UNIVERSITÀ DELLA CALABRIA
Dipartimento di FISICA

ANNUAL REPORT 2007

ACADEMIC YEAR 2006-2007

Scientific publications in 2007

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Introduzione

Dal momento che lal'esercizio di valutazione CIVR relativo agli anni 2001-2003, resta per il momento l'unico, è ancora ad esso che bisogna far riferimento 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 (2004-2007) 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 35 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 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; 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;
- *nell'ambito della fisica 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; la stima della sezione d'urto per il processo di collisione tra neutrini cosmici di energia ultra-alta e protone;
- *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);
- *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 studio dell'interazione tra proteine e liposomi e dei liposomi stabilizzati stericamente per drug-delivery; la dimostrazione dell'esistenza di una stretta correlazione tra struttura tridimensionale delle proteine e la loro stabilità termodinamica;

- *nel campo della fisica quantistica*: l'analisi delle proprietà critiche dell'*entanglement* e della fase di Berry in prossimità della transizione di fase superradiante; lo studio teorico della conduttanza attraverso un anello interferometrico a semiconduttore, che ha consentito di migliorare la conoscenza di una serie di effetti peculiari della meccanica quantistica quali la fase di Berry, e l'interferenza Bohm-Aharonov,
- *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 recenti disposizioni di legge (*Nature* **455**, 835-836), in particolare il sostanziale blocco del turn-over nelle università nei prossimi anni, 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 ottobre 2008

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

Introduction

Looking at the last CIVR evaluation, which remains the unique performed up to date, and which covers the years from 2001 to 2003, it can be seen that 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 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 35 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;
- *in the field of high energy 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; the calculation of the cross section for the process of collision between ultra-high energy cosmic neutrinos and protons;
- *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);
- *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 study of interaction between protein and liposome and of liposome sterically stabilized for drug delivery; the evidence of a deep correlation between the 3D structure of proteins and their thermodynamic stability;
- *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;

- *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 most recent research budget cuts by Italian government (*Nature* **455**, 835-836), mainly the possibility to fill only one in five vacant academic positions, 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, October 21, 2008

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

DEPARTMENTAL ADMINISTRATION

Head of Department:
Pierluigi VELTRI

Executive Board:
Elio COLAVITA, Giancarlo SUSINNO, Alessandro PAPA, Cesare UMETON, Luigi PAPAGNO, Ignazio GUERRA, Assunta BONANNO, Nicola SCARAMUZZA

Department Council:
14 Full Professors
20 Associate Professors
17 Senior Researchers
8 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. oberto 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*
10. Laura LA ROTONDA	*FIS/01*
11. Francesco MALARA	*FIS/01*
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. Anna CUPOLILLO	*FIS/01*
5. Maria DE SANTO	*FIS/07*
6. Vincenzo FORMOSO	*FIS/01*
7. Domenico GIULIANO	*FIS/02*
8. Antonella GRECO	*FIS/07*
9. Rita GUZZI	*FIS/07*
10. Fabio LEPRETI	*FIS/03*
11. Daniela PACILE'	*FIS/01*
12. Pasquale PAGLIUSI	*FIS/07*
13. Francesco PLASTINA	*FIS/01*
14. Leonardo PRIMAVERA	*FIS/05*
15. Pierfrancesco RICCARDI	*FIS/01*
16. Antonello SINDONA	*FIS/01*
17. Giuseppe STRANGI	*FIS/07*

Post-Doctoral Research Fellows

1. Cristina ADORISIO
2. Vincenzo BRUNO
3. Tommaso CARUSO
4. Francesco CAPORALE
5. Marco CASTRIOTA
6. Mario COMMISSO
7. Antonio DE LUCA
8. Luciano DE SIO
9. Enrico MACCALLINI
10. Salvatore MARINO
11. Evelin MEONI
12. Giuseppina NIGRO
13. Marco ONOFRI
14. Manuela PANTUSA
15. Marco PAPAGNO
16. Antonio POLICICCHIO
17. Clementina PROVENZANO
18. Sergio SERVIDIO
19. Francesco VALENTINI
20. Carlo VENA
21. Alessandro VELTRI
22. Rosa ZAFFINO
23. Bruno ZAPPONE

Phd Students in Physics

1. Marianna BARBERIO s.b.	*(XX Cycle)*
2. Rossella DE MARCO	(*XX Cycle*)
3. Salvatore FAZIO	(*XX Cycle*)
4. Alfonso POLICICCHIO	(*XX Cycle*)
5. Sara RUDI s.b.	(*XX Cycle)*
6. Daniela SALVATORE	(*XX Cycle*)
7. Rossella FALCONE	*(XXI Cycle)*
8. Mario GRAVINA	*(XXI Cycle)*
9. Stefano MALETTA s.b.	*(XXI Cycle)*
10. Maria MINNITI	*(XXI Cycle)*
11. Silvia PERRI	*(XXI Cycle)*
12. Antonio POLITANO	*(XXI Cycle)*
13. Francesco FRANCICA	*(XXII Cycle*)
14. Raffaele MARINO	*(XXII Cycle)*
15. Valentino PINGITORE	*(XXII Cycle)*
16. Massimo VENTURELLI	*(XXII Cycle)*
17. Georgios KALANTZOPOULOS	*(XXII Cycle)*

Phd Students in Science and Tecnology of Mesophases and Molecular Materails

1. Sameh FERJANI	(*XX Cycle*)
2. Luigia PEZZI	(*XX Cycle*)
3. Giancarlo COSCHIGNANO	(*XX Cycle*)
4. MariaRIVERA VELASQUEZ	*(XXI Cycle)*
5. Tania RUGIERO	*(XXI Cycle)*
6. Gaetano NICASTRO	*(XXI Cycle)*
7. Stefano D'ELIA	*(XXI Cycle)*
8. Houda SELLAME	*(XXI Cycle)*
9. Mario Ariosto MATRANGA	*(XXI Cycle)*
10. Emanuela BRUNO	*(XXII Cycle)*
11. Said HOUMADI	*(XXII Cycle)*
12. Salvatore ARLIA	*(XXII Cycle)*
13. Lara SELVAGGI	*(XXII 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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CAPUTI Lorenzo	6154-6173
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CIPPARRONE Gabriella	6115-6148
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CROSETTI Giovanni	6021
CUPOLILLO Anna	6160-6174
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
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
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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

Network and Computer Service	*6035*
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 (2007)

31 gennaio 2007
Prof. Yaroslav D. Sergeyev,
Infinity Computer and Calculus

7 febbraio 2007
Dott. Gennaro Corcella (*Univ. Roma La Sapienza*)
Monte Carlo generators for high-energy colliders

14 febbraio 2007
Prof. Raffaele Casciaro,
Numerical post-buckling analysis- Part. 2

19 febbraio 2007
Alain Noullez, Observatoire de Nice (*Francia*)
Statistica e decadimento delle grandi scale in turbolenza

21 febbraio 2007
Alain Noullez, Observatoire de Nice (*Francia*)
Global statistics in decaying burgers turbulence

22 Febbraio 2007
Dr. Loris Giorgini, (*Università di Bologna*)
Amplification of chirality and photoinduced properties in azoaromatic polymeric materials

14 marzo 2007
Dott. Bruno Zappone, (*Università della Calabria*)
Bio-lubrificazione nei giunti articolari

15 marzo 2007
Prof. Valerio Pirronello (*Università di Catania*)
Formazione di molecole su superfici d'interesse astrofisico

21 marzo 2007
Dott. A. Flachi (*Univ. Kyoto*)
Domain walls and Black holes in Collision

27 marzo 2007
Prof. Raouf Bennaceur (*Univ. Tunisi*)
Research in the Field of Solid State Physics at the "Laboratoire de Physique de la Matière Condensé" di Tunisi

4 aprile 2007
dott. P. Barone (Uni*v. Calabria*)
Indagini su superfici metalliche e nanostrutturate con varie tecniche spetttroscopiche: risultati ed applicazioni

18 aprile 2007
dott. Procolo Lucignano (*Univ. Napoli "Federico II")*
An Overview of Kondo Effect

3 maggio 2007
dott.ssa M. Pantusa (*Univ. Calabria*)
Interazioni molecolari all'interfaccia lipidi/proteine: albumina umana e membrane contenenti polimero-lipidi

16 maggio 2007
Dr. G. Liberti (*Univ. Calabria*)
Transizione di fase quantistica nel modello di Dicke

16 maggio 2007
Prof. Franco Buccella (*Università di Napoli*),
Successi e prospettive delle distribuzioni dei partoni dettati dalla statistica quantistica

4 Giugno 2007
Dr. George Mehl, (*Dept. Chemistry, University of Hull*)
Structure property correlations in rod-disk systems

7 Giugno 2007
Dr. Emmanuelle Lacaze (*Universitè Paris VI*)
How to observe ordered organic molecules : from the monolayer to the smectic bulk

11 Giugno 2007
Prof. Gaetano Zimbardo (*Univ. Calabria*)
L'Anno Eliofisico Internazionale: dal Sole alla Terra e ai confini dell'Eliosfera

11 giugno 2007
Dr. J.-B. Salmon (*CNRS-Rhodia-Univ. Bordeaux 1*) *France*
Microfluidic tools for investigating out-of-equilibrium dynamics

14 Giugno 2007
Dr. Philippe Barois (*CNRS-Bordeaux*)
Structural Studies of Liquid Crystals by Resonant Scattering of x-rays "

20 giugno 2007
dr. Philippe Barois (*Centre P.Pascal, CNRS, Université de Bordeaux 1*)
X-rays and their Interaction with Matter

22 giugno 2007
dr. Philippe Barois (*Centre P.Pascal - CNRS, Université de Bordeaux* 1)
Structural Studies of Soft Condensed Matter

26 Giugno 2007
Dr. Phil Dyer (*Department of Chemistry, Durham University*)
Metal-catalysed Olefin Oligomerization and Polymerisation: Past, Present and Future

27 Giugno 2007
Dr. Phil Dyer (*Department of Chemistry, Durham University*)
Coordination Chemistry of Responsive Phosphine-based Ligands and Aminophosphines: Old Compounds, New Reactions

27 giugno 2007
dr. Philippe Barois Barois (*Centre P.Pascal - CNRS, Université de Bordeaux* 1)
Advanced Tecniques (reflectivity photon correlation spectroscopy, resonant scattering)

17 Luglio 2007
Dr. Giovanni Bottega (*Università degli Studi di Milano*)
Studio sperimentale della turbolenza 2D in un plasma di soli elettroni

18 Luglio 2007
Dr. Francesco Cavaliere (*Università degli studi di Milano*)
Aspetti ingegneristici relativi alla realizzazione di una macchina di Penning-Malmberg per il confinamento di plasmi non neutri

4 settembre 2007
Prof. Giovanni Barbero (*Dipartimento di Fisica del Politecnico di Torino*)
Influenza del fenomeno dell'adsorbimento sulla spettroscopia di impedenza

6 settembre 2007
Prof. Yuri Reznikov (*Institute of Physics, Ukraine*)
Ferroelectric liquid crystal nano-colloids

19 settembre 2007
Prof. W. Matthaeus (*Univ. Delaware*)
Correlation, Anisotropy and Structure in solar wind turbulence

19 settembre 2007
Prof. S. Maniscalco (*Department of Physics, University of Turku, Finland*)
Moto Browniano Quantistico

19 dicembre 2007
prof. A. Levy (*Tel Aviv Univ.*)
Gluons in the proton and exclusive hard diffraction

21 settembre 2007
Prof. W. Matthaeus (*Univ. Delaware*)
Turbulence model for heating the solar corona and accelerating the fast solar wind

24 settembre 2007
Dott. S. Maniscalco (*Department of Physics, University of Turku, Finland)*
Effetto Zenone Quantistico

11 ottobre 2007
Dott. M. Papagno (*Dipartimento di Fisica, Università della Calabria*)
Competing orders in the electronic structure of La1.67Sr0.33NiO4 in the stripe phase regime studied by ARPES

26 novembre 2007
Dr. Renato Gatto (*Università Tor Vergata, Roma*)
Turbulent generation of large-scale structures in fluids and plasmas

10 Dicembre 2007
Prof. Lorenzo Marrucci (*Dipartimento di Scienze Fisiche, Università di Napoli Federico II e Centro CNR-INFM Coherenzia*)
Come mettere in rotazione un raggio di luce attorno al proprio asse utilizzando i cristalli liquidi

10 Dicembre 2007
Dott. A. De Salvo (*INFN-Roma 1*)
Il Computing con GRID e il suo utilizzo su esperimenti a LHC

12 dicembre 2007
Dott. G. P. Vacca (*INFN Bologna*)
Small x QCD: a framework for corrections on inclusive jet production from multiple interactions"

12 dicembre 2007
Prof. F. Gliozzi (*Univ. di Torino*)
The physics of the k-strings in gauge theories

LAUREA THESIS' IN 2007

May 3 *(a.y. 2005-06)*
Gennaro CORTESE
Studio del metodo della continuazione analitica nella teorie di gauge SU(2) a densità finita.
Relatore***:*** Prof. Alessandro PAPA

Lucia MARINO
Studi archeometrici su Monete Magnogreche
Relatore: Dr. Raffaele Giuseppe AGOSTINO

July 17 *(a.y. 2006-07)*
Stefano CIDONE
Analisi statistica dell'indice MIB30
Relatore: Prof. Vincenzo CARBONE

Dicember 11 *(a.y. 2006-07)*
Rosanna TASSONE
Studio delle proprietà morfologiche ed elettroniche dei nanotubi di carbonio mediante i microscopi SEM,TEM ed STM
Relatore: Prof. Elio COLAVITA

1st LEVEL DEGREE THESIS' IN 2006

July 19 (*a.y. 2006-07*)
Luigi TENUTA
Il legame alcalino-superficie a bassissimi ricoprimenti: misure spettroscopia ad alta risoluzione di perdita di energia degli elettroni
Relatore: Prof. Gennaro CHIARELLO

Nicolino Biagio LO GULLO (*a.y. 2006-07*)
Generazione dinamica di correlazioni quantistiche
Relatore: Francesco PLASTINA

Denise PERRONE (*a.y. 2006-07*)
Un modello a shell per la dinamo terrestre
Relatore: Prof. Vincenzo CARBONE

Michele LUCENTE (*a.y. 2006-07*)
Supersimmetria in meccanica quantistica
Relatore: Prof. Alessandro PAPA

Michele PISARRA (*a.y. 2006-07*)
Misure di emissione di elettroni nell'interazione di fasci elettonici con superfici metalliche
Relatore: Dr. Pierfrancesco RICCARDI

Antonio IAZZOLINO (*a.y. 2006-07*)
Risoluzione numerica della relazione di dispersione a due fluidi, per onde in plasmi magnetizzati
Relatore: Francesco VALENTINI

Beatrice MURDACA (*a.y. 2006-07*)
Contributo della luce Cerenkov al segnale da elettroni nei Cristalli Pbw04
Relatore: Prof.ssa Laura LA ROTONDA

Enrico Maria TROTTA (*a.y. 2006-07*)
Studio dei modelli numerici del "Community Coordinated Modeling Center" della NASA

Relatore: Prof. Gaetano ZIMBARDO

Mario Salvatore CARDACI (*a.y. 2006-07*)
Analisi dei risultati di una simulazione MHD per un Reversed Field Pinch.
Relatore: Prof. Pierluigi VELTRI

Raffaele FORMOSO (*a.y. 2006-07*)
Caratterizzazione morfologica ed elettrica di films sottili di PZT (piombo zirconio titanato) ottenuti mediante la tecnica sol-gel
Relatore: Prof. Nicola SCARAMUZZA

October 3
Domenico MEDURI (*a.y. 2006-07*)
Un modello dinamico per l'effetto dinamo: analisi delle correlazioni nell'inversione del campo geomagnetico e nell'esperimento della macchina di Bullard-Von Barman
Relatore: Prof. Vincenzo CARBONE

Santo REDA (*a.y. 2006-07*)
Misure di emissione di elettroni nell'interazione di fasci ionici con superfici metalliche
Relatore: Dr. Pierfrancesco RICCARDI

Dicember 12
Mirella PAONESSA (*a.y. 2006-07*)
L'analisi delle immagini tomografiche mediche mediante espansione nelle componenti principali.
Relatore: Prof. Vincenzo CARBONE

Annamaria LA SERRA (*a.y. 2006-07*)
Determinazione della relazione spazio temporale delle camere di precisione MDT con la miscela Ar:CO2(93:7).
Relatore: Prof. Marco SCHIOPPA

Elvira MAZZA (*a.y. 2006-07*)
Turbolenza nella ionosfera
Relatore: Prof. Gaetano ZIMBARDO

Emanuele MANCINI (*a.y. 2006-07*)
Crescita e caratterizzazione di nanotubi di carbonio allineati su substrati di SiC.
Relatore: Prof. Raffaele Giuseppe AGOSTINO

Maria Chiara ANGIOCCHI (*a.y. 2006-07*)
Test dosimetrici di un fascio terapeutico di elettroni con fibre scintillanti.
Relatore: Prof. Elio COLAVITA

Stefania STUCCI (*a.y. 2006-07*)
Caratterizzazione dei rivelatori a scintillazione per l'osservazione di sciami prodotti da raggi cosmici di altissima energia.
Relatore: Prof. Marco SCHIOPPA

Domenica CARLOMAGNO (*a.y. 2006-07*)
Misure del flusso differenziale dn/d omega per extensive air showers
Relatore: Prof. Marco SCHIOPPA

Antonio PALERMO (*a.y. 2006-07*)
Modelli semplificati per intermittenza spazio-temporale in turbolenza magnetoidrodinamica
Relatore: Prof. Pierluigi VELTRI

2nd LEVEL DEGREE THESIS' IN 2007

July 19

Alessandra APICELLA (*a.y. 2006-07*)
Liquid crystall anchoring on a cristalline substrate: a combined study Scanning tunnelling and optical microscopy
Relatore: Dott.ssa Maria Penelope DE SANTO

Roberta VASTA (*a.y. 2006-07*)
Adsorbimento di idrogeno molecolare su MWCNT a basse pressioni e basse temperature
Relatore: Prof.ssa Assunta BONANNO

Davide Remo GROSSO (*a.y. 2006-07*)
Distribuzione energetica di elettroni emessi da superfici metalliche di impiego negli accelleratori di particelle
Relatore: Prof.ssa Assunta BONANNO

October 10

Gianfranco MORELLO (*a.y. 2006-07*)
Studio di nuove miscele gassose per le camere di precisione dello spettrometro per muoni di ATLAS a S-LHC
Relatore: Prof. Marco Schioppa

Sandro DONATO (*a.y. 2006-07*)
Matematica ed ecologia: l'equazione di reazione diffusione come modello di dinamica delle popolazioni
Relatore: Prof. Vincenzo CARBONE

Francesca TEOCOLI (*a.y. 2006-07*)
Formazione di Monolayer organici su monolayer inorganici.
Relatore: Prof. Rioberto BARTOLINO

December 11

Melissa INFUSINO (*a.y. 2006-07*)
Modello per il random Lasing in cristalli liquidi nematici: diffusione luminosa e propagazione in mezzi di guadagno
Relatore: Prof. Cesare UMETON

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Studio di emissione laser random in sistemi dinamici turbolenti
Relatore: Dr. Giuseppe STRANGI

Abdulbast ZANUN (*a.y. 2006-07*)
Trasporto di particelle cariche in strati di corrente in presenza di turbolenza magnetica
Relatore: Dott.ssa Antonella GRECO

Gabriele INFUSINO (*a.y. 2006-07*)
Campo massivo di spin 3/2 in Spazio-Tempo de-Sitter.
Relatore: Prof. Alessandro PAPA

PhD THESIS' in 2007

(*15° Cycle*)
Vincenzo BRUNO
Caratterizzazione ottica e delle transizioni di fase termiche di cristalli liquidi smettici. Studio di celle a cristalli liquidi con l'inserzione di ossidi elettrocromici
Supervisore: Prof. Nicola SCARAMUZZA

(*19° Cycle*)

Angela MILAZZO
Produzione e sperimentazione di materiale multimediale per la creazione di percorsi didattici per l'insegnamento della fisica
Supervisore: Prof.ssa Assunta BONANNO

Peppino SAPIA
Produzione e Sperimentazione di Strumenti Multimediali Interattivi a Supporto della Creazione di Percorsi Didattici per l'Insegnamento/Apprendimento della Fisica
Supervisore: Prof.ssa Assunta BONANNO

(*20° Cycle*)

Rossana DE MARCO
A dynamical model for wave-particle interaction in collisionless plasmas
Supervisore: Prof. Vincenzo CARBONE

Salvatore FAZIO
Measurement of Deeply Virtual Compton Scattering cross sections at HERA and a new model for the DVCS amplitude
Supervisore: Dott.ssa Marcella CAPUA

Alfonso POLICICCHIO
Chemical and morphological influence on nanostructures: synthesis and characterization of Carbon-based materials
Supervisore: Prof. Raffaele AGOSTINO

Sara RUDI
Theretical Study of ion induced electronic processes at metal surfaces.
Supervisore: Dr. Antonello SINDONA

Daniela SALVATORE
Intensive irradiation studies, monitoring and commissioning data analysis on the ATLAS MDT chambers
Supervisore: Prof. Giancarlo SUSINNO

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, L'Aquila, Rome "La Sapienza") and with Italian Institutions (IFSI - CNR of Frascati, Osservatorio Astrofisico di Arcetri, Osservatorio Astronomico di Bologna) and foreign Institutions (Observatoire de Paris-Meudon (France); Observatoire de la Cote d'Azur, Nice (France); Space Research Institute, Moscow (Russia); University of California, San Diego (USA); Aristotle University of Thessaloniki (Greece); Abastumani Astrophysical Observatory, Tbilisi (Georgia); NASA Goddard Space Flight Center (USA); University of Worwick (UK); NSO, Sacramento Peak (USA); Forschungszentrum Dresden-Rossendorf (Germany); Institute of Atmospheric Physics, Prague (Czech Republic); Swedish Institute of Space Physics, Uppsala (Sweden)). The specific research themes under study during the year 2007 are described in the following.

1.1 MAGNETOHYDRODYNAMIC TURBULENCE AND KINETIC EFFECTS IN THE HELIOSPHERE

Complexity in sequences of impulsive energy release events: solar flares and earthquakes

Impulsive energy release events are observed in many natural systems. Solar flares and earthquakes are certainly among the most remarkable examples of such processes. On the bases of the analogies between the statistical properties of these phenomena, the existence of a universal physical mechanism in the occurrence of these impulsive events has been proposed in several works over the last few years. We compared the statistical properties of solar flares and earthquakes by analysing the energy distributions, the time series of energies and inter-event times, and, above all, the distributions of inter-event times per se. It is shown that the two phenomena have different statistics of scaling, and even the same phenomenon, when observed in different periods or at different locations, is characterized by different statistics that cannot be uniformly rescaled onto a single, universal curve. The results indicate apparent complexity of impulsive energy release processes, which neither follow a common behaviour nor could be attributed to a universal physical mechanism.

