spain), 21-24 October 2008

2. Politano A., Formoso V., Chiarello G.
New insights in alkali coadsorption with oxygen
Contribution to the 13th Workshop on Dynamical Phenomena at Surfaces, Cambridge (UK), 10-13 July 2008

3. Politano A., Formoso V., Chiarello G.
Interference effects in collective excitations in nanoscale thin Ag layers
contribution to NanoSea 2008, Frascati (Rome, Italy), 7-10 July 2008

4. Politano A., Formoso V., Chiarello G.
Dispersion and damping of surface plasmon in Ag thin films on metallic substrates
contribution to NanoSea 2008, Frascati (Rome, Italy), 7-10 July 2008

5. Politano A., Formoso V., Chiarello G.
New insights in alkali coadsorption with CO and O
Contribution to NanoSea 2008, Frascati (Rome, Italy), 7-10 July 2008.

5. CONDENSED MATTER PHYSICS: SURFACES AND NANOMATERIALS

Professors and Researchers
Giovanni Falcone
Antonino Oliva
Luigi Papagno
Assunta Bonanno
Lorenzo Caputi
Franco Piperno
Fang Xu
Michele Camarca
Anna Cupolillo
Daniela Pacilè
Francesco Plastina
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Marco Papagno
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Davor Pavuna *(École Polytechnique Fédérale de Lausanne, Switzerland)*
Stefan Facsko *(Institute of Ion Beam Physics and Materials Research- Dresden)*
Raul Baragiola *(Lab. for Atomic and Surface Physics, University of Virginia, Charlottesville, USA)*
Sdenek Sroubek *(Institute of Photonics and Electronics, Prague , Czech Republic)*
Valerio Pirronello *(Dip. di Fisica, Facoltà di Ingegneria, Università di Catania, Italy)*
Giuseppe Giuliani *(Istituto di Fisica "Volta", Università di Pavia, Italy)*
Marisa Michelini *(Dipartimento di Fisica, Università di Udine, Italy)*
Tony J. G. Apollaro *(Dipartimento di Fisica, Università di Firenze)*
Alessandro Cuccoli *(Dipartimento di Fisica, Università di Firenze)*
Andrea Fubini *(Dipartimento di Fisica, Università di Firenze)*
Paola Verrucchi *(INFM-CNR, Unità di Firenze)*
Luigi Amico *(DMFCI, Universita' di Catania)*
Wonmin Son *(University of Leeds, and Centre for Quantum Technologies, National University of Singapore)*
Vlatko Vedral *(University of Leeds, and Centre for Quantum Technologies, National University of Singapore)*
Sabrina Maniscalco *(Department of Physics, University of Turku, Finland)*

Jyrki Piilo *(Department of Physics, University of Turku, Finland)*
Kalle-Antti Suominen *(Department of Physics, University of Turku, Finland)*
Rosa L. Zaffino *(Université Pierre et Marie Curie, Paris),*
Davide Rossini *(Sissa, Trieste, Italy)*
Rosario Fazio *(Sissa, Trieste, Italy)*
Giuseppe Florio *(Dipartimento di Fisica, Universita' di Bari)*
Saverio Pascazio *(Dipartimento di Fisica, Universita' di Bari)*
Paolo Facchi *(Dipartimento di Matematica, Universita' di Bari)*
Daniel Lidar *(University of Southern California, Los Angeles)*
Paolo Zanardi *(University of Southern California, Los Angeles)*

5. CONDENSED MATTER PHYSICS

The research activity of the group is oriented in different fields, which can be resumed in the following sections:

5.1 Science in carbon nanostructures and grapheme
5.2 Non adiabatic response of a many electron system to a slowly varying, semiclassical perturbation
5.3 Quantum coherence and correlation
5.4 Ion interaction with nanostructures and solids
5.5 Multimedial education
5.6 Cultural Heritage

5.1 SCIENCE IN CARBON NANOSTRUCTURES AND GRAPHENE

Our scientific activity is based on the fields of surface science, particularly on surfaces studies of transition metals, chemisorption, synthesis and characterization of new materials; in recent years particular efforts have been devoted to the study of low dimensional carbon based nanostructures performing several experimental investigations on carbon nanotubes and graphitic layers. The importance of nanotechnology, with its intimate relation to electronics and its developing connections to bio-technology, is known to everybody. The study of low-dimensional electron systems has a long history and an immense intrinsic scientific interest but on the practical side, it is equally true that, such fields as nanophysics and nanotechnology are basically limited to the creation of truly low-dimensional nanoengineered materials. The building block material for all nanographitic forms is a flat monolayer of carbon atoms tightly packed into a two-dimensional (2D) honeycomb lattice, graphene, which has been studied theoretically for about sixty years [P. R. Wallace, Phys. Rev, 71 622 (1947)]. It is at the basis of the modeling of the electronic structure of carbon-based systems of all dimensionalities: it can be wrapped up into 0D fullerenes, rolled into 1D nanotubes or stacked into 3D graphite.

Regarding to this topic, our major achievement was the understanding of the variation of the electronic and chemical properties of bundles of Single Wall Carbon Nanotubes (SWCNTs) by insertion of electron donor species, such as alkali metal atom or nitrogen. Nitrogen implantation has revealed to be a promising technique to achieve significant amounts of substitutional impurities; in fact, nitrogen realizes a much more effective doping than alkali metal atoms, since small atomic concentrations lead to stronger modifications of the electronic properties of the system [Surf. Sci. 601, 2819 (2007)]. For this reason, nitrogen doping might be a valuable method to improve nanotube performances for industrial applications. Unlike nitrogen implantation, alkali metal intercalation does not alter the structural arrangement of carbon atoms, and so more subtle changes in the electronic structure can be followed up to the saturation limit [Surf. Sci. 601, 2828(2007)]. Finally, through the analysis of Carbon Nanotubes (CNTs), synthesized by arc-discharge, it was found the occurrence of Multi Wall CNTs encapsulating carbon linear chains [Surf. Sci. 601, 3926 (2007)]. A Raman temperature-dependent study has lead to the observation, for the first time, of the occurrence of a reversible phenomenon involving the chains, which might be representative of temperature driven reduction of the Peierls distortion of the linear carbon chain [Phys. Rev B 75, 121405 (R)(2007)]. Standard facilities for surface characterization, such as High Resolution Electron Energy Loss (HREELS), Low Energy Electron Diffraction (LEED), X-ray Photoelectron Spectroscopy (XPS), Ultra-violet Photoelectron Spectroscopy (UPS), and Auger Electron Spectroscopy (AES), were used in the above mentioned studies. This suggests that the same apparatus and techniques are suitable for investigating the electronic and vibrational properties of most nanomaterials interacting with metal and gases.

Currently our team is involved in the epitaxial growth of a monolayer graphite (MG) by chemical vapour deposition of hydrocarbons on metal surfaces, which represents the most promising alternative route to grow graphene sheets. Atomic epitaxial growth of graphene by chemical vapour deposition of hydrocarbons on metal surfaces was widely studied by

surface science techniques [A. Nagashima et al., Surf. Sci. 291, 93 (1993)]. It has been recognized that "monolayer graphite" (MG), which means graphite overlayer with a thickness of one atomic layer, is successfully grown on some solid surfaces. Various properties of this system have been studied by photoelectron spectroscopies (XPS, UPS), and high resolution (HR) electron energy loss spectroscopy (EELS). Because of large anisotropic chemical bonding of the graphite, the electronic states of MG on solid substrates have a stronger localization at the overlayer plane than other atomic overlayers reported in the literature. For this reason, MG may be considered to have typical 2D electronic states confined in one atomic-layer thickness and has the potential of providing a testing field for the physical world at a reduced scale. In particular, 2D plasmons, whose charge fluctuations are strongly localized at a monolayer, have been discussed theoretically for a long time [F. Stern, Phys. Rev. Lett. 18, 546 (1967), D.M. Newns, Phys. Lett. 38A, 341 (1972), C.C. Grimes et al., Phys. Rev. Lett. 36, 145 (1976)], although only a few experimental data have been reported so far [S. J . Jr Allen et al. Phys. Rev. Lett. 38, 80 (1977), A. Nagashima et al. Solid State Comm. 83, 581 (1992)] because it was difficult to prepare an excellent 2D sample with a large number of confined electrons.

One of the aims of our current experimental work is to bridge this gap with a detailed EELS study of weakly bonded MG.

We are growing graphene layers by cracking under vacuum ethylene at high temperature on Ni(111) single crystal surfaces. The process is automatically stopped when the substrate is covered completely with a graphite overlayer with the thickness of one atomic-layer. This is related to the fact that the surface reactivity of the substrate is extraordinary reduced by the graphite overlayer.

The electronic properties and consequently the anomalous behavior of electrons in graphene are expected to be very sensitive to the presence of substrate.

Actually, angle resolved EELS is capable of detecting the detailed plasmon dispersion, but such a study is so far missing for free-standing isolated sp2 carbon materials. Thus, the fundamental properties of ultra-thin films graphite can be discussed on the basis of the data, on dispersion relations of valence electrons, phonon dispersion and collective excitations, acquired with Angle Resolved Electron Spectroscopy (EELS and UPS mainly). The interfacial orbital mixing of the □ states of the overlayer with the d states of the reactive substrates is the origin for the phonon softening, modification of the □ band and two-dimensional plasmons with high electron density.

Understanding the interaction of epitaxial graphene layers with the metallic substrate is an important step from both fundamental and technological point of view. The influence of the substrate, indeed, induces a change in the charge distribution and consequently in the electronic properties of the overlayer in comparison with a free standing graphene sheet or with a 3D graphite stack.

5.2 NON ADIABATIC RESPONSE OF A MANY ELECTRON SYSTEM TO A SLOWLY VARYING, SEMICLASSICAL PERTURBATION

The research activity dealt with electronic processes induced at metal surface, and nanostructured materials, by localized, non adiabatical sources, such as slowly moving monoatomic particles, or suddenly switched on localized states. In particular, ion and electron beams of low impact kinetic energy~(of the order or less than 1 chilo-electronvolt) were considered and the characteristics of particles originating from surfaces were studied.

5.2.1 CHARGE EXCHANGE IN HYPERTHERMAL ALKALI ION NEUTRALIZAZION AT METAL SURFACES

Trajectory Dependent Neutralization in Hyperthermal Ion-Surface collisions Resonant neutralization of hyperthermal Na+ ions impinging on clean Cu(100) surfaces was studied, focussing on long lived electronic interactions involving the projectile and a target atom. Specific trajectories were considered where the incident particle undergoes multiple collisions within the first surface layers, interacting simultaneously with several target atoms, which leads to single emission of a surface atom that can resonantly exchange charge with both the solid and the projectile. The system was described via a semi-empirical, one-electron potential that includes the effect of a plane metal surface, with projected band gap, the projectile, whose charge state will be eventually investigated, and the substrate atom. On this basis, a model Hamiltonian of the Anderson–Newns type was constructed and the calculated neutralization probability was compared with the angle resolved neutral fraction measured by Keller et al. [C.A. Keller, C.A. DiRubio, G.A. Kimmel, B.H. Cooper, Phys. Rev. Lett. 75 (1995) 1654].

5.2.2 ION INDUCED ELECTRON EMISSION IN SOLIDS

Kinetic electron emission caused by the impact of singly charged Na ions upon the metal surfaces was analyzed in terms of the recently developed thermal hot-spot model, that heuristically describes the many-electron nature of the emission process. The model accounts for the exponential decrease of electron emission yields at projectile velocities below the thresholds of Auger processes. The agreement with experiments indicates that, in spite of its simplicity, the model well describes the basic physics of sub-threshold electron emission at lowest impact energies for Al and Au surfaces.

5.2.3 MANY BODY EXCITATIONS IN CARBON NANOTUBES

The role of the screened Coulomb repulsion in Auger core-valence-valence transitions from Graphene sheets and single wall Carbon nanotubes is discussed using a tight- binding approach, based on the expansion of the valence band wavefunctions into Slater type orbitals. A method to numerically calculate the spectrum of emitted electrons, within the Fermi's golden rule approximation, is proposed. The results are compared to the basic model that treats the experimental line-shape as the self- convolution of the (single particle) density of occupied states of both and bands. The broadening due to lifetime effects and many-body shake-up are tentatively modeled to reproduce measurements of Auger electrons ejected from bundles of single wall Carbon nanotubes irradiated with a primary electron beam of 1.8 keV.

5.3 QUANTUM COHERENCE AND CORRELATIONS IN CONDENSED MATTER SYSTEMS

This research line concerns the theoretical investigation of the role of quantum correlations (entanglement) in the physics of many body systems. The two main themes of the research performed in 2008 have been: (1) Quantum correlations in spin systems; (2) Control of decoherence and Entanglement dynamics

5.3.1 Quantum correlations in spin systems

We analyzed the finite size quantum instability of a spin chain undergoing a topological quantum phase transition of the BKT type, manifested as a sequence of magnetization and entanglement jumps when the magnetic field is varied. We have also shown the occurrence of edge entanglement and argued that this is a direct one-dimensional manifestation of the topological character of the transition. We have also discussed the effect of local magnetic impurities on the behavior of the system and found that both the magnetization and the quantum correlation properties are strongly modified due to the presence of Friedel-like oscillations that modifies the spatial behavior of the collective excitations of the system (spin waves).

5.3.2 Control of decoherence and Entanglement dynamics

We have studied the behavior of quantum coherence and entanglement for qubits coupled to non-markovian environments and discussed ways to avoid the decoherence (via a bang-bang control) or the entanglement decay (via the Quantum Zeno effect). In the first case, we studied a qubit coupled to a quantum critical spin bath, and we have shown that the coherence loss can be avoided by a pulsed control, whose efficiency is found to become higher and higher close to the environmental phase transition. In the second case, we studied the dynamics of two atoms (a qubit pair) spontaneously emitting into a lossy electromagnetic cavity, and we have shown that the entanglement decay can be slowed down by frequently monitoring the cavity field.

5.4 ION-MATTER INTERACTION

5.4.1 Ion interaction with nanostructures

In synchrotrons and colliders, beams of charged particles circulate in a storage ring in circumference in cold bore vacuum chambers. The relativistic particles emit synchrotron radiations which deteriorate the vacuum by desorbing gases such as H2, CO2, CO, H2O and CH4 from the walls. A solution of this problem is the installation of cryosorbers in the collider on cryogenic elements operating at very low temperatures. Several types of cryosorbers have been studied since a

few years. Due to its high specific surface area and large pore volume, porous carbon is considered as a good adsorbent. Our research has been carried out with a Temperature Programmed Desorption (TPD) study on H2 adsorption on multiwalled carbon nanotubes (MWNT) at very low pressure (<10-6 Torr) and temperature (12-30 K). Our results show a hydrogen take up limit in the range of 10-8 mol per gram depending on the adsorption temperature. We compare the MWNT cryosorption capacity with that of commonly used activated carbon and discuss the possibility of employing MWNT as cryosorber in large particle accelerators.

Carbon nanotubes (CNTs) have been studied for their electrical and optical properties. Single walled carbon nanotubes (SWNT) are elongated-shape members of the fullerene family. The properties of SWNT derive from their simple, rigid, nanometre-scale structure: a simple layer of carbon atoms rolled up to form a long cylinder. In particular the electronic and electrical properties are strongly influenced by tube diameter and chirality (which characterize the rolling directions). For instance, it is known that in a SWNT mat, the ratio between the conducting and semiconducting CNT is 1:2 and that semiconducting species show a band gap with an energy depending on diameter/chirality ratio. In our work we present a study of transport properties modification of Single-Wall Carbon Nanotubes (SWNT) interacting with the most common used alkali metals. We report resistivity measurements of SWNT mats as a function of Na, K, Cs and Li doping. Our results show that as alkali exposure increases, the doped sample resistance decreases, denoting a progressive sample metallization. Furthermore, the resistivity depends upon the deposited alkali species. We hypothesize that both atomic radius and specific conductivity of doping species can affect the transport properties.

