UNIVERSITÀ DELLA CALABRIA
Dipartimento di FISICA

ANNUAL REPORT 2006

ACADEMIC YEAR 2005-2006

Scientific publications in 2006

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Introduzione

In occasione dell'esercizio di valutazione CIVR, che copriva gli anni dal 2001 al 2003, 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. Nel triennio seguente (2004-2006) il dipartimento di Fisica è ulteriormente cresciuto, sia come numero di professori e ricercatori (ormai oltre 50) che come numero di dottorandi ed assegnisti (oltre 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, 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 tre 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 calabrese. 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, in accordo con le indicazioni più recenti della CRUI, 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.

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

Introduction

Looking at the recent CIVR evaluation, covering 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 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, according the last suggestions by CRUI, 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.

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

Arcavacata di Rende, 28 giugno 2007

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:
11 Full Professors
23 Associate Professors
14 Senior Researchers
9 Representatives of PhD students
9 Representatives of the Technical and Administrative Staff

Administative Secretary:
Giocondo PERRI

RESEARCH PERMANENT STAFF

Full Professors

1. Roberto BARTOLINO	*FIS07*
2. Lev BLINOV	*FIS03*
3. Elio COLAVITA	*FIS07*
4. Giovanni FALCONE	*FIS01*
5. Ignazio GUERRA	*GEO10*
6. Antonino OLIVA	*FIS01*
7. Luigi PAPAGNO	*FIS01*
8. Luigi SPORTELLI	*FIS07*
9. Giancarlo SUSINNO	*FIS01*
10. Cesare UMETON	*FIS01*
11. Pierluigi VELTRI	*FIS03*

Associate Professors

1. Raffaele AGOSTINO	*FIS01*
2. Riccardo BARBERI	*FIS07*
3. Orazio BARRA	*FIS01*
4. Rosina BARTUCCI	*FIS07*
5. Assunta BONANNO	*FIS01*
6. Lorenzo CAPUTI	*FIS01*
7. Vincenzo CARBONE	*FIS03*
8. Enzo CAZZANELLI	*FIS03*
9. Gabriella CIPPARRONE	*FIS03*
10. Gennaro CHIARELLO	*FIS07*
11. Giovanni CROSETTI	*FIS01*
12. Roberto FIORE	*FIS02*
13. Laura LA ROTONDA	*FIS01*
14. Francesco MALARA	*FIS01*
15. Alessandro PAPA	*FIS02*
16. Francesco PIPERNO	*FIS03*
17. Nicola SCARAMUZZA	*FIS07*
18. Marco SCHIOPPA	*FIS01*
19. Enrico TASSI	*FIS01*
20. Carlo VERSACE	*FIS01*
21. Galileo VIOLINI	*FIS02*
22. Fang XU	*FIS01*
23.Gaetano ZIMBARDO	*FIS06*

Senior Researchers

1. Michele CAMARCA	*FIS01*
2. Marcella CAPUA	*FIS01*
3. Anna CUPOLILLO	*FIS01*
4. Maria DE SANTO	*FIS07*
5. Vincenzo FORMOSO	*FIS01*
6. Domenico GIULIANO	*FIS02*
7. Antonella GRECO	*FIS07*
8. Rita GUZZI	*FIS07*
9. Pasquale PAGLIUSI	*FIS07*
10. Francesco PLASTINA	*FIS01*
11. Leonardo PRIMAVERA	*FIS05*
12. Pierfrancesco RICCARDI	*FIS01*
13. Antonello SINDONA	*FIS01*
14. Giuseppe STRANGI	*FIS07*

Post-Doctoral Research Fellows

1.Cristina ADORISIO
2.Vincenzo BRUNO
3.Tommaso CARUSO
4.Francesco CAPORALE
5.Marco CASTRIOTA
6.Francesca CASTROVILLARI
7.Federica CIUCHI
8.Antonio DE LUCA
9.Domenico DI GIACOMO
10.Fabio LEPRETI
11.Enrico MACCALLINI
12.Donatella MARMOTTINI
13.Anna MASTROBERARDINO
14.Evelin MEONI
15.Giuseppina NIGRO
16.Marco ONOFRI
17.Pasquale PAGLIUSI
18.Manuela PANTUSA
19.Marco PAPAGNO
20.Francesco VALENTINI
21.Carlo VENA
22.Alessandro VELTRI
23.Rosa ZAFFINO
24.Bruno ZAPPONE

Phd Students in Physics

1. Mario COMMISSO *(XIX Cycle)*
2. Tony APOLLARO *(XIX Cycle)*
3. Sergio SERVIDIO *(XIX Cycle)*
4. Claudia GIALLOMBARDO *(XIX Cycle)*
5. Antonio POLICICCHIO *(XIX Cycle)*
6. Marianna BARBERIO s.b. *(XX Cycle)*
7. Rossella DE MARCO (*XX Cycle*)
8. Salvatore FAZIO (*XX Cycle*)
9. Alfonso POLICICCHIO (*XX Cycle*)
10. Sara RUDI s.b. (*XX Cycle*)
11. Daniela SALVATORE (*XX Cycle*)
12. Rossella FALCONE *(XXI Cycle)*
13. Mario GRAVINA *(XXI Cycle)*
14. Stefano MALETTA s.b. *(XXI Cycle)*
15. Maria MINNITI *(XXI Cycle)*
16. Silvia PERRI *(XXI Cycle)*
17. Antonio POLITANO *(XXI Cycle)*

Phd Students in Science and Tecnology of Mesophases and Molecular Materails

1. Habib AYEB *(XIX Cycle)*
2. Valentin BARNA *(XIX Cycle)*
3. Luciano DE SIO *(XIX Cycle)*
4. Salvatore MARINO *(XIX Cycle)*
5. Clementina PROVENZANO *(XIX Cycle)*
6. Sameh FERJANI (*XX Cycle*)
7. Luigia PEZZI (*XX Cycle*)
8. Giancarlo COSCHIGNANO (*XX Cycle*)
9. MariaRIVERA VELASQUEZ *(XXI Cycle)*
10. Tania RUGIERO *(XXI Cycle)*
11. Gaetano NICASTRO *(XXI Cycle)*
12. Stefano D'ELIA *(XXI Cycle)*
13. Houda SELLAME *(XXI Cycle)*
14. Mario Ariosto MATRANGA *(XXI 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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BARTOLINO Roberto	6122
BARTUCCI Rosina	6074-6073
BLINOV Lev	6124
BONANNO Assunta	6170-6178
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CAPUA Marcella	6022
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CHIARELLO Gennaro	6157-6174
CIPPARRONE Gabriella	6115-6148
COLAVITA Elio	6156-6174
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
SCARAMUZZA Nicola	6113-6151
SCHIOPPA Marco	6017-6104
SCIOMMARELLA Francesco	6011
SINDONA Antonello	6059
SPORTELLI Luigi	6076-6073
STABILE Fedele	6027
STRANGI Giuseppe	6120
SUSINNO Giancarlo	6016-6104
UMETON Cesare	6117-6152
VELTRI Pierluigi	6136-6033
VERSACE Carlo	6116-6147
VIAPIANA Giovanni	6053
VIOLINI Galileo	6024
VIVONA Sonia	6007
XU Fang	6168-6178
ZIMBARDO Gaetano	6134-6033

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 (2006)

19 gennaio 2006
Prof. I. Ginzburg, (*Sobolev IM, Novosibirsk*)
Symmetries of two-Higgs doublet models, different vacua and possible relation to the history of time

21 Febbraio 2006
Dott. A. Carollo
Transizioni di fase e fase di Berry

1 marzo2006
Dr. Igor Ivanov (*INFN Cosenza*)
Diffrazione adronica: nuove possibilità per lo studio dei mesoni eccitati

8 marzo 2006
Prof. Kristoffer Rypdal, (*Institutt for fysikk og teknologi, Tromsø)*
Reduced Lorenz models for profile resilience and anomalous transport

11 Aprile 2006
Dott. A. Romito (*Weizmann Institute*)
Charge transport in super conducting SET",

17 maggio 2006
Dott. Tommaso Caruso (*Dipartimento di Fisica, Università della Calabria*)
Struttura elettronica di film di Carbonio nanostrutturati assemblati da fasci di cluster supersonici

24 maggio 2006
Prof. Derek Marsh (*Max Planck Institute for Biophysical Chemistry, Goettingen, Germany*)
TOAC spin labels in the backbone of alamethicin: EPR studies in lipid membranes

30 maggio 2006
Prof. Derek Marsh (*Max Planck Institute for Biophysical Chemistry, Goettingen, Germany*)
Lipid-protein interactions: lateral pressure profile, spontaneous curvature frustration...

Ciclo di seminari dal 29 maggio al 1 giugno 2006
Prof. Dr. Klaus Hermann, (*MAX-Planck Institutions of Berlin)*
Crystallography of Metal Oxide Surfaces

31 Maggio 2006
Prof. Zdenek Sroubek, (*Academy of Sciences,Czech Republic)*
Ionization of metal particles emitted from metals

7 giugno 2006
Prof. Enzo Di Fabrizio, (*INFM, Trieste)*
Nanotechnology for biomedicine

7 giugno2006
Dott. F. Le Preti (*Dipartimento di Fisica, Università della Calabria*)
I brillamenti solari come processo stocastico: analisi delle proprietà statistiche e modelli

22 Giugno 2006
Prof. A.G. Petrov, *(Bulgarian Academy of Science)*
Liquid Crystals in biology and medicine

23 Giugno 2006,
Prof. A.G. Petrov, *(Bulgarian Academy of Science)*
Liquid crystal physics and the physiscs of soft matter

20 Giugno 2006
Prof. C. Rosenblatt , (*Western Case Reserve Univerity, Cleveland, Ohio, USA)*
Nanocontrol and nanoimaging of liquid crystals

21 Giugno 2006
Prof. A.G. Petrov, *(Bulgarian Academy of Science)*
Flexoelectric effects in biological membranes

12 luglio 2006
Dott.ssa E. Meoni (*Dipartimento di Fisica, Università della Calabria*)
La fisica dell'Higgs del Modello Standard ad LHC: studio del canale H->ZZ->4 muoni con l'esperimento ATLAS*

14 luglio 2006
Dott. B. Alles (*INFN-Pisa*)
Study of the restoration of symmetries at the phase transition in finite density QCD with two colors