Statistical analysis of the polarity reversals of the geomagnetic field

We have investigated the temporal distribution of polarity reversals of the geomagnetic field. In spite of the common assumption that the reversal sequence can be modelled as a realization of a renewal Poisson process with a variable rate, we have shown that the polarity reversals strongly depart from a local Poisson statistics. The origin of this failure can be attributed to the presence of temporal clustering, thus suggesting the presence of long-range correlations in the underlying dynamo process. In this framework we have compared our results with the behaviour of different models that describe the time evolution of the reversals. The results obtained for a modified shell model, reproducing the non-linear features of the MHD equations, and for a turbulent α^2 dynamo model are in qualitative agreement with the data. In particular, time correlations due to the non-linear character of the models are observed as clustering of the reversals, which reproduces the behaviour observed in the geomagnetic reversals. In this view, our results can be interpreted as a strong evidence for the presence of correlations between reversal events in the geomagnetic field. Such correlations are only observed in models which include non-linear dynamics, and can be associated with the presence of some degree of memory in the underlying geodynamo process.

High resolution studies of the lower solar atmosphere

Convective and magnetic processes occurring at the solar surface on 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 magnetohydrodynamics 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 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. We further showed that a large fraction of the chromospheric acoustic power at frequencies below the acoustic cut-off, normally considered evanescent in the solar atmosphere, can propagate along small scale magnetic elements, giving rise to strong shocks in the chromosphere and to the variety of fibrillar structures that characterize the solar chromosphere.

Convective turbulence, global oscillations and solar activity

The interior of the Sun behaves like a resonant cavity, which supports the excitation of global oscillations at peculiar discrete frequencies. In presence of a gravitational field and density stratification, two modes can be excited, namely acoustic p-modes and gravitational g-modes. Since g-modes are concentrated near the centre of the Sun, they represents privileged probes to access the physics of the deep interior. Their observations, so far not unambiguously established, should furnish a fundamental improvement for heliosismology. Solar oscillations compete with a different process, namely the turbulent convection within the photosphere observed as a stochastic spatio-temporal behaviour of granulae that cover the whole surface of the Sun (except in sunspots). We investigated the spatio-temporal dynamics of the solar photosphere by performing a Proper Orthogonal Decomposition (POD) of line of sight velocity fields computed from high resolution data coming from the MDI instrument onboard the SOHO satellite. Using this technique, we are able to identify and characterize the different dynamical regimes acting on the system. Low-frequency oscillations, with frequencies in the range 20-130 □Hz, dominate the most energetic modes (excluding solar rotation), and are characterized by spatial patterns with typical scales of about 3000 km (the scale of the solar granulation). Patterns with larger typical scales, of the order of 10000 km, are associated to p-modes oscillations at frequencies of about 3000 □Hz. The POD have been used also to investigate the spatio-temporal features of the solar activity. Rather than the usual sunspots, daily observations of the green coronal emission in the period 1949-1996 are used as indicator of the 11-years solar cycle. We show that few POD modes suffice in describing both the space and time main periodicities. In particular two POD modes are enough to describe both the 11-years time periodicity and the "butterfly" diagram of the migration of active regions. Moreover, beside the basic periodicity, we found evidences for further intercycle temporal periodicities.

Alfvén wave dissipation in 3D coronal structures

The dissipation of Alfvén waves is one of the physical mechanisms proposed to explain the heating of the solar corona. Because of the very high values of the effective Reynolds/Lundquist number, the problem is how to move the wave energy on sufficiently small scales to be dissipated. In three-dimensional structures dissipative mechanisms are particularly efficient, since small scales can be generated exponentially ("fast dissipation" regime). In previous works we have demonstrated that Alfvén wave dissipation takes place with an increased rate within 3D configurations, in locations where magnetic lines have a chaotic behaviour. This means that pairs of nearby magnetic lines must exponentially take apart from each other. We have now quantitatively studied such an aspect using the so-called Kolmogorov entropy of magnetic lines, which gives a measure of the rate of exponential separation of magnetic lines. We calculated the spatial distribution and the local properties of the Kolmogorov entropy in a model of a complex force-free coronal magnetic field, which represents a structure above a quiet-Sun region. We found that the fastest generation of small scales takes place mainly around magnetic separators, which are the lines where magnetic separatrices intersect. As a consequence, most of energy deposition due to wave dissipation is along separatrices of the magnetic structure.

Turbulent energy cascade in solar wind plasma

The presence of a turbulent energy cascade has been suggested in the solar wind by the spectral properties of the fields. However, a firm, established observation requires the more detailed analysis of the only exact result in turbulence, namely the Yaglom law. This has been studied and observed in ordinary fluids. We have extended such approach to magnetized fluids, obtaining an exact relation that should hold in case of homogeneous, isotropic turbulence. This relation

uses the Elasser variables to build-up a mixed third-order moment, describing the presence of an energy cascade in magnetohydrodynamics. Such law has then be oberved from Ulysses data in the solar wind, showing for the first time without ambiguity the presence of an energy cascade. The compressible and incompressible cases have been studied and observed from the data. Moreover, this result allow a first experimental measurement of the energy transfer rate in the solar wind. From this result, it is possible to compare the turbulent energy with the energy needed to heat the solar wind during its expansion. The results show that the incompressible cascade is not enough to heat the plasma, while the compressible cascade can provide the energy necessary to the heating.

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. The nonlinear evolution of three-dimensional reconnection instabilities has been studied through numerical simulations in a current sheet where many resonant surfaces are simultaneously present at different locations of the simulation domain. The nonlinear evolution of the tearing instabilities produces the formation of anisotropic magnetohydrodynamic turbulence. The development of the energy spectrum is followed until the energy is transported to the dissipative length scale. The energy cascade takes place mainly in the direction perpendicular to the local average magnetic field. The direction of anisotropy varies with the spatial location and the spectral index is different both from what is found in inhomogeneous isotropic turbulence and from the values predicted for magnetohydrodynamic turbulence with a uniform magnetic field.

Kinetic cross-scale effects in solar wind turbulence

The problem of understanding which physical processes "replace" dissipation at small-scale in a collisionless plasma, like solar wind, is of key relevance in space physics. Several spacecraft observations have shown that the short-scale termination of the MagnetoHydroDynamics (MHD) energy spectra in solar wind is characterized by the occurrence of significant levels of electrostatic activity, whose maximum intensity usually occurs in regions where strong deviations from a Maxwellian distribution of particle velocities are observed, meaning that the short-scale system dynamics is presumably kinetic in nature.

The understanding of the short-scale temination of the MHD energy spectra in solar wind plasmas is nowadays one of the oustanding problems in space physics. The impressive recent technological development of supercomputers gives now the possibility of using kinetic Eulerian Vlasov codes that solve the Vlasov-Maxwell equations in multi-dimensional phase space. We recently developped a new hybrid-Vlasov code, that numerically solves the kinetic Vlasov-Maxwell equations for a nonrelativistic collisionless plasma. This code is used to investigate the short-scale termination of the turbulent energy spectra in solar wind.

Our numerical results have shown that taking into account kinetic effects in the development of the turbulent energy spectra represents the key ingredient to explain a wide set of spacecraft observations. In our kinetic simulations, we observed that when the energy is trasferred towards small scales along the turbulent cascade, wave-particle resonant interactions make the distributions of particle velocities depart from the Maxwellian shape, with the appearence of temperature anisotropy, generation of beams of accelerated particles and strong electrostatic activity at typical kinetic scales, consisting mostly of longitudinal ion-acoustic waves. Beside the branch of ion-acoustic waves, which is in agreement with solar wind data, the carefull analysis of the numerical signals from our kinetic simulations indicates the presence of a new branch of kinetic waves. Unfortunately, the available measurements in space plasmas do not allow a complete Fourier analysis at typical kinetic scales. In this view, it is desirable that future space missions could provide this crucial information, in order to test the effectiveness of the numerical model predictions.

1.3 TRANSPORT 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. 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.

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. Inside these structures a non negligible level of magnetic turbulence can be generated. In collaboration with colleagues from the Aristotle University of Thessaloniki, we have developed a numerical model to study the transport of particles accelerated by a flare inside the loop. It is found that some particles can be mirror trapped by the magnetic fluctuations, while others can free stream toward the loop foopoints, corresponding to anomalous transport regimes. In general, a non Gaussian transport behaviour is found. We are now considering 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.

Stochastic particle acceleration

Since the work by Fermi in 1949 on the origin of cosmic radiation, stochastic acceleration of charged particles in random electromagnetic fields is a topic of primary interest because it plays a crucial role in understanding many dynamical processes in astrophysics, space physics and laboratory plasmas. In this context, we investigated the two-dimensional diffusive dynamics of test particles in stochastic electromagnetic fields. The synthetic electromagnetic fluctuations are generated through randomly placed, oscillating magnetised “clouds”. We studied the mean square displacements of particles in both position and velocity spaces. As the oscillation frequency of the magnetised “clouds”, which produce the electromagnetic fields, increases, the diffusion in position space goes from a Brownian-like regime to anomalous diffusion, with ballistic motion for the highest investigated frequency. Correspondingly, diffusion in velocity space also shows a change from Brownian-like behaviour to anomalous diffusion. Although in general the diffusion properties in velocity space are not trivially related to those in position space, in the cases where anomalous diffusion is present, a broadening of the particle velocity distribution is also found, even if their shape remains nearly Gaussian. In other words, the anomalous diffusion mechanism at work is associated to an energization of the bulk particle population and not to the existence of high energy tails in the velocity distribution.

Stochastic acceleration of ions in the magnetotail by a Fermi-like model

The Earth's magnetotail is both a reservoir of plasma and magnetic energy, and a source of energetic particles with energies in the tens of keV range. These particles are observed as ion beam, and often their energy exceeds that corresponding to the available cross-tail potential drop, so that an additional acceleration mechanism is required. A test particle simulation has been performed in order to reproduce the interaction between electromagnetic fluctuations, frequently observed in the distant magnetotail, and an ensemble of charged particles. Electromagnetic perturbations are generated by random oscillating “clouds" positioned in the neutral sheet, and a constant dawn-dusk electric field component, E_y, has been also included. Particles are accelerated via a Fermi-

like process, and by varying the features of the electromagnetic fluctuations, the combined effect of E_y and of the moving clouds can explain a range of energetic ion observations. The acceleration time and the energies reached compare well with those observed in the distant magnetotail.

1.3. 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 magnetotail, and when strong turbulence levels are present. Because of its larger Larmor radius, it appears that the interaction of oxygen with magnetic turbulence is substantially different from that of hydrogen.

An extensive review of magnetic turbulence in the geospace environment, related to the INTAS 8943 project, coordinated by our group, is under way.

1.4. LABORATORY PLASMAS

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. A numerical code has been built up to study the magnetohydrodynamic turbulence in a reversed field pinch configuration by solving the compressible MHD equations in cylindrical coordinates. The compressibility requires that particular attention should be paid to the boundary conditions to have an accurate control of wave reflections from the boundaries of the computational domain. To fulfill these requirements, the boundary conditions are calculated by a decomposition into characteristic waves. Our simulations show the importance of a fully compressible MHD cylindrical code. Including compressibility not only eliminates an inconsistency of previous models, but it also modifies the time evolution.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2007

1. Greco A., Carbone V., Sorriso-Valvo L.,
   Non-Poisson intermittent events in price formation in a Ising spin model of market,
   Physica A **376**, 480-486 (2007) .

2. Malara F., Veltri P., De Franceschis M. F.,
   Alfvén wave dissipation and topological properties of 3D coronal force-free magnetic fields,
   Astron. Astrophys. **467**, 1275-1284 (2007) .

3. Gkioulidou M., Zimbardo G., Pommois P., Veltri P., Vlahos L.,
   High energy particle transport in stochastic magnetic fields in the solar corona,
   Astronomy and Astrophysics **462**, 1113-1120 (2007).

4. Pommois P., Zimbardo G., Veltri P.,
   Anomalous, non-Gaussian transport of charged particles in anisotropic magnetic turbulence,
   Physics of Plasmas **14**, 012311 (2007).

5. Bruno R., Carbone V., Chapman S., Hnat B., Noullez A. and Sorriso-Valvo L.,
   Intermittent character of interplanetary magnetic field fluctuations,
   Physics of Plasmas **14**, 32901-32906 (2007).

6. Perri S., Lepreti F., Carbone V., Vulpiani A.,
   Position and velocity space diffusion of test particles in stochastic electromagnetic fields,
   Europhysics Letters **78**, 40003 (2007).

7. Carbone V., De Marco R., Valentini F. Veltri P.,
   Wave-particle interaction in collisionless plasmas: The failure of Vlasov approximation in describing the approach to statistical equilibrium,
   EuroPhysics Letters **78**, 65001 (2007).

8. Greco A., De Bartolo R., Zimbardo G., Veltri P.,
   A three-dimensional kinetic-fluid numerical code to study the equilibrium structure of the magnetotail: The role of electrons in the formation of the bifurcated current sheet,
   Journal of Geophysical Research **112**, A06218 (2007).

9. Valentini F., P Travnicek, F. Califano, P. Hellinger, A. Mangeney,
   A hybrid-Vlasov model based on the current advance method for the simulation of collisionless magnetized plasma,
   Journal of Computational Physics **225**, 753-770 (2007).

10. Bruno R., D'Amicis R., Bavassano B., Carbone V., Sorriso-Valvo L.,
    Magnetically dominated structures as an important component of the solar wind turbulence,
    Annales Geophysicae **25**, 1913-1927 (2007).

11. Sorriso-Valvo L., Marino R., Carbone V., Noullez A., Lepreti F., Veltri P., Bruno R., Bavassano B., Pietropaolo E.,
    Observation of Inertial Energy Cascade in Interplanetary Space Plasma,
    Physical Review Letters **99**, 115001 (2007).

12. Stefani F., Xu M., Sorriso-Valvo L., Gerbeth G., Gunther U.,
    Oscillation or rotation: a comparison of two simple reversal models,

Geophysical and Astrophysical Fluid Dynamics **101**, 227-248 (2007).

13. Sorriso-Valvo L., Stefani F., Carbone V., Nigro G., Lepreti F., Vecchio A. and Veltri P.,
A statistical analysis of polarity reversals of the geomagnetic field,
Physics of the Earth and Planetary Interiors **164**, 197-207 (2007).

14. Valentini F., D'Agosta R.,
Electrostatic Landau pole for kappa velocity distributions,
Physics of Plasmas **14**, 092111 (2007).

15. Alexandrova A., Carbone V., Veltri P., Sorriso-Valvo L.,
Solar wind Cluster observations: Turbulent spectrum and role of Hall effect,
Planetary and Space Science **55**, 2224-2227 (2007).

16. Bruno R., D'Amicis R., Bavassano B.,Carbone V., Sorriso-Valvo L.,
Scaling laws and coherent structures in the solar wind,
Planetary and Space Science **55**, 2233-2238 (2007).

17. Taktakishvili A., Zimbardo G., Amata E., Savin S., Greco A., Veltri P., Lopez R. E.,
Ion escape from the high latitude magnetopause: analysis of oxygen and proton dynamics in the presence of magnetic turbulence,
Annales Geophysicae **25**, 1877-1885 (2007).

18. Onofri M., Veltri P., Malara F.,
Development and anisotropy of three-dimensional turbulence in a current sheet,
Phys. Plasmas **14**, 062304 (2007).

19. Onofri M., Primavera L., Malara F., Londrillo P.,
A compressible magnetohydrodynamic numerical code with time-dependent boundary conditions in cylindrical geometry,
J. Comput. Phys. **226**, 1874-1890 (2007).

20. Perri S., Zimbardo G.,
Evidence of superdiffusive transport of electrons accelerated at interplanetary shocks,
Astrophysical Journal Lett. **671**, L177-L180 (2007).

21. Servidio S., Carbone V., Primavera L., Veltri P., Stasiewicz K.,
Compressible turbulence in Hall Magnetohydrodynamics,
Planetary and Space Science **55**, 2239-2243 (2007).

22. Bruno R., D'Amicis R., Bavassano B., Carbone V., Sorriso-Valvo L.,
Scaling laws and coherent structures in the solar wind,
Planetary and Space Science **55**, 2233-2238 (2007).

23. Vecchio, A., Cauzzi, G., Reardon, K. P., Janssen, K., Rimmele, T.,
Solar atmospheric oscillations and the chromospheric magnetic topology,
Astronomy and Astrophysics **461**, L1-L4 (2007).

A.1.2 Publications on international journals accepted in 2007

1. De Bartolo R., Greco A., Veltri P.,
A 3D kinetic-fluid numerical code for stationary equilibrium states in magnetized plasmas,
in press on Computer Physics Communications.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2006

1. Bruno R., Bavassano B., D'Amicis R., Salem C., Carbone V., Marino R., Sorriso-Valvo L., and Noullez A., *Observations of turbulence and anomalous scaling in the solar wind,* in AIP Conference Proceedings – August 28, 2007 - Volume 932, TURBULENCE AND NONLINEAR PROCESSES IN ASTROPHYSICAL PLASMAS; 6th Annual International Astrophysics Conference, pp. 16-25 (2007).

2. Zimbardo G., Martino R., Veltri P., *Electron transport regimes and magnetic turbulence levels in coronal loops,* in Proceedings of the Second Solar Orbiter Workshop, ESA SP-641, L. Conroy, ESA Publications Division, European Space Agency, Noordwijk, The Netherlands (2007).

3. Zimbardo G., Perri S., Pommois P., and Veltri P., *Superdiffusive Transport of Energetic Particles in Solar Wind Turbulence,* in EARTH: OUR CHANGING PLANET, Proceedings of IUGG XXIV General Assembly, L. Ubertini, P. Manciola, S. Casadei, Umbria Scientific Meeting Association, Perugia, Italy (2007).

4. Cauzzi, G., Reardon, K. P., Vecchio, A., Janssen, K., Rimmele, T., *Acoustic Shocks in the Quiet Solar Chromosphere,* in The Physics of Chromospheric Plasmas ASP Conference Series, Vol. 368, Proceedings of the conference held 9-13 October, 2006 at the University of Coimbra in Coimbra, Portugal., P. Heinzel, I. Dorotovic, and R. J. Rutten., Astronomical Society of the Pacific, San Francisco, pp. 127(2007).

5. M. Onofri, L. Primavera, P.Veltri, F. Malara, *Magnetohydrodynamic turbulence produced by reconnection instability,* in proceedings of the 5th International Symposium on Turbulence and Shear Flow Phenomena (2007).

C INVITED PRESENTATIONS

C1. Invited presentations at international conferences in 2007

1. Zimbardo G., *Non Gaussian transport, strong turbulence, and nonlinear phenomena in the magnetosphere and ionosphere,* Workshop INTAS - South Caucasus 2007, Tbilisi, Georgia, 28/03 – 30/03 (2007).

2. Zimbardo G., Bitane R., Pommois P., and Veltri P., *On the heating mechanisms of the solar corona,* Space Plasmas and Astrophysics, Workshop in honor of Andre Mangeney, Paris Meudon, 11/09 – 14/09 (2007).

3. Sorriso-Valvo L., Bruno R., Carbone V., Marino R., Noullez A., Veltri P., *On the inertial range of solar wind turbulence,* AGU 2007, San Francisco, 10/12 - 15/12 (2007).

4. Veltri P., *Clustering of Polarity Reversals of the Geomagnetic Field,* Space Plasmas and Astrophysics, Workshop in honor of Andre Mangeney, Paris Meudon, 11/09 – 14/09 (2007).

5. M. Onofri, L. Primavera, F. Malara, P. Veltri, *Anisotropy in magnetohydrodynamic turbulence,* US-Japan Simulation Science Workshop, Austin (USA), 8/10 – 9/10 (2007).

C.2 Invited presentations at national conferences in 2007

1. Zimbardo G.,
   Il 2007, Anno Eliofisico Internazionale, e l'influenza dei raggi cosmici extragalattici,
   Convegno di orientamento e formazione sull'insegnamento della fisica del XX secolo, Progetto L.6/2000: Più veloce della luce, Serra San Bruno (VV), 19/10 – 20/10 (2007).

D PRESENTATIONS AT CONFERENCES
D1. Presentations at international conferences in 2007

1. Greco, G. Zimbardo, P. Veltri, R. De Bartolo,
   Ion transport processes and magnetotail structure by using 3D particle simulations and kinetic-fluid models,
   Workshop INTAS-South-Caucasus 2007, Tbilisi (Georgia), March 27 - March 31 2007.

2. Sorriso-Valvo, L.,
   Turbulence in solar wind: the inertial range and beyond,
   INTAS workshop 2007, Tbilisi (Georgia), 20 March-23 March 2007.

3. Sorriso-Valvo, L.,
   On the inertial range of solar wind MHD turbulence,
   EGU 2007, Vienna (Austria), April 15 –April 20 2007.

4. Sorriso-Valvo L.,
   Statistical properties of paleomagnetic reversals: data and models,
   EGU 2007, Vienna (Austria), April 15 –April 20 2007.

5. Sorriso-Valvo, L., Marino, R., Carbone, V., Bruno, R.,
   Observation of inertial range in solar wind turbulence,
   IHY 2007, Torino (Italy), June 18 – June 22 2007.

6. Valentini F.,
   Kinetic effects on Hall-Magnetohydrodynamics slab turbulence in solar wind plasmas,
   International workshop in honor of André Mangeney, Meudon, Paris (France), September 11- September 14 2007.

7. Greco A.,
   The role of the magnetic turbulence on the dynamics of non-adiabatic ions in the cross-tail current sheet.,
   IUGG 2007, Perugia (Italy), July 2 – July 13 2007.

8. Kossobokov V., Lepreti F., Carbone V.,
   Complexity in sequences of solar flares, earthquakes, and starquakes.,
   European Geosciences Union General Assembly 2007, Vienna (Austria), April 15 –April 20 2007.

9. Lepreti F., Carbone V., Veltri P.,
   Dynamical model for the spatio-temporal intermittency of the turbulent energy cascade: first results and possibleapplications to coronal loops,
   European Geosciences Union General Assembly 2007, Vienna (Austria), April 15 –April 20 2007.