Usually, three different techniques are widely applied to study the H2 adsorption rate, capacity, sticking and capture probability, and storage in solids: the volumetric method, which measures the pressure drop owing to hydrogen absorption after loading the specimen contained in a constant volume; the gravimetric method, which measures the sample weight changes due to absorption or desorption; and the temperature programmed desorption (TPD) technique. This latest measures the hydrogen signal during desorption in high vacuum using mass spectrometry; it is highly sensitive allowing one to study samples with masses even below 1 mg and is especially suited for loading of small quantities at low pressures. In our experimental study, H2 adsorption on multiwalled carbon nanotubes (MWCNTs) at low temperatures (12–30 K) and low pressures (2 _ 10_5 Torr) has been studied using the

temperature programmed desorption technique. Our results show that the molecular hydrogen uptake increases nearly exponentially from 6 _ 10_9 wt:% at 24.5 K to 2 _ 10_7 wt:% at 12.5 K and that the desorption kinetics is of the first order. Comparative measurements indicate that MWCNTs have an adsorption capacity about two orders higher than that of activated carbon (charcoal) making them a possible candidate as hydrogen cryosorber for eventual applications in accelerators and synchrotrons.

Many SWCNTs can be packed together into bundles in which they are weakly bonded in a triangular lattice. These tubular objects can be as long as many lm or even up to some mm so that they are typical one dimensional systems. The remarkable properties of these materials open up unprecedented great prospective for possible technological applications. We studied Nitrogen doping of single walled carbon nanotubes by 300 eV N2 ion implantation has been studied with X-ray photoelectron spectroscopy. We investigated the nitrogen doping concentration in the range of 1.5–11.3 at.% and post-irradiation annealing up to 1000 °C. We found that nitrogen atoms can be substitutionally inserted into the perfect sp2 hexagonal network, or bind to two sp2 carbon neighbors in a pyridine-like configuration, or be connected to three or four sp3 carbon atoms in a reconstructed double vacancy site and that the substitutional doping is the most stable bonding against high temperature annealing.

5.4.2 Ion interaction with solids

In particle accelerators with intense and positively charged bunched beams, the emitted synchrotron radiation can produce photoelectrons from the walls of the vacuum system. These electrons can be accelerated toward the opposite walls by the positive space charge of the bunched beam . If the secondary electron yield (SEY) at the walls of the vacuum chamber, i.e. the number of emitted electrons per incident electron, is larger than unity, then the electron population grows rapidly creating an electron cloud (EC) of high density. In our results we report experiments of 200 eV electron bombardment on surface of a real Cu sample used in the Large Hadron Collider (LHC) beam screen. Incidence angle dependent energy distribution curves of emitted electrons were measured and analyzed by separation into three energy regions of conventionally termed elastically reflected, rediffused and true-secondary electrons. Different angular dependences were observed for the three components. These results should have implications in simulation codes of the electron cloud effect in particle accelerators.

5.5 MULTIMEDIAL EDUCATION

Increasingly thorough and widespread research has shown that the majority of students has difficulty to learn essential physical concepts in the best of our traditional courses where students read textbooks, solve textbook problems, listen to well-prepared lectures, and do traditional laboratory activities. Education research in physics has shown that learning environments that engage students and allow them to take an active part in their learning process can lead to large conceptual gains compared to traditional instruction. Moreover, in literature has been shown that the direct learner involvement in building interpretative activities promotes formal thinking in the learning process. An active learning environment is often difficult to achieve in lecture sessions, but low-tech and easy to do real experiments have proved to be really effective to create an active learning environment with successful results both in large and smaller high school classes and in classes for pre-service and in-service teachers. Experimental activities have a crucial role in physics education, because they represent one of the methods peculiar to discipline and facilitate the connection between experience and interpretation. They acquire particular significance if related and linked to every day experience. In this context we propose a reasoned sequence of experiences based on easy found and low cost materials, suitable to shed light on essential concepts connected to a variety of physics fields. All illustrated four didactic proposals are carried out by using tinplate jars and each one drives at an integrated balancing between formal and informal education by scheduling various teaching methodologies in order to engage students having different learning styles.

In a subsequent work we report on the implementation and early assessment of a multimedia learning object, developed using the Java programming language, which also integrates in a creative way some internet freely available educational resources, intended to support the teaching/learning process of the historical Hertz experiment.

5.6 CULTURAL HERITAGE

Concerning the activity in Cultural Heritage, ceramic layers and decoration pigments of pottery fragments recovered from a Longbard settlement have been studied by Scanning Electron Microscopy (SEM) techniques applied to fractured samples. The samples were fractured just before the measurements and so materials of the site where the fragments have been obtained did not contaminate the analysed surfaces, given the brief exposition to air. The samples consisted of two terracottae and a ceramic fragment from graves of the excavation site. The terracottae contained different decorations: the bigger one was decorated with a so-called “brown band” decoration, while the smaller was decorated with a “red band” decoration. The third fragment was a terracotta bulk with a ceramic layer superimposed on it along with a clearly more visible decoration with respect to the other samples. The results show that the bulks of the analysed samples were composed of the usual silicates with very small and peculiar silver grains widely distributed within the bulk of the terracottae. Whilst the ceramic fragment comprises the same bulk structure, its surface layer shows the presence of lead, but no traces of tin have been found in this layer or in the bulk of this sample. In the decoration of this sample, the detection of heavy elements is very scarce. The terracotta fragments have the same bulk structure (including the presence of the silver grains), while the decorations of such samples show the presence of iron in both “brown band” and “red band”, with the iron content being greater in the latter band. Interestingly, since red ochre can brownish if it is burnt, no manganese has been detected in both samples so that the “brown band” can be only a burned “red band”. Moreover diagnostic studies have been performed on an ancient coin in order to find if the coin is authentic or is a coinage proof. Our investigation includes Scanning Electron Microscopy – Energy Dispersive X-ray (SEM-EDX) and Cathodoluminescence (CL). The coin is a Drachma representing on the obverse the portrait of Poseidon and, on the reverse the figure of Anfitrite riding a seahorse while Eros is shooting an arrow. The coin is well known in the numismatic studies and originals can also be found in Catanzaro, Naples or Milan museums. The EDX analysis, executed on narrow points of the surface, revealed Pb and Cu as main components of the coin on both side: 51% of Pb and 35% of Cu their weight. Surprisingly on both sides we found traces of gold. The maximum dimensions and the percentage in weight of the small revealed gold spots were respectively on the order of 20 μm and 95%. At the same time on these spots was executed luminescence emission induced by electron bombardment (CL). This analysis confirmed SEM results, even if, the presence of Au was more evident than in SEM analysis. In fact CL analysis showed a little presence of Au overall the sample surface.

A. PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2008

1. Cupolillo, M. Castriota, E. Cazzanelli, L. Caputi, C. Giallombardo, G. Mariotto and L. Papagno
Second order Raman scattering from linear carbon chains inside MWCNT
Journal of Raman Spectroscopy 39, 147 (2008)

2. Castriota M., Cazzanelli E., Caputi L., Cupolillo A., Giallombardo C., Papagno L. and Mariotto G.
Investigations on Raman bands from carbon linear chains in multiwalled carbon nanotubes.
Diamond and Related Materials 17 (7), 1716 (2008)

3. S. Maniscalco, F. Francica, R. L. Zaffino, N. Lo Gullo, and F. Plastina
Protecting Entanglement via the Quantum Zeno Effect
Phys. Rev. Lett. 100, 090503 (2008),Also selected by Virtual Journal of Quantum Information, Vol. 8, Issue 3, 2008

4. D. Rossini, P. Facchi, R. Fazio, G. Florio, D. Lidar, S. Pascazio, F. Plastina, and P. Zanardi
Bang-Bang control of a qubit coupled to a quantum critical spin bath
Phys. Rev. A 77, 052112 (2008)
Also selected by Virtual Journal of Quantum Information, Vol. 8, Issue 5, 2008

5. T. J. G. Apollaro, A. Cuccoli, A. Fubini, F. Plastina, and P. Verrucchi
Staggered magnetization and entanglement enhancement by magnetic impurities in S=1/2 spin chain
Phys. Rev. A 77, 062314 (2008), Also selected by Virtual Journal of Quantum Information, Vol. 8, Issue 6, 2008

6. T. J. G. Apollaro, A. Cuccoli, A. Fubini, F. Plastina, and P. Verrucchi
Entanglement modulation in a spin chain by a local impurity
Int. J. Quant. Info. 6, 567 (2008)

7. M. Barberio R. Vasta P. Barone, A. Oliva, L. Papagno, F. Xu, and V. Pirronello
Hydrogen Cryosorption on Multi Walled Carbon Nanotubes
Physical Review special topics – Accelerators and Beams 11, 113201 (2008)

8. M. Barberio, P. Barone, A. Bonanno, M. Camarca,E. Masciari, A. Oliva, F. Xu
Transport Properties of alkali-doped- single wall carbon nanotubes mats
Superlattices and Microstructures *doi:10.1016/j.spmi.2008.10.027*

9. M. Barberio, P. Barone, A. Bonanno and F. Xu
Oxygen Interaction with Single Walled Carbon Nanotubes
Superlattices and Microstructures *doi:10.1016/j.spmi.2008.10.027*8

10. M. Barberio, P. Barone, A. Bonanno, M. Camarca, A. Oliva, V. Pingitore, F. Xu
Visible Cathode- Luminescence from Carbon Nanotubes: The Role of Impurities
Physica Status Solidi A, 205, No. 6, 1391-1393 (2008)

11. F. Xu, M. Minniti, P. Barone, A. Sindona A. Bonanno, A. Oliva
Nitrogen Doping in single walled carbon nanotubes by low energy N_2^+ ion implantation
Carbon 46 (2008) 1489- 1496.

12. M. Commisso, P. Barone, A. Bonanno, R. Cimino, M. Minniti, D. Grosso, A. Oliva, P. Riccardi, F. Xu
Angular Dependence of Secondary Electron Emission from Cu Surfaces Induced by Electron Bombardment
Journal of Physics: Conference Series 100 (2008) 092013

13. C. Gattuso, A. Oliva , M. Davoli
Pigments and bulk composition of pottery fragments of a Longbard grave
Science and Technology for Cultural Heritage, Issue no. 17, Year 2008, Pisa/Roma

14. M.Barberio, M. Davoli, C. Gattuso, N. Noce, A. Oliva, V. Pingitore
A golden dracma from Bruttia: a counterfeit money revealed by Scanning ElectronMicroscopy and Cathodoluminescence
Journal of Mediterranean Archeology and Archeometry Vol. 8, n°2, pp 31-38 (2008)

15. C. Gattuso, G.M. Crisci, A. Oliva, B. Recchia
Image Analysis for the study of working on stone surfaces
Science and Technology for Cultural Heritage, N. 1/2 (2008).

A.1.2 Publications on international journals accepted in 2008

1. C. Giallombardo, A. Cupolillo, L. Papagno
Oxygen-driven surface segregation of lithium from single-wall carbon nanotubes
Diamond and Related Materials, accepted

2. Sindona, P. Riccardi, S. Maletta, G. Falcone
Double resonant neutralization in hyperthermal energy alkali ion scattering at clean metal surfaces
Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, accepted 19 November 2008, available online 13 December 2008;

3. M. Pisarra, M. Commisso, A. Sindona, P. Riccardi
Kinetic Electron Emission from Metal Surfaces by slow Na+ ions
Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, accepted 15 December 2008.

4. W. Son, L. Amico, F. Plastina, and V. Vedral,
Quantum instability and edge entanglement in the quasi-long-range order
Phys. Rev. A (2009), in press.

5. F. Francica, S. Maniscalco, J. Piilo, F. Plastina, and K.-A. Suominen,
Off-resonant entanglement generation in a lossy cavity
Phys. Rev. A (2009), in press.

6. A. Bonanno, G. Bozzo, M. Camarca, A. Oliva, P. Sapia
Four Physics Jars
Il Nuovo Cimento (2009) in press.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2008

1. M. Barberio R. Vasta P. Barone, A. Oliva, L. Papagno, F. Xu, and V. Pirronello,
Hydrogen Cryosorption on Multi Walled Carbon Nanotubes
EPAC 2008, Genoa, June 2008

2. M. Barberio, P. Barone, A. Bonanno, M. Camarca,E. Masciari, A. Oliva, F. Xu,
Transport Properties of alkali-doped- single wall carbon nanotubes mats
NANOSEA 200, Rome, July 2008

3. M. Barberio, P. Barone, A. Bonanno and F. Xu
Oxygen Interaction with Single Walled Carbon Nanotubes
NANOSEA 2008, Rome, July 2008

4. R. Vasta, M. Barberio, P. Barone, A. Bonanno, and F. Xu
Kr Adsorption on Single Walled Carbon Nanotubes Studied with Thermal Desorption Spectroscopy
NANOSEA 2008, Rome, July 2008

5. R. Vasta, M. Barberio, P. Barone, A. Bonanno, and F. Xu
Kr Adsorption on Single Walled Carbon Nanotubes Studied with Thermal Desorption Spectroscopy
NANOSMAT 2008, Barcelona, October 2008

6. M. Barberio, P. Barone, A. Bonanno, M. Camarca, V. Pingitore, A. liva, F. Xu,
Transport Properties of alkali-doped- single wall carbon nanotubes mats,
NANOSMAT 2008, Barcelona, October 2008

7. M. Barberio, P. Barone, A. Bonanno, M. Camarca,v. Pingitore, A. Oliva, F. Xu,
Transport Properties of alkali-doped- single wall carbon nanotubes mats,
NANOSCIENCE AND NANOTECHNOLOGY 2008, Frascati, October 2008

8. R. Cimino, M. Commisso, T. Demma, A. Grilli, P. Liu, M. Pietropaoli, V. Sciarra, V. Baglin, P. Barone, A. Bonanno,
Electron Energy Dependence of Scrubbing Efficiency to Mitigate E-cloud Formation in Accelerators
Proceeding of EPAC *2008 http: //accelconf.web.cern.ch/ AccelConf/e08/ papers/ tupp027.pdf* .

9. D. R. Grosso, P. Barone, A. Bonanno, M. Camarca, A. Oliva, F. Xu, M. Commisso, R. Cimino,
"Scrubbing" Process of Cu Surfaces Induced by Electron Bombardment
Proceeding of EPAC *2008 http://accelconf.web.cern.ch/AccelConf/e08/papers/tupp036.pdf.*

10. F. Xu, M. Barberio, P. Barone, A. Oliva, L. Papagno, V. Pirronello, R. Vasta,
Hydrogen Cryosorption on Multi Walled Carbon Nanotubes,
Proceeding of EPAC *2008 http://cern.ch/AccelConf/e08/papers/wepd045.pdf.*

11. A. Bonanno, P. Sapia, M. Camarca, A. Oliva,
Virtually exploring a pillar of experimental physics: The Hertz experiment,
Proceedings of the 9th International Symposium *FRONTIERS OF FUNDAMENTAL AND COMPUTATIONAL PHYSICS.*
AIP Conf. Proc. -- May 29, 2008 -- Volume 1018, pp. 244-247

C PRESENTATIONS AT CONFERENCES

C.1 Presentations at international conferences in 2008

1. Sindona A.
Auger KVV spectra from bundels of single walled Carbon Nanotubes
Oral Contribution Nanosea 2008, Second International Conference on Nanostructures SElf-Assembly Villa Mondragone, University of Rome Tor Vergata Monteporzio Catone, Rome, Italy 7 - 10 July 2008. (Parallel Session)

2. Sindona A.
Trajectory dependent nuetralization in hypertjermal ion scattering from metal surfaces
Oral contribution to IISC 17 17thInternational Workshop on Inelastic Ion-Surface Collisions Porquerolles, France 21-26 September 2008 (Plenary)

D.2 Poster Presentations at international conferences in 2008

1. F. Plastina,
Storage and transmission of entanglement in a spin chain
QCMC 2008, 20-8-2008, Calgary, Canada

2. A. Bonanno, P. Sapia, M. Camarca, P. Barone, G. Bozzo
MARIL: Multimedia Assisted Real Inexpensive Laboratory
"GIREP 2008 International Conference" – Cyprus, 18-22 August, 2008

D.2 Presentations at national conferences in 2008

1. F. Plastina,
Protecting entanglement with the quantum Zeno effect
IQIS08, Camerino, 27 October 2008

2. A. Bonanno, G. Bozzo, M. Camarca, A. Oliva, P. Sapia,
La fisica in barattolo
XCIV Congresso Nazionale della Società Italiana di Fisica – Genoa, 22-27 September 2008.