20 luglio 2006
Dr. Tibor Pali, (*Biological Research Centre, Szeged, Hungary)*
Spin label EPR studies of a membrane bound molecular machine: the vacuolar proton-ATPase

28 settembre 2006
Dott: Gianluigi Filippelli (*Dipartimento di Fisica, Università della Calabria*)
Rappresentazioni proiettive: Applicazioni alla teoria quantistica

3 ottobre 2006
Dr. Carlo Bruno *(Dipartimento di Fisica, Università della Calabria*)
Sviluppo di un calorimetro a fibre scintillanti per la dosimetria assoluta indipendente dal rateo di dose

4 Ottobre 2006
Prof. Volodya Kossobokov, (*International Institute of Earthquake Prediction Theory and Mathematical Geophysics, Russian Academy of Sciences)*
Earthquake Prediction: Principles, Implementation, Perspectives

10 ottobre 2006
Sergio Servidio (*Dipartimento di Fisica, Università della Calabria*)
Complexity in Astrophysical and Laboratory Plasmas

11 ottobre 2006
Dott. Antonio Policicchio (*Dipartimento di Fisica, Università della Calabria*)
Rare beauty decays with ATLAS detector at LHC and MDT chamber performances

11 ottobre 2006
Dott. Dario Zappalà (*INFN Catania*)
Rinormalizzazione della funzione d'onda di campi scalari tramite Gruppo di Rinormalizzazione

12 ottobre 2006
Dr.ssa C. Giallombardo (*Dipartimento di Fisica, Università della Calabria*)
Diffusion and implantation of dopants in carbon nanotubes: a spectroscopic investigation of chemical and electronic properties

12 ottobre 2006
Prof. Maurizio Consoli (*INFN Catania*)
Esperimento di Michelson - Morley e misure recenti

12 ottobre 2006
Dott. M. Commisso (*Dipartimento di Fisica, Università della Calabria*)
Emissione di elettroni nell'interaz. di fasci ionici ed elettronici con superfici metalliche e campioni di nanotubi di carbonio

16 ottobre 2006
Dott. Pietro Giudice (*Univ. Torino*)
k-string fluctuations: a study in the 3d Z_4 gauge theory

16 Ottobre 2006
Dott.ssa Rosita De Bartolo (*Dipartimento di Fisica, Università della Calabria*)
Three-Dimensional Hybrid code for Earth's Magnetotail Dynamics

18 ottobre 2006
Prof. Paolo Ciambelli (*Università di Salerno*)
CCVD: una tecnica versatile per la preparazione di nanotubi di carbonio

18 ottobre 2006
Prof.ssa Petra Rudolf , *(University of Groningen)*
Surface Science Research at the MSCplus: Organic thin films, metal clusters ...

19 ottobre 2006
Prof. Arturo Tagliacozzo (*Università di Napoli "Federico II*)
Mesoscopic Conductance Fluctuations in High-Tc Superconducting Grain-Boundary Junction

19 Ottobre 2006
Prof. Arturo Tagliacozzo (*Università di Napoli "Federico II*)
Mesoscopic Conductance Fluctuations in YBaCuO High-Tc Superconducting Grain Boundaries

19 Ottobre 2006
Prof.ssa Angela Agostiano*, (Dipartimento di Chimica, Università di Bari)*
Colloidal Nanocrystals as building block for supramolecular architectures

21 novembre 2006
Prof. T. Bellini (*UniMi*)
Fasi liquido cristalline di frammenti di DNA in soluzioni concentrate

5 dicembre 2006
Prof. C. Ktorides (*Univ. Athens*)
A non-perturbative, AdS/CFT motivated approach to the description of the Pomeron

6 dicembre 2006
Prof. B. Ermolaev (*Ioffe PTI, St. Petersburg*)
Total resummation of the leading logarithms of x vs Standard Approach for the Polarized DIS

12 dicembre 2006
Dott. L. Cosmai (*INFN-Bari*)
Esperimenti numerici sulla struttura del vuoto di QCD

13 dicembre 2006
Prof. P. Cea (*Universita`di Bari*)
Universo ellissoidale

13 Dicembre 2006
Prof. M. De Crescenzo (*Universita' di Roma "Tor Vergata*")
Photocurrent generation in carbon nanotubes and Si nanotubes characterization

LAUREA THESIS' IN 2006

May 3

Francesco FRANCICA
Condivisione dell'entanglement in un modello spin-bosone
Relatore: Dr. Francesco PLASTINA

Francesco DE SIMONE
Studi di Eco di Spin Elettronico su Complessi di Acidi Stearici/Albumina Umana
Relatore: Prof.ssa Rosa BARTUCCI

Domenico SALERNO
Modelli per la dispersione degli inquinanti in atmosfera.Applicazione dei codici di calcolo:CALINE 4,HYSPLIT 4.7.al centro urbano di Crotone
Relatore: Prof. Giovanni FALCONE

Emanuela BRUNO
Caratterizzazione di film sottili di Ossidi Ferroelettrici preparati con la tecnica sol-gel mediante differenti tecniche di Microscopia a Sonda.
Relatore: Prof. Nicola SCARAMUZZA

July 27

Concetta MAZZOTTA
Studio della resistenza alla radiazione di gamma e neutroni delle camere di precisione per muoni dell'esperimento ATLAS
Relatore: Prof. Marco SCHIOPPA

1st LEVEL DEGREE THESIS' IN 2006

July 27

Rossella MARTINO
Trasporto degli elettroni negli archi coronali.
Relatore: Prof. Gaetano ZIMBARDO

Roberta RASO
Studio delle propriet‡ elettroniche di nanotubi drogati con atomi di azoto mediante impiantazione ionica.
Relatore: Prof. Luigi PAPAGNO

Giuseppe PUCCI
Forze su scala nanometrica e microscopia a forza atomica
Relatore: Dr.ssa Maria Penelope DE SANTO

Ernesto PECORA
Misure di microscopia elettronica in trasmissione di nanostrutture metalliche su substrato di carbonio.
Relatore
Dr. Vincenzo FORMOSO

Giuseppe NISTICÒ
Correlazione tra le particelle energetiche di origine solare, le onde di EIT nella corona e le Coronal Mass Ejections.
Relatore: Gaetano ZIMBARDO

Angelica RANIA
Controlli di qualità su un Linac da 6 MV per radioterapia a fasci esterni.
Relatore: Prof. Antonino OLIVA

Elio MASCIARI
Analisi delle propriet‡ elettriche in nanostrutture di carbonio.
Relatore: Dr. Michele CAMARCA

October 11

Vincenzo LAVORINI
Misura del tempo caratteristico di decadimento del leptone mu nello stato libero e nello stato legato IS dell'alluminio.
Prof. Marco SCHIOPPA

Aldo BRUNETTI
Statistiche di esclusione non fermioniche.
Relatore: Dr. Domenico GIULIANO

Daniele Carmine PARROTTA
Formazione di difetti in cristalli liquidi nematici
Dr.ssa Maria Penelope DE SANTO

Dicember 12

Vincenzo CAPPARELLI
Osservazioni di turbolenze nella bassa atmosfera solare
Prof. Vincenzo CARBONE

Luisa LIJOI
Analisi della turbolenza nel vento solare in periodo di alta attivit‡: misure di ISEE3.
Prof. Pierluigi VELTRI

Alfonso RUFFO
Lo strumento delle Wavelet nell'analisi dei segnali acustici
Relatore: Prof.ssa Assunta BONANNO

2nd LEVEL DEGREE THESIS' IN 2005

Dicember 11

Rehab BITANE
Entropia Kolmogorov per il campo magnetico dei loop coronali.
Relatore: Prof. Gaetano ZIMBARDO

Raffaele MARINO
Una relazione esatta per il trasporto di energia turbolenta nella cascata MHD: applicazione al vento solare.
Relatore: Prof. Vincenzo CARBONE

Gianluca DE MASI
Interazione tra modi di grvità e struttura convettiva nel sole
Relatore: Prof. Pierluigi VELTRI

Pierluigi VELTRI
Analisi POD di scintigrafie renali sequenziali.
Relatore: Prof. Vincenzo CARBONE

PhD THESIS' in 2006 (19° Cycle)

10 ottobre 2006
Sergio Servidio (*Dipartimento di Fisica, Università della Calabria*)
Complexity in Astrophysical and Laboratory Plasmas

11 ottobre 2006

Dott. Antonio Policicchio (*Dipartimento di Fisica, Università della Calabria*)
Rare beauty decays with ATLAS detector at LHC and MDT chamber performances

12 ottobre 2006
Dr.ssa C. Giallombardo (*Dipartimento di Fisica, Università della Calabria*)
Diffusion and implantation of dopants in carbon nanotubes: a spectroscopic investigation of chemical and electronic properties.

12 ottobre 2006
Dott. M. Commisso (*Dipartimento di Fisica, Università della Calabria*)
Emissione di elettroni nell'interaz. di fasci ionici ed elettronici con superfici metalliche e campioni di nanotubi di carbonio.

12 ottobre 2006
Dott. Tony John Apollaro (*Dipartimento di Fisica, Università della Calabria*)
Properties of Entanglement in a Spin Chain with Impurities

1. ASTROPHYSICS

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Introduction

The research in Astrophysics in the Physics Department of University of Calabria is mainly devoted to study plasmas. 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 (Palermo, Basilicata) and with Italian Institutions (IFSI - CNR of Frascati, RFX - CNR of Padova, Osservatorio di Capodimonte) and foreign Institutions (Observatoire de Paris-Meudon, Space Research Institute, Moscow, University of California at San Diego, Aristotle University of Thessaloniki, Abastumani Astrophysical Observatory, Tbilisi, Georgia, and the NASA Goddard Space Flight Center). The specific research themes under study during the year 2006 are indicated in the following.