10. Lepreti F., Vecchio A., Reardon K., Carbone V., Capparelli V.,
    Analysis of velocity fluctuations in the solar atmosphere: relation between intermittency and chromospheric magnetic topology,
    European Geosciences Union General Assembly 2007, Vienna (Austria), April 15 –April 20 2007.

11. Zimbardo G.,

Magnetic turbulence in and around the magnetosphere: an overview,
Kick-off meeting of the INTAS 8943 research project, Tbilisi (Georgia), 20 March-23 March 2007.

12. Perri S., Zimbardo G.,
Evidence for superdiffusive transport of electrons accelerated by interplanetary shock waves,
The Sun, the Heliosphere, and the Earth, Heliophysics 2007, Bad Honnef (Germany), May 14, - May 18, 2007.

13. Zimbardo G., Greco A., Veltri P., Voros Z.,
Magnetic turbulence in and around the Earth's magnetosphere,
The Sun, the Heliosphere, and the Earth, Heliophysics 2007, Bad Honnef (Germany), May 14, - May 18, 2007.

14. Perri S., Zimbardo G.,
Evidence for Levy walks and non Gaussian propagators of energetic particles accelerated at interplanetary shock waves,
Chaos, Complexity and Transport: Theory and Applications, Marseille (France), June 4 –June 8 2007.

15. Bitane R., Zimbardo G., Pommois P., and Veltri P.,
Kolmogorov entropy of magnetic field lines in the percolative regime: numerical computation and application to electron transport in solar coronal loops,
Chaos, Complexity and Transport: Theory and Applications, Marseille (France), June 4 –June 8 2007.

16. G. Zimbardo, A. Greco, P. Veltri, Z. Voros, E. Amata, A.L. Taktakishvili, V. Carbone, L. Sorriso-Valvo, and I. Guerra,
Solar-Terrestrial relations: Magnetic turbulence in the Earth's magnetosphere and geomagnetic activity,
2nd European general assembly of the IHY, Torino (Italy), June 18 – June 22 2007.

17. Zimbardo G., Taktakishvili A. L., Greco A., Veltri P., Amata E., and Savin S.,
Transport of ionospheric oxygen across the turbulent magnetopause,
IAGA-IUGG XXIV General Assembly, Perugia (Italy), July 2 – July 13 2007.

18. Zimbardo G., Perri S., Pommois P., and Veltri P.,
Superdiffusive Transport of Energetic Particles in Solar Wind Turbulence,
IAGA-IUGG XXIV General Assembly, Perugia (Italy), July 2 – July 13 2007.

19. Sorriso-Valvo L., Carbone V., Nigro G., Meduri D., Stefani F., Bourgoing M.,
A statistical analysis of polarity reversals of the geomagnetic filed,
AGU 2007, San Francisco, December 10 – December 15 2007.

20. M. Onofri, L. Primavera, F. Malara, p. Veltri,
MHD turbulence produced by reconnection instability,
20th International Conference on Numerical Simulation of Plasmas, Austin (USA), October 10 –October 12 2007.

21. M. Onofri, L. Primavera, F. Malara, P. Veltri,
Spectral anisotropy in magnetohydrodynamic turbulence,
European Geosciences Union. General Assembly, Vienna (Austria), April 15 –April 20 2007.

Presentations at national conferences in 2007

1. Zimbardo G.,
Fenomeni turbolenti nei plasmi spaziali: simulazioni e confronto con i dati da satellite,
I° Meeting Scientifico ESS WP 2000, Agenzia Spaziale Italiana, Roma, 4 ottobre -5 ottobre 2007.

2. THEORETICAL PARTICLE PHYSICS AND APPLICATIONS

Professors and Researchers	Roberto Fiore Domenico Giuliano Alessandro Papa Galileo Violini
Postdoc fellows	Francesco Caporale
PhD students	Rossella Falcone (XXI cycle) Mario Gravina (XXI cycle)
Collaborators	I. Affleck (*University of British Columbia, Vancouver, Canada*) M. Caligiuri (*Università della Calabria, Cosenza, Italy*) P. Cea (*Università di Bari &INFN-Bari, Italy*) L. Cosmai *(INFN-Bari, Italy)* M. D'Elia (*Università di Genova & INFN-Genova, Italy*) V.S. Fadin (*Budker Institute for Nuclear Physics, Novosibirsk, Russia*) P. Gensini (*Università di Perugia & INFN-Perugia, Italy)* A.V. Grabovsky (*Budker Institute for Nuclear Physics, Novosibirsk, Russia*) R. Hurtado (*Universidad Nacional de Bogotà, Colombia*) D.Yu. Ivanov (*Sobolev Isntitute of Mathematics, Novosibirsk, Russia)* L.L. Jenkovszky (*Bogolyubov Institute for Theoretical Physics, Kiev, Ucraine*) P. Lucignano (*Università di Napoli, Italy*) A. Merlani (*Istituto del Restauro, Roma, Italy*) V. Magas *(Universidad Valencia)* F. Paccanoni (*Università di Padova & INFN-Padova, Italy*) G. Pancheri (*Laboratori Nazionali di Frascati, INFN, Italy*) O. Philipsen *(University of Muenster, Germany)* A. Prokudin *(Università di Torino & INFN-Torino, Italy)* E. Salusti (*Università di Roma – La Sapienza, Italy*) P. Sodano (*Università di Perugia & INFN-Perugia, Italy*) Y. Srivastava (*Università di Perugia & INFN-Perugia, Italy)* A. Tagliacozzo (*Università di Napoli, Italy*) M. Teper *(Oxford University, United Kingdom)* V.R. Zoller (*ITEP, Moscow, Russia*)

Introduction

The research activity during the AA 2006-07 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
- physics of kaon-nucleon interactions;
- non-linear wave-equations for fluids in porous material.

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 computational facilities of the Physics Department and of the Istituto Nazionale di Fisica Nucleare (INFN) – Gruppo Collegato di Cosenza.

2.1 QCD IN THE REGGE LIMIT AND HADRON PHENOMENOLOGY

2.1.1 QCD in the Regge limit

The quark and the gluon contribution to the BFKL kernel in the next-to-leading order (NLO) have been found in the coordinate representation by direct transfer of the contribution from the momentum representation where they were calculated before. This representation is convenient to study the conformal properties of the NLO BFKL kernel and the relation between the BFKL and color dipole approaches. The "dipole" form of the NLO BFKL kernel has been found also in supersymmetric Yang-Mills theories.

The systematic effects in the determination of the amplitude for the forward electroproduction of two light vector mesons in NLO BFKL have been estimated by considering different representations for the amplitude and different optimization methods of the perturbative series. The same amplitude has been determined using a collinearly improved kernel: it turned out that, due to the improvement, the optimal renormalization scale gets closer to the kinematical scale of the process.

2.1.2 Hadron Phenomenology

A factorized Regge-pole model for deeply virtual Compton scattering is suggested. The use of an effective logarithmic Regge-Pomeron trajectory provides for the description of both “soft" and “hard" dynamics. The model contains explicitly the photoproduction and the DIS limits and fits the existing HERA data on deeply virtual Compton scattering.

The J/Psi photoproduction has been studied in the framework of the analytic S-matrix theory. The differential and integrated elastic cross sections for J/Psi photoproduction are calculated from a Dual Amplitude with Mandelstam Analyticity (DAMA). It is argued that at low energies, the background, which is the low-energy equivalent of the high-energy diffraction replaces the Pomeron exchange. The onset of the high energy Pomeron dominance is estimated
from the fits to the data.

The Adler's theorem has been considered in the color dipole basis of small-x QCD. It establishes a connection between perturbative and non-perturbative descriptions of DIS and quantifies the effect of non-perturbative dynamics on would-be-perturbative observables. In particular, it provides a quantitative measure of the non-perturbative influence on the longitudinal structure function in charged current DIS and imposes stringent constraints on non-perturbative parameters of color dipole models. The analysis calls for new experimental tests of Adler's theorem in diffractive neutrino scattering.

2.2 LATTICE GAUGE THEORIES

The mass spectrum of the 3d 3-state Potts model has been considered in the broken phase (a) near the second order Ising critical point in the temperature - magnetic field plane and (b) near the weakly first order transition point at zero magnetic field. In the case (a), we have compared the mass spectrum with the prediction from universality of mass ratios in the 3d Ising class; in the case (b), we have determined a mass ratio which is then compared with the corresponding one in the spectrum of screening masses of the (3+1)d SU(3) pure gauge theory at finite temperature in the deconfined phase near the transition .

The method of analytic continuation from imaginary to real chemical potential is one of the most powerful tools to circumvent the sign problem in lattice QCD. This method is tested in a theory, 2-color QCD, which is free from the sign problem. The method gives reliable results, within appropriate ranges of the chemical potential, and a considerable improvement can be achieved if suitable functions are used to interpolate data with imaginary chemical potential. The analytic continuation of the (pseudo)critical line on the temperature-chemical potential plane itself turns out to be rather problematic and calls for a huge accuracy in the determination of the positions of the critical temperatures for varying chemical potential.

We have studied the Haldane conjecture in the O(3) non-linear sigma model with a theta term in two dimensions. According to the conjecture, the mass gap vanishes when theta equals π. We have shown by analytic continuation to real theta of data obtained from numerical simulation at imaginary theta that the model becomes massless at theta=3.10(5). A modified cluster algorithm has been introduced to simulate the model with imaginary theta. 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.

We are studying in collaboration with O. Borysenko (Kiev) the phase diagram of the 3D U(1) pure gauge theory at finite temperature. It is believed that this system undergoes a confinement/deconfinement phase transition of the BKT type, but, so far, a detailed numerical investigation of this expectation is missing.

A project carried on by R. Falcone in collaboration with M. Teper (Oxford) aims at studying features of the interaction potential between two static color sources in SU(N) pure gauge theories for large N in the confined phase.

The other PhD. student, M. Gravina, is studying in collaboration with O. Philipsen (Muenster) the phase diagram of 4D U(1) gauge theory with fermionic matter at non-zero temperature and density looking for the possible existence of an ultraviolet-stable fixed point.

2.3 FIELD THEORY OF CORRELATED DEVICES

2.3.1 Boundary field theory of SQUID devices

The boundary field theory description of an rf-SQUID and of a two-Josephson junction SQUID has been developed, leading to the construction of the theory at the fixed points of the phase diagram of these devices, as well as to the full classification of its most relevant deformations in terms of conformal primary fields. These are either given by vertex operators, or by instantons (phase slips) of the plasmon field, depending on whether the system is within the weakly, or the strongly coupled regime. This allowed for describing all the nonperturbative renormalization effects induced by quantum fluctuations of the phase of the superconducting order parameter by means of the two-boundary sine Gordon model and also for investigating the stability of the two regimes by looking at the relevance/irrelevance of the operators describing the boundary interactions.

2.3.2 One-dimensional networks of Josephson junctions

The possibility of using universal properties of a condensed matter system in designing quantum devices with enhanced coherent behavior has been exploited. For this purpose, a field theory model describing Y- shaped superconducting Josephson networks has been constructed and it has been shown that a finite coupling stable infrared fixed point emerges in its phase diagram. It has been proposed that a Y-shaped network operating near the new fixed point may support a two-level quantum system with frustrated entanglement with the environment. The derivation has been performed by using the boundary conformal field theory approach, which allows for a full field-theoretical treatment of the phase slips, describing quantum tunneling between the two degenerate levels.

2.4 TRANSPORT IN MANY-ELECTRON CORRELATED SYSTEMS

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

The behavior of the current across a normal one-dimensional device connected to two superconductors at a finite biasing voltage V is currently studied. In particular, the current research is focused onto the "ac"-Josephson current, and on the normal (quasiparticle)-state dissipative current across a noninteracting system. Furthermore, the analysis will be extended to the interacting case, by employing a pertinent bosonization scheme, accounting for Andreev-like boundary conditions.

2.4.2 Conduction across interferometric rings with the Path Integral formalism

A path integral real time approach has been employed to compute the DC conductance and spin polarization for electrons transported across a ballistic Quantum Ring, in the presence of Rashba spin-orbit interaction. In particular, using a piecewise semiclassical approximation for the particle orbital motion and exactly solving the spin dynamics, it has been possible to account for both Zeeman coupling and spin-orbit interaction at the same time. As a result, it has been possible to study the interplay between Berry phase, Aharonov Casher phase, Zeeman interaction and weak localization corrections in the quantum interference in the conductance. The results appear to be relevant for interpreting recent measurements on interferometric rings.

2.5 PHYSICS OF KAON-NUCLEON INTERACTIONS

During 2007, we defined the project of a review paper on Kaon-Nucleon Physics. This paper will involve Gensini and Violini, who will cover the theoretical aspects, and one experimentalist from Frascati (Petrascu) for the experimental part. Depending on whether certain aspects will be included or not, it is envisaged also the participation of Y. Srivastava. Moreover we started to consider the possibility of a formal presentation of the general problems of this area of Physics in a book, for which the possible team of authors should include Gensini, Srivastava and Violini. For what concerns research, we are still waiting for new data which make a new analysis sensible. Therefore there were no developments about the possibilities of the cooperation in data analysis with experimental groups which was mentioned in a LOI and in a paper submitted to in European Journal of Physics. The latter paper as well as another one, consisting of a presentation in a Conference in Poland, also written in 2006, have been published during 2007.

2.6 NON-LINEAR WAVE EQUATIONS FOR FLUIDS IN POROUS MATERIALS

Developing a previous research by Salusti and Merlani, we studied a system of two fluids in porous rocks. We obtained and determined the numerical solutions of, the non-linear wave equations for the pressure and the concentration of solutes in porous materials saturated with a fluid. The paper has been submitted for publication. We have received the comments of the referee and are working on them.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2007

1. V.S. Fadin, R. Fiore, A. Papa,
   On the coordinate representation of NLO BFKL,
   Nucl. Phys. B769 (2007) 108.

2. V.S. Fadin, R. Fiore, A. Papa,
   The Dipole form of the quark part of the BFKL kernel,
   Phys. Lett. B647 (2007) 179.

3. V.S. Fadin, R. Fiore, A.V. Grabovsky, A. Papa,
   The Dipole form of the gluon part of the BFKL kernel,
   Nucl. Phys. B784 (2007) 49.

4. D.Yu. Ivanov, A. Papa,
   Electroproduction of two light vector mesons in next-to-leading BFKL: Study of systematic effects,
   Eur. Phys. J. C49 (2007) 947.

5. M. Capua, S. Fazio, R. Fiore, L.L. Jenkovszky, F. Paccanoni,
   A Deeply Virtual Compton Scattering Amplitude,
   Phys. Lett. B645 (2007) 161.

6. R. Fiore, L.L. Jenkovszky, V.K. Magas, F. Paccanoni, A. Prokudin,
   J/Psi photoproduction in a dual model,
   Phys. Rev. D75 (2007) 116005.

7. R. Fiore, V.R. Zoller,
   Color dipoles, PCAC and Adler's theorem,
   JETP Lett. 85 (2007) 309.

8. R. Falcone, R. Fiore, M. Gravina, A. Papa,
   The Spectrum of massive excitations of 3-D 3-state Potts model and universality,
   Nucl. Phys. B767 (2007) 385.

9. R. Falcone, R. Fiore, M. Gravina, A. Papa,
   Screening masses in the SU(3) pure gauge theory and universality,
   Nucl. Phys. B785 (2007) 19.

10. P. Cea, L. Cosmai, M. D'Elia, A. Papa,
    Analytic *continuation from imaginary to real chemical potential in two-color QCD*,
    JHEP 0702 (2007) 066.

11. D. Giuliano. P. Sodano,
    Boundary Field Theory approach to the Renormalization of SQUID devices,
    Nucl. Phys. B 770 (2007) 332-370.

12. P. Lucignano, D. Giuliano, A. Tagliacozzo,
    Quantum Rings with Rashba spin orbit coupling: a path integral approach,
    Phys. Rev. B 76, 045324 (2007).

13. F. Ambrosino, G. Violini et al.,

Prospects for e+e- physics at Frascati between the phi and the psi,
Eur. Phys. J. C 50 (2007) 729.

14. P.M. Gensini, R. Hurtado, Y.N. Srivastava, G. Violini,
Is the Pentaquark the only Justification for Research on KN Physics?,
Acta Physica Polonica B 38 (2007) 2911.

A.1.2 Publications on international journals accepted in 2007

1. V.S. Fadin, R. Fiore,
The dipole form of the BFKL kernel in supersymmetric Yang-Mills theories,
to appear on Phys. Lett. B

2. F. Caporale, A. Papa, A. Sabio Vera,
Collinear improvement of the BFKL kernel in the electroproduction of two light vector mesons,
to appear on Eur. Phys. J. C.

3. P. Cea, L. Cosmai, M. D'Elia, A. Papa,
The critical line from imaginary to real baryonic chemical potentials in two-color QCD,
to appear on Phys. Rev. D.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS
B.1 Publications on international conference proceedings in 2007

1. D.Yu. Ivanov, A. Papa,
Vector Meson production from NLL BFKL,
talk given by D.Yu. Ivanov at 15th International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2007), Munich, Germany, 16-20 Apr 2007, published in *Munich 2007, Deep-inelastic scattering* 719-722.

2. R. Falcone, R. Fiore, M. Gravina, A. Papa,
Screening masses in the SU(3) pure gauge theory and universality,
presented by R. Falcone at 25th International Symposium on Lattice Field Theory, Regensburg, Germany, 30 Jul - 4 Aug 2007,
PoS(LATTICE 2007)183.

3. R. Falcone, R. Fiore, M. Gravina, A. Papa,
Universality and massive excitations in 3d 3-state Potts model,
presented by M. Gravina at 25th International Symposium on Lattice Field Theory, Regensburg, Germany, 30 Jul - 4 Aug 2007,
PoS(LATTICE 2007)187.

4. P. Cea, L. Cosmai, M. D'Elia, A. Papa,
Analytic continuation of the critical line in 2-color QCD at nonzero temperature and density,
presented by A. Papa at 25th International Symposium on Lattice Field Theory, Regensburg, Germany, 30 Jul - 4 Aug 2007,
PoS(LATTICE 2007)214.

5. B. Alles, A. Papa,
Numerical study of the mass spectrum in the 2D O(3) sigma model with a theta term,
presented by B. Alles at 25th International Symposium on Lattice Field Theory, Regensburg, Germany, 30 Jul - 4 Aug 2007,
PoS(LATTICE 2007)287.

C PRESENTATIONS AT SCHOOLS AND CONFERENCES

C.1 Presentations at international schools and conferences in 2007

1. A. Papa,
   NLO BFKL at work: the electroproduction of two light vector mesons,
   2-hour lecture given at the "School of QCD, Low-x, Saturation and Diffraction", Copanello (Italy), July 1-14, 2007.

2. F. Caporale, A. Papa, A. Sabio Vera,
   Collinear improvement of the BFKL kernel applied to light vector meson electroproduction,
   talk given by F. Caporale at the "School of QCD, Low-x, Saturation and Diffraction", Copanello (Italy), July 1-14, 2007.

3. D. Giuliano,
   Boundary Field Theory of SQUID devices,
   lecture given at the conference "Problemi Attuali di Fisica Teorica,
   Vietri S. M., Italy, March 2007.

4. D. Giuliano,
   Boundary Field Theory of Superconducting Devices,
   lecture given at the conference "Statistical Field Theory of Quantum Devices",
   Perugia, Italy, July 2007.

3. EXPERIMENTAL PARTICLE PHYSICS

The 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 by means of deep inelastic scattering at electron-proton accelerator HERA of DESY laboratory (Hamburg, Germany) with the experiment ZEUS.
3. Study of proton-proton interactions at LHC accelerator of CERN laboratory (Geneva, Switzerland) with the experiment ATLAS.

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 of about 450 physicists running a large particle detector at the electron-proton collider HERA at the DESY laboratory in Hamburg. Thus 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 HERA 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 Cosenza HEP group 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). Furthermore the Cosenza researchers participate, since 1991 when the detector start to operate, the data taking as well as the physics analysis.

In 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.

At the maximum beam energies the centre of mass energy is $(4 \cdot E_e \cdot E_p)^{1/2} \cong 314\text{GeV}$, much larger than previously achieved in such collisions, and the exploring distance scale 10^{-18}m of the proton structure can be reached. 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 electron-quark collider.

The very high energies offered by HERA permit one to probe deep inside the proton in order to study the structure of its constituents, the quarks and gluons. Following Heisenberg's uncertainty relation a measure for the smallest size Δ of resolved objects is the transverse momentum kick Q which the electron impacts to the proton, $\Delta \sim h/Q$ (h Plank constant). Q^2 values as high as 40000 GeV^2 can be reached at HERA corresponding to Δ= 10E-16 cm 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.

During this last year there are new ZEUS results on measurement of K0(S), Lambda, anti-Lambda, measurement of D*± meson production in e± p scattering at low Q^2 and exclusive ρ^0 production in deep inelastic scattering and other results are in progress: the combination of the ZEUS and H1 inclusive results (coord. E. Tassi); the studies on Deeply Virtual

Compton Scattering in diffraction, the measurement of the longitudinal component of the diffractive structure function and the future application of diffraction at LHC (M. Capua).

The Italian members of the Collaboration, with G. Susinno as group leader, are participating to the PRIN07 program. 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.

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

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

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 ranges in a wide interval of values from the mass-less gauge bosons to the top quark M_t=100 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: the whole of space is permeated by an undetectable field, similar in some ways to the electromagnetic field. 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, sometimes called the **God particle,** itself has a characteristic rest-mass. The best estimate value for this mass is 117GeV, with a theoretical 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 as yet inconclusive. It is expected that LHC, the multi-TeV p-p collider currently under construction at CERN, will be able to confirm or disprove the existence of the God particle. LHC will provide 10 times higher centre of mass energy and 100 times higher p-p collision rates than previous colliders. This opens up a new frontier of physics and ATLAS detector will explore this great potential.

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

2. a **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.

3. a **calorimeter** with an inner cylinder in highly granular liquid argon technology with Pb absorber, followed at large radius by an iron-scintillator calorimeter providing good resolution in a very cost-effective manner.
4. a 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 Cosenza HEP group are 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 undergraduates and doctorates student in the process.
During this year the Cosenza group has participated to many ATLAS activities:

installation and commissioning of BIL chambers at CERN;

ATLAS MDT aging studies at the neutron and gamma facility of ENEA Research Centre at Rome;

Design and development of **GNAM**, a low level data acquisition software for the ATLAS sub-detector online monitoring . The Cosenza group has partecipated and is currently responsible for GNAM, a C++ software that was developed 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

Monte Carlo simulation of muon spectrometer performances with GEANT 4.

study of the **rare semileptonic** decays of the B meson.
Semileptonic rare decays of beauty quark are an important test of the **Standard Model** and and a indirect way to search of **new physics beyond** the Standard Model**.** New analysis algorithms have been developed for the selection of rare decays in two muons, over the enormous combinatorial background level. It has been demonstrated the possibility of study such decay channels efficiently in ATLAS during the first run at low luminosity.

search for the Standard Model Higgs 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 Cosenza 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 multivariated 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.