3. A. Bonanno, G. Bozzo, M. Camarca, G. Falcone, A. Oliva, P. Sapia,
Force Concept Inventory e successo formativo nei corsi universitari
XCIV Congresso Nazionale della Società Italiana di Fisica – Genoa, 22-27 September 2008.

4. A. Bonanno, M. Camarca, A. Oliva, P. Sapia,
Laboratorio con materiale povero: un'esperienza di peer-tutoring
CIV Congresso Nazionale della Società Italiana di Fisica – Genoa,. 22-27 September 2008.

5. A. Bonanno, G. Bozzo, M. Camarca, G. Falcone, A. Oliva, P. Sapia,
Indagine comparativa sull'attitudine al ragionamento scientifico di studenti iscritti alle Facoltà di Scienze ed Ingegneria dell'UNICAL,
XCIV Congresso Nazionale della Società Italiana di Fisica – Genoa, 22-27 September 2008.

Books

1. R.A. Baragiola and P. Riccardi
in *Reactive Sputter Deposition*
edited by D. Depla and S. Mahieu - Springer Series in Material Science – Vol. 109 – 2008 – Chap.2

6. MOLECULAR BIOPHYSICS

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S. Cannistraro (*Biophysics and Nanoscience Centre, University of Tuscia, Viterbo, Italy*)
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Introduction

In the year 2008 the research activity of the Molecular Biophysics Group has essentially been focused on three main topics:

6.1. Self-assembled lipid structures and interactions at the lipid/protein interface
6.2. Thermostability, aggregation and molecular dynamic simulation of proteins.
6.3. Oxidative processes in food physics

The first research project has mainly concerned with the investigation of the physical properties of self-assembled supramolecular lipid structures used as carriers for drug delivery, with the interaction between the antimicrobial peptide alamethicin and lipid membranes, with the study of protein-ligand complexes, and on the conformational heterogeneity of Na,K-ATPase.

The second one, instead, has been focused on the thermal aggregation of β-lactoglobulin A in the presence and absence of the Cu(II) and Zn(II) transition metal-ions, on the investigation of the thermal stability of the protein umecyanin from horseradish roots and on the molecular dynamics simulation of the copper protein amicyanin from different sources.

AFM and SEM investigations of proteins solution adsorbed on the hydrophobic (silicon) inorganic surface have also been carried out with the aim to elucidate the role played by the physical properties of surfaces on the molecular protein assembly.

In the third project, the effects of the aromatic amino acids Trp and Tyr on the oxidation of linoleic acid in the absence and in presence of the enzyme lipoxygenase Type B have been studied with magnetic resonance technique and mass spectrometry.

In the following, the main research results obtained during the investigation are briefly presented in form abstracts.

6.1. SELF ASSEMBLED LIPID STRUCTURES and INTERACTIONS at the LIPID/PROTEIN INTERFACE

6.1.1 Low temperature phase behaviour of DPPC/Lyso-PPC mixtures. CW-ESR and ESEEM studies of chain labelled lipids

Lysophospholipids are single-chained micelle-forming lipids which are involved in many cellular and physiological

processes. They are present in the plasma membrane and are essential components of liposome formulations used in drug delivery such as thermosensitive liposomes. In order to elucidate the role played by lysolipids when mixed with bilayer forming lipids, we have studied fully hydrated binary dispersions of diacyl and lyso-lipids with identical acyl chain length, namely dipalmitoylphosphatidylcholine (DPPC) and lyso-palmitoylphosphocholine (Lyso-PPC) over the entire composition range (0÷100 mol%). This has been done by Continuous Wave and pulsed Fourier Transform-Electron Spin Resonance (CW and FT-ESR) spectroscopies of phosphatidylcholines that are spin-labelled along the acyl chain (n-PCSL, n = 5, 7, 10, 12 and 16). Conventional spin-label CW-ESR spectra are used to investigate the polarity profiles of the self-assembled lipid structures formed when increasing amount of Lyso-PPC are dispersed with DPPC. Electron Spin Echo Envelope Modulation (ESEEM) measurements are used to establish the profile of solvent (D_2O) penetration throughout the whole chain lipid length. At low concentration, the lysolipids induce interdigitation in the DPPC acyl chains in the frozen state. Both the hydrophobicity and the water concentration profiles are established and compared to those obtained in conventional lamellar membranes of DPPC. In the interdigitated supercooled gel phase, a positional isomer close to the terminal methyl end, normally located in the apolar region of lamellar phases, is equally exposed to the solvent as one near the apolar/polar interface. At high Lyso-PPC content, the lamellar phases are solubilized and converted in micelles of lysolipids. The profile of solvent accessibility in micelles of Lyso-PPC established by ESEEM measurements parallels the more indirect CW-ESR polarity data.

6.1.2 Intramembrane water associated with TOAC spin-labelled alamethicin: electron spin-echo envelope modulation by D_2O

Alamethicin is a 20-residue, hydrophobic, helical peptide, which forms voltage-sensitive ion channels in lipid membranes. The helicogenic, nitroxyl amino acid TOAC was substituted isosterically for Aib at residue positions 1, 8 or 16 in a F50/5 alamethicin analogue to enable EPR studies. Electron spin-echo envelope modulation (ESEEM) spectroscopy was used to investigate the water exposure of TOAC-alamethicin introduced into membranes of saturated or unsaturated diacyl phosphatidylcholines which were dispersed in D_2O. Echo-detected EPR spectra were used to assess the degree of assembly of the peptide in the membrane, via the instantaneous diffusion from intermolecular spin-spin interactions. The profile of residue exposure to water differs between membranes of saturated and unsaturated lipids. In monounsaturated phosphatidylcholine, D_2O-ESEEM intensities decrease from TOAC1 to TOAC8 and TOAC16 but not uniformly. This is consistent with a transmembrane orientation for the protoassembled state, in which TOAC16 is located in the bilayer leaflet opposite to that of TOAC1 and TOAC8. Relative to the monomer in fluid bilayers, assembled alamethicin is disposed asymmetrically about the bilayer midplane. In saturated phosphatidylcholine, the D_2O-ESEEM intensity is greatest for TOAC8, indicating a more superficial location for alamethicin, which correlates with the difference in orientation between gel- and fluid-phase membranes found by conventional EPR of TOAC-alamethicin in aligned phosphatidylcholine bilayers. Increasing alamethicin/lipid ratio in saturated phosphatidylcholine shifts the profile of water exposure towards that with unsaturated lipid, consistent with proposals of a critical concentration for switching between the two different membrane associated states.

6.1.3 Spontaneous transfer and partitioning of stearic acids between Human Serum Albumin and PEG:2000-grafted DPPC membranes

Electron spin resonance (ESR) spectroscopy is used to study the transfer of stearic acids between human serum albumin (HSA) and sterically stabilized liposomes (SSL) composed of dipalmitoylphosphatidylcholine (DPPC) and of submicellar content of poly(ethylene glycol:2000)-dipalmitoylphosphatidylethanolamine (PEG:2000-DPPE). Protein/lipid dispersions are considered in which spin-labelled stearic acids at the 16th carbon atom along the acyl chain (16-SASL) are inserted either in the protein or in the SSL. Two component ESR spectra with different rotational mobility are obtained over a broad range of temperature and membrane composition. Indeed, superimposed to an anisotropic protein-signal, appears a more isotropic lipid-signal. Since in the samples only one matrix (protein or membranes) is spin-labelled, the other component accounts for the transfer of 16-SASL between albumin and membranes. The two components have been resolved and quantified by spectral subtractions, and the fraction, fp(16-SASL), of spin labels bound non-covalently to the protein has been used to monitor the transfer. It is found that it depends on the type of donor and acceptor matrix, on the physical state of the membranes and on the grafting density of the polymer-lipids. Indeed, it is favoured from SSL to HSA and the fraction of stearic acids transferred increases with temperature in both directions of transfer. Moreover, in the presence of polymer-lipids, the transfer from HSA to SSL is slightly attenuated, especially in the brush regime of the polymer-chains. Instead, the transfer from SSL to HSA is favoured by the polymer-lipids much more in the mushroom than in the brush regime.

6.1.4 Conformational heterogeneity and spin-labelled –SH groups: Pulsed EPR of Na,K-ATPase

Membranous Na,K-ATPase from shark salt gland and from pig kidney was spin-labelled on Class I −SH groups in the presence of glycerol, or on Class II −SH groups in the absence of glycerol after prelabelling Class I groups with *N*-ethyl maleimide. The Class I-labelled preparations retain full enzymatic activity, whereas the Class II-labelled preparations are at least partially inactivated. The polarity of the environment, and the librational dynamics and conformational exchange, of the spin-labelled groups were studied with pulsed electron paramagnetic resonance (EPR) by using electron spin echo envelope modulation (ESEEM) spectroscopy and spin-echo detected (ED) EPR spectroscopy, respectively. ^{2}H-ESEEM spectra of membranes dispersed in D_2O reveal that Class I groups of the shark enzyme are more exposed to water than are those of the kidney enzyme or Class II groups of either species, indicating a more superficial membrane location in the former case. Spin-echo decay curves indicate conformational heterogeneity at low temperatures (< 150 K), but a more homogeneous conformational state at higher temperatures that is characterised by a single phase-memory T_{2M} relaxation time. Conventional EPR lineshapes also demonstrate conformational microheterogeneity at low temperatures: the inhomogeneously broadened lines narrow progressively with increasing temperature reaching an almost pure Lorentzian lineshape at temperatures of ca. 220 K and above. The inhomogeneous broadening at low temperature is well described by a Gaussian distribution of Lorentzian lines. ED-spectra as a function of echo-delay time demonstrate the onset of rapid librational motions of appreciable amplitude, and slower conformational exchange, at temperatures above 220 K. These motions could drive transitions between the different conformational substates, which are frozen in at lower temperatures but contribute to the pathways between the principal enzymatic intermediates at higher temperatures.

6.2. THERMOSTABILITY, AGGREGATION and MOLECULAR DYNAMIC SIMULATION of PROTEINS

6.2.1 Thermal study of β-lactoglobulin in presence of metal-ions

There is growing evidence that metal ions can accelerate the aggregation process of several proteins. This process, associated with several neuro-degenerative diseases, has been reported also for non-pathological proteins. In the present note, we report data on a research activity started in 2007 and completed this year on the effects of transition metal ions, Cu(II) and Zn(II), on the denaturation and aggregation processes of beta-lactoglobulin A (BLG-A) investigated by differential scanning calorimetry (DSC), fluorescence, electron paramagnetic resonance (EPR) and optical density. The DSC profiles reveal that the thermal behaviour of BLG-A is a complex process, strongly dependent on the protein concentration. For concentrations ≤ 0.13 mM, the thermogram shows an endothermic peak at 84.3 °C, corresponding to denaturation; for concentrations > 0.13 mM an exothermic peak also appears, above 90 °C, related to the aggregation of the denaturated BLG-A molecules. The thioflavin T fluorescence indicates that the thermally induced aggregates show fibrillar features. The presence of either equimolar Cu^{2+} or Zn^{2+} ions in the protein solution has different effects. In particular, copper binds to the protein in the native state, as evidenced by EPR experiments, and destabilizes BLG-A by decreasing the denaturation temperature by about 10 °C, whereas zinc ions probably perturb the partially denaturated state of the protein. The kinetics of BLG-A aggregation shows that both metal ions abolish the lag phase before the aggregation starts. Moreover, the rate of the process is 4.6-fold higher in the presence of copper, whereas the effect of zinc is negligible. The increase of the aggregation rate, induced by copper, may be due to a site-specific binding of the metal ion on the protein.

6.2.2 Thermal unfolding studies of a phytocyanin

The thermal stability of umecyanin, a stellacyanin from horseradish roots, has been investigated by differential scanning calorimetry, optical absorption and fluorescence spectroscopy at neutral and alkaline pH. Above pH 9 the Cu(II) protein experiences a blue shift of the main visible absorption band at about 600 nm and changes colour from blue to violet. The thermal transition of the protein is irreversible and occurs between 61.4 and 68.8 °C at pH 7.5 and between 50.7 and 57.4 °C at pH 9.8. The calorimetric data indicates that at both pH values the thermally induced transition of the protein between the native and denaturated states can be described in terms of the classical Lumry-Eyring unfolding model Native <-->Unfolded -->Final. The analysis of the reversible step in the unfolding pathway demonstrates a significant reduction in conformational stability(ΔG) of the alkaline form of the protein. Such a reduction is consistent with an enhanced flexibility of UMC at high pH and has mainly entropic character.

6.2.3 Molecular dynamics of amicyanin evidences a dynamically-restrained core region

Molecular dynamics has been employed to simulate the blue copper protein amicyanin from two different sources, *Paracoccus denitrificans* and *Paraccocus versutus*, with the aim of investigating the structural and dynamical properties common to the two molecules. The secondary and tertiary structure of the two amicyanins in the crystal is almost identical. In the simulation, they differ for the overall number of hydrogen bonds in the main chain. Nevertheless, the two proteins strictly maintain the starting conformation in correspondence with regions of the beta-barrel that are conserved in the folding architecture of the blue copper proteins. Principal component analysis indicates that the conformational subspaces corresponding to eigenvectors with the same index for each of the two molecules are not equivalent, but a core scaffold with constrained dynamics can be identified. Furthermore, two fairly flexible regions located on the opposite side with respect to the interaction sites with the partner molecules in the redox process can be evidenced in the protein structure. The results, compared with those obtained for other copper proteins, suggest that the dynamical properties of amicyanin could be controlled for functional advantages that may include the binding mechanism with the biological partners and the collective inner motions of the protein matrix required for the electron transfer, whereas long-range conformational changes in the redox reaction should be excluded.

6.2.4 Protein aggregation on solid surfaces

Environmental Scanning Electron Microscopy (ESEM) and Atomic Force Microscopy (AFM) were used to characterize the morphology of protein aggregates adsorbed on solid silicon substrates. We considered three model proteins, β-lactoglobulin, lysozyme and myoglobin, dissolved in pure distilled water. Droplets of 2 μL of native protein solutions were deposited on the surface and left to dry in air. Proteins self-assemble on the substrate and form complex patterns. During the early stages of drying, the protein initially uniformly dispersed in the solution migrates towards the droplet edge and forms a ring deposit similar to that observed during the drying of colloidal systems. Within the ring, we observed a spectacular accumulation of branched fibrils pointing towards the center of the droplet. In the inner regions of the droplet, we observed protein precipitates, dendritic protein formations and gel structures. We believe that protein fibrillation is triggered by protein misfolding due to strong interactions with the substrate. This leads to the creation of nucleation centers from which fibrils elongate via self-assembling under suitable solution conditions and flow.

6.3. OXIDATIVE PROCESSES IN FOOD PHYSICS

6.3.1 Free Radicals ESR and ESI-MS Study on the Oxidation of Linoleic Acid in Presence of Some Aminoacids

Free radicals involved in lipid oxidation can be measured by electron spin resonance spectroscopy (ESR), which is also widely used for the detection of free radicals in food systems in the fields of food irradiation, lipid oxidation, antioxidants, and food processing.

Using the combined techniques of on-line high-performance liquid chromatography/electron spin resonance and mass spectrometry (LC/ESR and LC/MS), Qian et al. (1, 2) identified spin trapped lipid-derived carbon-centered radicals formed in linoleic acid peroxidation and the reactions of two polyunsaturated fatty acids (linoleic and arachidonic acids) with soybean lipoxygenase (LOX). Statistical analyses of amino-acid distribution patterns in integral membrane proteins reveal a pronounced enrichment of tyrosine and tryptophan in the transmembrane domains of all major classes of membrane proteins (3). Tyrosine and tryptophan are especially enriched in the region contacting the membrane zone of the highest lipid density, which comprises the inner portion of the lipid headgroups and the beginning of the hydrocarbon tails.