1.1 PLASMA ASTROPHYSICS

1.1.1 Magnetohydrodynamic waves and turbulence in the solar atmosphere and in the solar wind

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 micro-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 micro-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, apart for 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 models of nanoflares

Energy injection in closed coronal structures by photospheric motions takes place mainly at time scales much larger than the Alfvén transit time. Nevertheless, fluctuations at frequencies larger than the photospheric driver can be excited by resonance phenomena, in form of standing Alfvénic fluctuations trapped inside the magnetic structure. Nonlinear interactions move the associated energy to small spatial scales, mainly in the direction perpendicular to the magnetic field. We studied such a phenomena by means of a shell model based on the reduced MHD equations, which accounts both for resonance and for nonlinear couplings. The model predicts time intermittency in the energy release at small scales; the statistical features predicted by the model favorably compare with observations. A comparison with intermittent structures observed in the solar wind turbulence suggests that coronal nano and microflares can be related to the dissipation of propagating current sheets at very small perpendicular wavelengths.

Particle acceleration by Fermi mechanism

In 1949 E. Fermi introduced a model that describes the acceleration of charged particles to very high energies, thus explaining the observed spectral properties of cosmic rays. The Fermi's model is based on the estimation of the probability of the occurrence of stochastic encounters of a charged particle with magnetized interstellar clouds. We investigated the dynamics of a realization of Fermi's relativistic acceleration mechanism that is a charged test particle oscillating between two reflecting plates that moves stochatiscally. By allowing the charge to radiate energy during each collision, we find that two main features of the system: 1) due to the radiation drag the energy gained by the particle is bounded, 2) the radiated energy represents a typical realization of an on-off intermittent process, due to numerous encounters with a very small emission, interrupted by short and intense bursts of radiation. This intermittent radiative process exhibits non-gaussian statistical features.

Turbulence and particle acceleration in microflares

Acceleration of high-energy particles represents a way to release energy in high-energy phenomena like solar flares. Similar features have been observed also in microflares, though at lower energies. A class of models relates particle acceleration to turbulence and it is based on wave-particle resonant interaction. We tried to include the effects of MHD turbulence intermittency, which were neglected in previous models; such effects mainly appears at small scales where the acceleration mechanism is more efficient. Our model treats nonresonant electron acceleration by kinetic Alfvén waves; such waves propagate quasi-perpendicularly at wavelengths comparable with the proton Larmor radius. Then, they should be naturally generated in the strongly magnetized coronal plasma within an MHD turbulence at the smallest scales. The model shows that during a microflare a power-law tail of suprathermal particles forms, reaching energies which can be of the order of 100 keV. Several features in the results of the model favorably compare with observations.

Turbulence and scale laws in the solar wind

The scale laws of turbulent low-frequency fluctuations in the solar wind have been studied in the past, mainly for the velocity field, and it has been shown that they are not different from those measured in ordinary fluids. The magnetic field presents characteristic scale laws which are similar to those of passive scalars measured in laboratory experiments. Such scale laws are also different from those of magnetic field observed in fusion plasmas. We have used spacecraft data to study problems related to the active or passive role that magnetic field plays in the solar wind. We have performed a series of statistical data analyses, using wavelet transform and based on: a) identification of intermittent events at all the scales; b) statistical properties as quiet times, Poissonian statistics, etc.; c) the possible interconnection between intermittent events in the velocity and magnetic field. We have studied the scale laws of fluctuations of the angle between magnetic and velocity field, at different scales and at different distances from the Sun. Hence, from MHD equations we have phenomenologically obtained the scale laws of the defined quantities. We also have found an exact law for MHD turbulence, analogous to the well known 4/5 law of Kolmogorov for the ordinary fluids. We have verified such relation from Ulysses spacecraft data, thus proving that solar wind is in a state of fully developed turbulence. These comparisons can be used as a further test to verify to which extent MHD describes solar wind turbulence.

Turbulence generated by magnetic tearing instabilities

In the Earth magnetotail current sheet, as well as in the current sheet of a plasma device as the RFX, a higher turbulence level has been identified, whose origin is probably the tearing instability which develops in the presence of a polarity inversion of the magnetic field. The nonlinear evolution of such instability generates a turbulence through energy transfer from large to small scales. It is also responsible for the formation of large scale structures in consequence of magnetic island coalescence. A 3D MHD simulation code has been built up to study a configuration where unstable modes develop at different resonance surfaces. The results show that in the presence of a guide field the nonlinear evolution is characterized not only by mode coalescence on a single resonant surface but also by a direct energy cascade to resonant surfaces increasingly distant from the current sheet center, with the consequent formation of small scale structures on the sides. We have studied the spectral properties of the resulting turbulence, as spectral index and anisotropy, at different locations within the current sheet. Such properties can be compared with measures in the magnetotail current sheet.

Models of spatio-temporal intermittency in fully developed turbulence

Modeling the intermittent behaviour of turbulent energy dissipation processes both in space and time is often a relevant problem when dealing with phenomena occurring in high Reynolds number flows, especially in astrophysical and space fluids. We have proposed a dynamical model to describe the spatio-temporal intermittency of energy dissipation rate in a turbulent system. This is done by using a shell model to simulate the turbulent cascade and introducing some heuristic rules, partly inspired by the well known p-model, to construct a spatial structure of the energy dissipation rate. In order to validate the model and to study its spatially intermittency properties, a series of numerical simulations have been performed. These show that the level of spatial intermittency of the system can be simply tuned by varying a single parameter of the model and that scaling laws in agreement with those obtained from experiments on fully turbulent hydrodynamic flows can be recovered. We suggest that the model could represent a

useful tool to simulate the spatio-temporal intermittency of turbulent energy dissipation in those high Reynolds number astrophysical fluids where impulsive energy release processes can be associated to the dynamics of the turbulent cascade.

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 modeled 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 behavior 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.

1.2 NORMAL AND ANOMALOUS TRANSPORT PROCESSES IN THE HELIOSPHERE

High energy charged particle diffusion 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.

Anomalous diffusion in the Earth magnetopause and magnetotail

A relevant level of magnetic turbulence is observed by spacecraft both inside and around the magnetosphere. Such a turbulence can be excited either by shear flows in the magnetosheath and magnetotail, by magnetic reconnection, or by kinetic instabilities of the mirror type of two-stream type. We made a comparative analysis of this turbulence in the different magnetospheric regions. Magnetic and plasma turbulence have a strong influence on transport and energization phenomena. The plasma transport across the magnetopause has been studied by a test particle simulation in which a sheared background magnetic field is included, as well as a model turbulence similar to that observed in the Earth magnetopause. This model has allowed us to calculate the plasma flux across the magnetopause. We are now considering the transport of ionospheric oxygen across the magnetopause, in connection with turbulence in the cusp regions. The numerical results shown that oxygen ions can cross the magnetopause more easily than hydrogen ions, but are heated less. On the other hand, they can acquire a substantial level of ordered kinetic energy because of their large gyroradius.

Anomalous transport processes in the solar transition region and in coronal loops

The solar transition region represents the border between a region dominated by a collisional transport (photosphere) and a non-collisional region (the corona). In order to study the transport processes in these conditions we have developed a new Montecarlo numerical code which iteratively solves the Boltzmann equations. It allows us to calculate the evolution of electron distribution function and to evaluate the departures from a Maxwellian. The code has allowed us to build a new model of the solar transition region. We present the results obtained when starting with a Maxwellian distribution function at the lower boundary, but solving the collisional Boltzmann equation, which is better suited to describe both the collisional low altitude region and the corona where collisions do not occur very frequently.

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 collegues 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.

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. In contrast with the one-fluid MHD models, the particle or hybrid simulations can provide information about current carriers. In this study the magnetotail is modeled as a magnetic field reversal with a normal magnetic field component where no magnetic fluctuations were initially added. 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.

1.4. LABORATORY PLASMAS

1.4.1 Simulations of nonlinear kinetic waves by Vlasov codes

In kinetic theory, the time evolution of the distribution function obeys a continuity equation (Vlasov equation), when collisions between particles are absent. The Vlasov equation is a nonlinear partial differential equation, whose analytical solution is available only in a few simplified linear cases, but the nonlinear regime, including the most interesting physical phenomena, must be investigated numerically. We recently developed a numerical scheme for the integration of the Vlasov-Maxwell system of equations for a non-relativistic plasma in a five-dimensional phase space (2D in physical space and 3D in velocity space), in hybrid approximation, where the Vlasov equation is solved for the ion distribution function and the electrons are treated as a fluid. In the Ohm equation for the electric field, effects of electron inertia have been retained, in order to include the small scale dynamics up to characteristic lengths of the order of the electron skin depth. The low frequency approximation is used by neglecting the time derivative of the electric field, i.e. the displacement current in the Ampere equation. The code is implemented in a parallel version to exploit the computational power of the modern massively parallel supercomputers and it is particularly indicated for the numerical analysis of physical phenomena in the range of frequencies around the ion cyclotron frequency. Recent numerical simulations showed that a temperature anisotropy in the ion distribution function is produced as a result of a 1D-turbulent cascade of Alfvén waves, when the energy is transferred to length scales of the order of the ion skin depth.

1.4.2. Self-organization in dynamical models of laboratory plasmas

We investigated the inviscid nonlinear dynamics of a low-beta plasma, through a dynamical system obtained by a Galerkin projection of MHD equations. We show that a single Fourier mode dominates over the whole energy spectrum, a self-organization mechanism within turbulence being responsible for this effect. Our results are in agreement with observations of an analogous phenomenon, say the emergence of a quasi single-helicity stato in reversed field pinch laboratory plasmas.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2006

1. Carbone V., Sorriso-Valvo L., Vecchio A., Lepreti F., Veltri P., Harabaglia P., Guerra I.,
   Clustering of Polarity Reversals of the Geomagnetic Field,
   Physical Review Letters **96**, 128501-1--128501-4 (2006).

2. Chiaravalloti F., Milovanov A.L., Zimbardo G.,
   Self-similar transport processes in a two-dimensional realization of multiscale magnetic field turbulence,
   Physica Scripta **T122**, 79-88 (2006) .

3. Zimbardo G., Pommois P., Veltri P.,
   Superdiffusive and subdiffusive transport of energetic particles in solar wind anisotropic magnetic turbulence,
   Astrophysical Journal **639**, L91-L94 (2006)

4. Décamp N., Malara F.,
   Particle acceleration and intermittent turbulence in coronal loops,
   Astrophys. J. Lett. **637**, L61-L64 (2006) .

5. Vecchio A.,
   A full-disk analysis of pattern of solar oscillations and supergranulation,
   Astronomy and Astrophysics **446**, 669V- (2006) .