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 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, fem, event by event.
Once the effects of the dominant source of fluctuations, *i.e.*, fluctuations in the e.m. energy fraction fem, 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 Cosenza 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.

A PUBLICATIONS ON REVIEW

A.1 Publications on international review

A.1.1 Publications on international review published on 2007

1. P. Branchini, S. Di Luise, E. Graziani, C. Mazzotta, E. Meoni, G. Morello, A. Passeri, F. Petrucci, A. Policicchio, D. Salvatore and M. Schioppa,
ATLAS MDT chamber behaviour after neutron irradiation and in a high rate background
Nucl. Instrum. Meth. A581:171-174, 2007.

2. P. Branchini, S. Di Luise, E. Graziani, A. Passeri, F. Petrucci, C. Mazzotta, E. Meoni, G. Morello, A. Policicchio, D. Salvatore, M. Schioppa,
Intensive irradiation study on Monitored Drift Tubes Chambers
IEEE Trans.Nucl.Sci.54:648-653,2007.

2. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Exclusive rho0 production in deep inelastic scattering at HERA
PMC Phys. A1:6, 2007.

3. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Dijet production in diffractive deep inelastic scattering at HERA
Eur. Phys. J. C52:813-832, 2007.

4. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Forward-jet production in deep inelastic ep scattering at HERA
Eur. Phys. J. C52:515-530, 2007.

5. C. Adorisio, G. Avolio, V. Romano, M. Schioppa, P. Turco (Calabria U. & INFN, Cosenza) , R. Caloi, G. De Zorzi, F. Lacava (Rome U. & INFN, Rome)
A non-invasive technique to replace the anode wires into the drift tube chambers of the muon spectrometer of the ATLAS experiment at the LHC proton proton collider
Nucl. Instrum. Meth. A575:532-538, 2007.

6. E. Meoni et al.
Gamma and neutron massive irradiation tests of the ATLAS MDT chambers
Nucl. Instrum. Meth. A572:187-188, 2007.

7. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
High-E(T) dijet photoproduction at HERA
Phys. Rev. D76:072011, 2007.

8. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Bose-Einstein Correlations of Charged and Neutral Kaons in Deep Inelastic Scattering at HERA
Phys. Lett. B652:1-12, 2007.

9. P. Branchini, S. Di Luise, E. Graziani, C. Mazzotta, E. Meoni, G. Morello, A. Passeri, F. Petrucci, A. Policicchio, D. Salvatore, M. Schioppa,
Neutron irradiation test on ATLAS MDT chambers
Nucl. Instrum. Meth. A574:57-64, 2007.

9. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Multijet production at low x(Bj) in deep inelastic scattering at HERA.
Nucl. Phys. B786:152-180, 2007.

10. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Measurement of D mesons production in deep inelastic scattering at HERA
JHEP 0707:074, 2007.

11. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Diffractive photoproduction of D+-(2010) at HERA*
Eur. Phys. J. C51:301-315, 2007.

12. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Measurement of D+- meson production in e+- p scattering at low Q**2*
Phys. Lett. B649:111-121, 2007.

13. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Leading neutron energy and pT distributions in deep inelastic scattering and photoproduction at HERA
Nucl. Phys. B776:1-37, 2007.

14. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Measurement of K0(S), Lambda, anti-Lambda production at HERA
Eur. Phys. J. C51:1-23, 2007.

15. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Measurement of open beauty production at HERA in the D muon final state*
Eur. Phys. J. C50:299-314, 2007.

16. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Measurement of azimuthal asymmetries in neutral current deep inelastic scattering at HERA
Eur. Phys. J. C51:289-299, 2007.

17. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Inclusive-jet and dijet cross-sections in deep inelastic scattering at HERA
Nucl. Phys. B765:1-30, 2007.

18. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Measurement of prompt photons with associated jets in photoproduction at HERA
Eur. Phys. J. C49:511-522, 2007.

19. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Measurement of neutral current cross sections at high Bjorken-x with the ZEUS detector at HERA
Eur. Phys. J. C49:523-544, 2007.

20. M. Capua, S. Fazio, A. Mastroberardino, M. Schioppa, G. Susinno, E. Tassi and ZEUS Collaboration
Event shapes in deep inelastic scattering at HERA
Nucl. Phys. B767:1-28, 2007.

21. W. Vandelli et al.
Strategies and tools for ATLAS online monitoring
IEEE Trans. Nucl. Sci. 54:609-615, 2007.

24. L. La Rotonda & NOMAD Collaboration
Search for the exotic Theta+ resonance in the NOMAD experiment
Eur. Phys. J. C49:499-510, 2007.

25. L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno & DREAM Collaboration

Measurement of the Contribution of Neutrons to Hadron Calorimeter Signals
Nucl. Instrum. Meth. A581:643-650, 2007.

26. L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno & DREAM Collaboration
Contributions of Cherenkov Light to the Signals from Lead Tungstate Crystals
Nucl. Instrum. Meth. A582:474-483, 2007.

A.1.2 Publications on international journals accepted in 2007

1. L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno & DREAM Collaboration
Dual-Readout Calorimetry with Lead Tungstate Crystals
to appear on Nucl. Instrum. Meth. A.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2007

1. D. Salvatore et al.,
Neutron intensive irradiation test on ATLAS MDT chambers at TAPIRO nuclear reactor
Nucl. Phys. Proc. Suppl. 172:183-186, 2007.

2. D. Salvatore et al.
The GNAM system in the ATLAS online monitoring framework
Nucl. Phys. Proc. Suppl. 172:317-320, 2007.

3. D. Salvatore et al.
The ATLAS Data Acquisition and Trigger: Concept, design and status
Nucl. Phys. Proc. Suppl. 172:178-182, 2007.

4. A. Policicchio and G. Crosetti,
Rare semileptonic beauty decays in ATLAS", Prepared for Physics at LHC
Cracow, Poland (2006); Acta Phys. Polon. B38, 947 (2007).

PRESENTATIONS AT SCHOOLS AND CONFERENCES

C.1 Presentations at international schools and conferences in 2007

1. A. Policicchio and G. Crosetti,
Study of DiMuon Rare Beauty Decays with ATLAS and CMS,
Prepared for 15th International Conference on Supersymmetry and the Unifcation of Fundamental Interactions
SUSY07, Karlsruhe, Germany (2007), arXiv:0710.1206 [hep-ex].

4. SURFACE ELECTRON SPECTROSCOPY GROUP (SPES)

Professors and Researchers	Elio Colavita *(Group Leader)* Raffaele G. Agostino Gennaro Chiarello Vincenzo Formoso Tommaso Caruso
Postdoc fellows	Enrico Maccallini
PhD students	Alfonso Policicchio Antonio Politano Georgios Kalantzopoulos
Technicians	Salvatore Abate Giovanni Desiderio Vito Fabio Eugenio Li Preti
Collaborators	P. Milani *(University of Milano, Italy)* P. Rudolf *(Material Science Center, University of Groningen, The Netherlands)* A. Goldoni *(Elettra, Trieste, Italy)* S. La Rosa *(Elettra, Trieste, Italy)* S. Scalese *(CNR, Catalina, Italy)* D. Gournis *(University of Ioannina, Greece)* G. Froudakis *(University of Crete, Greece)* P. Trikalitis *(University of Crete, Greece)* F. Alamgir *(Georgia Institute of Technology, Atlanta, USA)* Innova –Technology solutions *(Chieti, Cosenza – Italy)*

Research subjects:
1) Chemisorption on metal surfaces and their electronic properties;
2) Spectroscopic and morphological studies on carbon- and metal-oxide nanostrucures;
3) New materials for enhanced hydrogen adsorption: structural (EF-TEM and SEM) and thermodynamical (PcT) characterizations.
4) Selective transport across membranes studied by high resolution microscopies.

Introduction

The long-established scientific research activity of the SPES group in the field of the spectroscopic characterization of the physico-chemical properties of the surfaces has been gradually implemented by new actions in the applied physics field by means of energy resolved Electron Microscopy and Volumetric Adsorption apparata.

The “traditional” work on high resolution spectroscopic investigation of surface electronic states was dedicated to depict both the water interaction with Na quantum well states on Cu(111) and the CO-Na coadsorption on Ni(111). As a major result, we identified the arising of a Mie resonance on the Na/Cu(111) surface. Concerning the effect of the CO and Na coadsorption on Ni(111), we shown that the former affects the vibrational properties of Na adatoms.

A series spectroscopic studies, involving also the use of synchrotron radiation facilities, were carried out on Carbon and metal-oxide nanostructured material grown by a pulsed supersonic cluster beam deposition method. In particular, we observed the presence on the ns-TiO_2 surface of a certain amount of Ti 3d defect states in the band gap. 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 nanocomposites 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.

The "new" activities of the SPES group concern the study of new materials for hydrogen storage. This was performed in collaboration with both academic and industrial partners (University of Ioannina and Crete (Greece) and the INNOVA company). The hydrogen storage capacity of different porous material designed in the University of Crete and synthesised in the University of Ioannina and Crete was tested.

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

The last activity, but not least, is the academic research Spin-off enterprise of the SPES Group (DeltaE s.r.l.) dealing with advanced instrumentation production (http://www.deltae.it/principale.htm).

4.1 CHEMISORPTION ON METAL SURFACES AND THEIR ELECTRONIC PROPERTIES

4.1.1 Water interaction with Na quantum well states

Collective electronic excitations occurring in Na layers grown on Cu (111) and in H_2O/Na/Cu(111) have been investigated at room temperature by high resolution electron energy loss spectroscopy.
Loss spectra taken for a coverage between 0.55 and 0.70 monlayers of Na are characterized by a feature at 3.0 eV assigned to a Mie resonance. A further increase in the Na coverage leads to the appearance of the Na surface plasmon at 3.9 eV. Water molecules dissociate on Na layers as shown by the appearance of the OH–Na vibration. Upon water adsorption, relevant effects on both electronic excitations and vibrational modes were observed as a function of Na coverage (Ref. 1 and 2).

4.1.2 Alkali coadsorption with CO

The coadsorption of NaCO on Ni(111) has been investigated using high-resolution electron energy loss spectroscopy. Loss measurements showed that coadsorbed CO molecules dramatically affect the vibrational properties of Na adatoms. The Na-Ni vibration energy at 22 meV measured on the Na-Ni system shifted down to 12 meV for the CO-NaNi surface. This result was ascribed to a charge transfer from Na to CO. On the contrary, no appreciable shift of the Na-Ni stretching frequency was observed for the coadsorption of Na with oxygen (Ref. 3).

4.2 SPECTROSCOPIC AND MORPHOLOGICAL STUDIES ON CARBON- AND METAL-OXIDE NANOSTRUCURES

4.2.1 Photoemission investigation on nanostructured TiO_2 growth by cluster assembling

Nanostructured titanium dioxide (ns-TiO_2) films were grown by a pulsed supersonic cluster beam deposition method in collaboration with the Prof. Milani group at the Physics Department of the Univesity of Milano. Transmission electron microscopy demonstrates that films are mainly composed by TiO_2 nanocrystals embedded in an amorphous TiO_2 phase while their electronic structure was studied by photoemission spectroscopy. The cluster assembled ns-TiO_2 films are expected to exhibit several structural and chemical defects owing to the large surface to volume ratio of the deposited clusters. Indeed ultraviolet photoemission spectra (hv = 95.0 eV) from the valence band unveil the presence of a restrained amount of surface Ti 3d defect states in the band gap. The Ti local electronic structure was then studied by performing valence band resonant photoemission 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 the surface defects and the fully oxygen coordinated Ti atoms and the evolution following thermal treatments and water exposures (Ref.4).

4.2.2 Electrical and spectroscopical characterization of carbon/titania nanocomposites

We have investigated the electrical transport properties of nanostructured carbon and carbon/titanium oxide nanocomposite films produced by supersonic cluster beam deposition and irradiated by highly focused vacuum UV photon beam.

Transmission electron microscopy demonstrates that films are composed by titania nanoparticles embedded in an amorphous nanostructured carbon matrix. The electronic structure was studied by ultraviolet photoemission spectroscopy (hv=95 eV) at the Spectromicroscopy beamline of the Elettra synchrotron light source.
Irradiation with the ultraviolet beam (95 eV), focused on a micrometer spot, modifies the film electronic structure. We observe in fact a relevant increase of the photoemission intensity at the Fermi level, suggesting that the films acquire a "metallic" character. The effect was explained with the formation of defects (i.e. dangling bonds) in the carbon matrix and titania nanoparticles following the UV irradiation.
An electrical characterization of the irradiated films was accomplished by "writing" with the UV beam stripes on films deposited between gold contacts.
The increment of the conductivity is of four orders of magnitude for pure nanostructured carbon films and at least eight orders of magnitude for films containing 9 at. % of titanium. A partial reversibility of the process is observed by exposing the modified films to molecular oxygen or directly to air. We demonstrate the capability of writing micrometric conductive strips 2–3 microns width and 60 microns length and controlling the variation of the conductivity as a function of the titanium concentration (Ref.5).
New activities are under development on the optical, electronic, vibrational and structural properties of extended interfaces between nanostructured carbon and water. This investigation was supported by the PRIN national fund under a 2-year project coordinated by Prof. Milani.

4.2.3 Electronic and structural characterization of carbon nanotubes

The electronic and chemical structure of Carbon Nanotubes synthesized by decomposition of acetylene over Fe-Co bimetallic catalysts in different growth conditions, were analyzed by valence band photoelectron spectroscopy and scanning electron microscopy. A clear relationship between the bonding features and the growth condition allowed us to determine the key parameters in terms of temperature, growth time and catalyst content. Furthermore, the analysis allowed a determination of the byproducts (Ref.6).

4.3 NEW MATERIALS FOR ENHANCED HYDROGEN ADSORPTION: STRUCTURAL (EF-TEM AND SEM) AND THERMODYNAMICAL (PCT) CHARACTERIZATION.

4.3.1 New nanostructured materials for hydrogen storage

The SPES group has been involved in 2007 in collaborations with academic and industrial partnerships of the Universities of Ioannina and Crete (Greece) and the company INNOVA(Italy). This collaboration concerns the hydrogen storage capacity of different porous materials designed and synthesised in the University of Ioannina and Crete. Their structure and chemical composition was sampled by Energy Filtered-TEM, variable pressure-SEM and XRD measurements. The local and long range order structure of the materials under investigation (organisilicates of the MCM-41 class) show a hexagonal or cubic symmetry of the nanometer-sized pores whose specific surface areas are on the 1000 m^2/g range.

A new experimental system, a volumetric isothermal adsorption apparatus (fPcT 80), has been also developed in collaboration with the DeltaE srl spin-off company (http://www.deltae.it/principale.htm) in order to obtain the hydrogen adsorption capacity of the samples up to 80 bar and temperatures ranging between 77K and 500K. The design of the fPcT 80 apparatus together with the data acquisition and analysis software allowed the overcoming of several errors affecting the gas adsorption measurements at high pressures and low temperatures were the "ideal gas" description is not correct. The layout of the developed fPcT 80 system and the measurements obtained with it are discussed in articles submitted to international peer reviewed journals.

4.4 SELECTIVE TRANSPORT ACROSS MEMBRANES STUDIED BY HIGH RESOLUTION MICROSCOPIES

4.4.1 Electron microscopy studies of biological membranes by high resolution microscopies

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.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2007

1. Politano A. , Agostino R. G. , Colavita E. , Formoso V. , Chiarello G. ,
   High resolution energy loss measurements of Na/Cu(111) and H_2O/Na/Cu(111): Dependence of water reactivity as a function of Na coverage,
   Journal of Chemical Physics, Vol. 126, n. 24 (2007) pp. 244712-1-244712-5.

2. Politano A. , Agostino R. G. , Colavita E. , Formoso V. , Chiarello G.,
   Electronic properties of self-assembled quantum dots of sodium on Cu (111) and their interaction with water
   Surface Science, Vol. 601, n. 13 (2007) pp. 2656-2659.

3. Politano A. , Formoso V. , Agostino R. G. , Colavita E. , Chiarello G. ,
   Influence of CO adsorption on the alkali-substrate bond studied by high-resolution electron energy loss spectroscopy.
   Physical Review B, Vol. 76, n. 23 (2007) pp. 23340-23340.

4. Caruso T., Lenardi C., Mazza T., Policicchio A., Bongiorno G., Agostino R.G., Chiarello G., Colavita E., Finetti P., Prince K.C., Ducati C., Piseri P., Milani P.,
   Photoemission investigation on nanostructured TiO2 growth by cluster assembling,
   Surface Science, Vol. 601, n. 13 (2007) 2688-2691.

5. M. Amati, C. Lenardi, G. Bongiorno, V.Cassina, P. Podestà, L. Ravagnan, R. G. Agostino, T. Caruso, C. Ducati, P. Piseri, S. La Rosa, and P. Milani,
   Electrical conductivity of cluster-assembled carbon/titania nanocomposite films irradiated by highly focused vacuum ultraviolet photon beams,
   Journal of Applied Physics 101 (2007) 064314.

6. A.Policicchio, T. Caruso, G. Chiarello, E. Colavita, V. Formoso, R.G. Agostino, T. Tsoufis, D. Gournis, S. La Rosa,
   Electronic, chemical and structural characterization of CNTs grown by acetylene decomposition over MgO supported Fe-Co bimetallic catalysts.
   Surface Science 601 (2007) 2823-2827.

7. Chiarello, G., Formoso, V., Infusino, E., Marino, A., Agostino, R.G., Colavita, E.
   Effects of predosed oxygen and hydrogen on CO adsorption on Ni(1 0 0)
   Surface Science 601 (2007) 104-111.

8. G. Tamma, G. Procino, A. Strafino, E. Bononi, G. Meyer, M. Paulmichl, V. Formoso, M. Svelto, and G. Valenti
   Hypotonicity Induces Aquaporin-2 Internalization and Cytosol-to-Membrane Translocation of ICln in Renal Cells
   Endocrinology, March 2007, 148(3):1118–1130

A.1.2 Publications on international journals accepted in 2007

1. 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, in press.

2. 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, in press.

3. 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, in press.

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, in press.

5. Politano A. , Agostino R. G. , Formoso V. , Chiarello G. ,
Short-range interactions in Na coadsorption with CO and O on Ni(111),
ChemPhysChem, in press.

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

7. 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, in press.

8. Politano A. , Formoso V. , Chiarello G.,
Temperature effects on alkali-promoted CO dissociation on Ni(111),
Surface Science, in press.

9. Politano A. , Formoso V. , Chiarello G.,
Alkali adsorption on Ni(111) and their coadsorption with CO and O,
Applied Surface Science, in press.

10. Maccallini E., Kalantzopoulos G., Tsoufis T., Agostino R.G., Chiarello G., Formoso V., Caruso T., Policicchio A., Gournis D. and Colavita E., Metallic tin-filling effects on Carbon *Nanotubes revealed by atomically resolved spectro-microscopies,*
Journal of NanoResearch, in press.

11. T.Caruso, C.Lenardi, R.G.Agostino, M.Amati, G.Bongiorno, T.Mazza, A.Policicchio, V.Formoso, E.Maccallini, E.Colavita, G.Chiarello, P.Finetti, F.Sutara, T.Skála, P.Piseri, K.C.Prince, P.Milani
Electronic structure of cluster assembled nanostructured Ti O2 by resonant photoemission at the Ti L2,3 edge
Journal of Chemical Physics, in press.

12. 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 Series, in press.

D PRESENTATIONS AT CONFERENCES

D.1 Presentations at international conferences in 2007

1. Politano A., Agostino R.G, Colavita E., Formoso V., Tenuta L., Chiarello G.,
Vibrational measurements of Na/Ni(111) and Na+CO/Ni(111),
Oral presentation. Nanosmat- International Conference on Surfaces, Coatings and Nanostructured Materials, Algarve (Portugal), 09-11 July 2007.

2. Politano A., Agostino R.G, Colavita E., Formoso V., Chiarello G.,
Collective excitations in nanoscale thin alkali films: Na/Cu(111)
Nanosmat- International Conference on Surfaces, Coatings and Nanostructured Materials, Algarve (Portugal), 09-11 July 2007.

3. R.Gengler, D.Gournis, E.Maccallinic ,P.Rudolf.
   Langmuir Blodgett films composed of alternating 2D networks of different photomagnetic materials
   Belgian Physical Society meeting 2007, University of Antwerpen, Belgium, 20/5/2007, poster contribution.

4. E.J.M. Vertelman, P. J. van Koningsbruggen, A. Meetsma, R. Gengler, F. Lusitani, E. Maccalini, P. Rudolf, T.T.A. Lummen, A. Pugszly, P.H.M. van Loosdrecht, J. Luzon and R. Broer
   Synthesis of the Ferromagnetic-Paramagnetic Switch RbxMn[Fe(CN)6]y.zH2O
   E-MRS meeting, Strasbourg, 28/5/2007-1/6/2007, poster contribution.

5. Maccallini E. , Kalantzopoulos G. , Agostino R. G. , Chiarello G. , Formoso V. , Caruso T. , Policicchio A. , Gournis D. , Tsoufis T. , Colavita E.
   Metallic Tin-filling Effects on Carbon Nanotubes Revealed by Atomically Resolved Spectro-microscopies.
   Nanosmat 2007 - International Conference on Surfaces, Coatings and Nanostructured Materials, Algarve, Portugal, 9-11 2007, poster contribution,

6. Policicchio A. , Caruso T. , Agostino R. G. , Maccallini E. , Castriota M.
   Electronic, chemical and structural characterization of CNTs grown by SiC surface decomposition
   IVC17/ICSS13 and ICN+T 2007, Stockholm, Sweden, 2-6 July 2007, poster contribution.