In this investigation, model systems made of linoleic acid, various amino acids, LOX Type IB (from soybean) and α-[4-pyridyl 1-oxide]-N-t-butyl nitrone (POBN) spin trapper, were designed to study whether specific amino acids could act as regulators in lipid oxidation. ESR coupled with ESI-MS spectra were compared to investigate the formation of spin adducts. The data collected in this research activity, clearly indicates a direct free radical transfer from oxiding linoleic acid to specific amino acids like tyrosine, tryptophane, histidin. Amino lipids may constitute a novel class of pharmacologically useful cytoprotective antioxidants and food additives.

[1] Free Radical Biol. Med. 33, 998-1009 (2002);
[2] Free Radical Biol. Med. 34, 1017-1028 (2003);
[3] Radiat. Phys. Chem. 64, 61-66 (2002)

A PUBLICATIONS on SCIENTIFIC JOURNALS
A.1 Publications on international journals
A.1.1 Publications on international journals printed in 2008

1. R. Bartucci, R. Guzzi, M. De Zotti, C. Toniolo, L. Sportelli and D. Marsh,
Backbone dynamics of alamethicin in lipid membranes: spin-echo EPR of TOAC spin labels
Biophysical Journal 94, 2698-2705 (2008)

2. M. Pantusa, L. Sportelli, R. Bartucci,
Phase behaviour of DPPC/Lyso-PPC mixtures by spin-label ESR and spectrophotometry
Spectroscopy 22, 153-163 (2008)

3. M. Pantusa, L. Sportelli, R. Bartucci,
Spectroscopic and calorimetric studies on the interaction of Human Serum Albumin with DPPC/PEG:2000-DPPE membranes
Eur Biophys J 37, 961-973 (2008)

4. A. Stirpe, B. Rizzuti, M. Pantusa, R. Bartucci, L. Sportelli, R. Guzzi,
Thermally induced denaturation and aggregation of BLG-A: effect of the Cu^{2+} and Zn^{2+} metal ions
Eur Biophys J 37, 1351-1360 (2008)

5. R. Guzzi, L. Sportelli, K. Sato, S. Cannistraro, C. Dennison,
Thermal unfolding studies of a phytocyanin
Biochim Biophys Acta 1784, 1997-2003 (2008)

A.1.2 Publications on international journals accepted in 2008

1. B. Rizzuti, L. Sportelli, R. Guzzi,
Molecular dynamics of amicyanin reveals a conserved dynamical core for copper proteins
Proteins: Structure, Function and Bioinformatics (2008), accepted

2. M. Pantusa, A. Stirpe, L. Sportelli, R. Bartucci,
Spontaneous transfer and equilibrium partitioning of stearic acids between Human Serum Albumin and PEG:2000-grafted DPPC membranes
Eur Biophys J (2008) accepted

3. R. Bartucci, R. Guzzi, L. Sportelli, D. Marsh,
Intramembrane water associated with TOAC spin-labeled Alamethicin: Electron spin-echo envelope modulation by D_2O
Biophysical Journal, (2008) accepted

A.1.3 Publications on international journals submitted in 2008

1. R. Guzzi, R. Bartucci, L. Sportelli, M. Esmann, D. Marsh
Conformational heterogeneity and spin-labelled –SH groups: Pulsed EPR of Na,K-ATPase
Biophysical J. (2008) submitted

2. A. Russo, S. Caputo, M. Pantusa, E. Perri, G. Sindona, L. Sportelli,
Amino acids as Modulators of Lipid Oxidation Mechanism. The identification and structural characterization of spin adducts intermediates by ESR and Tandem Mass Spectrometry
Free Radical Biology and Medicine (2008), submitted

D PRESENTATIONS at CONFERENCES

D.1 Presentations at international conferences in 2008

1. A. Russo, M. Pantusa, E. Perri, G. Sindona, L. Sportelli,
Free Radicals ESR and ESI-MS Study on the Oxidation of Linoleic Acid in Presence of Some Amino Acids
5th International Conference on Nitroxide Radicals, SPIN'2008, 7-11th Sept. 2008, Ancona - Italy

D.2 Presentations at national conferences in 2008

1. M. Pantusa, R. Bartucci, L. Sportelli,
Conventional ESR on the binding and spontaneous transfer of stearic acids between HSA and DPPC bilayers.
IX Convegno Nazionale GIRSE 2008 (Gruppo Italiano Risonanza di Spin Elettronico) 27-30 September 2008, Giovinazzo (BA, Italy)

2. B. Rizzuti, L. Sportelli, R. Guzzi,
Molecular Dynamics of Amicyanin evidences a dynamically-restrained core region
XIX Concresso Nazionale SIBPA (Società Italiana di Biofisica Pura ed Applicata), 17-20 September 2008, Rome, Italy.

3. R. Guzzi, L. Sportelli, K. Sato, S. Cannistraro, C. Dennison,
Thermal unfolding studies of a phytocyanin
XIX Concresso Nazionale SIBPA (Società Italiana di Biofisica Pura ed Applicata), 17-20 September 2008, Rome, Italy

4. M. Pantusa, R. Bartucci, A. Stirpe, L. Sportelli,
Binding and spontaneous transfer of stearic acids between HSA and DPPC membrane
XIX Concresso Nazionale SIBPA (Società Italiana di Biofisica Pura ed Applicata), 17-20 September 2008, Rome, Italy

5. B. Rizzuti, L. Sportelli, R. Guzzi,
Topological constraints determine the protein dynamics in the blue copper protein family
XIX Concresso Nazionale SIBPA (Società Italiana di Biofisica Pura ed Applicata), 17-20 September 2008, Rome, Italy

6. A. Russo, M. Pantusa, E. Perri, G. Sindona, L. Sportelli,
The effect of some amino acids on the oxidation of linoleic acid: An EPR and ESI-MI study
National Conference on Mass Spectrometry, 30 June 2008, Siena, Italy

7. PHYSICS AND APPLICATIONS OF THE SOFT MATTER

Professors and Researchers	Roberto Bartolino Riccardo C. Barberi Lev M. Blinov Enzo Cazzanelli Gabriella Cipparrone Maria Penelope De Santo Pasquale Pagliusi Nicola Scaramuzza Giuseppe Strangi Roberto Caputo Cesare Umeton Carlo Consolato Versace
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Bulgarian Academy of Sciences - Sofia *(Bulgaria)*
Moscow State University *(Russia)*
Centre Paul Pascal - Bordeaux *(France)*
University of Colorado - Boulder *(USA)*
University of Tunis *(Tunisia)*
College de France - Paris *(France)*
University of Marseille *(France)*
University of Exeter *(UK)*
Chalmers University - Goteborg *(Sweden)*
University of Kent *(USA)*
Polytechnic of Madrid *(Spain)*
Polytechnic of Bucharest *(Romania)*
University of Gent *(Belgium)*
University of Ljublijana *(Slovenia)*
Russian Academy of Sciences *(Russia)*
University of Tblisi *(Georgia)*
Philips Research Center *(The Netherlands*)
Hewlett Packard Research Center *(UK)*
University of Nizhny - Novgorod *(Russia)*
University of California - Berkeley *(USA)*
University of Nebraska *(USA)*
University of Ohio *(USA)*

Introduction

The research activity of the group is going towards different fields of the soft matter using the huge experience obtained in a long standing previous activity, specifically in liquid crystals.

Generally speaking the scientific interests of the group can be resumed as in the following:

7.1.1 MATERIALS, IN CLOSE COLLABORATION WITH CHEMIST GROUPS, BOTH FROM UNIVERSITY OF CALABRIA AND FROM OUTSIDE: NEW LIQUID CRYSTALS, COLLOIDAL SYSTEMS, NANOPARTICLES AND LIQUID CRYSTALS, POLYMERS, PHOTOPOLYMERS, BLENDING OF LIQUID CRYSTALS AND POLYMERS….. CHARACTERISATION (DIELECTRIC, RAMAN, ELLIPSOMETRY, ELECTRON MICROSCOPY…)

VIBRATIONAL SPECTROSCOPY LABORATORY

In the year 2008 the research on thin films and nanostructures presents further advancements, both for the improvement of synthesis methods and their application to new materials. A remarkable part of the characterization of the new materials has been performed by using the vibrational spectroscopy, in particular, micro-Raman technique. The well established research on the inorganic thin films with electrochromic properties has been extended to other oxide films, studied also for the particular side-application as rectifying layers in asymmetric nematic liquid crystal cells. The new activity on ferroelectric crystals, in particular PZT, studied by using several experimental techniques, allowed to gain interesting results on the properties of such materials as rectifying layer in nematic liquid crystal cells, depending on the thermal treatments performed on the films.

The study on the nanostructured carbon forms has been developed on different kinds of nanotubes. A basic resaerch has been continued on the MWCNT containing linear carbon chains. A specific analysis on the second order Raman modes from linear carbon chains has been carried out. The very high relative intensity of these modes give some selective answer about the different model proposed for the geometry of such linear chains. These results have been presented to international conferences and published on high level journals. In addition, Raman characterization were performed on carbon nanotubes investigated for their possible application as functionalized materials.

A new research has been developed on the characterization of the properties of monolayer graphene sheets, deposited by the mechanical exfoliation technique. An interesting spatial dependence of the Raman frequencies for II order 2D overtone was discovered, and later correlated to the presence of strains in some mono layer region.

Finally, the applications of the micro-Raman Spectroscopy to the study of archaeological handiworks have been developed,

in collaboration with archaeologists, by analyzing the mineralogical characteristic of the mortars collected in different points of the walls of the roman "House of the Hercules wedding" in Pompei, with the aim to discriminate between the authentic ancient roman mortars and those originating from uncontrolled modern restoration works. A significant correlation has been found between the classification coming from Raman data and the ones based on historical and archaeological studies.

Electro-optical response due to mixed conduction electrodes,

The usual liquid crystal cells show an electrooptical response symmetric to the applied voltage. On the contrary, when mixed conduction films such as tungsten trioxide or vanadium pentoxide are inserted on one side of the cell, the electro-optical response is asymmetric with respect to the applied voltage. Depending on the structural phase of the inserted film the electro-optical response is in phase (transmission ON during the anodic polarization on metal oxide electrode, transmission OFF during the cathodic one) or in opposition of phase (reverse combination). The first case has been explained by the formation of a double charge layer at the interface metal oxide–liquid crystal, because of migration of protons contained in the oxide films. The other case has been found after hightemperature treatments of metal oxides deposited on glass– ITO substrates, and it appears quite similar to the response collected by using films of ferroelectric materials such as lead zirconium titanate (PZT). This fact suggests a possible interpretation in terms of dielectric response, when the mixed conduction films undergo high-temperature treatments. A comparative study of films of WO3, V2O5, and PZT is carried out in this work as a function of the annealing temperature.

Ferroelectric response and induced biaxiality in the nematic phase of a bent-core mesogen

The search for the still undiscovered ferroelectric nematic (FN) liquid crystal (LC) phase is actively fuelled by the fascinating fundamental and technological perspectives offered by these materials, in particular due to their envisaged easy and fast response to an external electric field, coupled to fluidity and self-healing ability typical of nematics that is crucial to their use in electro-optical devices. The properties of this new phase of matter are expected to be very different from those of conventional ferroelectric liquid crystals (FLCs), which correspond to more solid-like smectic (Sm) phases, typically formed by chiral mesogens. The existence of FNLC is not forbidden from a theoretical point of view and recent computer simulations have demonstrated polar fluid phases obtained from elongated asymmetric particles with polyphilic character. Unfortunately, despite years of intensive experimental quest, and claims that some achiral polymeric and lyotropic systems

exhibit this phase, no successful demonstration of FNLCs has yet been given in low molecular weight thermotropic systems. Here we wish to report on a significant step in that direction and on the intriguing relation of this phase to the recently proposed induced biaxial nematic phase.

Anomalous conductivity in PZT thin film deposited on copper substrate electrode.

Electrical properties of ferroelectric films are influenced by many factors such as the method of obtaining the ferroelectric film itself and the characteristic of the substrate electrode. Here, conductivity measurements were performed on PZT (lead zirconium titanate) thin films deposited by sol-gel synthesis on a copper electrode aiming to investigate the electric properties and to individuate the predominant charge carriers of such samples. A new power law, describing the transport mechanism across the PZT film, has been found.

7.1.2 SURFACES AND INTERFACES: CHARACTERISATION, INTERACTION LC-SURFACES, POLYMER SURFACES, ANCHORING, EFFECTS ON EELCTROOPTICS AND PHOTONICS

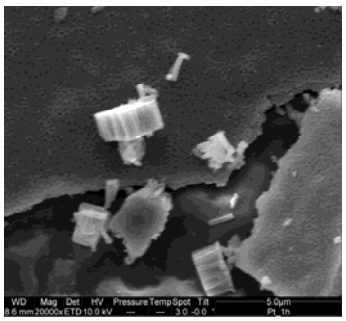
THE INFLUENCE OF DRYING TEMPERATURE ON THE CLOSED-PACKED STRUCTURE OF SILANIZED MONOLAYERS DEPOSITED ON INDIUM TIN OXIDE (ITO) SUBSTRATES

Molecular organization of self-assembled n-dimethyl-n-octadecyl-3-aminopropyltrimethoxysilychloride (DMOAP) layers on ITO coated glass substrates was thoroughly investigated. The layer thickness for each deposition was determined by Variable Angle Spectroscopic Ellipsometry (VASE), while from static contact angle measurements we deduced valuable information regarding the ordering of the molecular structures at solid-air interface. In particular, the DMOAP thin film formation was studied for two different drying temperatures (85°C and 120°C). While at T_{drying}=85°C we observed the formation of a molecular monolayer characterized by a closed-packed structure, at the higher temperature the DMOAP molecules 'bend' at the substrate as they stack in relatively disordered clusters. A qualitative interpretation of this phenomenon is given, in good agreement both with the obtained experimental data and experimental investigation reported in scientific literature. The observations regarding the DMOAP molecular level organization in function of substrate temperature could bring essential information to the self assembly research community and also explain some important

physical phenomena occurring at interfaces.

Surface treatment and bulk density of ions in nematic liquid crystals.

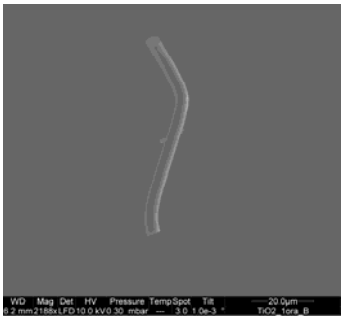
The frequency dependence of the electrical impedance of a nematic sample, in the shape of a slab,is investigated. The measurements are performed by means of an external voltage of small amplitude, in such a manner that the liquid crystal behaves as a linear system, from the electrical point of view. Our measurements indicate that the real part of the impedance presents a large plateau, .nishing at the frequency of Debye, whereas the imaginary part diverges in the low frequency region, indicating that the electrodes of the cell behave as blocking electrodes. From the value of the plateau of the resistance of the cell and from the frequency of Debye, we can conclude that the surface treatment to orient the nematic liquid crystal has a strong in.uence on the bulk density of ions.



FUNCTIONAL SURFACES FOR LIQUID CRYSTALS DEVICES

Thin-film technology is pervasive in many applications, including microelectronics, communication, optical electronics, catalysis, coatings as well as energy generation and conservation strategies. Progress in each of these areas depends upon the ability to selectively and controllably deposit thin films which

range in thickness from a few angstroms to micrometers so to attain specific physical properties. This requires the control, often at the atomic level, of film microstructure and microchemistry. Understanding the physical and chemical properties underlying thin films is thus central to advancing thin-film technology. In fact, over the past 40 years, thin films have been applied in a wide variety of devices, making two-dimensional thin-film technology an increasingly common everyday item.



Recently TiO_2 nanotubes have attracted the interest of a large number of researchers (Journal of Material Chemistry 17(2007)1451-1457) both for energy production (Nano Letters 6(2006)215-218, gas sensors (Thin Solid Films 496(2006)42-48) and for their interesting optical properties (Thin Solid Films 515(2006)2091-2096).

Different procedures have been defined to produce ordered TiO2 nanotube layer: by anodization of titanium foils (Journal of Material Science 42(2007)5539-5543, by sol gel synthesis (Macromolecules 41(2008)4551-4554) and by anodization of sputtered Ti films (Advanced Functional Materials 15(2005)1291-1296).