6. Vecchio A., Primavera L., Carbone V.,
   Periodic and aperiodic travelling pulses in population dynamics: an example from the occurrence of epidemic infections,
   Physical Review E **73**, 031913-1 -- 031913-6 (2006)

7. Valentini F., O'Neil T., Dubin D.,
   Excitation of nonlinear electron acoustic waves,
   Physics of Plasmas **13**, 052303-1-052303-7 (2006) .

8. Bruno R., Bavassano B., D'Amicis R., Carbone V., Sorriso-Valvo L. and Pietropaolo E.,
   On the Radial Evolution of Alfvénic Turbulence in the Solar Wind,
   Space Science Reviews **122**, 321-328 (2006).

9. Sorriso-Valvo L., Carbone V., Bruno R. and Veltri P.,
   Persistence of small-scale anisotropy of magnetic turbulence as observed in the solar wind,
   Europhysics Letters **75**, 832-838 (2006).

10. D'Amicis R., Bruno R., Bavassano B., Carbone V., Sorriso-Valvo L.,
    On the scaling of waiting-time distributions of negative IMF Bz component,
    Annales Geophysicae **24**, 2735-2741 (2006).

11. Lepreti F., Carbone V., Veltri P.,
    Model for intermittency of energy dissipation in turbulent flows,
    Physical Review E **74**, 026306-1-026306-9 (2006).

12. Onofri M., Isliker H., Vlahos L.,
    Stochastic Acceleration of Turbulent Electric Fields Generated by 3D Reconnection,
    Physical Review Letters **96**, 151102 (2006).

13. De Bartolo R., Carbone V.,
    The role of the basic three--modes interaction during the free decay of Magnetohydrodynamic turbulence,
    Europhysics Letters **73**, 547-552 (2006).

14. De Marco R., Carbone V., Veltri P.,

A modified Fermi model for wave--particle interactions in plasmas,
Physical Review Letters **96**, 125003 (2006).

15. Zimbardo G.,
Magnetic turbulence in space plasmas: in and around the Earth's magnetosphere,
Plasma Physics and Controlled Fusion **48**, B295-B302 (2006).

16. Vecchio A., Carbone V., Lepreti F., Primavera L., Sorriso-Valvo L., Veltri P., Straus Th.,
POD analysis of photospheric velocity field: solar oscillations and granulation,
Memorie della Società Astronomica Italiana, Supplementi **9**, 63-66 (2006).

17. Zimbardo G., Pommois P., Ippolito A., Veltri P.,
Angular size of coronal mass ejections deduced from energetic particle observations,
Memorie della Società Astronomica Italiana, Supplementi **9**, 75-78 (2006)

A.1.2 Publications on international journals accepted in 2006

1. M. Gkioulidou, G. Zimbardo, P. Pommois, P. Veltri, L. Vlahos,
High energy particle transport in stochastic magnetic fields in the solar corona,
in press on Astronomy and Astrophysics.

2. P. Pommois, G. Zimbardo, and P. Veltri,
Anomalous, non-Gaussian transport of charged particles in anisotropic magnetic turbulence,
in press on Physics of Plasmas.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2006

1. Décamp N., Malara F.,
Electron acceleration in turbulent coronal loops by kinetic Alfvén waves,
in SOHO 17 – 10 Years of SOHO and Beyond - published on CD ROM, H. Lacoste, ESA Publications Division (2006) .

2. Zimbardo G., Ippolito A., Veltri P., and Pommois P.,
Correlation between flares, energetic particle propagation in solar wind turbulence, and the angular size of coronal mass ejections,
in Proceedings of Soho17: 10 years of Soho and beyond, ESA SP-617, H. Lacoste, ESA Publications Division, Noordwijk, Netherlands, pp. P204 (2006).

3. Gkioulidou M., Zimbardo G., Pommois P., Veltri P., and Vlahos L.,
High energy particle transport in stochastic magnetic fields in coronal loops,
in Proceedings of Soho17: 10 years of Soho and beyond, ESA SP-617, H. Lacoste, ESA Publications Division, Noordwijk, Netherlands, pp. P203 (2006).

4. Valentini F., O'Neil T. M., D. H. E. Dubin,
Excitation and Decay of Electron Acoustic Waves,
in Workshop on Nonneutral Plasma Physics (2006).

5. A. Kabantsev, F. Valentini, and C. F. Driscoll,
Experimental Investgation of Electron-Acoustic Waves in Electron plasmas,
in Workshop on Nonneutral Plasma Physics (2006).

6. Vecchio A., Carbone V., Lepreti F., Veltri P., Straus Th., Sorriso-Valvo L.,
The interplay between complex pattern formation and global dynamics of the photosphere,
in Proceedings of the conference "SOHO 17: 10 Years of SOHO and Beyond", ESA SP-617, H. Lacoste, ESA Publications Division, Noordwijk, Netherlands (2006).

7. Lepreti F., Carbone V., Veltri P.,
A dynamical model for the spatio-temporal intermittency of the turbulent energy cascade: first results and possible applications to coronal loops,

in Proceedings of Soho 17: 10 Years of Soho and beyond", ESA SP-617, H. Lacoste, ESA Publications Division, Noordwijk, Netherlands (2006).

8. Onofri M., Primavera L., Malara F., Veltri P.,
A numerical code for studying the compressible MHD turbulence in a Reversed Field Pinch device,
in 33rd EPS Conference on Plasma Physics, F. De Marco, G. Vlad, Europen Physical Society, pp. P4.161 (2006).

9. S. Servidio, V. Carbone, P. Veltri, L. Primavera, F. Malara, K. Stasiewicz,
Numerical simulation of small-scale fluctuations in space plasmas: compressible turbulence in Hall Magnetohydrodynamics,
in 33rd EPS Conference on Plasma Phys. Rome, 19 - 23 June 2006 ECA Vol.30I, O-5.009 (2006).

10. Kossobokov V., Lepreti F., Carbone V., Harabaglia P., Guerra I.,
Complessità nelle serie temporali di eventi sismici e brillamenti solari, in Riassunti estesi delle comunicazioni al 25° Convegno Nazionale del Gruppo Nazionale di Geofisica della Terra Solida (GNGTS), GNGTS, Trieste, pp. 49-49 (2006).

C INVITED PRESENTATIONS

C1. Invited presentations at international conferences in 2006

1. Valentini F., O'Neil T. M., Dubin D. H. E.,
Excitation of nonlinear Electron Acoustic Waves,
NNP06, Workshop on Non Neutral Plasma Physics, Aarhus (Denmark), 26/06 -30/06 (2006).

2. Zimbardo G.,
Magnetic turbulence in collisionless plasmas: in and around the Earth's magnetosphere,
33rd European Physical Society Conference on Plasma Physics, Roma, June 19 – 23, 2006.

3. Veltri P.,
MHD Turbulence through the Heliospere,
First European General Assembly of the International Heliophysical Year, Paris, 10/01-13/01 (2006).

4. V. Carbone,
Turbulence in space plasmas,
American Geophysical Union general assembly (AGU Fall Meeting), December, 11-15, 2006, S. Francisco CA (USA).

C.2 Invited presentations at national conferences in 2006

1. Lepreti F., Carbone V., Malara F., Nigro G., Veltri P.,
Magnetohydrodynamic turbulence in the active regions of the solar atmosphere,
XCII Congresso Nazionale della Società Italiana di Fisica (SIF), Torino, 18/09-23/09 (2006).

2. Zimbardo G.,
Turbulence and transport in astrophysical plasmas,
Scuola Nazionale di Astrofisica, Ciclo VIII, corso IV, Trieste, 1 ottobre-6 ottobre 2006.

D PRESENTATIONS AT CONFERENCES

D1. Presentations at international conferences in 2006

1. Carbone, V.; Sorriso-Valvo, L.; Vecchio, A.; Lepreti, F.; Veltri, P.; Guerra, I.; Harabaglia, P.,
The clustering of polarity reversals of the geomagnetic field: a constraint for geodynamo modelling,
E.G.U. 2006, Wien, April 2-April 7 2006.

2. Vecchio A., Carbone V., Lepreti F., Primavera L., Sorriso-Valvo L., Veltri P., Alfonsi G., Straus Th.,
Proper Orthogonal Decomposition of Solar Photospheric Motions,
E.G.U. 2006, Wien, April 2-April 7 2006.

3. Vecchio A., Primavera L., Sorriso-Valvo L., Carbone V.,
Periodic behavior and stochastic fluctuations of solar activity: Proper Orthogonal Decomposition analysis,

E.G.U. 2006, Wien, April 2-April 4 2006.

4. Sorriso-Valvo L., Carbone V., Bruno R.,
Small scale anisotropy of interplanetary magnetic field,
E.G.U. 2006, Wien, April 2-April 4 2006.

5. Sorriso-Valvo L., Carbone V., Guerra I., De Rose C., Harabaglia P.,
Non-poisson statistics of quiet times in seismic time series: a local test,
E.G.U. 2006, Wien, April 2-April 7 2006.

6. Greco A., De Bartolo R., Veltri P., Zimbardo G.,
The role of electrons in the formation of double peak in the cross-tail current density by using a three-dimensional hybrid code,
EGU 2006, Wien, April 2-April 7 2006.

7. Zimbardo G., Pommois P., Veltri P.,
Numerical simulation of anomalous, non Gaussian transport of charged particles in anisotropic magnetic turbulence,
EGU 2006, Wien, April 2-April 7 2006.

8. Kabantsev A. A., Driscoll C. F., Valentini F.,
Experimental Investigation of Electron Acoustic Waves in Electron Plasmas,
NNP06, Workshop on Non Neutral Plasma Physics, Aarhus (Denmark), 26/06 - 30/06 (2006).

9. Valentini F., O'Neil T. M., Dubin D. H. E., Kabantsev A. A., Driscoll C. F.,
Excitation of nonlinear electron acoustic waves,
Second International Workshop on the Theory and Applications of the Vlasov equation, Firenze (Italy), September 18-September 20 2006

10. Valentini F., O'Neil T. M., D. H. E. Dubin,
Excitation of nonlinear Electron Acoustic waves,
APS meeting, 48th Annual Meeting of the Division of Plasma Physics, , October 30-November 3, 2006.

11. Greco, R. De Bartolo, G. Zimbardo, P. Veltri,
A Three-dimensional Hybrid Code to Study the Magnetotail Dynamics: the Role of Electrons in the Formation of the Bifurcated Current Sheet, AGU Fall Meeting, San Francisco, December 11 – 15, 2006.