7. Maccallini E**.**, Kalantzopoulos G., Cazzanelli E., Ciuchi F., Matranga A., Caruso T., Policicchio A., Chiarello G., Formoso V., Colavita E., Agostino R.G.,Tsoufis T., Gournis D., Tomou A., Panagiotopoulos I.
   Morphology and structure of anchored carbon nanotubes encapsulating crystalline β-tin nanowires candidates for photovoltaic applications.
   Chemical Nanotechnology Talks VIII, “Energising a Sustainable Future”, 20-21/11/2007, Messe Frankfurt, Germany, poster contribution “

5. SOLID STATE PHYSICS: SURFACES AND NANOMATERIALS

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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 graphene

5.2 Non adiabatic response of a many electron system to a slowly varying, semiclassical perturbation
5.3 Ion formation in sputtering
5.4 Ion induced collective excitations in solids
5.5 Many body excitations in carbon nanotubes
5.6 Quantum coherence and correlation
5.7 Ion interaction with nanostructures
5.8 Ion interaction with solids
5.9 Multimedial education

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; regarding to this topic, 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.

Among the major achievement of this work was the understanding of the effects induced on the electronic and chemical properties of Single Wall Carbon Nanotube bundles by the insertion of electron donor species. We pointed out that different topics can be investigated through alkali metals or nitrogen atoms. Nitrogen implantation has revealed to be a promising technique to achieve significant amounts of substitutional impurities; nitrogen realises a much more effective doping than alkali metals, as small atomic concentrations lead to stronger modifications of electronic properties. 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 properties can be followed up to the saturation limit. Lithium, in particular, has allowed to observe the modifications in the valence band states and van Hove singularities, which are representative features of the one-dimensional nature of nanotubes. These results have revealed the occurrence of cross-links among tubes mediated by Li-C covalent-like bond. Finally, through the analysis of CNTs synthesized by arc-discharge method we have found out the occurrence of Multi Wall CNTs encapsulating carbon linear chains. A Raman temperature-dependent study has allowed to observe for the first time 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.

Although graphene has been used extensively as a basis for the discussion of the electronic structure of carbon nanotubes and other graphitic materials of all dimensionalities, only very recently this model-system turned into reality when free-standing graphene was unexpectedly found four years ago, becoming the subject of intense study. The discovery of graphene has sparked great interest mainly for its peculiar electronic structure in which electrons mimic massless relativistic particles. The technique that allowed the isolation of graphene is based on the micromechanical cleavage of bulk graphite; this method allows to obtain single sheets of graphene with a tipical size of few tens of microns, sufficient for some research purposes but inappropriate for many conventional spectroscopy investigations performed in conventional Ultra High Vacuum (UHV) chambers.

We are currently collaborating with the Department of Physics, University of California –Berkeley (USA)– in the synthesis of graphene and few –layers graphene (FLG) samples, obtained by the micromechanical cleavage technique. We have performed the first photoabsorption experiment in UHV conditions of a free layer of graphene, showing the electronic properties of graphene and FLG samples as probed by Near Edge X-rays Absorption Fine Structure (NEXAFS) in a PhotoEmission Electron Microscope (PEEM). This experiment, which requires an experimental set-up ad hoc, was performed at the SIM beamline of the Swiss Light Source (SLS). Moreover, further investigations on the chemical interaction between graphene samples and some selected gases were planned.

Our interest is also focused in attempting new methods for the synthesis of single-layer graphene. If we think of graphene as an unfolded carbon nanotube, our recent investigations on these one dimensional carbon structures can provide a useful guide in searching for graphene properties and applications.

Currently our team is involved in the epitaxial growth of graphene by chemical vapour deposition of hydrocarbons on metal surfaces, which represents the most promising alternative route to grow graphene sheets. In particular, we are growing graphene layers (are grown) by cracking under vacuum ethylene at high temperature on Ni(111) single crystal surfaces. We plan our experimental investigation in two directions: synthesis of low dimensional carbon materials (one or more "graphene" layers and/or carbon ribbon) and characterization of their electronic properties by means of Electron Energy Loss Spectroscopy (EELS), Angle Resolved Photoemission Spectroscopy (ARPES), Raman microscopy and Scanning Tunnelling Microscopy (STM).

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.
The comprehension of electronic properties of graphene is of a paramount importance from more points of view. Firstly, its electron transport is described by Dirac equation and this allows access to quantum electrodynamics in a simple condensed matter experiment. Secondly, its ballistic transport at room temperature combined with chemical and mechanical stability, makes it a promising candidate for application in nanodevice-like context. Finally, the possibility to investigate its properties experimentally allows to better understand the other carbon allotropes and to resolve controversies.

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

The research activity focused on non adiabatic excitations of a many electron system interacting with a semiclassical probe, i.e., an external potential whose typical time is large on the femtosecond-scale of non radiative, electron-hole recombination processes.

Applications were proposed in the field of atomic collision in solids, with the main motivation that slow ions reflecting from (or within) a solid target provide a unique source for electronic excitations confined just to the surface region, making the related spectroscopies very surface sensitive tools to study solids. Besides, several questions of both fundamental and practical interest are involved, concerning the ionization/neutralization of projectiles, the mechanisms of electron and photon emission, and the characteristics of sputtered particles from the solid. More importantly, the project has opened the way to study the effect of atomic intercalation into nanomaterials, specifically examining the electronic properties of Litihum intercalated, single walled carbon nanotubes.

In general, the interaction of an ion impinging on a target material presents a highly dynamic many-body problem that should take into account the trajectory followed by the projectile, the geometric structure of the target material, the (multi-)electron exchange between target and projectile as well as the accompanying excitation of both collision partners. At present, most models handle the trajectories followed by the projectile classically while they combine both classical and quantum mechanical concepts in the treatment of the electronic ion-target system. The classical treatments of ion trajectories make extensive use of Monte Carlo based simulation codes in which the paths followed by the projectiles are in principle made up of sequences of trajectory-changing binary projectile-target collisions.

The electronic ion-target system is mostly treated in terms of a model Hamiltonian formalizing the interaction between the discrete electronic projectile levels and the valence bands of the material. Electron transfer occurs usually either by one electron processes, such as in resonant electron tunneling, or by two electron Auger-type processes, such as Auger neutralization or Resonant neutralization followed by Auger De-excitations.

5.3 ION FORMATION IN SPUTTERING

In recent years, considerable progress has been achieved in the theoretical description of resonant electron exchanges for which non-perturbation methods have been developed and applied to the description of many-electron atoms on simple metallic surfaces, generally using a jellium model. A vary cumbersome problem is positive/negative ionization of secondary atoms sputtered from solid surfaces, because of the complicated physical and chemical reactions occurring during ejection. We have proposed a generalized time dependent Anderson-Newns Hamiltonian, obtained from first principles, to describe the interaction of secondary Ag^- and Au^- atoms ejected from clean Ag (100) and Au (100) surfaces. Surface effects were explained in terms of quasi-molecular interactions between secondary emitted and their nearest-neighbor substrate atoms that, in the collision cascade generated by the primary ion beam, provide the initial impulse to emitted particles. We used a pseudo-potential to describe surface, which takes into account the effect of a projected band gap in the metal band structure. Besides, we modeled the motion of ejected atoms with simple analytical trajectories. We developed a parameter-free theory whose numerical solution produced excellent agreement with the studied experiments (P.A.W. van Der Heide, Nucl. Instr. and Meth. B 157 (1999) 126).

5.4 ION INDUCED COLLECTIVE EXCITATIONS IN SOLIDS

Another active and alive field is secondary electron emission from positive atomic ion impacts, because of the huge number of applications to solid, clusters and biomolecules and water. From a theoretical point of view, the ejection of an electron from a solid can be described by the following three mechanisms: excitation of the electron, transport of the

excited electron to the surface, and finally, emission from the surface. The minimum energy which a bound electron must gain in order to be emitted from a conductor equals the excitation energy to the conduction band of the solid, plus the energy which is needed to overcome the work function of the target-vacuum interface. However, if the electron is excited at some depth below the surface, it may lose energy during the transport to the surface. This means that an initial energy even higher than the minimum energy is required to transport electrons from the depth of the solid to outside the surface. Particle-induced secondary electron emission is normally divided into two different mechanisms, in which either the translational kinetic energy or the internal potential energy of the incident projectile is transferred to a target electron. The requirement for potential electron emission from a conductor is that energy which is released when an incident ion is either neutralized, or else relaxes to a lower excited state, is larger than twice the work function of the surface. Potential emission occurs for most multiply-charged atomic ions, but only for a few singly-charged atomic ions such as ions of hydrogen and noble gases. Kinetic electron emission can occur when kinetic energy from the incident particle is transferred to target electrons. The detailed mechanism for kinetic emission is not well understood, which is reflected in poor predictions of the threshold velocity below which kinetic emission should not be observed. On the other hand, potential electron emission has been long discussed in terms of two-electron, Auger type processes, such as Auger neutralization and resonant neutralization followed by interatomic Auger de-excitation.

In Auger Neutralization, the electrostatic repulsion between two target electrons leads to one of the electrons tunneling to neutralize the incoming ion, and the other being excited. Recent experimental studies have shown that the energy released by ion neutralization at metal targets can also produce collective excitations in the conduction band, such as surface plasmons (P. Riccardi et Al, Phys. Rev. Lett. 84, 378 (2000)), whose decay occurs predominantly by excitation of a single conduction electron. Although some models have been proposed to describe the creation of Plasmon excitations, a theory of these processes is still lacking as well as with theoretical results to be compared with experimental data.

We have found another collective excitation (A. Sindona et Al., Phys. Rev. A 71, 52903 (2005)) due to the sudden change of charge of the projectile, which leads to a rearrangement of the ground state of conduction electrons on a long time-scale; this final-state effect parallels the sudden creation of a core hole by absorption of a soft x-ray photon~(G.D. Mahan, Phys. Rev. 163, 612 (1967); P. Nozieres and C.T. De Dominicis, Phys. Rev. 178, 1097 (1969)), known as Fermi edge singularity, and reflects in the broadening of the kinetic energy distributions of ejected electrons, for a given incident ion velocity. We have included the effect of a projected band gap in the metal band structure of the target material and we have applied the model to Auger electron emission induced by slow Ar+ ions at polycrystalline Al surfaces, at varying incident energy and angles.

5.5 MANY BODY EXCITATIONS IN CARBON NANOTUBES

We have developed a model to describe the asymmetric features of x-ray photoemission spectra from bundles of clean and Li-intercalated single-walled carbon nanotubes (SWCN)sdue to shake up processes in both metallic and semiconducting bands, with energy gaps below 1 eV. Using the tight binding method, we have determined the effect of the suddenly created core hole- in the 1s-state of a carbon atom- on the many electron states of □ and □* bands. We have computed the energy distributions of many body excitations created at the expense of the photoelectron energy in (10, 10) and (16, 0) tubes, thus, obtaining an merit function for the x-ray photo-peak, resulting from the superposition of a symmetric and an asymmetric components. The latter describes to the average behavior of shake up electrons in tubes of different chirality and changes with the concentration of dopants. Further Development have concerned the role of shake up processes in kinetic energy distributions of KVV electrons ejected from bundles of clean SWCNs.

5.6 QUANTUM COHERENCE AND CORRELATION

A further research line of the group is the theoretical investigation of the role of quantum correlations (entanglement) in many body systems. Both solid state and atom-optical systems have been studied in this respect, with particular attention to 1) collective quantum behaviour displayed by coherent mesoscopic systems and to 2) the presence of criticality (that is, quantum phase transitions) in strongly correlated magnetic and optical systems.

5.6.1 Quantum correlations and entanglement in many-body systems

We discuss the ground state entanglement of the degenerate two mode Jahn-Teller model in the presence of a strong transverse magnetic field as a function of the vibronic coupling strength. A complete characterization has been obtained of the phenomenon of entanglement sharing in a system composed by a qubit coupled to two bosonic modes. Using the residual I-tangle, we found that three-partite entanglement is significantly present in the system in the parameter region near the bifurcation point of the corresponding classical model.

5.6.2 Quantum communication in spin systems

We described a spin 1/2 chain (or qubit register) with always-on exchange interaction (XX model in transverse field) in the presence of spatial inhomogeneities of the external magnetic field. Similarly to the phenomenon of Anderson localization, we found that this system has a localized eigenstate which can be used to store or trap quantum information. We characterized the fidelity of storage and the leakage of information from this storing site. Moreover, we found that entanglement localizes at the defect and obtained its localization length. We have also shown how the control of the local effective magnetic field allows to manipulate the static and dynamical properties of entanglement. In particular, the propagation of quantum correlations can be driven to a great extent so as to achieve an entanglement transfer on demand toward a selected site.

5.7 ION INTERACTION WITH NANOSTRUCTURES

The research on carbon nanotubes (CNTs) is in a developing stage with encouraging results on both single wall carbon nanotube, SWNT and multi walled carbon nanotube, MWNT.

Cathodo-luminescence (CL) has been applied to several samples obtaining luminescence spectra by electron bombardment on bundles of pristine single walled (SWCNT) and multi walled carbon nanotubes (MWCNT). The spectra show several common peaks at 1.76, 1.94, 2.06, and 2.22 eV which disappear after heating the samples up to 1300 K. it has been shown that these transitions are extrinsic to nanotubes and originate from nickel oxide impurities, residual catalyst material used in the growth processes, such conclusions are also confirmed by X-ray photoelectron spectroscopy (XPS) and energy dispersed X-ray analysis measurements.

Preliminary studies have been performed on luminescence emission from bundles of multiwalled carbon nanotube (MWCNT) induced either by heating (thermo-luminescence, TL) or by ion bombardment of (iono-luminescence, IL) the sample. For N2 exposure we do not observe any evidence of N2 absorption on the sample. For 2 keV Nþ2 ion bombardment or Na vapour deposition or Na+ ion implantation, IL spectra show a continuous decrease of luminescence intensity. These results are interpreted as due to an increasing sample doping. Moreover an X-ray photoemission and electron energy loss study has been conducted on 3 keV Nþ2 ion implantation in single wall carbon nanotubes. Our results show that nitrogen atoms can bind to carbon in tetrahedral sp3, defects related pyridine-like, and triangular sp2 configurations and such bondings are stable for annealing up to 650 K. Heating at higher temperatures results in preferential substitutional nitrogen doping. This technique opens a new channel for controlled doping in carbon nanotubes for device applications.

On the other hand doping of nanostructures has been studied by electron spectroscopy on low energy Na+ ion implantation and Na atom intercalation in single walled and multi walled carbon nanotube mat samples. Our results show that these two different methods yield quite different dopant spatial distribution since implanted sodium atoms remain on the surface while intercalated alkali metal particles readily diffuse in the bulk.

Electric resistivity measurements of a clean multi-walled carbon nanotube (MWNT) mat sample was studied at temperatures T between 300 and 1900 K. We found that the resistivity q decreases monotonously with increasing temperature without showing any sign of turn up. Our results can be well fitted with a power law of T_a within the framework of one dimensional Luttinger liquid theory with a = 0.13 or with a simple thermally activated inter shell hopping model. As an example of possible use of CNT's in absorber based cryopumps, a Temperature Programmed Desorption (TPD) study has been measured for H2 adsorption on multiwalled carbon nanotubes (MWNT) at very low pressure (10-6 Torr) and temperature (12-30 K). A comparison with charcoal shows that MWNTs are more effective as hydrogen molecule cryosorbers. Finally such luminescence techniques (Cathodoluminescence) have been also applied to diagnostic studies performed on an ancient coin in order to find if the coin is authentic or is a coinage proof. The coin is a Drachma and 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.

5.8 ION INTERACTION WITH SOLIDS

The electron emission problem in large accelerators has benn studied by performing 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.

Further results have been achieved in the interaction of alkali ions with metal surfaces in low energy collisions. The results indicate an autoexcitation mechanism as the key role in the double vacancy production during the 2p-levels electron excitation. In addition we find a remarkable contribution to electron emission from asymmetric collisions between incoming ions that have survived neutralization at the surface and target atoms, leading to excitation via a vacancy transfer process. Measurements of the total electron emission yields show an increase by more than an order of magnitude at impact energies above the threshold for this process. The measurements show the strong interplay between different emission mechanisms, such as projectile and target Auger electron emission, decay of bulk plasmons and electronic collision cascade. Measurements performed using sodium projectile show that a significant contribution to the total electron emission yield comes also from a vacancy transfer process in excitations by vacancy transfer processes.In addition energy distributions of electrons emission in the interaction of higher energy heavy projectiles with clean metal surfaces are reported. Our measurements show that total electron emission yield depends exponentially on the inverse of the velocity of the projectiles. Concerning the kinetic electron emission, we observe a broad continuum background with superimposed structures due to the decay of bulk plasmons and to Auger decay of 2p-levels excitations produced by electron promotion leading to the conclusion that kinetic electron emission is dominated by electron promotion in close atomic collisions.

5.9 MULTIMEDIAL EDUCATION

The Galilean invariance of work–energy theorem, at an elementary mechanics level, has not been deeply discussed in the past, nor have its implications in connection with other fundamental mechanical laws been investigated. In our research effort we give some further insight into the work–energy theorem, showing that its Galilean invariance implies the impulse theorem. We also introduce a formalism to determine temporal details of motion only by means of energetic considerations. Applications of the formalism are also presented, which are interesting both for graduates and for university undergraduates.

In addition we payed attention to the remarkable series of experiments conducted by Heinrich Hertz between 1885 and 1889 had an exceptional influence on subsequent development of science and technology. In these experiments, in fact, by generating and detecting electromagnetic waves (EMW), he succeeded in demonstrating that the predictions done by J. C. Maxwell some decade before were correct. In particular , he used an oscillator made of polished brass knobs, connected to an induction coil and separated by a tiny gap over which sparks could leap. If Maxwell's predictions were correct, electromagnetic waves would be transmitted during each series of sparks. To confirm this, Hertz made a simple receiver of looped wire. At the ends of the loop were small knobs separated by a tiny gap. The receiver was placed away from the (possible!) transmitter. If electromagnetic waves were radiating from the oscillator sparks, they would induce a current in the loop that would send sparks across its gap. This occurred when Hertz turned on the oscillator, producing the first transmission and reception of electromagnetic waves. Among other things, with its experiments Hertz found out how to make the electric and magnetic fields detach themselves from wires and go free as Maxwell's waves, so allowing all subsequent well known technological applications. Nevertheless, notwithstanding their exceptional importance, it is fairly rare to find these experiments treated in educational context. In this connection, by using the Java programming language, we have developed a virtual environment aiming to interactively illustrate the main features of Hertz-like experiments. By using it, the learner may explore the setup of a typical Hertz experiment, also trying to trigger sparks in the receiver by turning on current in the transmitter.

Finally two interesting interdisciplinary tools have been developed based on the cycloid and the logarithmic spiral. The suggested trip is addressed to students and is planned by using a virtual and interactive laboratory supported by both MatCos ambient and Java programming tools. The contents are elaborated by different points of view (physical, mathematical, graphical, natural sciences etc.) to the end of unifying the mathematical description with natural phenomena, stimulating the learning process by exploiting critical revisions, historical development, real applications and the use of already known concepts.

A. PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2007

1. E. Cazzanelli, M. Castriota, L. S. Caputi, A. Cupolillo, C. Giallombardo, and L. Papagno
   High-temperature evolution of linear carbon chains inside multiwalled nanotubes
   Phys. Rev B 75, 121405 (R) (2007)

2. E. Cazzanelli, L. Caputi, M. Castriota, A. Cupolillo, C. Giallombardo and L. Papagno
   Carbon linear chains inside multiwalled nanotubes
   Surface Science 601, 3926 (2007)

3. A.Sindona, A. Cupolillo, F. Plastina, C. Giallombardo, G. Falcone and L. Papagno
   Many body shake up in x-ray photoemission from bundles of lithium-intercalated single-walled carbon nanotubes.
   Surface Science 601, 2805 (2007)

4. A. Cupolillo , C. Giallombardo, L. Papagno
   Electronic properties of alkali–metal intercalated single walled carbon nanotubes
   Surface Science 601, 2828 (2007)

5. D. Pacilé, M. Papagno, M. Lavagnini, H. Berger, L. Degiorgi and M. Grioni
   Photoemission and optical studies of ZrSe3, HfSe3, and ZrS3
   Physical Review B 76, 1 (2007)

6. Ch. R. Ast, J. Henk, A. Ernst, L. Moreschini, M. C. Falub, D. Pacilé, P. Bruno, K. Kern and M. Grioni
   Giant spin splitting through surface alloying: Experiment and Theory
   Physical Review Letters 98, 186807 (2007)

7. Ch. R. Ast, G. Wittich, P. Wahl, R. Vogelgesang, D. Pacilé, M. Falub, L. Moreschini, M. Papagno, M. Grioni and K. Kern
   Local detection of spin-orbit splitting by scanning tunnelling spectroscopy
   Physical Review B 75, 201401(R) (2007)

8. T. Sainsbury, T. Ikuno, D. Okawa, D. Pacilé, J. M. J. Fréchet and A. Zettl
   Self assembly of gold nanoparticle at the surface of amine and thiol functionalized boron nitride nanotubes
   Journal of Physical Chemistry C 111, 12992 (2007)

9. A. Sindona, P. Riccardi, S. Maletta, S.A. Rudi and G. Falcone,
   Negative ionization of the secondary ions of silver and gold sputtered from their elemental surfaces
   Nuclear Instrument and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 256, 468 473 (2007)

10. A. Sindona, P. Riccardi, S. Maletta, S.A. Rudi and G. Falcone,
    Wave packet study of the secondary emission of negatively charged, monoatomic ions from sputtered metals
    Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 258, 226-229 (2007)

11. A. Sindona, S.A. Rudi, S. Maletta, R.A. Baragiola, G. Falcone and P. Riccardi
    Fermi edge singularities in ion-induced electron emission from plane metal surfaces
    Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 257, 438-441 (2007)

12. A. Sindona, F. Plastina, A. Cupolillo, C. Giallombardo, G. Falcone and L. Papagno

Many body shake up in X-ray photoemission from bundles of lithium-intercalated single-walled carbon nanotubes
Surface Science 601, 2805-2809 (2007)

13. T. J. G. Apollaro and F. Plastina,
Quantum information storage in the localized state of a spin chain
Open Sys. & Information Dyn. 14, 41 (2007).