Thin films of TiO2 mesotubes have been obtained by the the anodization of Titanium layers deposited by DC magnetron sputtering on different types of substrates (glass, silicon, ITO-glass).

A good adhesion of the Ti films on the substrates has been obtained heating them at a temperature between 250°C and 500°C during the sputtering process.

By now several nanostructured substrates have been obtained differing in length, diameter and order of the nanotubes depending on both the anodization procedure and the anodization parameters i.e. nature of the electrolyte and applied voltage.

Nanotubes diameter can range from about 100nm to 300nm (meso-scale), while their length can reach the macro-scale.

Further development will regard the optimization of the experimental procedure to obtain highly ordered transparent nanotube films and the intercalation of both metal atoms and fluorescent materials to get materials with peculiar optical properties for novel application.

Surface induced photorefractivity in pure liquid crystal cells

We have reported the first two-beam coupling investigation of the surface-induced photorefractive effect (SIPRE) in optically twistable nematic liquid crystal cell. The unique space-charge field of SIPRE has been exploited to achieve optical tuning of the photorefractive gain. A reconfigurable photoaligning substrate is used to adjust the twist-angle, which is proved to be a control parameter for the photorefractive gain. The amplitude of the optical modulation increases gradually with the twist, from zero to 130cm^{-1}. Its phase shift changes from 0 to 90 with the polarization state of the two interfering beams. These results have paved the way to the all-optical control of the photorefractive gain.

Reactive polymer surfaces for Liquid crystal alignment

Surface-specific sum-frequency vibrational spectroscopy (SFVS) is a unique technique that can yield vibrational

spectra that are directly related to interfaces and surfaces structure. We have used it to study the photo-induced surface structural change of polyvinyl cinnamate (PVCi), which has been considered a potential polymeric material for photo-alignment of LC in real device applications.

It has been demonstrated that PVCi (and its derivatives) coated substrates after linearly polarized UV irradiation can homogeneously align an LC film in the direction perpendicular to the linear polarization. The orientation of the cinnamate side chains is believed to be responsible for the induced LC alignment. There exist, however, two proposed surface molecular structures of PVCi (and derivatives) induced by irradiation. One is photo-induced dimerization and the other trans-cis isomerization of the cinnamate side chains.

We have investigated UV-irradiated PVCi surfaces, both rubbed and unrubbed, using SFVS to determine their surface structural changes. The vibrational spectra of dimerized and undimerized cinnamate chains are different and their input/output polarization dependence yields information about orientations of selected moieties. Our SFVS results indicate that the dimerization process dominates at the PVCi surface even when the irradiation dosage is low. We have also carried out azimuthal LC anchoring energy measurements on the UV-irradiated PVCi surfaces. They provide supplementary information on surface anisotropy, especially with saturated UV irradiation.

Surface Force Apparatus (SFA)

In February 2008, LICRYL has purchased a Surface Force Apparatus (SFA), that became operational in November 2008. An SFA measures normal and friction forces between two macroscopic surfaces separated in a gas or a liquid by a distance D variable from several microns to direct contact. D can be measured with sub-nanometer resolution using a multiple-beam optical interferometric technique which is based on fringes of equal chromatic order (FECO). It is also possible to masure the refractive index n (sensitivity ±0.01) and determine the geometry of the contact between the surfaces, including the radius of curvature, deformations and damage due to load and shear.

Usually, the surfaces of the SFA are composed of flexible transparent sheets of mica that are silvered on the outer face for optical interferometry and glued onto crossed cylindrical lenses. Other materials can also be used, including polymers and glass. The surfaces can be further modified *in situ* by adsorption of surfactants or polymers, with plasma treatment or through vacuum deposition to vary the physical-chemical properties of the surfaces, such as adhesion energy, hydrophobicity, roughness, wear-resistance, etc. Traditionally, the SFA is used to study the forces acting between colloidal particles and droplets in aqueous solutions, such as the direct measurement of Van der Waals and double-layer electrostatic forces (DLVO forces), as well as hydration and structural forces. The SFA is also used to measure adhesion and lubrication of hydrocarbons, adsorbed monolayers of surfactants and polymers, and, more recently, to study proteins and biopolymers. At LiCryL, SFA will be used to study liquid crystals confined to nanometric geometries, where they undergo uncommon structural transitions due to the strong influence of surface anchoring and biaxiality. In addition, SFA will be used to study long, flexible and strongly hydrated biopolymers, which show lubricating and wear properties in aqueous solution and could have important biomedical applications in the cure of arthritic diseases of the articular cartilage.

Biaxial order reconstruction in nematics

Over the last four years, research in nematic electro-optics has been greatly stimulated by the demonstration that biaxial order reconstruction in nematics supports fast coherent switching between two topologically distinct textures. Thermotropic nematics consist of rigid molecular core units, which are usually represented by physicists as simple rods, characterized by cylindrical symmetry. These ideal calamitic units can be used to build a nematic phase with uniaxial order. For this reason, nematic materials are usually described by the scalar order parameter S and the director **n**, with **n** indicating the average molecular orientation and S the degree of scalar order. Nevertheless, under strong external constraints, uniaxial nematics can induce a local and/or transient biaxial order at the nanometric scale, making the **n**,S description inadequate, thus the significant contribution of order reconstruction, which requires a tensorial description of the nematic material. This effect depends on ξ_b, the nematic biaxial coherence length, which we at LiCryL are, at present, characterizing so to be able to control experimentally. In fact, nematic order reconstruction can be used to obtain optimal bistable electro-optical devices as it can connect two nematic textures of distinct topologies and optical properties. Therefore, suitable customized nematic doping offers a promising means to obtain novel electro-optic materials with defined characteristics for electro-optical and/or photonics applications. Note also that biaxial order reconstruction is also present in liquid crystal electro-optical bistable devices, even when only defects are created or eliminated. This is the case, for instance, of "zenithal bistable electro-optical devices" and "postaligned bistabile nematic displays" that represent today the new technological frontier for liquid crystal applications.

We have also developed an improved bi-dimensional numerical model using the Q-tensor description that gives good agreement with experimental data. We now solve bi-dimensional cases, adding to the elastic energy expressed with the

Landau-de Gennes-Khalatnikov Q-representation method, the third order terms in the Landau representation to remove the degeneracy between splay and bend elastic constants. Moreover, the temperature dependence of the coefficients of the elastic constants expressions is taken into account and the scalar order parameter is evaluated by calculating the minimum of the Landau-de Gennes potential. The model well reproduces the reconstruction order thresholds and forecast the role of inhomogeneous surface treatment observed experimentally.

7.2 CONFINED SYSTEMS, NANOSCIENCES, PHOTONICS: LASING, GRATING, MEMORIES, HOLOGRAPHY, POLYCRIPS, SOLITONS

LASING IN LIQUID CRYSTALS

There are three types of activity: (i) continuation of investigation of leaky modes in thin Fabri -Perot structure, particularly, with cholesteric liquid crystals (CLC) and (ii) study of gain spectra in dye-doped nematic liquid crystals (NLC) and dye-doped suspensions of nanoparticles. (iii) study of the field controlled hybrid structures CLC-NLC-CLC.

(i) Using a planar cell consisting of a prism and a flat glass, a precise measurements of the angles have been measured, at which quasi-in-plane leaky (QIPL) laser modes propagate within a thin layer of a CLC doped with a laser dye. The modes are generated in the amplifying CLC layer due to strong Fresnel reflections from the glass boundaries at propagation angles very close to 90 deg with respect to the cell normal. The gain has been found for the particular eigenmodes, whose propagation angles have been measured. (ii) The amplified spontaneous emission (ASE) intensity and gain spectra in polarized light have been measured in a dye doped nematic mixture for different pump intensity and director orientation. In spite of the inherent scattering of the nematic phase, its gain can exceed that of the isotropic phase. A possibility for switching the NLC gain by an external electric field is shown. In the suspension of nanoparticles with the same scattering length as in NLC, a strong suppression of gain was observed. (iii) In a hybrid CLC-NLC-CLC structure, the feedback necessary for lasing was controlled by the voltage induced phase retardation of the nematic layer. Therefore, the field control of the laser spectra has been demonstrated.

Polarization holography in molecular materials

Polarization gratings in liquid crystals (LC), LC-polymers composite materials have been widely investigated because of their peculiar diffraction properties, which open the way to promising application in displays and photonic technologies.

1D and 2D LC gratings, obtained by means of different assembling of polarization holograms recorded on photo-aligning substrates, have been investigated. 1D grating has been demonstrated to reach near-100% efficiency, even in the thin-grating configuration, and have been proposed for effective tunable color filter. The 2D gratings diffract light in different directions with different polarization states, that can be optically controlled. Orthogonal circularly and linearly polarized diffraction orders are simultaneously obtained by irradiating the grating with a linearly polarized beam. In both cases, an external ac voltage allows to completely control the diffracted energy distribution and their spectral component.

Supramolecular structuring in photosensitive organic materials

The possibility to manipulate the local molecular environment provides unique advantages for building a new generation of materials science technologies. The control of the physico-chemical properties of the supramolecular structures can be performed not only by means of the supramolecular chemistry but also via external stimuli, when the proper functionalities are present in the material. One intriguing possibility is to exploit the light.

We performed the experimental investigation of supramolecular chiral structures in and non-chiral azo polymer (amorphous and LC), induced by circularly polarized light. The polymer film undergoes a light guided inhomogeneous supramolecular modification, both in the transverse and longitudinal directions. The resulting chiral structures exhibits interesting possibility to manipulate the light polarization, showing long time stability and full reconfigurability.

In the frame of the PRIN project "Synthesis and Functional Characterization of Photo-active Organic Semiconductors" we have studied the possibility of improving the photoconduction and photorefractivity of several organic polymeric materials through the light induced supramolecular organization. Indeed, it is well known that the intermolecular interactions that induce the superstructural organization allow the optimum exploitation of the properties of molecular materials. In particular, the activities planned include the following:

- Studies of the photoconductivity in the chiral media by standard techniques, and the influence of light ellipticity and handedness.
- Control of the supramolecular organization of the chiral structure using light and its influence on transport properties.

The light induced control of chirality will be performed by exploiting the photochromic functionalities and their interactions with linearly/ elliptically/circularly polarized light.

Optical trapping and manipulation

We have demonstrated the optical trapping and manipulation of liquid crystals droplets in form of water emulsion, exploiting interferometric techniques. We have studied the manipulation possibilities offered by optical holography and, in particular by light polarization patterns, on micron-sized droplets of LC with radial and bipolar configurations. We have widely investigated the polarization patterns obtained by the interference of orthogonally polarized laser beams, in particular s- and p-polarized and opposite circularly polarized beams, an the opportunity they offer to exert both optical forces and torques simultaneously.

More recently, we have approached the investigation of the "unconventional" optical trapping of low-index isotropic particles in higher-index nematic liquid crystals, where the trapping is closely linked to the elastic and optical properties of the LC.

CD (circular dichroism) spectrograph for real-time and artefacts-free measurements

A novel and simple diffractive spectrographic method for real-time measurements of circular dichroism (CD) has been considered from a theoretical and experimental approach. A demonstrator prototype of the CD spectrograph has been developed and its performance has been compared with a commercial phase-modulation CD spectrograph. The main element of the device is a polarization holographic grating, recorded in a thin photosensitive organic film, by two interfering opposite circularly polarized beams. A peculiarity of this grating is that the amplitude of the +1 (-1) order of diffraction is proportional to the right (left) circular polarization component of the incoming beam. We have demonstrated that the CD spectrum of a specimen can be easily evaluated from the intensities of the diffracted beams. A white light beam passing through the specimen is diffracted from the grating and the intensities of the ± 1 orders of diffraction are measured. Due to the spectral selectivity of the grating, the CD at each wavelength can be evaluated at the same time using two linear array detectors. CD measurements of isotropic sample (i.e. solutions) can be performed either with a linearly polarized or an unpolarized white light beam. In case of general anisotropic samples (i.e., films), showing both linear and circular anisotropies (birefringence and dichroism), the adoption of unpolarized white light with the proposed device allows for artefacts-free measurement of the true-CD spetrum.

Holograms for cultural heritage

In the frame of the project "MESSIAH — Metodologie, Strumenti e Servizi Innovativi per l'Archeologia Subacquea - Laboratori Tecnologici Regionali per la Tutela dei Beni Culturali" – Parco Scientifico Tecnologico della Provincia di Crotone, a laboratory for laser holography has been built up. The activity has been carried out in collaboration with prof. Ventseslav Sainov from CLOSPI laboratory of Sofia (Bulgaria). The Denisyuk scheme has been used to record several holograms of medium –small size objects which show good diffraction efficiency and long time stability. We are planning to upgrade the actual set up to record color holograms.

Random Lasing in Liquid Crystals

The diffusion and transport of light waves in complex dielectric structures have encouraged a wide series of experimental and theoretical investigations, revealing one of the most challenging and exciting scientific area of the past decade. Active random media repeatedly demonstrated to be suitable candidates for obtaining random laser action, mainly based on the resonant feedback mechanisms in multiple scattering, thus eliminating the need for an external cavity, like in the case of regular lasers. Light localization and interference effects which survive the multiple scattering events have been invoked to explain the random lasing observed in many exotic and complex systems. Random lasing modes come from the eigenstates of disordered systems and open a particular chapter in the study of the interplay between localization and amplification. Random laser action in a partially ordered, dye doped nematic liquid crystal with long-range dielectric tensor fluctuations has been extensively investigated. Above a given pump power the fluorescence curve collapses and discrete sharp peaks emerge above the residual spontaneous emission spectrum. The spectral line-width of these emission peaks is narrow banded, typically around 0.5nm. The main physical characteristics of this novel systems for various confinement geometries and under different conditions are reported . The far field spatial distribution of the emission intensity shows a huge number of bright tiny spots spatially overlapped and the intensity of each pulse strongly fluctuates in time and space Finally, the chaotic behaviour which regulates the amplification mechanism in dye-doped complex fluids has been quantitatively described through the Shannon entropy. The results have shown that it is highly chaotic with a peculiar dependence on the temperature of the system.

Tunable Micro-Lasers

Cholesteric liquid crystals (CLC) posses a self-organized supramolecular helicoidal periodic structure in which periodicity can be set from 100nm to infinity and which are also characterised by 100% selective reflection of circularly polarized light. With such characteristics, CLCs provide the basis for a new generation of all-optical devices, optical switches and novel sensors for a number of applications, such as a compact laser which is tunable from near-UV to the mid-infrared region. When a photoluminescent dye is hosted in a CLC matrix which has been prepared using nematic liquid crystals and chiral dopants, the dye acts as an active material in a resonator. Laser emission can therefore be obtained from the mixture when it is illuminated with a pump laser. The possibility to modify the helical pitch and then the Photonic Band Gap (PBG) structure of CLCs is an area of extensive study at LiCryL, leading to the identification of new methods for obtaining tunable lasers.

The first tuning strategy developed in our laboratories uses a three layer cell prepared with two cholesteric layers sandwiching a layer containing an isotropic mixture of a photoluminescent dye. One of the chiral layers contains a wide band gap material while the second layer consists of a series of small band gap materials. The narrow band gap cholesterics can be obtained inducing in the same cell a variation of the helical pitch. Two strategies to vary the pitch, and then the position of the band gap were investigated. The first strategy is based on the phototransformation of a photosensitive optically active dopant, while the second one relies on the variation of the concentration of a non photosensitive chiral compound. Through the combination of these two cholesteric layers, a set of mirrors that can selectively reflect different wavelengths is obtained. The separation of the active medium from the cholesteric liquid crystal matrices allows: to avoid the degradation of the CLC structure caused by the absorption of the pumping energy and to use the optimal thickness both for the CLC layers and for the dye solution layer. When the pumping beam hits the cell a narrow band gap cholesteric is selected and lasing is obtained in the region where the gaps overlap. A different laser wavelength is emitted from different regions of the cell under the pumping beam irradiation. From this new device we have obtained for the first time a wider modulation of the laser emitted wavelength from 420 nm to 790 nm. With a proper dye, longer laser emission wavelengths could be achieved that would be optimal for applications in biomedicine and cosmetics.