12. Bruno, R., D'Amicis, R., Bavassano, B., Cattaneo, M.B., Carbone, V. and Sorriso-Valvo, L.,,
Observing MHD turbulence around 0.2 AU,
Second Solar Orbiter workshop, Athens, October 16 - 20 October 2006.

13. Sorriso-Valvo, L.,
The clustering of polarity reversals of the geomagnetic field: a constraint for geodynamo modelling,
Réunion GDR Turbulence - Dynamo, Nice, November 3-6, 2006.

14. Onofri M., Primavera L., Londrillo P., Malara F., Veltri P.,
A numerical code for studying the compressible MHD turbulence in cylindrical geometry with appropriate boundary conditions,
33rd European Physical Society Conference, Roma, June 19 – 23, 2006.

15. Vecchio A., Carbone V., Lepreti F., Veltri P., Straus Th., Sorriso-Valvo L.,
The interplay between complex pattern formation and global dynamics of the photosphere,
Soho 17: 10 years of Soho and beyond, Giardini Naxos (ME), May 07 – 12, 2006.

16. Lepreti F., Carbone V., Veltri P.,
Dynamical model for the spatio-temporal intermittency of the turbulent energy cascade: first results and possible applications to coronal loops,
Soho 17: 10 years of Soho and beyond, Giardini Naxos (ME), May 07 – 12, 2006

17. Zimbardo G., Pommois P., Veltri P.,
Numerical simulation of anomalous, non Gaussian transport of charged particles in anisotropic magnetic turbulence, European Geoscience Union, General Assembly, Vienna, April 2 – 7, 2006.

18. Zimbardo G., Pommois P., Veltri P.,
Superdiffusive and subdiffusive transport of energetic particles in solar wind anisotropic turbulence,
American Geophysical Union Joint Assembly, Baltimore, USA, May 23 – 26, 2006.

19. Zimbardo G., Ippolito A., Veltri P., and Pommois P.,
Correlation between flares, energetic particle propagation in solar wind turbulence, and the angular size of coronal mass ejections,
Soho 17: 10 years of Soho and beyond, Giardini Naxos, Taormina, May 7 – 12, 2006.

20. Gkioulidou M., Zimbardo G., Pommois P., Veltri P., and Vlahos L.,
High energy particle transport in stochastic magnetic fields in coronal loops,
Soho17: 10 years of Soho and beyond, Giardini Naxos, Taormina, May 7 – 12, 2006.

21. Zimbardo G., Martino R., Veltri P.,
Electron transport regimes and magnetic turbulence levels in coronal loops,
Second Solar Orbiter Workshop, Athens, October 16 – 20, 2006.

22. Rossana De Marco, Vincenzo Carbone, Pierluigi Veltri,
A Fermi-like model for wave-particle interaction in plasmas,
33rd European Physical Society Conference On Plasma Physics, Roma, 19/06/-23/06 2006.

23. Malara F., Decamp N.,
Electron acceleration in turbulent coronal loops by kinetic Alfvén waves,
Soho17: 10 years of Soho and beyond, Giardini Naxos, Taormina, May 7 – 12, 2006.

24. V. Carbone,
Compressible turbulence in Hall Magnetohydrodynamics,
International Conference on "Dynamical Processes in Space Plasmas", Dead Sea - Israel, May 7-15 (2006).

25. V. Carbone, R. De Marco, P. Veltri,
A simple model for the wave-particle interactions,
International Workshop "Vlasovia 2006", 18-20 September 2006, Firenze (Italy).

Presentations at national conferences in 2006

1. Kossobokov V., Lepreti F., Carbone V., Harabaglia P., Guerra I.,
Complessità nelle serie temporali di eventi sismici e brillamenti solari,
25° Convegno Nazionale del Gruppo Nazionale di Geofisica della Terra Solida (GNGTS), Roma, 28/11-30/112006.

2. FIELD THEORY IN PARTICLE PHYSICS AND IN CORRELATED SYSTEMS. MODELS AND MATHEMATICAL METHODS.

Professors and Researchers Roberto Fiore
Domenico Giuliano
Alessandro Papa
Galileo Violini

Postdoc fellows Igor Ivanov (INFN)
Donatella Marmottini
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)*
I.F. Ginzburg (*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*)
A.V. Kotikov (*Joint Institute for Nuclear Research, Dubna, Russia*)
P. Lucignano (*SISSA, Trieste, Italy*)
A. Merlani (*Istituto del Restauro, Roma, Italy*)
N.N. Nikolaev (*Forschungzentrum Jülich, Germany*)
F. Paccanoni (*Università di Padova & INFN-Padova, Italy*)
G. Pancheri (*Laboratori Nazionali di Frascati, INFN, Italy*)
E. Salusti (*Università di Roma – La Sapienza, Italy*)
A.A. Savin (*DESY, Hamburg, Germany*)
P. Sodano (*Università di Perugia & INFN-Perugia, Italy*)
Y. Srivastava (*Università di Perugia & INFN-Perugia, Italy)*
A. Tagliacozzo (*Università di Napoli, Italy*)
V.R. Zoller (*ITEP, Moscow, Russia*)

Introduction

The research activity during the AA 2005-06 included the following subjects:

- phenomenology of hadron collisions and Quantum Chromodynamics (QCD) in the high-energy limit;
- electroweak theory beyond the standard model;
- 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 multi-Regge form of QCD amplitudes with gluon exchanges has been proved in the next-to-leading approximation. The proof is based on the bootstrap relations, which are required for the compatibility of this form with the *s*-channel unitarity.

The "non-Abelian" part of the quark contribution to the BFKL kernel in the next-to-leading order (NLO) has been found in the coordinate representation by direct transfer of the contribution from the momentum representation where it was calculated before. This representation is convenient to study the conformal properties of the NLO BFKL kernel and
of the relation between the BFKL and color dipole approaches.

The amplitude for the forward electroproduction of two light vector mesons in next-to-leading order BFKL has been calculated. It is written as a convolution of two impact factors for the virtual photon to light vector meson transition with the BFKL Green's function. A study of the systematic effects in the determination of this amplitude has been
carried out, by considering different representation for the amplitude and different optimization methods of the perturbative series.

2.1.2 Hadron Phenomenology

A simple analytic expression has been found for the (spin-averaged) neutrino-nucleon cross section for ultra-high energies at twist-2, obtained as the asymptotic limit of the previous findings. This expression gives values for the cross section in remarkable numerical agreement with the previous numerical evaluation in the energy region relevant for forthcoming neutrino experiments. The role and the relevance of saturation and recombination effects has been discussed in this approach, in comparison with other recent suggestions.

The shadowing effect has been studied in highly asymmetric diffractive interactions of left-handed and right-handed W-bosons with atomic nuclei. The target nucleus is found to be quite transparent for the charmed-strange Fock component of the light-cone W^+ in the helicity state $\lambda=+1$ and rather opaque for the *c* anti-*s* dipole with $\lambda=-1$. The shadowing correction to the structure function $\Delta xF_3 = xF_3^{\nu N} - xF_3^{\text{anti-}\nu\, N}$ extracted from ν Fe and anti-ν Fe data is shown to make up about 20% in the kinematical range of CCFR/NuTeV.

A review article has been published on the diffractive production of vector mesons.

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 deep-inelastic-scattering limits and fits the existing HERA data on deeply virtual Compton scattering.

It is suggested to measure Pomeron phase and discover odderon via the measurement of charge asymmetry of pions in the diffractive processes $ep \to e\,\pi^+\pi^-\,p$ and $eA \to e\,\pi^+\pi\,A$, and in the processes $A\,A \to A\,\pi^+\pi\,A$ with two rapidity gaps.

2.2 ELECTROWEAK THEORY BEYOND THE STANDARD MODEL

In the two-Higgs-doublet model, different Higgs doublets can be viewed as components of a generic "hyperspinor". The Higgs potential of this model has been decomposed into irreducible representations of the SU(2) group of transformations of this hyperspinor. Invariant combinations of the Higgs potential parameters are determined, which provide simple and concise sets of conditions for the hidden Z_2-symmetry, Peccei-Quinn symmetry, and
explicit CP-conservation.

The Higgs potential of 2HDM keeps its generic form under the group of transformation GL(2,C), which is larger than the usually considered reparametrization group U(2). This reparametrization symmetry induces the Minkowski space structure in the orbit space of 2HDM. Exploiting this property, a geometric analysis of the number and properties
of stationary points of the most general 2HDM potential has been performed, including the possible spontaneous CP-violation.

2.3 LATTICE GAUGE THEORIES

The mass spectrum of the 3d 3-state Potts model is 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 compare the mass spectrum with the prediction from universality of mass ratios in the 3d Ising class; in the case (b), we determine a mass ratio to be 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 agreement in the comparison in the case (a) would represent a non-trivial test of validity of the conjecture of spectrum universality. A positive answer to the comparison in the case (b) would suggest the possibility to extend this conjecture to weakly first order phase transitions.

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.

2.4 FIELD THEORY OF CORRELATED DEVICES

It has been shown that the quantum properties of some Josephson SQUID devices are described by a boundary sine Gordon model. When applied to a single junction SQUID (the rf-SQUID), this approach has succeeded in reproducing known results by Glazman and Hekking. Also, it provides a detailed analysis of the regimes accessible to an rf-SQUID and to a two-Josephson junction SQUID device (the dc-SQUID). Within the boundary field theory approach, the normal component of the current-response of a SQUID device to an externally applied voltage has been computed, and it has been show that the equation describing the current-voltage characteristic function reduces to well-known results when the infrared cutoff is suitably chosen. This has allowed for tracing out new and interesting connections between superconducting devices, quantum Brownian motion, fermionic quantum wires and, more generally, quantum impurity problems.