14. G. Liberti, R. L. Zaffino, F. Piperno and F. Plastina
Entanglement sharing in E \otimes □Jahn-Teller model in the presence of a magnetic field
Phys. Rev. A 76, 042332 (2007).
Also selected by the Virtual Journal of Quantum Information, Vol. 7, Issue 11, Novembre 2007

15. F. Plastina, and T.J.G. Apollaro,
Local Control of Entanglement in a Spin Chain
Phys. Rev. Lett. 99, 177210 (2007).
Also selected by the Virtual Journal of Nanoscale Science & Technology, Vol. 16, Issue 20, November 2007
Also selected by the Virtual Journal of Quantum Information, Vol. 7, Issue 11, November 2007

16. P. Barone, A. Bonanno, M. Commisso, M. Minniti, A. Oliva, P. Riccardi
Auger electron emission in the interaction of slow Na+ ions with Al surfaces
Radiation Physics and Chemistry 76, 499-503 (2007)

17. M. Barberio, P. Barone, A. Bonanno, M. Camarca, F. Xu
Thermo- and iono- luminescence on MWCNT bundles
Radiation Physics and Chemistry 76, 492-494 (2007)

18. F. Xu, M. Minniti, C. Giallombardo, A. Cupolillo, P. Barone, A. Oliva, L. Papagno
Nitrogen ion implantation in single wall carbon nanotubes
Surface Science 601, 2819-2822 (2007)

19. M. Commisso, A. Bonanno, M. Minniti, P. Barone, P. Riccardi, A. Oliva, L. Papagno, F. Xu
Characterization of Carbon Nanotubes Exposed to Na or bombarded with Na+ at Room Temperature
Surface Science 601, 2832-2835 (2007)

20. M. Barberio, M. Camarca, P. Barone, A. Bonanno, A. Oliva, F. Xu
Electric Resistivity of Multi-walled Carbon Nanotubes at High Temperatures
Surface Science 601, 2814-2818 (2007)

21. M. Minniti, M. Commisso, A. Sindona, E. Sicilia, A. Bonanno, P. Barone, R. A. Baragiola, P. Riccardi
Kinetic electron emission from Al surfaces by slow ions
Physical Review B 75, 045424 (2007)

22. M. Minniti, M. Commisso, A. Sindona, P. Barone, A. Bonanno, A. Oliva, P. Riccardi
The role of Al-Auger electrons in kinetic electron emission from Al surfaces by slow Ne+ and Na+ ions
Nuclear Instruments and Methods in Physics Research B 257, 618-622 (2007).

23. M. Commisso, M. Minniti, A. Sindona, A. Bonanno, A. Oliva, R.A. Baragiola and P. Riccardi
The Role of Atomic Collisions in Kinetic Electron Emission from Al surfaces by Slow Ions
Nuclear Instruments & Methods B 256, 474-477 (2007)

24. M. Minniti, M. Commisso, A. Sindona, A. Bonanno, A. Oliva and P. Riccardi
Electron Emission in the Interaction of 300 eV Na+ Ions with Al Surfaces
Nuclear Instruments & Methods B 258, 96-98 (2007)

25. A. Sindona, S.A. Rudi, S. Maletta, R.A. Baragiola, G. Falcone, P. Riccardi,
Fermi edge singularities in ion-induced electron emission from plane metal surfaces
Nuclear Instruments & Methods B 257, 438–441 (2007)

26. A. Sindona, P. Riccardi, S. Maletta, S.A. Rudi, G. Falcone
Negative ionization of the secondary ions of silver and gold sputtered from their elemental surfaces
Nuclear Instruments & Methods B 256, 468–473 (2007)

27. A. Sindona, P. Riccardi, S. Maletta, S.A. Rudi, G. Falcone
Wave packet study of the secondary emission of negatively charged, monoatomic ions from sputtered metals
Nuclear Instruments & Methods B 258, 226-229 (2007)

28. A. Sindona, S.A. Rudi, S. Maletta, R.A. Baragiola, G. Falcone and P. Riccardi
Auger Electron Emission from Metals Induced by Low Energy Ion Bombardment: Effect of the Band Structure and Fermi Edge Singularity
Surface Science 601 (5), 1205-1211 (2007)

29. M. Camarca, A. Bonanno and P. Sapia
Revisiting work–energy theorem's implications
Eur. J. Phys. 28, 1181–1187 (2007)

A.1.2 Publications on international journals accepted in 2008

1. A. 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, (2008) accepted

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

3. Ch. R. Ast, D. Pacilé, L. Moreschini, M. C. Falub, M. Papagno , K. Kern and M. Grioni, J. Henk, A. Ernst, S. Ostanin and P. Bruno
Spin-orbit split two-dimensional electron gas with tunable Rashba and Fermi energy
Physical Review B, (2008) accepted

4. D. Pacilé, J. C. Meyer, C. O. Girit and A. Zettl
The two dimensional phase of boron nitride: few atomic layers and suspended membranes
Applied Physics Letters, (2008) accepted

5. S. Maniscalco, F. Francica, R. L. Zaffino, N. Lo Gullo and F. Plastina
Protecting Entanglement via the Quantum Zeno Effect
Phys. Rev. Lett., accepted

6. 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., accepted

7. M. Barberio; P. Barone; A. Bonanno; M. Camarca; A. Oliva; V. Pingitore, F. Xu
Visible Cathode- Luminescence from Carbon Nanotubes: The Role of Impurities
Phys. Stat. Sol. (a), (2008) accepted

8. V. Pingitore, M. Barberio, A. Oliva, N. Noce, C. Gattuso, M. Davoli,

A golden drachma from Bruttìa: counterfeit money revealed by Scanning Electron Microscopy and Cathodoluminescence
Mediterranean Archaeology & Archaeometry (2008) , accepted

9. 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), accepted

10. A. Bonanno, P. Sapia, M. Camarca, A. Oliva
Virtually exploring a pillar of experimental physics: the Hertz experiment.
American Institute of Physics (IOP) 2008, accepted

A.2 Publications on national journals

A.2.1 Publications on national journals printed in 2007

1. A. Bonanno, M. Camarca, P. Sapia, A. Serpe
Un learning object su una curva dalle proprietà sorprendenti: la cicloide
"*DIDAMATICA 2007: Informatica per la didattica"* vol. I, pp. 69-78 (2007).

A.2.2 Publications on national journals accepted in 2008

1. A. Bonanno, M. Camarca, P. Sapia
Come la Natura si Attorciglia: un Learning Object multimediale sulla Spirale Logaritmica
DIDAMATICA 2008, accepted

B PUBLICATIONS ON CONFERENCE PROCEEDINGS
B.1 Publications on international conference proceedings in 2007

C INVITED PRESENTATIONS
C.1 Invited presentations at international conferences in 2007

1. Francaviglia M., Paese S., Sindona A.
Mandala Making with Mathematica
Bratislava (Slovacchia), 05-09/02/2007, Oral Presentation,

2. M. Barberio, M. Camarca, P. Barone, A. Bonanno, A. Oliva, F. Xu
Electric Transport Properties of Multi Walled Carbon Nanotubes mat
ICNTE 2007 (Bologna, maggio 2007 – Oral Contribution)

D PRESENTATIONS AT CONFERENCES
D.1 Presentations at international conferences in 2007

1. Sindona A., Maletta S., Rudi S
Auger KVV spectra from bundels of single walled Carbon Nanotubes
Trends in NanoTechonology 2007, San Sebastian (Spain), Sept. 01-06, 2007.

2. Sindona A., Maletta S., Rudi S
Auger KVV spectra from Graphene,
Trends in NanoTechonology 2007, San Sebastian (Spain), Sept. 01-06, 2007.

3. M. Barberio, P. Barone, A. Bonanno, M. Camarca, A. Oliva, F. Xu
   Visible Cathode-luminescence from Carbon Nanotubes: The Role of Impurities
   Trends in NanoTechonology 2007, San Sebastian (Spain), Sept. 01-06, 2007

4. M. Barberio, P. Barone, A. Bonanno, M. Camarca, A. Oliva, F. Xu
   Preliminary results on transport properties of alkali-metal-doped Single-Wall carbon Nanotubes mats
   Chemical NanoTechonology Talks VIII

5. M. Barberio, R. Vasta, P. Barone, A. Oliva, L. Papagno, F. Xu and V. Pirronello
   Hydrogen Cryosorption on Multi Walled Carbon Nanotubes
   International Conference on Nano Science and Tecnology (ICN+T 2007)

6. P. Sapia, A. Oliva, A. Bonanno,
   MM vs. traditional recitations in teaching/learning geometrical optics: an italian school network investigation
   "12th International Conference on Multimedia in Physics Teaching and Learning" – Wroclav, Sept. 13-15, 2007.

7. A. Bonanno, P. Sapia, M. Camarca, A. Oliva
   Experimental activities and interdisciplinary education supported by multimedia
   GIREP-EPEC Conference: Frontiers of Physics Education" – Opatija, Croatia, Aug. 26-31, 2007

8. F. Plastina
   Local control of entanglement in a spin chain
   International conference "Quantum information and many-body quantum systems", March 26, 2007, Centro di Ricerca E. De Giorni, Pisa (Italy) , oral presentation.

9. F. Plastina
   Entanglement and Berry phase in the Dicke model
   Central european workshop on quantum optics, June 3, 2007, Palermo, Italy, oral presentation

D.2 Poster Presentations at international conferences in 2007

1. M. Barberio, R. Vasta, P. Barone, A. Bonanno, L. Papagno, F. Xu
   Molecular Hydrogen Adsorption on MWCTs at Low Temperature and Low Pressure
   NANOSMAT 2007 (Portimao, Portuga, July 2007 – Poster session)

D.2 Presentations at national conferences in 2007

1. P. Sapia, A. Bonanno, D. Tavano
   Musealità on-line ed attività integrate per l'esplorazione di strumenti scientifici di interesse storico
   "Comunicare Fisica 2007" – Trieste 1-6 ottobre 2007

2. A. Bonanno, B. Bitonti, P. Sapia
   Percorsi interdisciplinari ed attività laboratoriali: La fisica incontra la chimica e la botanica
   "Comunicare Fisica 2007" – Trieste 1-6 ottobre 2007

3. A. Bonanno, M. Camarca, P. Sapia, A. Serpe
   La realtà Fisica e la sua rappresentazione: un percorso integrato tra fisica, matematica ed informatica attraverso una cicloide
   "III Convegno Nazionale di didattica della fisica e della matematica" – Torino 13-15 settembre 2007.

Books

1. B.M. Dibilio, P. Sapia, F. Sartogo.

Dal Fenomeno alla Legge Fisica - Percorsi d'Apprendimento per il Biennio della Scuola Secondaria di Secondo Grado
2 voll. Edizioni "Il Capitello", Torino, 2007.

2. M. Recchi, P. Sapia
Dal Fenomeno alla Legge Fisica" – DVD multimediale per la Scuola Secondaria di Secondo Grado
Edizioni "Il Capitello", Torino, 2007.

3. R. A. Baragiola, P. Riccardi
Electron Emission from Surfaces Induced by Slow Ions and Atoms
in "Reactive Sputter deposition" chap.2 – Edited by S. Mahieu and D. Depla (Springer 2008)– in press

6. MOLECULAR BIOPHYSICS

Professors and Researchers: Luigi Sportelli
Rosa Bartucci
Rita Guzzi
Bruno Rizzuti, (Lab. Licryl, CNR-INFM, Cosenza)

Post-*doc fellows:* Manuela Pantusa
Andrea Stirpe

Undergraduate Students: Francesco De Simone
Cristina Vecchio

Technical staff: Bruno De Nardo,
Carmine Prete

Collaborators: D. Marsh (*MPI for Biophysical Chemistry, Goettingen, Germany*)
S. A. Dzuba, D. A. Erilov (*Institute for Chemical Kinetics and Combustion, Novosibirsk, Russian Academy of Science and Dept. of Physics, Novosibirsk, Russian Federation*)
C. Toniolo, M. De Zotti (*Dip.to Chimica, Università di Padova, Italy*)
D. Grasso, C. La Rosa, D. Miliardi (*Dip.to di Chimica, Università di Catania, Italy*)
G. W. Canters, M. Ph. Verbeet (*Gorlaeus Laboratory, University of Leiden, Netherland*)
M. Esmann (*Aarhus University, Dept. of Biochemistry, Denmark)*
C. Dennison, K. Sato (*Institute for Cell and Molecular Biosciences, Newcastle University, UK*)
S. Cannistraro, L. Andolfi (*Biophysics and Nanoscience Center, Università della Tuscia, Viterbo, Italy*)
Anna Russo, G. Sindona (*Dip. to di Chimica, University of Calabria)*
S. Morante, V. Melicozzi (*Dip.to di Fisica, Università di Roma Tor Vergata*)
M. Leone, V. Militello *(Dip. to di Fisica, Università di Palermo)*
M.P. De Santo, B. Zappone *(Lab. Licryl, CNR-INFM, Cosenza)*

Introduction

The research activity of the Molecular Biophysics Group has essentially been concerned with two main topics:
1. Self-assembled lipid structures and interactions at the lipid/protein interface, and
2. Thermostability, aggregation and molecular dynamic simulation of proteins.

The first research project has concerned with the physical properties of supramolecular lipid structures for drug delivery, with the backbone dynamics of the antimicrobial peptide alamethicin inserted into lipid membranes and on the human serum albumin interacting with sterically stabilised liposomes. The second one, indeed, has been focused on the thermal aggregation of proteins in presence of transition metal-ions and on molecular dynamics and stability of cupredoxins. In the following, the main results obtained are briefly presented.

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

6.1.1 Phase behaviour of DPPC/Lyso-PPC mixtures by spin-label ESR and spectrophotometry

The influence of lysopalmitoylphosphatidylcholine (Lyso-PPC) on lamellar dispersions of dipalmitoylphosphatidylcholine (DPPC) has been investigated by spectrophotometry and electron spin resonance (ESR) of spin-labelled phosphatidylcholine at the C-5 or at the C-16 positions in the *sn*-2 acyl chain (5- and 16-PCSL). On increasing the concentration of Lyso-PPC up to 10 mol%, the spectral anisotropy of 5-PCSL is slightly reduced whereas that of 16-PCSL

is markedly increased. This effect of the lysolipid on the DPPC lipid chain mobility is evident from 10 to 50 mol% at low temperature in the gel phase, disappears in the fluid phase, is associated with the lack of the pre-transition in the mixed lipid dispersions and it is interpreted as interdigitation of the DPPC lipid chains. At intermediate concentrations and for temperatures in the gel phase, the ESR spectra of both labels in DPPC and Lyso-PPC mixtures are the superposition of an anisotropic lamellar component and of an isotropic micellar signal, suggesting the coexistence of lamellar and micellar aggregates. Chain interdigitation and lamellar-micellar coexistence are not evident for temperature above the melting transition temperature. At high Lyso-PPC content ($\geq$ 60 mol%) the mixed lipid dispersions reach the optical clarity, the main transition is no more detected and spin-label ESR spectra typical of micellar dispersions are detected in the whole temperature range investigated.

6.1.2 Backbone dynamics of alamethicin in lipid membranes: spin-echo EPR of TOAC spin labels

Alamethicin F50/5 is a hydrophobic peptide that is devoid of charged residues and which induces voltage-dependent ion channels in lipid membranes. The peptide backbone is likely to be involved in the ion conduction pathway. Electron spin-echo spectroscopy of alamethicin F50/5 analogues in which a selected α-aminoisobutyric acid residue (at position n = 1, 8 or 16) is replaced by the TOAC amino-acid spin label was used to study torsional dynamics of the peptide backbone in phosphatidylcholine bilayer membranes. Rapid librational motions of limited angular amplitude were observed at each of the three TOAC sites by recording echo-detected spectra as a function of echo delay time, 2τ. Simulation of the time-resolved spectra, combined with conventional EPR measurements of the librational amplitude, shows that torsional fluctuations of the peptide backbone take place on the subnanosecond to nanosecond timescale, with little temperature dependence. Associated fluctuations in polar fields from the peptide could facilitate ion permeation.

6.1.3 Spectroscopic and calorimetric studies of HSA interacting with PEG:2000-DPPE/DPPC membranes

The molecular interactions at the lipid-protein interface have a great biophysical interest because of the development of protein-resistant surface coatings obtained by inclusion of polymer-lipids in vesicle membranes, which are used as long circulating drug carriers.
We have studied the interaction of the most abundant plasma protein, human serum albumin (HSA), with membranes composed of common diacyl lipids of dipalmitoylphosphatidylcholine (DPPC) and sub-micellar amounts of the polymer-lipid dipalmitoylphosphatidylethanolamine-PEG:2000 (PEG:2000-DPPE). The three domains of HSA have been investigated with different techniques: domain I by electron spin resonance labelling the unique free sulfhydryl group at Cys34 with a maleimido spin-label; domain II by intrinsic fluorescence of the single Trp214, and domain III by the extrinsic fluorescence of *p*-nitrophenyl anthranilate conjugated with Tyr411. Differential scanning calorimetry was also used to get insight into molecular properties of dispersions of HSA with or without polymer-grafted membranes.
The results evidence that the HSA domains possess different properties and are differently affected by the interaction with DPPC. The protein adsorbs to the surface of DPPC membranes and undergoes an up-shift of the thermal unfolding temperature and a decrease of the transition enthalpy. The primary protein adsorption is strongly reduced at low mushroom content of the polymer-lipids. The secondary adsorption at the polymer brush restricts the protein dynamics and increases the thermodynamic stability of HSA.

6.2. THERMOSTABILITY, AGGREGATION and MOLECULAR DYNAMIC SIMULATION of PROTEINS

6.2.1 Effects of Cu(II) and Zn(II) on beta-lactoglobulin A thermal denaturation and aggregation

Protein aggregation is associated with several neuro-degenerative diseases, including the Alzheimer's, the Parkinson's. There is a growing evidence that metal ions are able to accelerate the aggregation process of several proteins. In the present work the effects of copper and zinc ions on the denaturation and aggregation process of Beta-lactoglobulin A (BLG-A) are investigated by differential scanning calorimetry (DSC), optical density and fluorescence. The DSC profiles revealed that the thermal behaviour of BLG-A is a complex process consisting of an endothermic peak at about 80 °C (denaturation) and an exothermic peak above 90 °C which represents the aggregation of the denaturated molecules. Both the shape and the position of the two peaks are strongly dependent on the protein concentration and on the scan rate.
The presence of equimolar copper and zinc ions in the protein solution has different effects. In particular, copper is more effective than zinc in destabilizing BLG-A by decreasing the denaturation temperature of about 10 °C. The increase of the

metals concentration reduces such a destabilization. This result may be due to the reduction of the net charge of the protein suggesting a central role of the electrostatics in the aggregation of BLG-A.
The kinetics of BLG-A aggregation, followed by monitoring the apparent absorbance of the protein solution at 400 nm, show that both metal ions abolish the lag phase before aggregationt. Moreover, the rate of the process is 4.7-fold higher when copper ion is added to the protein in a 1:1 molar ratio to the solution whereas the effect of zinc is negligible.

6.2.2 Structure, dynamics and function of cupredoxins: insights from classical molecular dynamics

The monomeric cupredoxins, or blue copper proteins, represent a highly divergent family of small proteins that mediate electron transfer reactions in various plants and bacteria. In spite of large sequence differences, all the cupredoxins share the same topology, with 7 to 9 beta-strands arranged in a Greek-key folding motif and organized in two sandwiched beta-sheets. Various hypotheses have been proposed to account for the structural similarities among the blue copper proteins. In particular, a common architecture might be necessary to dictate the protein dynamics, because coordinate collective movements of protein amino acids are required to carry out their function.
To clarify this point, we have performed classical molecular dynamics simulations of azurin and amicyanin, two representative members of the cupredoxin domain. Both proteins were simulated in atomic detail with the GROMOS force field, under various computational conditions. The production trajectories were analyzed in search of coordinated displacements of amino acid residues by using dynamical cross correlations and principal component analysis. Results were compared with the experimental data and with simulations reported for other proteins.
Our findings reveal that the two proteins possess a fairly rigid structure, with few preferential and many almost-equivalent collective degrees of freedom. Large-scale atomic fluctuations are mostly localized at the two ends of the protein scaffold. One end, which includes the active site and the surface hydrophobic patch where the electron donor molecule binds, shows motions coordinated with specific regions in the rest of the protein. The protein scaffold is rigid on the whole, but the two sandwiched beta-sheets can slightly move with respect to each other to protect the hydrophobic core. This behavior is consistent with the high variability of the relative position of the two sheets in the blue copper proteins. In contrast, the protein region that extends from the copper site and through the center of the molecule is scarcely influenced by the reciprocal movements of the beta-sheets. The result suggests that this region could be part of the electron transfer pathway for the cupredoxins. Furthermore, it would explain why the amino acid residues and the hydrogen bonds belonging to this region are strongly conserved within the blue copper protein family.

6.2.3 The role of the α-helix on the thermal unfolding pathway and thermodynamic stability of azurin

The role played by the α-helix in determining the structure, the stability and the unfolding mechanism of azurin was addressed by studying an helix-depleted azurin variant produced by site-directed mutagenesis. Protein structure was investigated by CD, 1D 1H-NMR, fluorescence spectroscopy measurements and MD simulations, whilst EPR, UV-Vis and cyclic voltammetry experiments were carried out to investigate the geometry and the properties of the Cu(II) site. The effect of the α-helix depletion on the thermal stability and the unfolding pathway of the protein was determined by DSC, UV-Vis and fluorescence measurements at increasing temperature. The results show that in the absence of the α-helix segment the overall protein structure is maintained, and that only the Cu site is slightly modified. By contrast, protein stability is diminished by about 60% with respect to the wild type azurin. Moreover, the unfolding pathway of the mutant azurin involves the presence of detectable intermediates. If compared with previous studies concerning other small β-sheet cupredoxins, the whole of the results support the hypothesis that the presence of the alfa-helix can switch the folding of azurin from a hierarchic to a non-hierarchic mechanism in which the highy conserved β-sheet core provides a scaffold for cooperative folding of the wt protein.