Another strategy to obtain tunable mirrorless laser relies on the use of specially prepared materials, fluorene derivatives. At present, dye doped cholesteric liquid crystal lasers contain at least three compounds: a nematic material, an optical active dopant and a luminescent dye, that have to be carefully selected according to their optical, solubility, transparency and thermal stability properties. We envisage the possibility to use fluorene based materials, that can act at the same time as chirality promoters and luminescent compounds, to obtain a finely tunable laser emission.

INVESTIGATION AND APPLICATIONS OF POLICRYPS GRATINGS.

POLICRYPS is a structure made of perfectly aligned liquid crystal films separated by slices of almost pure polymer. Under suitable experimental and geometrical conditions, the structure is obtained by curing a homogeneous syrup of liquid crystal, monomer and curing agent molecules with a spatially modulated pattern of UV radiation. From an optical point of view, POLICRYPS is a holographic diffraction grating with a spatial periodicity that can be easily made of sub-micrometric scale, exhibiting diffraction efficiency values as high as 98%. Depending on the used substrate, the POLICRYPS grating can be utilized both in transmission or reflection, with negligible scattering losses, and can be switched ON and OFF by application of an external electric field of the order of few V/μm. Concerning this structure, in the period of observation (2008), our interest has been devoted to the following arguments:

a) Characterization of an active control system for holographic setup stabilization

We have realized and characterized an active control system of the optical holographic setup used for fabrication of holographic gratings in liquid-crystalline composite materials. The system exploits a reference diffraction grating and a piezomirror in closed-loop feedback. The piezoelectric mirror exhibits a hysteresis that depends not only on the applied voltage, but also on the history of the mirror motion. In an open-loop configuration, the hysteresis can be reduced by adjusting the delay time between the application of two different control voltage values; in a closed-loop operation, it is possible to eliminate the residual hysteresis. By testing the system in different conditions, it has been shown that residual fluctuations are comparable to the resolution of the piezomirror operation.

b) Theoretical characterization of the holographic recording of diffraction grating in multicomponent media

We have implemented a theoretical model describing the formation of holographic diffraction gratings in multicomponent materials. The concentration of the chemical species in the initial mixture plays a fundamental role in determining the final features of the realized sample; our investigation is devoted to determine the best initial mixture realizing good holographic gratings. Along with the model, that is valid for any initial the multicomponent mixture, we report a complete characterization of the numerical solution of the model for two well known cases: H-PDLC and POLICRYPS

grating. Obtained results are in good agreement with experimental observation, showing that our model represent a necessary reference for fabrication and the characterization of holographic diffraction gratings in multicomponent materials.

c) Characterization at conical incidence

Recently, a characterization of POLICRYPS gratings at conical incidence has been performed. Results show a good tolerance range of conical tilting with the grating, indicating it is suitable for applications in e.g. display systems. A detailed characterization has shown that a uniform high diffraction efficiency can be achieved by moving the incident angles along the Bragg angle of incidence in 3D space. Experimental measurements have been compared with theoretical calculations obtained by using a rigorous model. A very good agreement has been obtained.

d) POLICRYPS gratings as switchable phase modulators

POLICRYPS gratings can be used as well as electrically controlled optical phase modulators. Arbitrarily polarized light normally incident on the structure experiences a birefringence that depends on the anisotropy of the composite liquid crystalline material and on the geometrical cell parameters. The sample behaves as a retardation plate in good agreement with the Jones matrices formalism. The birefringence of the modulator can also be tuned by applying a suitable voltage, while a negligible birefringence variation is detected by increasing the incidence power. This makes POLICRYPS structures suitable as switchable phase retarders for high power laser beams.

e) All-optical switching of POLICRYPS gratings containing azo-compounds

An all-optical switching effect takes place when a light beam of suitable wavelength irradiates a “layered” structure made of polymer slices alternated to films of well aligned liquid crystal which contain also a small percentage of azo-LC molecules. The simple and reliable fabrication procedure exploits a holographic UV curing technique. The observed switching effect takes place in samples that exhibit diffraction efficiency as high as 85% and is induced in less than 0.5 s by an unfocused pump beam of 245 mW/cm2 power density.

f) Interference filters with POLICRYPS gratings.

Fabrication and optical characterization of a hybrid tunable integrated interference filter. It consists of a diffused ionexchanged channel waveguide on a borosilicate glass substrate with a cover of the same glass to form a gap filled with a POLICRYPS holographic grating acting as overlayer for the underneath waveguide. The filter structure includes aluminum coplanar electrodes to electrically control the grating properties, allowing the tunability of the filter. The electric driving power required to tune the filter is in the range of submilliwatts due to the efficient liquid crystal electro-optic effect.

MODELING OF LASING PHENOMENA

Phenomena associated to lasing in random or quasi-random media are of growing interest both from theoretical and experimental points of view. Recent studies show that nematic liquid crystals are good candidates as scattering host for these lasing systems. A theoretical analysis and Monte Carlo simulations have been performed for different modellizations of scattering in nematics coupled with a two-level system which describes the dye action. A simple description of light diffusion in nematics is inadequate to describe the localization process that is at the basis of the laser action; therefore, different physical phenomena have to be taken into account.

Optic properties of lead zirconate titanate thin films

Lead zirconium titanate PbZr0.53Ti0.47O3 _PZT_ thin films have been obtained by sol-gel synthesis, deposited on different substrates _float glass, indium tin oxide _ITO_-coated float glass, and intrinsic silicon wafer_, and later subjected to different thermal treatments. The morphologic and the structural properties of both PZT thin films and substrates have been investigated by scanning electron microscope and their composition was determined by energy dispersive x-ray _EDX_analysis. Moreover, variable angle spectroscopic ellipsometry provides relevant information on the electronic and optical properties of the samples. In particular, the optical constant dispersion of PZT deposited on ITO-coated float glasses shows a small absorption resonance in the near IR region, not observed in PZT films deposited on the other substrates, so that such absorption resonance can be explained by interfacial effects between ITO and PZT layers. This hypothesis is also supported by EDX measurements, showing an interdiffusion of lead and indium ions, across the PZT-ITO

interface, that can generate a peculiar charge distribution in this region.

Morphological and electrical investigations of lead zirconium titanate thin films

In recent years, interest in PbZr0.53Ti0.47O3 _PZT_ films has been rapidly increasing due to their technological applications as ferroelectric materials. In the present work, PZT films are obtained by sol-gel synthesis and deposited by spin coating on a transparent conductor substrate, with a perspective application as rectifying layers in asymmetric nematic liquid crystal cells. An extensive investigation is carried out on the effects of different annealing temperatures, with regard to the film texture and to the electric polarization properties, by using low vacuum scanning electron microscopy, atomic force microscopy, and electrostatic force microscopy. It has been observed that PZT domains self-organize into flower-like dendritic structures with a “rosetta” shape at the early stage of crystallization, occurring for annealing temperatures higher

than 600 °C; the dimensions of such structures increase versus the annealing temperature. The ferroelectric properties of the PZT films have been related to the observed domains.

7.3 APPLICATIONS: SENSORS, DEPOLARIZING SYSTEMS, EHD, LCD, CD

DEPOLARIZING OPTICAL SYSTEMS

Light depolarization processes have been studied by observing the light depolarization effects originating by spatial inhomogeneities of the wavefront polarization. Our description holds both for wavefront consisting in different polarization regions and resulting from the incoherent overlap of light beams having different intensities and polarizations. For a natural light beam, the Stokes parameters are measured as averages performed over the points of the wavefront and introducing the correlation function between two points of the local polarized wavefront we have find that the degree of polarization of the light beam depends on both the correlation function and the number of uncorrelated polarization states.

7.5 NANO-IMAGING OF BIOLOGICAL AND BIOCOMPATIBLE MATERIALS AND SURFACEFORCE APPARATUS (SFA)

Scanning probe microscopy is extensively used in biological and biomedical investigations. Advanced microscopy techniques, such as Atomic Force Microscopy (AFM), Scanning Tunnelling Microscopy (STM) and Environmental Scanning Electron Microscopy (ESEM), are finding application in these fields since they are non-destructive and can be performed in liquid-humid environments.

In the last year using AFM in liquid, we have studied the mechanical properties of intraocular lenses, used for cataract surgery, as well as their topographical features. Bacterial adhesion to intraocular lenses during the implantation in the human body is the main cause of endhophthalmitis. We believe that a better knowledge of the biomaterial adhesive properties, on micro and nano scale, can lead to a better understanding of the adhesion mechanisms of bacteria on lenses. This research, together with experiments in vitro, is essential to design improved biomaterials.

At present AFM, STM and ESEM are being used to investigate the aggregation properties of proteins. In particular we are focusing our research on two different kinds of protein: □-lactoglobulin and vmh2.

The first protein is used as a “model-protein” to study the different types of aggregation that can occur: globular aggregates or fibrils formation. In particular the formation of fibrils is important since it is related to several medical diseases (Alzheimer, Parkinson). We are studying the aggregation mechanisms of proteins as influenced by the presence of a substrate. Droplets of 2 μL of native protein solutions are deposited on the surface and left to dry in air. Proteins self-assemble differently on the various substrates forming complex patterns.

The second protein is an hydrophobin extracted by a fungus, Pleurotus Ostreatus, which properties are only partially investigated. This protein is specially interesting as biocompatible material. We are studying the possibility to obtain homogeneous coatings of hydrophobins on model surfaces such as silicon and mica. Thin and homogeneous hydrophobin coatings were obtained using Langmuir Blodgett techniques and spin coating. The wetting and friction properties of these layers at micro and nano scales is under investigation.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2008

1. L.M. Blinov, V.V. Lazarev, G. Cipparrone, P. Pagliusi, T. Rugiero,
Liquid crystal as laser medium with tunable gain spectra
Optics Express, 16, 6625-30 (2008).

2. M.I. Barnik, L.M. Blinov, V.V. Lazarev, S.P. Palto, N.M. Shtykov, B.A. Umanskii, S.V. Yablonsky,
Lasing from photonic structure: cholesteric-voltage controlled nematic-cholesteric liquid crystal
J. Appl. Phys. 103, 123113-1-7 (2008)

3. L.M. Blinov, G.Cipparrone, V.V. Lazarev, P. Pagliusi, T. Rugiero, B.A. Umanskii,
Polarized Spectra of Amplified Spontaneous Emission and Gain for Glycerin Solutions of Dye Rhodamine640
J. Nonlinear Opt. Phys. & Mat. 16, 519-32 (2008).

4. L.M. Blinov,
Scattering and amplification of light in nematic liquid crystal layer
JETP Lett. 88, 189-91 (2008).

5. L.M. Blinov, G. Cipparrone, G. Chidichimo, P. Pagliusi, T. Rugiero,
Band narrowing and gain spectra of laser dye solutions with scattering TiO2 nanoparticles
J. Nonlinear Opt. Phys. & Mat. 17, 1-13 (2008).

6. L.M. Blinov, G.Cipparrone, A. Mazzulla, V.V. Lazarev, P. Pagliusi, S.P. Palto,
Quasi-in-plane leaky modes in lasing cholesteric liquid crystal cells
J. Appl. Phys. 104, 103115-1-7 (2008)

7. N.M. Shtykov, M.I. Barnik, V.V. Lazarev, S.P. Palto, B.A. Umanskii, L.M. Blinov, G. Cipparrone,
Amplification of laser emission from cholesteric liquid crystals by planar cells with laser dye nematic and isotropic solutions
MCLC, 494, 258-71 (2008)

8. G. Chilaya, A. Chanishvili, G. Petriashvili, R. Barberi, G. Cipparrone, A. Mazzulla, M.P. De Santo, H. Sellame, M.A. Matranga,
Lasing in Three Layer Systems Consisting of Cholesteric Liquid Crystals and Dye Solution
MCLC, 495, 449-457 (2008)

9. P. Pagliusi, C. Provenzano, G. Cipparrone,
Surface-induced photorefractivity in twistable nematics: toward the all-optical control of gain
Opt. Expr. 16, 16343-16351 (2008)

10. G. Cipparrone, P. Pagliusi, C. Provenzano, V.P. Shibaev,
Reversible photoinduced chiral structure in amorphous polymer for light polarization control
Macromolecules 41, 5992-5996 (2008)

11. P. Pagliusi, C. Provenzano, A. Mazzulla, L. Giorgini, G. Cipparrone,
Spectrograph based on a single diffractive element for real-time measurement of circular dichroism
Appl. Spectr. 62, 465-468 (2008)

12. A. Cupolillo, M. Castriota, E. Cazzanelli, L. Caputi, C. Giallombardo, G. Mariotto, and L. Papagno,
Second order Raman scattering from linear carbon chain inside MWCNT
Journal. of Raman Spectroscopy 39, pp. 147-151 (2008)

13. M. Castriota, E. Meduri, T. Barone, G. De Santo and E. Cazzanelli,
Micro-Raman investigations on the fresco "Trapasso della Vergine" in the Church of S. Giovanni Battista of Paterno Calabro, in southern Italy
Journal of Raman Spectroscopy 39, pp. 284-288 (2008)

14. M. Castriota, V. Cosco, T. Barone, G. De Santo, P. Carafa and E. Cazzanelli,
Micro Raman characterizations of Pompei's mortars
Journal of Raman Spectroscopy, 39, pp. 295-301 (2008)
Signaled on the site "Spectroscopy now".

15. E. Bruno, M.P. De Santo, M. Castriota, S. Marino, G. Strangi, E. Cazzanelli and N. Scaramuzza,
Morphological and Electrical Investigations of Lead Zirconium Titanate Thin Films Obtained by Sol Gel Synthesis on Indium Tin Oxide Electrode
Journal of Applied Physics 103, 064103, pp.1-6 (2008)

16. A. Policicchio, T. Caruso, R.G. Agostino, E. Maccallini, G. Chiarello, E. Colavita, V. Formoso, M. Castriota, E. Cazzanelli,
Electronic, chemical and structural characterization of CNTs grown by SiC surface decomposition
Journal of Physics: Conference Series100, pp. 052093-052097 (2008)

1. M. Castriota, E. Cazzanelli, L. Caputi, A. Cupolillo, C. Giallombardo, L. Papagno and G. Mariotto,
Investigations on Raman bands from carbon linear chains in multiwalled carbon nanotubes
Diamond and Related Materials 17, n. 7-10, , pp.1716-1723 (2008)

18. M. Castriota, S. Marino, G. Strangi, C. Versace, N. Scaramuzza and E. Cazzanelli,
Electro-Optical Response due To Mixed Conduction Electrodes, Compared to Ferroelectric ones, in Asymmetric Nematic Liquid Crystal Cells
Ionics (DOI. 10.1007/s11581-008-0256-6).

19. S. D'Elia, M. Castriota, A. Policicchio, C. C. Versace, N. Scaramuzza, E. Cazzanelli, R. G. Agostino, C. Vena, G. Strangi and R. Bartolino,
Thermally induced modifications of the optical properties of lead zirconate titanate thin films obtained on different substrates by sol-gel synthesis
Journal of Applied Physics 104, 123522, pp.1-10 (2008)

20. R.Ceccato, S. Dirè, T. Barone, G. De Santo, and E. Cazzanelli,
Growth of nanotubes in sol-gel-derived V_2O_5 powders and films prepared under acidic conditions
Journal of Material Research 24, pp.475-481 (2009), DOI: 10.1557/JMR.2009.0061

21. S. Ferjani, L. Sorriso-Valvo, A. De Luca, V. Barna, R. De Marco and G. Strangi,
Statistical analysis of random lasing emission properties in nematic liquid crystals
Phys. Rev. E 78, 1707-1707 (2008)

22. S. Ferjani, V. Barna, A. De Luca, C. Versace and G. Strangi,
Random lasing in freely suspended dye-doped nematic liquid crystals
Optics Letters 33 (6), 557-559 (2008)

23. A. Veltri, M. Infusino, S. Ferjani, and G. Strangi,
Model for light scattering and lasing in dye-doped nematic liquid crystals
Molec. Cryst. and Liq. Cryst. 488317-326 (2008)

24. Barna, V; Strangi, G; Barna, ES,
Photopolarimetric investigations of the anchoring energy strength for a nematic liquid crystal on polyaniline

boundary surfaces
J. of Optoelectronics and Adv. Mater. 10 (12):3403-3408 2008

25. C. Vena, C. Versace, G. Strangi, St. D'Elia, and R. Bartolino,
Fréedericksz transition in homeotropically aligned liquid crystals: a photopolarimetric characterization
Phys. Stat. Sol. (c) 5, No. 5, 1257–1260 (2008).