2.5 TRANSPORT IN MANY-ELECTRON CORRELATED SYSTEMS

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

When a one-dimensional electronic chain is connected to two bulk superconductors, it exhibits a Josephson current smoothly depending on the phase difference between the superconductors, except when the parameters are tuned to to give perfect Andreev reflection. At different values of the system parameters, the current crosses over from a sinusoidal-like, to a sawtooth-like behavior, as first pointed out by Affleck, Caux and Zagoskin. The behavior of the current across the chain at finite phase difference and at a finite biasing voltage V is currently studied. While the Josephson current is expected to take an "ac"-dependence on time, due to the voltage V, since the one-particle spectrum in the chain is gapless, a "normal", dissipative component of the current is expected to arise, as well. at finite V. A detailed study at perfect Andreev reflection has confirmed this expected scenario. Pertinently tuning the model parameters allows to study the two components of the current within any regime, at least for noninteracting systems. Such an analysis is the subject of a paper currently in preparation. As a further development of the research, the generalization to the case of an interacting electron chain will be considered.

2.5.2 Conduction across interferometric rings with the Path Integral formalism

We have set up a path-integral formalism suitable to study the conductance across an Aharonov-Bohm interferometric ring, in the presence of a Rashba interaction. Within such an approach, we have studied the combined effects of spin-orbit and Zeeman interaction on the conductance across the ring, by numerically accounting for weak localization effects due to disorder. The results, which are contained in a paper in preparation, appear to be in a good agreement with the experiment.

2.6 PHYSICS OF KAON-NUCLEON INTERACTIONS

We are currently revising the programs of analysis of low-energy Kaon-Nucleon reactions in order to include the first results from Dafne, that have solved the kaonic atoms puzzle, and to be ready to take into account the results of the second generation experiments at Dafne. An analysis of the perspective of the field which is acquiring new momentum in view of the programs of Dafne2 and of several new theoretical analyses published this year has appeared. In particular from SIDDHARTA it is expected to reach a deeper understanding of the p-wave interaction. In connection

with the discussions on the future of Dafne, and following our proposal of a collaboration with the LNF experimental groups active at Dafne (in particular DEAR/SIDDHARTA and KLOE), referred to in last year report, we presented a contribution at the Frascati meeting discussing this matter. This has led to the participation in a LOI and in a paper in collaboration with experimentalists, recently accepted for publication in Europhysics Journal C. Our contribution to the Kazimierz final meeting of the EURIDICE project is also accepted for publication in the Proceedings of the meeting. A seminar on this topics has been given at the University of Ferrara in November. Moreover the FLAVIANET network was joined, which to some extent represents the followup of Euridice. An expansion of the collaboration which could include other subjects on Kaon physics is being explored with the Institute of Theoretical Physics and Mathematics of Tehran.

2.7 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.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2006

1. V.S. Fadin, R. Fiore, M.G. Kozlov, A.V. Reznichenko,
   Proof of the multi-Regge form of QCD amplitudes with gluon exchanges in the NLA,
   Phys. Lett. **B639** (2006) 74.

2. D.Yu. Ivanov, A. Papa,
   Electroproduction of two light vector mesons in the next-to-leading approximation",
   Nucl. Phys. **B732** (2006) 183.

3. R. Fiore, L.L. Jenkovszky, A.V. Kotikov, F. Paccanoni, A. Papa,
   Asymptotic neutrino-nucleon cross section and saturation effects,
   Phys. Rev. **D73** (2006) 053012.

4. R. Fiore, V.R. Zoller,
   Left-right asymmetry of nuclear shadowing in charged current DIS,
   Phys. Lett. **B632** (2006) 87.

5. I.P. Ivanov, N.N. Nikolaev, A.A. Savin,
   Diffractive vector meson production at HERA: From soft to hard QCD,
   Phys. Part. Nucl. **37** (2006) 1.

6. M. Capua, S. Fazio, R. Fiore, L.L. Jenkovszky, F. Paccanoni,
   A Deeply Virtual Compton Scattering Amplitude,
   Phys. Lett. B645 (2006) 161.

7. I.F. Ginzburg, I.P. Ivanov,
   How to measure the Pomeron phase in diffractive dipion photoproduction,
   Eur. Phys. J. **C45** (2006) 193.

8. I.P. Ivanov,
   Two-Higgs-doublet model from the group-theoretic perspective,
   Phys. Lett. **B632** (2006) 360.

9. M.L. Caligiuri, P.M. Gensini, R. Hurtado and G. Violini,
   Recientes desarrollos y perspectivas de la fisica de las interacciones Kaon-Nucleon a las energias bajas e intermedias,
   Revista Colombiana de Fisica **38** (2006) 1635.

A.1.2 Publications on international journals accepted in 2006

1. D.Yu. Ivanov, A. Papa,
   Electroproduction of two light vector mesons in next-to-leading BFKL: Study of systematic effects,
   to appear on Eur. Phys. J. C, hep-ph/0610042.

1. R. Falcone, R. Fiore, M. Gravina, A. Papa,
   The spectrum of massive excitations of 3-D 3-state Potts model and universality,
   to appear on Nucl. Phys. B, hep-lat/0612016.

2. P. Cea, L. Cosmai, M. D'Elia, A. Papa,
   Analytic continuation from imaginary to real chemical potential in two-color QCD,
   to appear on JHEP, hep-lat/0612018.

3. I.P. Ivanov,
   Minkowski space structure of the Higgs potential in 2HDM,
   to appear on Phys. Rev. D, hep-ph/0609018.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2006

1. A. Papa
   QCD in the Regge limit: From gluon Reggeization to physical amplitudes,
   in "Sense of Beauty in Physics – A volume in honour of Adriano Di Giacomo", Editors M. D'Elia et al.,
   Pisa University Press (2006), pp. 453-464.

2. I.F. Ginzburg, I.P. Ivanov,
   How to measure Pomeron phase and discover odderon at HERA and RHIC,
   Acta Phys. Polon. B37 (2006) 841.

3. P. Cea, L. Cosmai, M. D'Elia, A. Papa,
   Analytical continuation from imaginary to real chemical potential in 2-color QCD under scrutiny,
   In "Lattice 2006 - 24th International Symposium on Lattice Field Theory", Tucson, Arizona, 23-28 July 2006,
   PoS(LAT2006)**143**, 2006, hep-lat/0610088.

4. A. Papa,
   NLO BFKL at work: the electroproduction of two light vector mesons,
   Diffraction 2006 - International Workshop on Diffraction in High Energy Physics, Milos (Greece), September 6, 2006.

5. M. Capua, S. Fazio, R. Fiore, L.L. Jenkovszky, F. Paccanoni,
   A factorized Regge-pole model for Deeply Virtual Compton Scattering,
   Diffraction 2006 - International Workshop on Diffraction in High Energy Physics, Milos (Greece), September 6, 2006.

C PRESENTATIONS AT CONFERENCES

C.1 Presentations at international conferences in 2006

1. D. Giuliano,
   Boundary Field Theory Approach to the renormalization of SQUID Devices,
   XIII Workshop on Statstical Mechanics and non-perturbative Field Theory, Bari (Italy), September 20, 2006.

2. A. Papa,
   Electroproduction of two vector mesons in the NLO BFKL: recent results,
   Low-x Meeting, Lisbon (Portugal), June 29, 2006.

3. P. Cea, L. Cosmai, M. D'Elia, A. Papa,
   Analytical continuation from imaginary to real chemical potential in 2-color QCD under scrutiny,
   International Symposium on Lattice Field Theory, "LATTICE 2006", Tucson, July 23 - 28, 2006.

4. A. Papa,
   NLO BFKL at work: the electroproduction of two light vector mesons,
   PoS(DIFF2006)027.

5. P. Cea, L. Cosmai, M. D'Elia, A. Papa,
   2-color QCD with finite chemical potential: the method of analytical continuation,
   XIII Workshop on Statstical Mechanics and non-perturbative Field Theory, Bari (Ialy), September 20, 2006.

6. M. Capua, S. Fazio, R. Fiore, L.L. Jenkovszky, F. Paccanoni,
   A factorized Regge-pole model for Deeply Virtual Compton Scattering,
   PoS(DIFF2006)049.

7. P.M. Gensini, G. Pancheri, Y. Srivastava, and G. Violini,
   Low-energy Kaon-Nucleus Interactions at a Phi-factory,
   Meeting on e^+e^- Physics Perspectives, Frascati (Rome, Italy), 2006.

ORGANIZATION OF CONFERENCES

1. *Diffraction 2006* - International Workshop on Diffraction in High Energy physics.

Milos (Greece), September 5-10, 2006.

EDITORSHIP OF CONFERENCE PROCEEDINGS

1. R. Fiore, C. Ktorides, I,P. Ivanov, A. Papa,
   "Diffraction 2006 - International Workshop on Diffraction in High Energy physics"
   Milos (Greece), September 5-10, 2006,
   Proceedings of Science (DIFF2006).

3. EXPERIMENTAL PARTICLE PHYSICS

The experimental particle physics studies the most 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:

1. 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.
2. 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

Scattering experiments have been a huge success in revealing the complex world of structure of matter. The basic concept is quite simple: a point-like and energetic test particle (i.e. electron) is scattered on a target (i.e. proton) and its angular and energy distribution are measured. The first time that this technique was employed (1911) revealed that the atom has a positively charged core with a radius of less than 30 fm (Rutherford-Geiger-Marsden). Since 1911 many scattering experiments have been performed to explore the structure of nucleus on scale smaller and smaller. The "object" size □ that can be resolved in the scattering process is determined by the four momentum Q transferred from the test particle to the target one. From the uncertainty relation it follows that □≈1/Q, therefore to increase the resolution it is required larger momentum transfer and hence higher beam energies. This is best achieved in the storage rings where the test and the target particle collide head-on. 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 820GeV energy respectively. The electrons meet protons in a head-on collision in four points along the ring where are located as many detectors always ready to record any interesting event coming from the interaction point. The four experiments are known as H1, ZEUS, HERMES and HERA-B.

At the maximum beam energies the centre of mass energy is $(4 \square E_e \square E_p)^{1/2}$ □ 314GeV, 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 Cosenza HEP group has been involved, since 1988, in the design, construction, testing, calibration, alignment, running and maintenance of three sub-detectors of ZEUS experiment: Forward Muon Spectrometer, Leading Proton Spectrometer and Vertex Detector. Furthermore the Cosenza researchers participate, since 1991 when the detector start to operate, the data taking as well as the physics analysis.

During this last year there are new ZEUS results on high-Q**2 deep inelastic scattering cross sections with a longitudinally polarised positron beam, prompt photons with associated jets in photoproduction, neutral current cross sections at high Bjorken-x and event shapes in deep inelastic scattering.