A PUBLICATIONS on SCIENTIFIC JOURNALS
A.1 Publications on international journals
A.1.1 Publications on international journals printed in 2007

1. B. Rizzuti, L. Sportelli and R. Guzzi
Structural, dynamical and functional aspects of the inner motions in the blue copper protein azurin
Biophys. Chem. 125, 532-539 (2007)

2. F. De Simone, R. Guzzi, L. Sportelli, D. Marsh, and R. Bartucci
Electron spin-echo studies of spin-labelled lipid membranes and free fatty acids interacting with human serum albumin
Biochim. Biophys. Acta 1768, 1541-1549 (2007)

3. A. Stirpe, L. Sportelli, H. Wijma, M. Ph. Verbeet, Guzzi R.
Thermal stability effects of removing the type-2 copper ligand His306 at the interface of nitrite reductase subunits
Eur. Biophys J. 36, 805-813 (2007)

4. G. D. Manetto, D. M. Grasso, M. Miliardi, M. Pappalardo, R. Guzzi, L. Sportelli, M. P. Verbeet, G. W. Canters and C. La Rosa
The role played by the Alfa-helix in the unfolding pathway and stability of Azurin: swiching between hierarchic and non-hierarchic folding
ChemBioChem 8, 1941-1949 (2007)

5. M. Pantusa, R. Bartucci, L. Sportelli
Calorimetric and spin-label ESR studies of PEG:2000-DPPE containing DPPC/lyso-PPC mixtures
Colloid Polymer Sci. 285, 649-656 (2007)

A.1.2 Publications on international journals accepted in 2007

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 J. (2007), accepted

2. M. Pantusa, L. Sportelli, R. Bartucci
Phase behaviour of DPPC/Lyso-PPC mixtures by spin-label ESR and spectrophotometry
Spectroscopy (2007), accepted

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. (2007), accepted

4. A. Stirpe, R. Bartucci, B. Rizzuti, 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. (2007), submitted

D PRESENTATIONS at CONFERENCES
D.1 Presentation at international conferences in 2007

1. R. Guzzi, A. Stirpe, C. Vecchio, L. Sportelli
Effects of Cu(II) and Zn(II) on beta-lactoglobulin A denaturation and aggregation
European Biophysical Societies Association (EBSA), July 14-19, 2007; London - England

2. M. Pantusa, R. Bartucci, L. Sportelli
Spectroscopic and a calorimetric studies of HSA interacting with DPPC/PEG:2000-DPPE membranes
European Biophysical Societies Association (EBSA), July 14-19, 2007; London - England

3. M. Pantusa, F. De Simone, L. Sportelli, R. Bartucci
Phase behaviour of DPPC/lyso-PPC mixtures by CW-ESR and ESEEM studies of chain labelled lipids
12th European Conference on the Spectroscopy of Biological Molecules, September 1-6, 2007; Bobigny (Paris region), France

4. M. Pantusa, L. Sportelli, R. Bartucci
Spin-label ESR , fluorescence and Calorimetric studies of HSA interacting with PEG:2000-grafted DPPC membranes
12th European Conference on the Spectroscopy of Biological Molecules, September 1-6, 2007; Bobigny (Paris region), France

5. B. Rizzuti, L. Sportelli, R. Guzzi
Structure, dynamics and function of cupredoxins: insights from classical molecular dynamics
Theoretical Biophysics, TheoBio-07 – 3rd Symposium on Theoretical Biophysics, June 16-20, 2007; Cetraro (CS), Italy

7. PHYSICS AND APPLICATIONS OF THE SOFT MATTER

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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 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…)

DISORDERED SOLID PHASES
Disordered solid phases, containing appreciable amounts of hydrogen ions, are grown at the surface of rhenium oxide crystals, because of the high reactivity of this compound with ambient moisture. To investigate such phenomena, a comparative study is performed on ground powder and thermally evaporated or
sputtered films using x-ray diffraction and micro-Raman spectroscopy. Two types of solid phases were found in the films: HxReO3 distorted perovskite structures, based on corner-sharing ReO6 octahedra as in the bulk crystals, and ordered HReO4 crystalline structures, based on tetrahedral perrhenate ions. The complex impedance measurements on ReO3 films support the hypothesis of mobile hydrogen ions in such defective films. Moreover, this relevant protonic conductivity allows the application of these films as active layers inserted into asymmetric
nematic liquid-crystalline cells to rectify the electro-optical response of such devices, with performances quite similar to previously studied oxides such as WO3.
PDLC FILMS
Nematic droplets of variable size of E7 were dispersed in a photopolymer NOA65 matrix by the method of UV photopolymerization-induced phase separation. Dielectric and flexoelectric oscillation of the director orientation in the droplets were excited by an ac driving voltage in the range 1Hz to 3 kHz. Both thelinear and quadratic electro-optical response of the PDLC films were studied by the flexoelectric spectroscopy method and by laser light diffraction. The temperature and voltage dependence of the 1st and 2nd harmonic electro-optic spectra (amplitude and phase of the transmitted light vs frequency) were obtained, and strikingly deep minima in all spectra were found. These minima were interpreted as resulted from a spatial filtering (i.e. selective diffraction) of the time-modulated components of the transmitted light.
VIBRATIONAL SPECTROSCOPY

In the year 2007 the research on thin films and nanostructures presents further advancements, both for the improvement of synthesis methods and their application to new materials, both with regard to the characterization of the materials 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, like ReO3, 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 performd on the films.
Moreover, investigations concerning the Raman characterization of materials of great technological interest have been performed, in collaboration with groups of other universities and research institutions, for instance the measurements on TiO2 powders specially synthesized for deposition on thin films, made in collaboration with a group of Palermo University and the joint investigation, based on micro-Raman and visible-UV spectrophotometry, on titanyl-phthalocyanine films deposited by the supersonic molecular beam technique, in collaboration with CNR-FBK of Trento.
The study on the nanostructured carbon forms has been developed on different kinds of nanotubes. The Raman scattering from linear carbon chains inside multiwalled nanotubes allowed to reveal a Peierls transition of such chains, dependent on the temperature of the system, whose variation was obtained by modulating the impinging laser power. Such results have been presented to international conferences and published on high level journals.
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.

7.2 Surfaces and interfaces: characterisation, interaction lc-surfaces, polymer surfaces, anchoring, effects on eelctrooptics and photonics

THIN FILMS OF PZT
Interest in thin films of PZT _lead zirconium titanate PbZr0.47Ti0.53O3_ has increased because of their potential applications. For instance, the insertion of PZT in asymmetric nematic liquid crystal cells induces a rectified electro-optical response similar to that observed in such cells because of the insertion of metal oxide layers with ionic conductivity. In the present work several PZT films have been investigated, obtained by different thermal treatments after sol-gel synthesis and spin coating deposition. The observed rectifying effect, due to the insertion of PZT films in asymmetric liquid crystal cells, has been attributed to the presence of an internal field made from the reorientation of nanodomains of PZT. The presence of such internal fields is demonstrated and an estimation of it is given. Moreover, asymmetric nematic liquid crystal cells made with PZT films show considerable
improvements in both contrast and response time.
FUNCTIONAL SURFACES FOR LIQUID CRYSTALS DEVICES
Thin film technology is pervasive in many applications, including microelectronics, communication, optical electronics, catalysis, coating of all kinds, energy generation and conservation strategies,. Progress in each of these areas depends upon the ability to selectively and controllably deposit thin films - thickness ranging from few angstroms to micrometers - with specified physical properties. This, in turn, requires control - often at the atomic level - of film microstructure and microchemistry.
In this regard, physics and technology of thin films can play an important role to achieve this goal. The production of thin films for device purposes has been developed over the past 40 years. Thin films as a two dimensional system are of great importance to many real-world problems. Thus, knowledge and determination of the nature, functions and new properties of thin films can be used for the development of new technologies for future applications.
This research program is focused on the fabrication, characterization and applications of functional surfaces for liquid crystal technology.
At first a method to obtain thin films of well order TiO2 nonotubes will be developed, then the effect on the anchoring and electrical properties of nematic liquid crystals will be evaluated.
SURFACE INDUCED PHOTOREFRACTIVITY IN PURE LIQUID CRYSTAL CELLS
Highly sensitive photo-electrical reorientation effects have been investigated in pure LC cell with twisted configuration. As previously reported the surface induced photorefractive effect is characterized by very large nonlinear coefficients (>10 cm2/W) and a photorefractive gain that depends on the cell configuration. Exploiting a photo-electrically active substrate

and a photo-aligning substrate a optically twistable nematic cell has been obtained where the photorefractive gain has been tuned from zero to 130cm-1.

REACTIVE POLYMER SURFACES FOR LIQUID CRYSTAL ALIGNEMENT

Recently, photo-induced LC alignment has attracted much attention. Being a non-contact method, it avoids the disadvantages of rubbing. It also allows photo-induced switching of LC alignment via switching of polarization of irradiation. The polarized light supposedly induces an anisotropic structural change of the polymer surface that enables surface-induced alignment of the deposited LC film. Much recent research effort has been directed to finding the photo-induced structural change, but the techniques employed are often not surface-specific or sufficiently sensitive to allow probing of the surface structure of a polymer at the molecular level. Surface-specific sum-frequency vibrational spectroscopy (SFVS) is unique in this respect as it can yield surface vibrational spectra that are directly related to the polymer surface structure. We describe here how it can be used to study at the molecular level photo-induced surface structural change of polyvinyl cinnamiate (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 uv polarization. The orientation of the cinnamate side chains is believed to be responsible for the induced LC alignment. Interaction of LC molecules with the cinnamate side chains orients the first LC monolayer at the surface, which, in turn, orients the LC film through LC molecular correlation. 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. The C=C stretch mode at 1637 cm-1 for trans-cinnamate (1628 cm-1 for cis-cinnamate) is expected to disappear upon dimerization. The phenyl ring on the cinnamate chain should have an orientation change upon dimerization that can be detected from the polarization dependence of the CH stretch spectra. On the other hand, photo-induced isomerization of cinnamate chains would only alter the azimuthal anisotropy in the phenyl ring spectra if cis-cinnamate should rapidly transform back to the trans isomer. 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.

7.3 Confined systems, nanosciences, Photonics: lasing , grating, memories, holography, polycrips, solitons

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 (BORN) 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 BORN, which requires a tensorial description of the nematic material. BORN effects depend on □b, the nematic biaxial coherence length, which we at LiCryL are, at present, characterizing so to be able to control experimentally. In fact, BORN 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 BORN is always 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.

NANOLAYERS OF PTFE

Planar nematic layers of 5CB oriented by ‘‘sliding on’’ nanolayers of PTFE were studied by electrooptic methods. Deposited layers have been characterized by AFM and polarizing videomicroscopy. By using a drop method it was established that the preferred director alignment is tilted opposite to the sliding direction. In some of these samples an unusual modulated domain pattern after switching off a prolonged a.c. excitation was observed for the first time. A possible relation between the domain origin and loosely deposited PTFE layers was suggested.

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 (2007), 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.

PROPAGATION AND CHARACTERIZATION OF OPTICAL SPATIAL SOLITONS.

Model for molecular director configuration in a liquid crystal cell with multiple interfaces

The study of optical solitons and light filaments steering in liquid crystal requires the utilization of particular cells designed for top view investigation and realized with an input interface which enables the control of the molecular director configuration, preventing light scattering. Since the director orientation imposed by this additional interface was estimated, up to now, only by experimental observations, we have implemented a simple model describing the distribution of the director orientation inside a liquid crystal sample under the anchoring action of multiple interfaces. The model is based on the elastic continuum theory, and strong anchoring is taken into account for boundary conditions. Results are in good agreement with experimental observations.

3. INVESTIGATION OF LIQUID CRYSTALS ACTED ON BY A MULTIPLE IRRADIATION

a) Different reorientational regimes in a liquid crystalline medium undergoing multiple irradiation

We have performed a numerical approach to the nemato-elasticity differential equation in a nematic liquid crystal cell when irradiated with multiple gaussian beams. Solutions have been carried out on a configuration with two coplanar beams illuminating the sample in order to compare it with particular nonlinear phenomena experimentally studied in the past. A new set of experimental measures were realized confirming the validity of the numerical model. Solutions for an instable case showing nonlocal effects have been also investigated as an example of the broader class of systems this approach can describe.

b) Non-linear effects in NLC media undergoing two beams irradiation

A Nematic Liquid Crystal crossed by the overlap of multiple laser beams gives rise to different phenomena, such as the cancellation of reorientation and critical reorientation. A nonlinear 2D theoretical model is presented to describe these effects in the case of two laser beams impinging on a homeotropically aligned cell. By comparing the theoretical estimation of the re-orientational effect to the observed optical divergence of one beam, it is shown that they depend on the same

phenomenon, although they are not directly correlated.

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 combination of a CLC pitch gradient with the spatial distribution of different dyes within a single cell enables laser tuning over a wide range of wavelengths, from ultraviolet (~370 nm) to red (~680) nm. Further studies have also shown how laser emission can be obtained from a luminescent dye-doped CLC which is excited by another dye-doped CLC laser, resulting in a mirror-less CLC laser with a very low lasing threshold. The cascade of two CLC cells containing two different dyes was possible because the emission band of the first cell overlaps with the absorption band of the second cell. This system of low-threshold mirror-less lasers emphasizes the main advantages of using organic materials for lasing applications. All preliminary characterizations of these CLC-laser systems confirm remarkable lasing features and suggest fascinating future developments.

LASING IN LIQUID CRYSTALS: FROM RANDOM TO PERIODIC

Random lasing in fully disordered systems having organic and inorganic nature are objects of extensive studies since the beginning of last decade. The interest mainly emerges from the unexpected role played by disorder in the laser action. The disorder was considered detrimental for the optical feedback in cavity laser, until was demonstrated that multiple scattering materials including a gain medium act as random laser. Due to a random walk with optical gain inside these systems, diffusive lasing action is encountered. 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.

Our research project deals with a completely new approach, the vast and still unexplored world between ordered and disordered system is investigated by driving a dye doped liquid crystal through a cascade of electro-hydrodynamic instabilities. This system provided a wide window of disorder where it was possible to investigate the emission properties. In particular, our systems under optical excitation generates narrow banded lasing peaks in several dynamic scattering regimes. The constellation of localized modes is selected by properly choosing the gain profile.

POLARIZATION HOLOGRAPHY IN MOLECULAR MATERIALS

Polarization gratings in LC, LC-polymers composite materials have attracted great interest because of peculiar diffraction properties which open the way to promising application in displays and photonic technologies. Several materials and configurations have been investigated.

1D and 2D LC gratings, obtained by means of different assembling of polarization holograms recorded on photo-aligning substrates, have been investigated. Near 100% efficiency has been obtained in case of 1D gratings. 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 irradiating the grating with a linearly polarized beam. In both cases, an external ac voltage allows to completely control the diffracted energy distribution.

SUPRAMOLECULAR CHIRALITY INDUCED IN ACHIRAL POLYMERS BY CIRCULARLY POLARIZED LIGHT

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.

TUNABLE LASING IN LIQUID CRYSTALS

Driven by the possibility to develop a compact laser system, the tuning of dye-doped cholesteric liquid crystal lasers controlled by light emitting diodes (LEDs) has been investigated.

The lasing wavelength of dye-doped cholesteric liquid-crystal lasers is optically tuned by the reversible photoisomerization of the azo- or azoxynematic components of the cholesteric mixture. The laser can be tuned over a range of almost 70 nm. The nematic components are easily and reversibly isomerized by illumination from light-emitting diodes at 405 and 466 nm.

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 Denisyuk scheme has been used to record reflection holograms which could be reproduced using white light. The activity has been carried out in collaboration with prof. Ventseslav Sainov from CLOSPI laboratory of Sofia (Bulgaria). Several holographic plates has been tested. Holograms of ten object of medium –small size has been produced, which show good diffraction efficiency and long time stability.

7.4 Applications: sensors, depolarizing systems, EHD, LCD, CD

DEPOLARIZING OPTICAL SYSTEMS

Light emitted by natural sources is often depolarized but it rapidly becomes partially polarized owing multiple reflections. On the other hand many applications in electro-optics, telecommunications and scientific instrumentations require completely depolarized light, for this reason scientific and technological interest in light depolarizing systems which do not alter the beam profile and propagation of the light beam is continuously growing,

In the last few years our activity in this field concerned the observation of light depolarization effects in turbulent media and in liquid crystals composite systems, now we are studying the light depolarization in the disorder evolution that occurs during the Fréedericksz transition in homeotropically aligned nematic liquid crystals films. We focused our attention on the time behavior of the degree of polarization which reveals interesting characteristics of the disorder due to domains of different director orientation on mesoscopic scale, while a huge depolarization effects can be observed during the transient, the shape and the propagation of the light beam is not modified. Our research program provides the study of these transient depolarization effects to realize optical depolarizers.

CD (CIRCULAR DICHROISM) SPECTROMETER FOR REAL TIME MEASUREMENTS

In this study, a novel and simple diffractive spectrographic method for real-time measurements of circular dichroism (CD) is 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 spectrometer. 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. Here we demonstrate 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.

7.5. Nano-imaging of biological and biocompatible materials and Surface Force Apparatus (SFA)

NANO-IMAGING OF BIOLOGICAL AND BIOCOMPATIBLE MATERIALS

At LiCryL, we are developing scanning probe tools for biological and biomedical applications. In fact, advanced nano-microscopy techniques, such as Atomic Force Microscopy (AFM), are finding extensive application in these fields since they are non-destructive and can be performed in liquid environments. In recent years, using AFM, we have studied the biomechanical response of the cornea following a surgical treatment known as corneal photoablation. AFM was also used to investigate the biophysical properties of intra-ocular lenses made of biomaterials and used as a popular replacement of the natural crystalline lens following cataract surgery.

At present nano-microscopy is 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).

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 and on materials used for bioimplants. This research is important from both a fundamental point of view, to fully investigate these hydrophobins, and from a technological one, to improve

bioimplants.
Finally, to investigate the mechanical properties of bio and biocompatible materials, new techniques to prepare probes for Colloidal Probe Microscopy are being developed at LiCryL.

SURFACE FORCE APPARATUS (SFA)

LiCryL is actually working on a Surface Force Apparatus (SFA) that will be operational by summer 2008. An SFA measures normal and frictional forces between two macroscopic surfaces which are separated in a gas or a liquid by a distance D which varies from several microns to zero. 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), which also allows for the measurement of the refractive index n (sensitivity ±0.01) and the determination of the geometry of inter-surface contact. Through measurements of the radius of curvature of the surfaces, it is possible to visualize surface deformations and damage due to load or 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

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2007

1. F. Ciuchi, H. Ayeb, G. Lombardo,, R. Barberi, G. Durand
Control of transient biaxial order in calamitic nematics
Appl. Phys. Lett 91, 244104 (2007)

2. G. Chilaya, A. Chanishvili, G. Petriashvili, R. Barberi, R. Bartolino, G. Cipparrone, A. Mazzulla, P.V. Shibaev,
Reversible tuning of lasing in cholesteric liquid crystals controlled by light-emitting diodes
Advanced Materials, 19-4, 565 (2007)

3. B. Zappone, K. J. Rosenberg, J. N. Israelachvili,
Role of nanometer roughness on the adhesion and friction of a rough polymer surface and a molecularly smooth mica surface
Tribology Letters, 26-3, 191-201 (2007)

4. B. Zappone, Ruths, GW Greene, et al.
Adsorption, lubrication, and wear of lubricin on model surfaces: Polymer brush-like behavior of a glycoprotein
Biophysical Journal, 92-5, 1693-1708 (2007)

5. A.G. Petrov, Y. Marinov, S. D'Elia, S. Marino, C. Versace, N. Scaramuzza,
Dielectric and flexoelectric oscillations in PDLC studied by flexoelectric spectroscopy and laser light diffraction
Journal of Optoelectronics and Advanced Materials 9(2), (2007) 420-423.

6. Y. Marinov, S. D'Elia, A. G. Petrov, C. Versace, N. Scaramuzza,
Pretilted nematic layers of 5CB on PTFE treated glass supports
Molecular Crystals and Liquid Crystals 465(1) (2007) 301-308

7. S. Marino, M. Castriota, G. Strangi, E. Cazzanelli, N. Scaramuzza,
Asymmetric Nematic Liquid Crystal Cells Containing Lead Zirconium Titanate (PZT) Films
Journal of Applied Physics 102 (2007) 013112.
Selezionato per il Virtual Journal of Nanoscale Science and Technology 16 (5) 2007

8. M. Castriota, E. Cazzanelli, G. Das, R. Kalendarev, A. Kuzmin, S. Marino, G. Mariotto, J. Purans and N. Scaramuzza
Proton Presence and Motion in Rhenium Oxide Films and Their Application to Liquid Crystal Cells
Molecular Crystals and Liquid Crystals 474 (2007) 1-15

9. Pezzi L., Veltri A., De Luca A., Umeton C. P.,
Non-Linear Effects in NLC Media Undergoing Two Beams Irradiation
Molecular Crystals and Liquid Crystals 465 (2007) 71-80.

10. Veltri A., Sukhov A., Caputo R., De Sio L., Umeton C. P.,
Theoretical characterization of the holographic recording of diffraction grating in multicomponent media
Molecular Crystals and Liquid Crystals 465 (2007) 187-200.

11. Veltri A., Pezzi L., De Luca A., Umeton C. P.,
Different reorientational regimes in a liquid crystalline medium undergoing multiple irradiation
Optics Express 15 (2007) 1663-1671.

12. Pezzi L., Veltri A., De Luca A., Umeton C. P.,
Model for molecular director configuration in a liquid crystal cell with multiple interfaces
Journal of Nonlinear Optical Physics and Materials 16 (2007) 199-206.

13. Caputo R., De Sio L., Jak M.J.J., Hornix E.J., de Boer D.K.G., Cornelissen H.J.,
Short period holographic structures for backlight display applications
Optics Express 15 (2007) 10540-10552.

14. Vena C., Versace C., Strangi G., et al.,
Light depolarization effects during the Freedericksz transition in nematic liquid crystals
Optics Express 15 (2007) 17063-17071.

15. Vena C., Versace C., Strangi G., et al.,
Electrohydrodynamic instabilities in doped M5 nematic liquid crystals
Molecular Crystals and Liquid Crystals 465 (2007) 217.

16. Di Paola, M. Addamo, M. Bellardita, E. Cazzanelli, L. Palmisano,
Preparation of photocatalytic brookite thin films
Thin Solid Films 515, 7-8 (2007) 3527-3529.

17. J Purans, A Kuzmin, E Cazzanelli and G Mariotto,
Disorder-induced Raman scattering in rhenium trioxide (ReO_3)
J. Physics: Condens. Matter 19 (2007) 226206-226214.

18. E. Cazzanelli , M. Castriota, L.Caputi, A. Cupolillo, C. Giallombardo and L. Papagno,
High temperature evolution of linear carbon chains inside multiwalled nanotubes
Phys. Rev. B Rapid Comm. 75 (2007) 121405-121408.
Selected for the April 9, 2007 issue of Virtual Journal of Nanoscale Science & Technology

19. E. Cazzanelli, L. Caputi , M. Castriota, A. Cupolillo, C. Giallombardo, L. Papagno,
Carbon Linear Chains Inside Multiwalled Nanotubes
Surface Science 601 (2007) 3926–3932.

20. M. Castriota , N. Epervrier , E. Cazzanelli,
Raman spectroscopic monitoring of the sol-gel synthesis, spin coating deposition and thermal treatments of vanadium pentoxide films
Ionics 13 (2007) 205-211 (2007).

21. N. Coppedè, T. Toccoli, A. Pallaoro, F. Siviero, K. Walzer ,M.Castriota, E. Cazzanelli and S. Iannotta,
Induced structural order and phase control on Titanyl Phthalocyanine thin films by Supersonic Molecular Beam Deposition
J. Phys. Chemistry A 111(49) (2007) 12550 -12558.