26. S. Houmadi, F. Ciuchi, M. P. De Santo, L. De Stefano, I. Rea, P. Giardina, A. Armenante, E. Lacaze and M. Giocondo, *Langmuir−Blodgett Film of Hydrophobin Protein from Pleurotus ostreatus at the Air−Water Interface*
Langmuir, 24 (22), pp 12953–12957 (2008)

27. Lombardo, G., Ayeb, H., Ciuchi, F., De Santo, M.P., Barberi, R., Bartolino, R., Virga, E.G., Durand, G.E., *Inhomogeneous bulk nematic order reconstruction*,
Phys. Rev. E - Statistical, Nonlinear, and Soft Matter Physics, 77 (2), 020702 (2008)

28. Chilaya G, Chanishvili A, Petriashvili G, Barberi R, Cipparrone G, Mazzulla A, De Santo MP, Sellame H, Matranga MA, Lasing in Three Layer Systems Consisting of Cholesteric Liquid Crystals and Dye Solution, Mol. Cryst. Liq. Cryst. (2008) 495, 449-457

29. G. Lombardo, H. Ayeb, and R. Barberi,
Dynamical numerical model for nematic order reconstruction
Phys. Rev. E 77 (5) 051708 (2008)

30. H. Ayeb, F. Ciuchi, G. Lombardo, R. Barberi,
Metallomesogens as biaxial dopants in a calamitic nematic liquid crystal
Mol. Cryst. Liq. Cryst. (2008) 481, 73-79

31. F. Ciuchi, M. Giocondo, R. Barberi,
Electrically controlled defects at a liquid crystal-polyimide interface
Liquid Crystals (2008) 35 (1) 99-102

32. B. Zappone, E. Lacaze,
Surface-frustrated periodic textures of smectic-A liquid crystals on crystalline surfaces
Phys. Rev.E 78, 061704 (2008)
(selected for the Virtual Journal of Nanoscale Science & Technology, December 22, 2008).

33. B. Zappone, P. J. Thurner, J. Adams, G. E. Fantner, P. K. Hansma,
Effect of Ca2+ ions on the adhesion and mechanical properties of adsorbed layers of human Osteopontin
Biophysical Journal, 95 (2008) 1-12.

34. G. W. Greene, B. Zappone, B. Zhao, O. Soderman, D. Topgaard, G. Rata, J. Israelachvili,
Changes in pore morphology and fluid transport in compressed articular cartilage and the implications for joint lubrication
Biomaterials, 29 (2008) 4455-4462.

35. B. Zappone, G. W. Greene, E. Ouroudjev, G. D. Jay, J. N. Israelachvili,
Molecular aspects of the boundary lubrication by human Lubricin: effect of disulphide bonds and enzymatic digestion
Langmuir, 24, 1495 – 1508 (2008)

36. M. Xu, L. De Sio, R. Caputo, C.P. Umeton, A.J.H. Wachters, H.P. Urbach and D.K.G. de Boer,
Characterization of the diffraction efficiency of polymer-liquid-crystal-polymer-slices gratings at normal and conical incidence
Opt. Exp. 16, 19, 14532 (2008).

37. M.J.J. Jak, R. Caputo, E.J. Hornix, L. de Sio, D.K.G. de Boer, H.J. Cornelissen,
Colour-Separating Backlight for Improved LCD Efficiency
Journal of SID, 16, 803 (2008).

38. A. d'Alessandro, D. Donisi, L. De Sio, R. Beccherelli, R. Asquini, R. Caputo, C. Umeton,
Tunable integrated optical filter made of a glass ion-exchanged waveguide and an electro-optic composite holographic grating
Opt. Exp. 16, 13, 9254 (2008).

39. D. Donisi, A. d'Alessandro, R. Asquini, R. Beccherelli, L. De Sio, R. Caputo, C. Umeton,
Realization of an optical filter using POLICRYPS holographic gratings on glass waveguides
Mol. Cryst. Liq. Cryst., 486, 31/[1073] (2008).

40. L. De Sio, N.V. Tabyrian, R. Caputo, A. Veltri, C. Umeton,
POLICRYPS Structures as Switchable Optical Phase Modulators
Opt. Exp. 16, 11, 7619 (2008).

41. L. De Sio, A. Veltri, A. Tedesco, R. Caputo, A.V. Sukhov, C. Umeton,
Characterization of an Active Control System for Holographic Set-up Stabilization
App. Opt. 47, 1363 (2008).

42. A. De Luca, V. Barna, T. J. Atherton, G. Carbone, M. E. Sousa and C. Rosenblatt,
Optical Nanotomography of Anisotropic Fluids
Nature Physics, 4, 869, (2008)

43. V. Barna, A. De Luca and C. Rosenblatt,
Nanoscale alignment and optical nanoimaging of a birefringent liquid
Nanotechnology, 19, 325709, (2008)

44. A. De Luca et al.,
LASER PHYSICS: Random lasing needs no boundaries
LaserFocusWorld 44, N° 4, April (2008)

45. L. De Sio, A. Veltri, C. Umeton, S. Serak, and N. Tabiryan,
All-optical switching of holographic gratings made of polymer-liquid-crystal-polymer slices containing azo-compounds
Appl. Phys. Lett. 93, 181115 (2008)

A.1.2 Publications on international journals accepted in 2008

1. L. M. Blinov, S. P. Palto,
Cholesteric Helix: Topological Problem, Photonics and Electro-optics
to appear on Liquid Crystals (invited paper for the De Gennes memorial issue).

2. G. Petriashvili, M. A. Matranga, M. P. De Santo, G. Chilaya, R. Barberi,
Wide band gap materials as a new tuning strategy for dye doped cholesteric liquid crystals laser
to appear on Optics Express.

3. G. Petriashvili, A. Chanishvili, G. Chilaya, M. A. Matranga, M. P. De Santo, R. Barberi,
Novel UV Sensor Based on a Liquid Crystalline Mixture Containing a Photoluminescent Dye
to appear on Molecular Crystals and Liquid Crystals.

4. G. W. Greene, T. Anderson, H. Zeng, B. Zappone, J. N. Israelachvili,
Force Amplification Response of Actin Filaments under Confined Compression

to appear on PNAS.

5. R. Caputo, A. De Luca, L. De Sio, L. Pezzi, G. Strangi, C. Umeton, A. Veltri, R. Asquini, A. d'Alessandro, D. Donisi, R. Beccherelli, A.V. Sukhov and N.V. Tabiryan,
POLICRYPS: a liquid-crystalline composed nano/micro structure with a wide range of optical and electro-optical applications
to appear on J. Opt. A: Pure Appl. Opt.

6. S. D'Elia, N. Scaramuzza, F. Ciuchi, C. Versace, G. Strangi, and R. Bartolino,
Ellipsometry investigation of the effects of annealing temperature on the optical properties of indium tin oxide thin films studied by Drude-Lorentz model
to appear on Applied Surface Science

7. E. Cazzanelli, M. Castriota, S.Marino, N.Scaramuzza, J. Purans, A. Kuzmin, R. Kalendarev, G. Mariotto, G.Das
Characterization of Rhenium Oxide Films and their application to liquid crystal cells
to appear on Liquid Crystals

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2008

1. G. Chilaya, A. Chanishvili, G. Petriashvili, R. Barberi, G. Cipparrone, A. Mazzulla, M.P. De Santo, H. Sellame, M.A. Matranga,
Single mode lasing in multilayer sandwiched systems consisting of cholesteric liquid crystals and dye solution
Proceedings of SPIE - The International Society for Optical Engineering, 6637, art. no. 66370M (2007)

2. G. Strangi, S. Ferjani, V. Barna, A. De Luca, C. Versace, N. Scaramuzza, R. Bartolino,
Random Lasing in Dye Doped Nematic Liquid Crystals: the Role of Confinement Geometry Proceedings of SPIE: Liquid Crystals and Application in Optics 6587 (2007) 65870P-1 – 65870P-9

3. Jak M.J.J., Caputo R., Hornix E.J., de Sio L., de Boer D.K.G., Cornelissen H.J.,
Colour Separating Backlight for Improved LCD Efficiency
Proceedings of Eurodisplay 2007, S10-2, p.175.

4. Caputo R., De Sio L., Jak M.J.J., Hornix E.J., de Boer D.K.G., Cornelissen H.J. Krijn M.P.C.,
New System Concept for Colour Separating Backlights
Proceedings of Asia Display 2007 (SID), 2, p. 1011.

5. M. Castriota**,** E. Meduri, T. Barone, G. De Santo and E. Cazzanelli,
Micro-Raman investigations on the pigments fresco "Trapasso della Vergine" in the Church of "S. Giovanni Battista" of Paterno Calabro, in southern Italy
Proceeding of 3th International Workshop on: Science, Technology and Cultural Heritage, edited by G. Bonizzoni, A. Riggio, Cassino, (2008), 159.

6. L. Caputi, M. Castriota, E. Cazzanelli, A. Cupolillo, C. Giallombardo, G. Mariotto and L. Papagno,
Carbon nanotubes containing carbon linear chains
Proceeding of XVIII National Congress of the Italian Association of Science and Technology, edited by G. Bonizzoni, A. Riggio, Florence, (2008), 41.

C INVITED PRESENTATIONS

C.1 Invited presentations at international conferences in 2008

1. S.P. Palto, L.M. Blinov,
Specific features of switching and electrooptics of ferroelectric liquid crystals (invited)
XVIII All-Russian conference on physics of ferroelectrics., June, 9-14, 2008, Abstracts, p.35.

2. A. De Luca, V. Barna, T. J. Atherton, G. Carbone and C. Rosenblatt
Optical Nanotomography of Liquid Crystals
22nd International Liquid Crystal Conference, ILCC-2008, Jeju (Korea), June 29 – July 4 (2008)

D PRESENTATIONS AT CONFERENCES

D.1 Presentations at international conferences in 2008

1. S.P. Palto, L.M. Blinov, V.V. Lazarev, S.G. Yudin,
Field amplification and ferroelectric switching in a bilayer structure "linear dielectric- ferroelectric
XVIII All-Russian conference on physics of ferroelectrics., June, 9-14, 2008, Abstracts, p.126

2. Blinov L.M.,
Lasing on leaky modes in dye-doped liquid crystals: pro and contra (oral)
8th Congress of Italian Liquid crystal Society, 4-7 June, 2008, Acitrezza (Catania, Italy), Abstracts, p.14

3. V.V. Lazarev, L.M. Blinov, S.P. Palto, S.G. Yudin,
Ferroelectric switching in double layer Langmuir-Blodgett heterostructure Linear Dielectric- Ferroelectric (oral)
11th European Conf. on Organized Films, Potsdam, 9-11 July, 2008. Abstracts, p. L35.

4. T. Rugiero, L.M. Blinov, G. Cipparrone, P. Pagliusi,
Polarized gain spectra of a nematic liquid crystal
2nd Int. Conf. On Photonics of Liquid Crystals, Cambridge, June, 2008

5. C. Provenzano, P. Pagliusi, V.P. Shibaev and G Cipparrone,
Light polarization control via photoinduced supramolecular chiral structure in azobenzene polymer
8th National Congress of the Italian Liquid Crystal Society, SICL-08, Acitrezza (Catania, Italy), June 4-7, 2008

6. I. Ricardez-Vargas, P. Pagliusi, C. Provenzano and G. Cipparrone,
Optical manipulation of liquid crystal droplets using interference patterns
EPS - CMD 22, 2008- The 22nd General Conference of the Condensed Matter Division of the European Physical Society", Rome, Italy, August 25 – 29, 2008

7. E. Cazzanelli, M. Castriota, D. Pacilè, L. Papagno and G. Mariotto,
Spatial dependence on observed Raman frequencies and disorder in monolayer graphene
EPS - CMD 22, 2008- The 22nd General Conference of the Condensed Matter Division of the European Physical Society", Rome, Italy, 25/08 – 29/08, 2008

8. G. Strangi, S. Ferjani, V. Barna, A. De Luca, C. Versace and R. Bartolino,
Laser Action in Liquid Crystals: From Random to Periodic
22nd International Liquid Crystal Conference, ILCC-2008, Jeju (Korea), June 29 – July 4 (2008)

9. A. De Luca, V. Barna, T. J. Atherton, G. Carbone and C. Rosenblatt,
Optical Nanotomography of Liquid Crystals
8th National Congress of the Italian Liquid Crystal Society, SICL-2008, Acitrezza (Catania, Italy), June 4-7 2008

10. E. Bruno, S. Marino, M. Castriota, F. Ciuchi, E. Cazzanelli, N. Scaramuzza,
Morphological, electrical investigations and optical properties of lead zirconium titanate thin films deposited on ITO and on SiO_2 substrate
2nd International Symposium on Transparent Conductive Oxides, Crete, Greece, October 22 – 26, 2008

8. BIOMEDICAL PHYSICS

Area coordinator:	L. Sportelli (Molecular Biophysics Group)
Professors and researchers:	A. Santaniello (professore a contratto of Biomedical Physics)
	R. Guzzi (University of Calabria, Molecular Biophysics Group)
	V. Carbone (University of Calabria, Astrophysics Group)
	R. Bartolino (University of Calabria, Soft Matter Group)
Undergraduate students:	A. Giorno, I. Bonetti
Graduate students:	G. Sceni (Master student: Diritto e Management Sanitario, Dipartimento di Scienze Giuridiche)
Collaborators:	G. Barca, R. Siciliano (Azienda Ospedaliera di Cosenza, U. O. Fisica Sanitaria)
	E. Jorio (University of Calabria, Dipartimento di Scienze Giuridiche)

Research subjects:
1 Modifications induced by irradiation in biomedical materials
2 Transfer to medicine of theoretical models and methods

Introduction

The activities on Biomedical Physics themes, involving researchers from different groups of the Department, were performed on two subjects:

1) irradiation of materials of biomedical interest and investigation of their physical modifications for dosimetric purposes;
2) application to biomedical data and health systems of theoretical approaches and methods.

Fractionate dose administration in radiotherapy requires dosimetry with new materials with reduced detection sensitivity. In particular, electron paramagnetic resonance (EPR) dosimetry at doses below 1 Gy is under investigation by using sugars, dithionates and formates, with a possible extension to even lower doses in modified materials based on the above mentioned ones. The study of the behaviour of the radioinduced radicals is crucial for the development of low dose EPR dosimetry. Within this frame, we calibrated the dose response of new EPR dosimetric materials upon irradiation with clinical photon beam in the therapeutic range.

Modern medicine imaging and biomedical experiments are concerned with the interpretation of large data sets often affected by noise, artefacts and redundancy. Algebraic treatments of the data simplify the interpretation and evidence details which would remain otherwise unrecognized. Complex systems, like health organisations, undergo failures which can be reduced if not eliminated by a management taking advantage form the analysis of the risks involved in multiple, interrelated activities. Besides psychological aspects (patient and medical/nursing staff satisfaction) important material goals benefit from risk analysis in these systems (health preservation of the patient, reduced expenses for the sanitary system).

8.1 MODIFICATIONS INDUCED BY IRRADIATION IN BIOMEDICAL MATERIALS

Lithium formate monohydrate ($HCO_2Li{\cdot}H_2O$), fructose ($C_6H_{12}O_6$) and sucrose ($C_{12}H_{22}O_{11}$) were irradiated with photon beams from a LINAC accelerator at energies of several MeV in the dose interval 0.5–50 Gy with a dose rate of the order of several 10^{-2} Gy/min. The irradiations were performed by R. Siciliano and G. Barca of the AO of Cosenza in collaboration with A. Santaniello. Photon beams are known to induce stable radicals, which are suitable for dosimetric purposes, in sugars and salts of the formic acid. The EPR measurements, performed at the Molecular Biophysics Laboratory by R. Guzzi in collaboration with A. Santaniello, looked for the stable radical EPR signals in order to obtain the calibration curve as a function of the dose. Further study as a function of the irradiation and environmental conditions is planned, both on pristine and modified materials.