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

Physicists: C. Adorisio
G. Crosetti
E. Lamanna
L. La Rotonda
V. Lavorini
C. Mazzotta
E. Meoni
G. Morello
A. Policicchio
D. Salvatore

M. Schioppa
G. Susinno
P. F. Zema

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=174 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 Higg's 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 Higg's 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 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.

Rare B-decays, produced by Bottom to s,d quark FCNC transitions, are forbidden at the tree level in the Standard Model (SM). These decays occur at the lowest order only through one-loop ``penguin" and ``box" diagrams. The branching ratios of these decays are very smal. Rare B-decays careful investigation is mandatory for testing ground of the Standard Model and offer a complementary strategy in the search of new physics by probing the indirect effects of new interactions in higher order processes. The probing of loop-induced couplings provide a means of testing the detailed structure of the SM at the level of radiative corrections. In particular, FCNC involving b to s,d transitions, provide an excellent probe of new indirect effects by yielding informations on the masses and coupling of the virtual particles running in the loops and this explain the attention they have received in recent years. The study of such decays give also other opportunities: to find the values of |Vts| and |Vtd| CKM matrix elements and to provide new informations on long-distance QCD effects in matrix elements of the tensor current.

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:

1. 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.
2. 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.
3. 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 is actively involved in various aspects of the design, construction and installation of the muon spectrometer detector system since 1994. During this period the hardware projects in which the group participated have employed and trained many undergraduate and doctorate students in the process.

During this year the Cosenza group has participated to many ATLAS activities:

gas leak recovery of BIL chambers at CERN;
installation and commissioning BIL chambers at CERN;
ATLAS MDT aging studies at the neutron and gamma facility of ENEA Research Centre at Rome;
realization of a low level, real time data acquisition software for the ATLAS sub-detector to monitoring the data during test beam and the first period of ATLAS data taking.
Monte Carlo simulation of muon spectrometer performances with GEANT 4.
study of the rare semileptonic decays of the B meson
study of Higgs signals using the muon spectrometer.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on scientific journals

A.1.1 Publications on scientific journals printed in 2006

1. Avolio G., La Rotonda L., Mazzotta C., Meoni E., Morello G., Policicchio A., Salvatore D., Schioppa M., et al.
   Monitored Drift Tubes aging under intensive gamma irradiation.
   Nucl. Instrum. Meth. A568 (2006) 624-633.

2. ZEUS Collaboration; M. Capua, A. Mastroberardino, M. Schioppa, G. Susinno, et al.
   *Measurement of high-Q**2 deep inelastic scattering cross sections with a longitudinally polarised positron beam at HERA.*
   Phys. Lett. B637 (2006) 210-222.

3. Nomad Collaboration; La Rotonda et al.,
   Production properties of K(892)+- vector mesons and their spin alignment as measured in the NOMAD experiment.*
   Eur. Phys. J. C46 (2006) 69-79.

A.1.2 Publications on international journals accepted in 2006

1. A. Policicchio and G. Crosetti,
   Rare semileptonic decays in ATLAS.
   Acta Phys. Pol B.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2006

1. C. Adorisio, C. Cernoch, M. Cirilli, S. Palestini, A. Di Girolamo, P. Valente, S. Zimmermann,
   Aging studies on Atlas muon spectrometer drift tubes,
   Nucl. Phys. Proc. Suppl. 150 (2006) 168-171.

2. P. Adragna, A. Dotti, C. Roda, R. Ferrari, W. Vandelli, P.F. Zema,
   GNAM: A low-level monitoring program for the ATLAS experiment,
   IEEE Trans. Nucl. Sci. 53 (2006) 1317-1322.

3. G. Avolio, P. Branchini, S. Di Luise, E. Graziani, L. La Rotonda, C. Mazzotta, E. Meoni, A. Passeri, F. Petrucci, A. Policicchio, D. Salvatore, M. Schioppa, A. Tonazzo,
   MDT Chamber Ageing Test At Enea Casaccia Neutron and Gamma Facilities,
   Astroparticle, Particle and Space Physics, Detectors and Medical Physics Applications Proceedings of the 9th Conference, Villa Olmo, Como (Italy), 17-21 Ottobre 2005, pp. 797-801, Casa Editrice: World Scientific Publishing Compapy}, Aprile 2006, Singapore, ISBN 981-256-798-4.

4. SURFACE ELECTRON SPECTROSCOPY (SPES)

Professors and Researchers	Elio Colavita *(Group Leader)* Gaetano Cannelli Raffaele Agostino Gennaro Chiarello Vincenzo Formoso
Postdoc fellows	Tommaso Caruso Enrico Maccallini
PhD students	Alfonso Policicchio Antonio Politano
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. Larosa *(Elettra, Trieste, Italy)* S. Scalese *(CNR, Catalina, Italy)* D. Gournis *(University of Ioannina, Greece)* F. Alamgir *(Brookhaven National Laboratory, New York, USA)*

Research subjects:
1) Chemisorption on metal surfaces, their electronic properties;
2) Carbon and metal-oxide nanostrucures spectroscopic studies.

Introduction

The scientific research of the group has been carried out essentially along two lines:
1) Chemisorption on metal surfaces and their electronic properties;
2) Carbon and metal-oxide nanostrucures spectroscopic studies.

The strong influence of surfaces electronic states on a variety of physical phenomena occurring at surfaces has attracted our interest. The former line deals with such studies carried out by High Resolution Electron Energy Loss Spectroscopy.

The latter research line deals with a) characterization of nanostructured carbon thin films containing well ordered graphene multilayers, onion and nanotubes, b) carbon/metal nanocomposites and metal-oxide nanocrystalline films. The study is performed in collaboration with the Group of prof. Milani at CIMAINA, University of Milano. The films are prepared by supersonic cluster beam deposition. The strategic importance of nanostructured films in several technological fields is acknowledged. We also acknowledge the collaboration with the Group of prof. Petra Rudolf of the University of Groningen on magnetic and clay nanocomposites. Elettra synchrotron light source was used for photoemission studies on nanocrystalline films.

Several characterization studies on nanostructured materials have been carried out at the Electron Microscopy Laboratory of the Physics Department equipped with Transmission and Secondary Electron Microscopies.

4.1 CHEMISORPTION ON METAL SURFACES AND THEIR ELECTRONIC PROPERTIES

4.1.1 Plasmon of Shockley Surface States

High resolution electron energy loss spectroscopy was used to investigate the low energy collective excitations of the Cu(111) surface. Measurements showed, for the first time, a collective mode with an energy of 1.1 eV. The measured dispersion of the plasmon mode was negative. We suggest that this novel mode arises from the oscillation of electrons confined to the Cu(111) surface within quasi two dimensional Shockley surface states. Moreover, we show that the acoustic-like mode theoretically proposed for the (111) surface of noble metals is not observed in copper. The behaviour of the plasmon dispersion curve and the lack of the acoustic mode call for specific theoretical interpretations of the present experimental results (Ref.1).

4.1.2 CO Adsorption on Ni(100) and the Effects of Predosed Oxygen and Hydrogen Layers

The vibrational properties of CO on Ni (100) were investigated by high resolution electron energy loss spectroscopy. Loss measurements were performed as a function of temperature and CO exposures. At room temperature, regardless of CO coverage, we found stretching energies at 250 meV and 240 meV, assigned to CO at atop and bridge sites, respectively. At low temperature and for CO exposures lower than 0.6 L, the loss spectra showed a single stretching peak at 240 meV which is assigned to CO at bridge sites. For higher doses, a new intense peak at 260 meV appeared in the loss spectra. The rise of this new loss strongly influenced the intensity of the peak at 240 meV suggesting the occurrence of dipole couplings between adjacent CO molecules. This unusual high stretching frequency leads us to assign the peak at 260 meV to the stretching vibration of CO molecules which are weakly bonded to the Ni surface. We suggest that the formation of this phase is due to an electronic effect arising from a reduced back donation of electrons into the empty □ orbital of CO (ref.1). We performed high-resolution electron energy loss experiments on (CO/O)/Ni(100) and (CO/H)/Ni(100) systems. Oxygen and hydrogen interact differently with Ni(100) surface, nevertheless, both species do not affect to a great extent the vibrational properties of CO. A phase of CO molecules weakly bonded to the surface and unaffected by coadsorbed oxygen and hydrogen, is found. A coverage of 0.5ML of predosed oxygen chemically passivates the Ni(100) surface and inhibits any CO adsorption at room temperature. CO sites are unambiguously determined for each predosed Ni(100) surface. (Ref.2, Ref.3).

4.2 CARBON- METAL-OXIDE NANOSTRUCURE SPECTROSCOPIC STUDIES

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. 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 = 50 eV) from the valence band unveil the presence of a restrained amount of surface Ti 3d defect states in the band gap (Ref. 4). 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 (Oral Communications D2.2; D2.3).

4.2.2 Functionalisation of Fulleropyrrolidine and Pyrrolidine Derivatives.

Fulleropyrrolidine and pyrrolidine derivatives were studied using X-ray photoemission spectroscopy in order to determine the effects of the C_{60}-cage on the pyrrolidine nitrogen, as well as the influence of further derivatisation. Charge transfer from the carbon pyrrolidine ring to the C_{60}-cages is observed and this charge redistribution influences not only the carbon atoms but also the nitrogen. The major influence of different functionalization groups on the pyrrolidine nitrogen is whether or not they lead to quaternisation while no differences could be detected for different groups (methyl group or alkyl chain) producing one or the other configuration. However, the type of counter ion is important for the stability of the pyrrolidinium nitrogen: demethylated nitrogen, always found to be present in iodide counter balanced compounds, disappears in compounds counter balanced with BF^-_4 anion. (Ref.5).

4.2.3 Magnetic, Electronic and Optical Properties of Prussian Blue

The Prussian Blue (PB) analogues are switchable magnetic material, in which the interplay between two different adjacent metal ions is crucial for the observation of photoinduced phenomena. The chemical formula is $A_xB[C(CN)_6]_y$, where A is an alkali metal (Rb, Na, Li, …) and A and B are transition metal with different valence states (Fe^{2+}, Fe^{3+} , Mn^{2+}, Mn^{3+}, Co^{2+},…). Defects in the are present $[C(CN)_6]$ units which can be filled from water molecules. The synthesis and detailed characterization of a few samples of the compound $Rb_xMn[Fe(CN)_6]_y$ zH2O was obtained. The composition of the materials significantly depends on the applied preparative conditions. Analysis of spectroscopic results (FTIR, Raman, 57Fe Mo¨ssbauer, XPS) and X-ray powder diffraction data yielded a further assessment of the difference in structural features in terms of the amount of Fe(CN)6 vacancies and the associated number of water molecules. The characteristic individual magnetic behavior, as well as the metal-to-metal charge-transfer capabilities of the various samples, could be related to significant changes within the structures that appear to be associated with the synthetic method used. (Ref.6).