22. L.M. Blinov, G. Cipparrone, A. Mazzulla, P. Pagliusi, V.V. Lazarev,
Lasing in cholesteric liquid crystal cells: Competition of Bragg and leaky modes
Journal of Applied Physics 101 (5) (2007) 053104.

23. L.M. Blinov, G. Cipparrone, A. Mazzulla, P. Pagliusi, V.V. Lazarev, S.P. Palto,
Simple voltage tunable liquid crystal laser
Applied Physics Letters 90 (13) (2007) 131103.

24. L.M. Blinov, S.P. Palto, V.V. Lazarev, G. Cipparrone, A. Mazzulla, P. Pagliusi
Quasi-in-plane leaky lasing modes from thin waveguiding layers of nematic and cholesteric liquid crystals
Molecular Crystals and Liquid Crystals 465 (2007) 37.

25. C. Provenzano, P. Pagliusi, G. Cipparrone,
Electrically tunable two-dimensional liquid crystals gratings induced by polarization holography
Optics Express 15(9) (2007) 5872-5878.

26. L.M. Blinov, G. Cipparrone, V.V. Lazarev, B.A. Umanskii,
Planar amplifier for a microlaser on a cholesteric liquid crystal
Applied Physics Letters 91 (6) (2007) 061102.

27. L.M. Blinov, V.V. Lazarev, S.P. Palto , G. Cipparrone, A. Mazzulla, P. Pagliusi,
Electric field tuning a spectrum of nematic liquid crystal lasing with the use of a periodic shadow mask
Journal of nonlinear optical physics and materials 16 (1) (2007) 75.

28. 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 Rhodamine-640
Journal of nonlinear optical physics and materials 16 (4) (2007) 519.

A.1.2 Publications on international journals accepted in 2007

1. G. Lombardo, H. Ayeb, F. Ciuchi, M. P. De Santo, R. Barberi, R. Bartolino, E.G. Virga, and G. E. Durand
Inhomogeneous bulk nematic order reconstruction
Phys. Rev. E (accepted)

2. G. Lombardo, H. Ayeb, and R. Barberi,
Dynamical numerical model for nematic order reconstruction,
Phys. Rev. E (accepted)

3. H. Ayeb, F. Ciuchi, G. Lombardo, R. Barberi
Metallomesogens as biaxial dopants in a calamitic nematic liquid crystal
Mol. Cryst. Liq. Cryst. (accepted)

4. F. Ciuchi, M. Giocondo, R. Barberi,
Electrically controlled defects at a liquid crystal-polyimide interface
Liquid Crystals (accepted)

5. E. Bruno, M.P. De Santo, M. Castriota et al.,
Morphological and electrical investigations of lead zirconium titanate thin films obtained by sol-gel synthesis on indium tin oxide electrodes
Journal of Applied Physics (accepted)

6. B. Zappone, G.W. Greene, E. Oroudjev et al.,
Molecular aspects of boundary lubrication by human lubricin: Effect of disulfide bonds and enzymatic digestion
Langmuir (accepted)

7. C. Vena, C.Versace, G.Strangi, S.D'Elia, R.Bartolino,
Fréedericksz transitinon in homeotropic alligned liquid crystals: a photopolarimetric characterization
Physica Status Solidi C (accepted)

8. P. Pagliusi, C. Provenzano, , A. Mazzulla, L. Giorgini, G. Cipparrone,
Spectrograph based on a single diffractive element for real time measurement of circular dichroism
Applied Spectroscopy (accepted)

9. L.M. Blinov, G. Cipparrone, V.V. Lazarev, P. Pagliusi and T. Rugiero,
Liquid crystal as laser medium with tunable gain spectra
Optics Express (accepted)

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2007

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.

C INVITED PRESENTATIONS

C.1 Invited presentations at international conferences in 2007

1. P. Pagliusi, C. Provenzano and G. Cipparrone,
   Surface photorefractivity in twisted nematics: toward all-optical control of gain
   European Conference on Liquid Crystals 2007, Lisbon (PT), July 2-6, 2007 (oral presentation).

2. L.M. Blinov, G. Cipparrone, A. Mazzulla, P. Pagliusi, V.V. Lazarev and S.P. Palto,
   Voltage tunable lasers on dye doped nematic liquid crystals
   European Conference on Liquid Crystals 2007, Lisbon (PT), July 2-6, 2007 (oral presentation).

3. G. Cipparrone, C. Provenzano, P. Pagliusi, V.P. Shibaev, S.G. Kostromin
   Photo-induced supramolecular chirality in azo-containing amorphous a-chiral polymer
   12th International Topical Meeting on Optics of Liquid Crystals (OLC-2007), Puebla (MEX), October 1-5, 2007. (oral presentation).

4. P. Pagliusi, G. Cipparrone and C. Provenzano,
   Surface-induced photorefractivity in twistable nematics: toward the all-optical control of gain
   12th International Topical Meeting on Optics of Liquid Crystals (OLC-2007), Puebla (MEX), October 1-5, 2007 (oral presentation).

5. G. Chilaya, A. Chanishvili, G. Petriashvili, R. Barberi, R. Bartolino, G. Cipparrone, A. Mazzulla, et al.,
   Broadband tunable ultraviolet-visible cholesteric liquid crystal lasers: new strategies and developments
   12th International Topical Meeting on Optics of Liquid Crystals (OLC-2007), Puebla (MEX), October 1-5, 2007 (oral presentation).

D PRESENTATIONS AT CONFERENCES

D.1 Presentations at international conferences in 2007

1. G. Strangi, S. Ferjani, V. Barna, A. De Luca, C. Versace, N. Scaramuzza, R. Bartolino,
   Random lasing in freely suspended nematic liquid crystals films

SPIE Europe: Optics and Optoelectronoc, Prague, Czech Republic, April 16-19, 2007.

2. S. D'Elia, M. Castriota, C. Versace, E. Cazzanelli, N. Scaramuzza, C. Vena,
Optical and Morphological Properties of PZT Thin Films Deposited by sol-gel Method on Different Substrates
4th International Conference on Spectroscopic Ellipsometry, Stockholm, Sweden, June 11-15, 2007.

3. Veltri A., De Luca A., Pezzi L., Coschignano G., Umeton C. P., Alberucci A., Conti C., Peccianti M., Assanto G.,
Nematic Liquid Crystal Cells for Optical Spatial Solitons (Nematicons)
SPIE - Photonics West OPTO Emerging Liquid Crystal Technologies II, San Jose, USA, 21- 24 January, 2007.

4. Pezzi L., Veltri A., De Luca A., Umeton C.P.,
Discrete diffraction as a direct solution of Maxwell's equations
NOMA'07, Cetraro (Italy), 03-09 June, 2007.

5. Rosenblatt C., Carbone G., De Luca A., Barna V., Sousa M.,
Optical nanotomography og liquid crystals
NOMA'07, Cetraro (Italy), 03-09 June, 2007.

6. d'Alessandro A., Donisi D., Asquini R., Beccherelli R., De Sio L., Caputo R., Umeton C. ,
NOMA'07, Cetraro (Italy), 03-09 June, 2007.

7. Caputo R., De Sio L., Jak M.J.J., Hornix E.J., de Boer D.K.G. , Cornelissen H.J.,
Short period holographic structures for backlight display applications
NOMA'07, Cetraro (Italy), 03-09 June, 2007.

8. Veltri A. , Infusino M., Ferjani S., Strangi G.,
Model for light scattering and lasing in dye-doped nematic liquid crystals
12th International Topical Meeting on Optics of Liquid Crystals (OLC-2007), Puebla (MEX), October 1-5, 2007.

9. Strangi G., Ferjani S., Carbone F., Barna V., De Luca A., Versace C.C.,
Laser Action in Nematic Liquid Crystals: from Partially Ordered to Turbulent Systems
12th International Topical Meeting on Optics of Liquid Crystals (OLC-2007), Puebla (MEX), October 1-5, 2007.

10. De Luca A., Barna V., Carbone G., Rosenblatt C.,
Optical Nanotomography of Liquid Crystals
12th International Topical Meeting on Optics of Liquid Crystals (OLC-2007), Puebla (MEX), October 1-5, 2007.

11. 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
Asia Display 2007 (SID), Shanghai, China, 2007

12. Caputi L., Castriota M., Cazzanelli E., Cupolillo A., Giallombardo G., Mariotto G., Papagno L. ,
Carbon Nanotubes containing Linear Carbon Chains
Proceedings of AIV "XVIII National Congress on Vacuum Technology", Florence, 2-4 April, 2007

13. D'Elia S., Castriota M., Bruno E., Policicchio A., Versace C.C. , Vena C., Agostino R.G., Strangi G., Cazzanelli E., Scaramuzza N.,
Optical and morphological properties of PZT thin films deposited by sol-gel method on different substrates
4th International Conference on Spectroscopic Ellipsometry (ICSE-4), Stockholm, Sweden, 11-15 June 2007

14. Castriota M., Cosco V., Barone T., De Santo G., Carafa P., Cazzanelli E.,
Micro Raman characterizations of Pompei's mortars
GNSR 2007, Catania, June 2007.

15. Caputi L., Cazzanelli E., Castriota M., Cupolillo A., Giallombardo C., Mariotto G., Papagno L., *Second order Raman scattering from linear carbon chain inside MWCNT* GNSR 2007, Catania, June 2007.

16. Castriota M., Marino S., Strangi G., Versace C.C., Scaramuzza N., Cazzanelli E., *Electro-optical response due to mixed conduction electrodes, compared to ferroelectric ones, in asymmetric nematic liquid crystal cell* 11th EuroConference on Science and Technology of Ionics", Batz-sur-Mer, France, September 2007

17. Castriota M., Cazzanelli E., Caputi L., Cupolillo A., Giallombardo C., Papagno L., Mariotto G., *Investigations on Raman bands from carbon linear chains in multiwalled carbon nanotubes* Diamond 2007, 18th European Conference on Diamond, Diamond-like Materials, Carbon Nanotubes, Nitrides and Silicon Carbide, Berlin (DE), September 2007

18. Maccallini E., Kalantzopoulos G., Cazzanelli E., Ciuchi F., Matranga M.A., Caruso T., Policicchio A., Chiarello G., Formoso V., Colavita E., Agostino R.G., Tsoufis T., Gournis D., Tomou A., Panagiotopoulos I., *Morphology and structure of Anchored carbon nanotubes encapsulating crystalline β-tin nanowires Candidates for photovoltaic applications* Chemical Nanotechnology Talks VIII, Frankfurt , 20-21 November, 2007.

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. Formoso (*University of Calabria, SPES Group*)
V. Carbone (*University of Calabria, Astrophysics Group*)
R. Bartolino (*University of Calabria, Soft Matter Group*)

Undergraduate students: M. Paonessa
Graduate students: R.M. Corno, P. Gigliotti (*Master students: 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

Several researchers of the Department were involved in studies on Biomedical physics themes. The scientific activities concerned two subjects:

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

As regards the first activity, polymeric materials were irradiated with clinical electron beams. Electron beams necrotise surface tissues, and, especially at high dose rates, electron irradiation is performed as an adjuvant therapy to surgical removal of cancer tissues. Plastics are currently employed in biomedical apparatuses since their behaviour in the biological environment and response to physical excitations are similar to those of the living tissue. Plastics are used as phantoms for radiation dosimetry, and are irradiated in relation to therapeutic, diagnostic and technological activities.

As regards the second activity, two lines were addressed: the first one refers to modern medicine imaging and biomedical experiments, which are concerned with the interpretation of large data sets often affected by noise, artefacts and redundancy. The data interpretation takes advantage from algebraic treatments, like a reduction of the dimensionality. The second line of activity concerns risk aspects in complex systems like health organisations. Complex systems undergo failures which can be reduced if not eliminated by proper management. The advantages are psychological (patient and medical/nursing staff satisfaction) and material (health preservation of the patient, reduced expenses for the sanitary system).

8.1 MODIFICATIONS INDUCED BY IRRADIATION IN BIOMEDICAL MATERIALS

Polymethylmethacrylate (PMMA) and polystyrene (PS) were irradiated with electron beams at energies of several MeV in dose steps of the order of 5 Gy with a dose rate of the order of several 10^{-2} Gy/min. The total doses approached 100 Gy. We performed the irradiation with a LINAC accelerator at the AO of Cosenza in collaboration with R. Siciliano and G. Barca. Our experimental investigations by means of EPR and SEM techniques were performed by A. Santaniello in collaboration with R. Guzzi of the Molecular Biophysics Group and V. Formoso of the SPES Group. We looked for stable radicals and topographic changes by means of EPR and SEM techniques, respectively. Photon beams are known to induce short- and long-lived radicals for doses above several hundreds Gy. We observed no traces of permanent modifications for electron beam irradiation at total doses in the therapeutic range.

8.2 TRANSFER TO MEDICINE OF THEORETICAL MODELS AND METHODS

8.2.1 Application of algebraic methods to biomedical data

Analysis of renal scintigraphy

We applied the Proper Orthogonal Decomposition to the spatial and temporal evolution of renal scintigraphy, as a diagnostic technique which 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. First 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. The analysis has been found to be very promising towards an objective detection of anomalies or malfunctioning processes within the kidney.

Analysis of tomographic images

We performed preliminary work aiming to the application of the Proper Orthogonal Decomposition approach to pattern recognition in time-dependent tomographic imaging. Use of the similar but less powerful Principal Component Analysis is reported in recent literature as applied to SPECT and PET tomographic data. The first principal components identify or enhance patterns contained in the images, and can be associated to a given pathology. This is because the first principal components refer to correlated features, i.e. medically and biological relevant behaviours, while uncorrelated noise and artefacts correspond to the last, negligible principal components. The temporal evolution of the principal component is essential in order to identify a specific physiological or pathological behaviour. The data analysis can benefit from the optimised procedures involved in POD.

Data analysis and modeling of prey-predator systems

We analyzed data coming from the incidence of Dengue Hemorrhagic Fever (DHF) in Thailand, showing that the process is accompanied by the presence of traveling waves of incidence. We found that, apart for a basic yearly periodic incidence, some aperiodic bursts can exists, whose origin is not yet completely understood. Invasion of virus within an already existing population can be described by prey-predator models. We built up a model to describe the spatio-temporal behavior of DHF based on a prey-predator scheme which gives rise to a reaction-diffusion set of equations. First results of numerical simulations of the model describe traveling waves of invasion, and in this framework aperiodic pulses seems to be present within the model when some parameters are varied.

The dynamics of HIV infection can be roughly described by a simple model of three ordinary differential equations where both Reverse Transcriptase Inhibitors and Protease Inhibitors therapies are included. We investigate the dynamical behavior of the model by including the possibility that the HIV virus must resist to drug through a time dependent fitness process. Within the model we found the possibility of latency periods of virus and restoring of immunodeficiency. The duration of these periods depends catastrophically on a parameter that describes the rate of resistance to drug acquired by the HIV virus. When the system is near the critical value, a very small improvement against the virus resistance suffices to strongly increase the latency period of infection.

8.2.2 Risk analysis and management of health systems

Risk management is one of the basic reference points of a global approach to quality, safety, and responsibility of the professionals within health organisations, known as “Clinical Governance”. According to this, both the medical and the nursing staffs can and have to be involved in specific and coordinated actions aiming to reduce the number of the incidents and malpractices. Risk assessment, evaluation and management refer to analytical models and practical instruments developed in other contexts or specifically developed for the medical and nursing environments. These methods are presently refined in specific practical contexts. Risk analytical models and management were preliminary studied and reviewed with respect to nursing and medical care in two theses 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:
1)“*Profili di responsabilità infermieristica nel risk management sanitario*”, P. Gigliotti, Laureato in Scienze Infermieristiche e Ostetriche, Responsabile del personale di assistenza presso l’Ospedale di Castrovillari e Lungro, a.a.

2006-2007;
2)"*La malpratica in sanità e la catena dell'errore umano*", M. R. Corno, dottore in Medicina Generale, Responsabile del Centro di Riabilitazione accreditato "Don Milani" di Lungro, a.a. 2006-2007).

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.3 Publications on international journals submitted in 2007

1. P. Veltri jr., A. Vecchio, V. Carbone,
   Proper Orthogonal Decomposition analysis to investigate the spatial and temporal behavior of renal scintigraphy,
   Phys. Med. Biol., submitted.

2. S. Donato, L. Primavera, A. Vecchio, V. Carbone,
   Complex dynamics of a predator-prey system,
   Phys. Rev. E, submitted.

3. V. Carbone
   Latency period of infection and absence of CD4+ T cells depletion in a dynamical model of HIV evolution,
   Europhys. Lett., submitted.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2007

1. R.Brancaccio, M.Bettuzzi, F.Casali, M.P.Morigi, A.Berdondini, C.Bruno, Y.F.Tchuente Siaka, A.Santaniello, E.Lamanna, A.S.Fiorillo, G.Barca, and F.Castrovillari ,
   Study and realization of real-time in-depth dosimetry system for IORT (intra operative radiation therapy),
   Hard X-Ray and Gamma-Ray Detector Physics IX within the SPIE Symposium on Optical Engineering and Applications, Proceedings of SPIE, Volume n° 6706, 67061H (San Diego, 26-30 August)

2. E. Lamanna, A.S. Fiorillo, C. Bruno, A. Santaniello, Y.F.T. Siaka, A. Berdondini, M. Bettuzzi, R. Brancaccio, F. Casali, M.P. Morigi, G. Barca, F. Castrovillari,
   Dosimetry of high intensity electron beams produced with dedicated accelerators in intraoperative radiation therapy (IORT),
   IEEE 2007 Nuclear Science Symposium and Medical Imaging Conference N15-303 (Hawaii, October 28 to November 3).

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:
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M.R. Gallipoli (*CNR — Tito Scalo (PZ), Italy*)
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G. Neri, B. Orecchio and D. Presti (*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)*
C. Fallico and S. Troisi *(Calabria Univ., Arcavacata, Italy)*

RESEARCH LINES

Introduction

The research group is engaged in many lines of activity, in spite of its lean composition. In most cases this is 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 features of the 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 that deals with the complex relations between earthquakes and geological structures. 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 observation, while the propagation model includes the mechanical discontinuities met with by seismic waves along their path to 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 the 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 2007 the reorganization started 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. 8.6 below).

During 2007, the operation continued of about ten seismic 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 Groups of the Physics Department.

The main goal has been the modelling the pattern of the time evolution of some physical observables, like the seismicity. The main result is the retrieval of a relation that describes the pattern of both of main events and seismic sequences. A fal1-out of this investigation is the observation that world wide distributed main events have a pattern of occurrence that shows a weak correlation of every event with those preceding it.

Similar statistical techniques have been applied to the inversion of the Earth magnetic, leading to very interesting results.

9.3 Applied Geophysics

Among the surveying techniques that can be used to map buried geological bodies, the magnetic survey is one of the most interesting. It consists in measuring the intensity of the magnetic field within a closely spaced grid (about 1 km step). Then the main component of the signal due to source in earth core is subtracted from the observed data. In a similar manner also the periodical variation are subtracted. The remaining portion of the signal, termed magnetic anomaly, can be attributed to variations in the magnetic susceptibility of the rocks that compose the Earth crust. The interpretation of this residual field consists in creating a geometrical model of the buried structures that causes a synthetic field as similar as possible to the observed one.

The research group is currently working on the construction of a detailed magnetic map of Calabria, involving students too, when possible. The effort will obviously take several years.

9.4 Environmental geophysics

This branch of geophysics deals with the investigation of very shallow phenomena that most directly affects human activities and the environment where they happen.

Among the many possible techniques, the research group concentrates on the analysis of the content of 222 of gases flowing from. soils. It is in fact well known that excessive Rn concentrations can be extremely dangerous to human health, this gas is naturally discharged in particular geodynamic areas. Since it is rather heavy, it has the tendency not to be dispersed in the atmosphere, particularly in closed and badly ventilated buildings.

Continuous recording of the CO_2, H_2 and H_2S flowing from soil continued during 2007 by means of the prototype of the gas monitoring station built in the frame of the CIPE Project completed in 2004.

9.5 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 2007, two different field experiments were continued.

The first one, in the framework of CALARCO, is a joint effort with Lamont Observatory of the Columbia University. It consists of a network of 9 GPS receiver installed throughout a transect in North Calabria, in WNW-WSW direction. All observation sites will remain 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 funded by INGV in the frame of a national research program supported by the national Civil Protection Department. The first phase was carried out in autumn 2006 and the second in the spring 2007. Three pre-existing planimetric networks were integrated by newly established benchmarks and measured contemporeaneously by temporary GPS observations. This work led to the realization of a network of 34 sites in Central and Southern Calabria.

9.6 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 is underway that 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.

Newly available resources in the framework of the ReSiSCal program (Rete Sismica Scolastica Calabrese = Scholastic Calabrian Seismic Network) allowed a revival of this long-term project. This program was founded by the Culture Dept of the Calabrian Regional Government and is aimed to install a set of seismic stations equipped with professional instruments in some secondary schools distributed all over the Calabrian territory. A first high-quality seismographic station, equipped with broad-band seismographic sensor and high dynamic electronics, started to operate in autumn 2007. Its signals are recorded and utilized also by the National Earthquake Center of INGV in Rome.

D PRESENTATIONS AT CONFERENCES

D.1 Presentations at international conferences in 2007

1. I. Guerra
   Recent geodetic surveys and seismic activity in Central Calabria
   "Calabrian Arc Project" Workshop – Lamont-Doherty Earth Obs., Columbia Univ., Palisades, New York, 29-31-Aug 2007.

D.2 Presentations at national conferences in 2007

1. Zimbardo G., Greco A., Zoltan V., Amata E., Taktakishvili A.L., Carebone V., Sorriso-Valvo L. and Guerra I.
   Solar-Terrestrial relations: Magnetic turbulence in the Earth's magnetosphere and geomagnetic activity
   2nd European general assembly of the IHY, Torino, Giugno 2007.

2. Vecchio A. , Carbone V. and Guerra I.
   A statistical analysis of polarity reversals of the geomagnetic field
   26th Conv. Ann. GNGTS, Roma, 2007.

3. Gervasi A., Harabaglia P. , Rosa A.B., De Rose C. and Guerra I.
   Sismicità recente e strutture sismogenetiche nell'area del terremoto irpino del 1980: studio preliminare
   26th Conv. Ann. GNGTS, Roma, 2007.

4. Orecchio B., Gervasi A., Guerra I., Neri G. and Presti D.
   Evidenze di interazione fra strutture longitudinali e trasversali dell'Arco Calabro dall'analisi dell'attività sismica
   26th Conv. Ann. GNGTS, Roma, 2007.