8.2 TRANSFER TO MEDICINE OF THEORETICAL MODELS AND METHODS

8.2.1 Application of algebraic methods to biomedical data

Proper Orthogonal Decomposition as a diagnostic technique

The Proper Orthogonal Decomposition has been used as a diagnostic technique to investigate the spatial and temporal evolution of renal scintigraphy. This technique can be useful to detect abnormalities in renal morphology or renal function. We analyzed images of the radiation emitted by a radiopharmaceutical within the kidney, acquired by a gamma-camera, the time behavior being constructed by a series of snapshots. Each POD mode gives us information about the transit of radiopharmaceutical within the kidney, and in particular on the accumulation and expulsion processes of the radioactive tracer. Results show that the first fundamental mode gives us information about the main properties of capitation and expulsion, further eigenfunctions give information about energetically less relevant phenomena. However, these modes are useful to evidence physiological phenomena that are not captured by the first main mode.

Data analysis and modeling of prey-predator systems

We investigate the complex dynamics of a prey-predator system described by reaction-diffusion equations with a Holling type functional response for predation. The model describes the spreading of a virus from the center of a spatial domain, so we use a polar geometry starting from a predator concentration at the center of the spatial domain and a nonhomogeneous distribution of prey throughout the spatial domain. We observe the existence of travelling waves that propagate from the center towards the external region. As the values of the free parameters are changed, the model supports periodic, aperiodic and chaotic spatio-temporal travelling waves. Numerical results can be qualitatively compared with the dynamics of occurrence of the Dengue Haemorrhagic Fever in Thailand where aperiodic pulses of incidence are observed, starting from Bankong, in all the 72 provinces.

8.2.2 Risk analysis and management of health systems

Risk analysis is one of the basic elements of a global approach to the management of complex organisations, including health systems, aiming to reduce the number of the incidents and malpractices. Risk assessment, evaluation and management, as applied to the medical and nursing environments, refer to analytical models and practical instruments derived from technological and economical contexts sharing the complexity of the structure and of the interrelations. Management aspects in a diagnostical medical context is under analysis in a thesis supervised by A. Santaniello in collaboration with prof. E. Jorio of the Dipartimento di Scienze Giuridiche and prof. Bartolino of the Soft Matter Group (Thesis of the Master in “Diritto e Management Sanitario”, Dipartimento di Scienze Giuridiche “*Tomografia ad Emissione di Positroni (PET-TC): aspetti gestionali, diagnostici e implicazioni strategiche di una tecnologia innovativa*”, G. Sceni, Fisico Medico, Responsabile dell’U.O. di Fisica Sanitaria presso l’Azienda Ospedaliera Bianchi-Melacrino-Morelli di Reggio Calabria.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.3 Publications on international journals submitted in 2008

1. P. Veltri jr., A. Vecchio, V. Carbone,
Proper Orthogonal Decomposition analysis to investigate the spatial and temporal behavior of renal scintigraphy,
Physica Medica., (2008), submitted.

2. S. Donato, L. Primavera, A. Vecchio, V. Carbone,
Complex dynamics of a predator-prey system,
Chaos, Solitons and Fractals, (2008), submitted.

3. V. Carbone
Latency period of infection and absence of CD4+ T cells depletion in a dynamical model of HIV evolution,
Physica A, (2008), submitted.

9. GEOPHYSICS

Professors and Researchers: Ignazio Guerra

Postdoc fellows: Anna Gervasi (*from National Institute of Geophysics and Volcanology (INGV), National Center for Seismology and Seismic Engineering*)

Collaborators:
P. Harabaglia and M. Mucciarelli (*Basilicata University, Potenza, Italy*)
M.R. Gallipoli (*CNR — Tito Scalo (PZ), Italy*)
A. Moretti (*Univ. of L'Aquila, L'Aquila, Italy*)
G. Neri, B. Orecchio, D. Presti and F. Tafaro (*Univ. of Messina, Messina, Italy*)
D. Costantino *(Polytechnic Univ., Bari, Italy)*
W.J. Kim, A. Lerner-Lam, L. Seeber, M. Steckler and C. Stark (*Lamont-Doherty Observatorv, Columbia Univ., New York, USA*)
V. Carbone, A. Vecchio, P. Veltri *(Calabria Univ., Arcavacata, Italy)*
L. Sorriso-Valvo *(LICRYL, INFN/CNR, Cosenza)*

Graduate students
C. De Rose
E. Tomaselli

Technical staff: G. Latorre

RESEARCH LINES

Introduction

The research group in Geophysics is engaged in many lines of activity, in spite of its lean composition. This is mainly due to the nature of its activities, based on the elaboration of experimental data collected by means of observations that have to be carried on over long span of time. The group indeed was established about thirty years ago in a department different from Physics with the explicit finality of answering the requirement of seismological observations in Calabria, a region characterized by a seismic risk among the highest in the Mediterranean Basin. This origin is still conditioning its programs, mainly of observational nature.

Due to the relatively great distance from the nearest centres of geophysical research and the relevance of the geodynamical problems arising from the peculiar features of the calabrian territory, the group at the Department of Physics is a reference point for both researchers, from abroad too, as well as some public administrations.

9.1 Seismotectonics

Seismotectonics is the branch of seismology deals with the complex relations between earthquakes and geological structures and with the reconstruction of the ongoing dynamical processes. It is based on the accurate location of the seismic sources, that in turn requires a model as more realistic as possible for the elastic waves propagation in the studied area. Generally, an iterative process is performed: new seismographic data help to better constrain the velocity model that in turn leads to better locations. The maps of seismicity resulting from the above mentioned activity is then correlated to the tectonic features observed in the area. In particular the space distribution of the seismic foci can trace the position of the slip surfaces at depths not accessible to direct observations, while the propagation model includes the mechanical discontinuities met with by seismic waves along their path towards the seismic stations. Seismograms contain further information that allows for determining the dynamics of the phenomena at the seismic sources. The reconstruction of the geometry of the geological bodies and their present kinematics is the result of these research activities.

Accurate seismotectonic investigations are essential in Calabria because of the peculiarity of seismic activity in the region. The area hosted in fact most of the largest earthquakes reported in Italy in historical times. However it had been practically quiescent since 1908. Moreover the adjacent Tyrrhenian Sea is the seat of deep earthquakes attributable to the interaction of the Eurasian and African plates, that represents one of the more interesting geodynamical problems in the Mediterranean area. Therefore the monitoring of the local seismicity and its relation to the tectonic features is an important task for the scientific investigation devoted to the seismic risk assessment.

In this frame, most of the daily effort of the research group is dedicated to the management of the Calabrian Regional Seismic Network. This network has the dual role of providing an almost real time monitoring of the area and of incrementing

the available waveform data bank. The first is useful in civil protection tasks, the collected information being sent to National Institute of Geophysics and Volcanology, Rome (INGV); the second is the basic instrument to conduct seismotectonic investigations.

In 2008 continued the efforts in the reorganization of the permanent Calabria Seismic Network, taking advantage from the high quality instruments made available in the framework of the ReSiSCal project described in a following section (see sect. 9.5 below). The first remote station installed in 2007 in the frame of this project was in normal operation and its signals are forwarded in real time to the recording centre of INGV in Rome too.

During 2008, the operation continued of the stations residual from the temporary network installed since 2003 in the frame of the CAT/SCAN project in cooperation with the Lamont-Doherty Earth Observatory (Columbia University, New York).

9.2 Statistical Geophysics

This line of research is mainly based on a joint effort with the Astrophysics Group of the Physics Department and Basilicata University. The main goal is to model the pattern of the time evolution of the seismic activity in order to characterize the pattern of its occurrence both on global and regional scale.

9.3 Geodesy

Ground deformations is the geophysical phenomenon more frequently associated to the seismic activity in its various stages. It is detected by successive or continuous measurements of the coordinates of reference points (benchmarks). Both classical, optical and modem, GPS techniques can be applied.

In 2008, two different field experiments were continued. The first one, in the framework of of the CALARCO project, is a joint effort with Lamont Observatory of the Columbia University. It consists of a network of 9 GPS receiver installed at the end of 2006 throughout a transect in Northern Calabria, in WNW-WSW direction (fig. 9.1). The coordinates of the antennas are recorded continuously at intervals of 5 sec. All the receivers will remain still operational for some years. Seven of them are connected to the web while the last two require a periodic download of the recorded data.

The second experiment was the third survey of CALNET, the network of GPS benchmarks installed in Central and Southern Calabria (fig. 9.2). Measurements of the GPS coordinates of each benchmark, are taken in this case for at least 48 hours by using portable instruments.

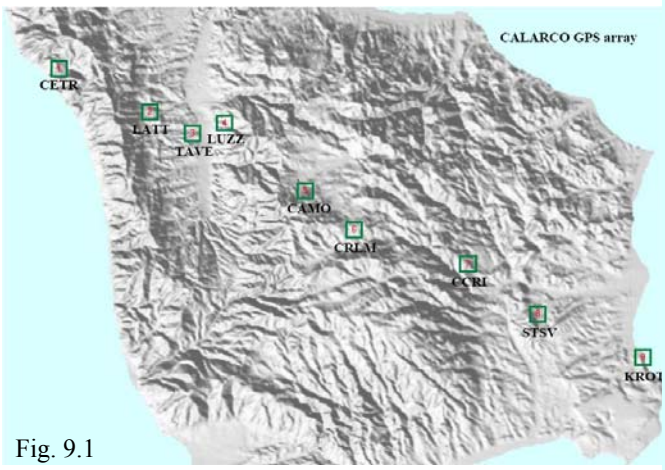


Fig. 9.1

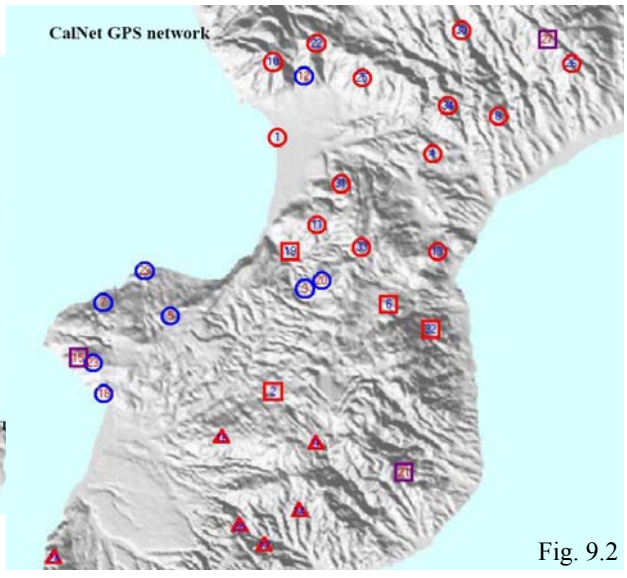


Fig. 9.2

9.4 Dissemination and diffusion of scientific culture

Noteworthy efforts are dedicated to the diffusion of the geophysical culture, in the attempt of convincing the general public and future university students which too much frequently attribute the seismology to scientific field different from physics.

The Geophysics Laboratory is open to school visits and a set of demonstration tools is available to make seismology understandable and appealing. Every years it is visited by hundreds of pre-university scholars.

A program (ReSiSCal, Rete Sismica Scolastica Calabrese = Scholastic Calabrian Seismic Network) is underway which will lead to the installation of a seismic network in about ten schools in the whole Calabria. Two of them are operating since about several years in Bisignano and Cosenza. The third one was activated in Northern Calabria, on the eastern slope of the Sila Massif.

9.5. Educational activities

A Summer School of Geodynamics (Uplift and deformation of the Calabrian Arc) has bee n held in the first half of September at the Physics Department. It was organized by the Geophysical Research Group in collaboration with the Lamont-Doherty Earth Observatory, funded by U.S. National Research Foundation, Calabria University and INGV. 39 PhD and post-doc students coming from about ten different country attended the lectures given by about twenty researchers from USA, Canada, UK, France and Italy. The School was aimed to the diffusion and discussion of the results from CAT/SCAN and CALARCO projects.

9.6 Further activities

Prof. Guerra has been member of the Technical-Scientific Committee of the Scientific Meeting *1908 – 2008 Scienza e Società a cento anni dal Grande Terremoto*, Reggio Calabria, 10-12 dicembre 2008" organised by INGV, Messina University and Italian State Agency for Seismic Risk for the centennial anniversary of the great 1908 earthquake in the Messina Straits held in Reggio Calabria (Dec 10-12, 2008).

The Geophysical Group was called to provide scientific support to the noteworthy civil defence exercise organised in the same occasion at Reggio Calabria by the relevant administrative bodies (Project ES2008 – ERMES: *Earthquake Simulation 2008 – Efficacious Reaction of MEssina Straits*).

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

1. Baccheschi P., Margheriti L., Steckler M.S. and CAT/SCAN Seismology Team (Abruzzese L., Amato A., Armbruster J., Di Luccio F., Gervasi A., Guerra I., Lerner-Lam A., Persaud P. and Seeber L.)
   SKS splitting in Southern Italy: anisotropy variations in a fragmented subduction zone
   Tectonophys., 462, p. 49-67, Dec 2008 -doi:10.1016/j.tecto.2007.10.014, 2008.

2. Vecchio A., Carbone V., Sorriso-Valvo L., De Rose C., Guerra I., and Harabaglia P.,
   Statistical properties of earthquakes clustering,
   Nonlinear Processes in Geophysics, 15, 333-338, 2008.

D PRESENTATIONS AT CONFERENCES

D.1 Presentations at international conferences in 2008

1. A. Vecchio, V. Carbone, I. Guerra, P. Harabaglia, B. Rosa,
   Quasi-periodic traveling waves of large-scale Earth's global seismicity,
   EGU Fall Meeting 2008, S. Francisco, USA, 15/12-19/12 2008.

2. Vecchio, A., Carbone, V., Sorriso-Valvo, L., Harabaglia, P., Guerra, I.
   Statistical properties of earthquakes clustering
   EGU General Assembly, Wien, 2008.

D.2 Presentations at national conferences in 2008

1. Rosa A.B., Vecchio A., Tamburriello G., Carbone V., Guerra I. e Harabaglia P.
   Coerenza spazio temporale dell'attività sismica in Italia
   27° Conv. Ann. Gr.Naz. Geofis. Terra Solida, Trieste, 2008.

2. De Rose C., Gervasi A., Guerra I., Mucciarelli M. e Tafaro F.
   Misure di Rumore Sismico a Messina e Reggio Calabria: risultati preliminari
   27° Conv. Ann. Gr.Naz. Geofis. Terra Solida, Trieste, 2008.

3. Costantino D., Anzidei M., Guerra I., Angelini M.G. e Caprino G.
   Studio delle deformazioni crostali della rete Calabria con metodo GPS
   12ª Conf. Naz. ASITA, L'Aquila 21 Ott. 2008.

4. Guerra I. e Gervasi A.
   Sismicità crostale recente della Calabria
   Convegno *1908 – 2008 Scienza e Società a cento anni dal Grande Terremoto*, Reggio Calabria, 2008.

5. Guerra I., Anzidei M., Costantino D., Angelini M.G., Caprino G. e Gervasi A.
   La rete GPS CalNet
   Convegno *1908 – 2008 Scienza e Società a cento anni dal Grande Terremoto*, Reggio Calabria, 2008.

6. Guerra I., De Rose C., Gervasi A., Mucciarelli M. e Tafaro F.
   Misure di rumore sismico a Messina e Reggio Calabria: risultati preliminari
   Convegno *1908 – 2008 Scienza e Società a cento anni dal Grande Terremoto*, Reggio Calabria, 2008.

7. Tolomei C., Tomaselli E., Stramondo S., Salvi S., Gervasi A., Guerra I. e Attori S.
   Interferometria SAR applicata alla misura dei movimenti del suolo nella Piana di Gioia Tauro
   Convegno *1908 – 2008 Scienza e Società a cento anni dal Grande Terremoto*, Reggio Calabria, 2008.