4.2.4 Clays Nanocomposites

Smectite clays are a class of layered aluminosilicate minerals with a unique combination of swelling, intercalation, and ion exchange properties that make them valuable nanostructures in diverse fields. Their structure consists of an octahedral alumina layer fused between two tetrahedral silica layers. Smectite clays have a cation

exchange capacity, which depends on the substitution of low-valent atoms, such as Mg^{2+} for Al^{3+} in the octahedral sheet, and Al^{3+} for Si^{4+} in the tetrahedral sites. As a consequence, the layers are negatively charged and neutrality is obtained, for example, by hydrated cations present in the galleries. The intercalation process in these systems is equivalent to ion exchange and, unlike for intercalation compounds of graphite, it does not involve necessarily charge transfer between the guest and host species. These materials have the natural ability to adsorb organic or inorganic guest cationic species (and even neutral molecules) from solutions, and it is this cation "storage" that gives unique properties to clay minerals, which can be used as catalysts, templates in organic synthesis, or as building stones for composite materials. The nature of the microenvironment between the aluminosilicate sheets regulates the topology of the intercalated molecules and affects possible supramolecular rearrangements or reactions, such as self assembling processes that are usually not easily controlled in the solution phase.

4.2.5 Clay-Fulleropyrrolidine Nanocomposites

Organic derivatization of fullerenes can help solubilization both in organic solvents and in water and also influence their properties. The chemical functionalization of the fullerene sphere produces a large number of different derivatives that combine the desirable properties of C60 with the solubilizing power of the side chains. One of the most versatile addition reactions is the [1,3]-dipolar cycloaddition of azomethine ylides, which produces the so-called fulleropyrrolidines, in which the nitrogen and/or carbon atoms in the pyrrolidine ring can be variously functionalized. The insertion of a water-soluble bisadduct fulleropyrrolidine derivative into the interlayer space of three layered smectite clays was carried out. The composites were characterized by a combination of powder X-ray diffraction, transmission electron microscopy, X-ray photoemission and FTIR spectroscopies, and laser flash photolysis measurements. The experiments, complemented by computer simulations, give insight into the formation process, structural details, and properties of the fullerene/clay nanocomposites. The reported composite materials constitute a new hybrid system, where C60 differs from its crystals or its solutions, and open new perspectives for the design and construction of novel C60-based organic/clay hybrid materials. (Ref.7).

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2006

1. Politano A., Chiarello G., Formoso V., Agostino R.G, Colavita E.,
   Plasmon of Shockley surface states in Cu(111): A high-resolution electron energy loss spectroscopy study,
   Selected for publication on Virtual Journal of Nanoscale Science and Technology, Nuova Serie, Physical Review B 2006, Vol. 74, n.8, pp. 081401-081404.

2. Formoso V., Marino A., Chiarello G., Agostino R.G., Colavita E., Caruso T.,
   CO adsorption on Ni(100):Evidences for a weakly bound phase by HREELS measurements,
   Surface Science: journal devoted to the physics and chemistry of interfaces, 2006, Vol. 600, pp.1456-1461.

3. Chiarello G., Formoso V. Infusino E. Marino A., Agostino R.G., Colavita E.,
   Effects of predosed Oxygen and Hydrogen on CO adsorption on Ni(100),
   Surface Science: journal devoted to the physics and chemistry of interfaces, 2007, Vol. 601, pp.104-111.

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,
   Published online on Surface Science, doi: 10.1016/j.susc.2006.12.025

5. D. Benne, E. Maccallini, P. Rudolf, C. Sooambar, M. Prato,
   XPS study on functionalisation of fulleropyrrolidine and pyrrolidine derivatives,
   Carbon, 2006,Vol. 44, pp. 2896–2903.

6. E.J.M. Vertelman, E. Maccallini, D. Gournis, P. Rudolf, T. Bakas, J. Luzon, R. Broer, A. Pugzlys, T.T.A. Lummen, P.H.M. van Loosdrecht, P.J. van Koningsbruggen,
   The Influence of Defects on the Electron-Transfer and Magnetic Properties of $Rb_xMn[Fe(CN)_6]_y{\cdot}zH_2O$,
   Chemistry of Material, 2006, Vol. 18, Issue 7, pp. 1951-1963.

7. D. Gournis, L. Jankovic, E. Maccallini, D. Benne, P. Rudolf, J.-F.Colomer, C. Sooambar, V. Georgakilas, M. Prato, M. Fanti, F. Zerbetto, G.H. Sarova, D.M. Guldi,
   Clay-Fulleropyrrolidine Nanocomposites,
   Journal of American Chemical Society, 2006, Vol. 128, pp. 6154-6163.

D PRESENTATIONS AT CONFERENCES

D.1 Presentations at international conferences in 2006

1. Politano A., Agostino R.G, Colavita E., Formoso V., Chiarello G.,
   Electronic properties of quantum dots of sodium on Cu(111) and their interaction with water,
   Oral presentation. NanoSEA-Nanostructures Self-Assembling, Aix en Provence, 02-06 July 2006.

2. E. Maccallini,
   Characterization of Clays nanocomposites by X-ray diffraction and X-ray photoemission,
   Oral contribution. CASSIUSCLAYS Network Meeting, Villasimius (Ca), Italy, 2-3/6/2006.

3. A. Policicchio, T. Caruso, G. Chiarello, E. Colavita, V. Formoso, R.G. Agostino, T. Tsoufis, D. Gournis, S. La Rosa ,
   Electronics, chemical and structural characterization of CNTs growth by acetylene decomposition over MgO supported Fe-Co bimetallic catalysts,
   NanoSEA- Nanostructures Self-Assembling, Aix en Provence, 04/07/ 2006.

4. T. Caruso, C. Lenardi, T. Mazza, A. Policicchio, G. Bongiorno, R.G. Agostino, G. Chiarello, E. Colavita, P. Finetti, K.C. Prince, C. Ducati, P. Piseri, P. Milani,
   Photoemission investigation on nanostructured TiO2 growth by cluster assembling,
   NanoSEA- Nanostructures Self Assembling, Aix en Provence, 04/07/ 2006.

D.2 Presentations at national conferences in 2006

1. Barbieri G., Brunetti A., Lentini F., Agostino R.G., Kim M., Formoso V., Drioli E., Lee K., *Characterization and Testing Of Pd-Doped PVDF Hollow Fibers For Dissolved Oxygen Removal*, Atti del convegno "ECI Conference" Advanced Membrane Technology III", Cetraro CS - Italy, 2006.

2. T. Caruso, A. Policicchio, V. Formoso, R.G. Agostino, G. Chiarello, E. Colavita, T. Mazza, C. Lenardi, E. Barborini, P. Milani and P.Finetti, *Highlighting the electronic structure of cluster assembled nanostructured TiO2 by resonant photoemission at the Ti L edge*, Oral presentation, Workshop SILS "Spettroscopia di nanoparticelle con radiazione di sincrotrone", March 1-2, 2006, Palazzo Feltrinelli, Gargnano, Brescia, Italia

3. T. Caruso, *Nanostructured TiO_2 films analyzed by resonant photoemission spectroscopy at the Ti $L_{2,3}$ edges*, Oral presentation, XIV Congresso Società Italiana di Luce di Sincrotrone, Napoli, July 6-8, 2006.

5. SOLID STATE PHYSICS: SURFACES AND NANOMATERIALS

Professors and Researchers
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Lorenzo Caputi
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Raul Baragiola *(Lab. for Atomic and Surface Physics, University of Virginia, Charlottesville, USA)*
Zdenek Sroubek *(Acad. Science Czech Republic, URE, Prague)*
Valerio Pirronello *(Dip. di Fisica, Facoltà di Ingegneria, Università di Catania, Italy)*
Giuseppe Giuliani *(Istituto di Fisica "Volta", Università di Pavia, Italy)*
Marisa Michelini *(Dipartimento di Fisica, Università di Udine, Italy)*
Angelo Carollo (Institute for Quantum Optics and Quantum Information, Innsbruck, Austria)

Introduction

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

5.1 Science in carbon nanotubes and nanostructures
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 Ion interaction with nanostructures
5.7 Ion interaction with solids
5.8 Multimedial education
5.9 Quantum coherence and correlation

5.1 SCIENCE IN CARBON NANOTUBES AND NANOSTRUCTURES

Intercalation of SWCNT bundles with sodium and lithium atoms, performed at room temperature, allowed us to better understand the different mechanism of interaction of each alkali with nanotubes. UPS, EELS [1] and XPS [2]measurements revealed that sodium doping induced only a Fermi level shift due to charge transfer, while it did not affect the valence and conduction band states and the C 1s core level of SWCNTs. Sodium atoms seem therefore to contribute only to an increase of charge carriers without interacting with nanotubes, which keep their electronic properties unchanged.
On the contrary, lithium induces striking changes of valence and conduction band states and this behaviour suggests the existence of hybridized states due to the formation of covalent-like bonds. The formation of links among tubes leads to a transition from a one- to a three-dimensional system, evidenced by the suppression of interband transitions between vHs of semiconducting tubes. This interpretation is also supported by a lithium-induced C 1s core level broadening, which is compatible with the formation of new states in the gap-region of semiconducting tubes. Photoemission measurements on Li-intercalated SWCNT bundles exposed to oxygen at room temperature have revealed the occurrence of chemical reactions between lithium and oxygen atoms on the sample surface. The enhanced sample reactivity, caused by the alkali presence, allows the adsorption of oxygen, which in turn induces a remarkable de-intercalation of lithium atoms from the bulk. This process, which does not occur immediately, results in a strong increase of the lithium surface concentration, and is followed by the formation of both lithium peroxide and oxide. Moreover, a temperature-dependent study has shown that lithium peroxide has a less stable bond than lithium oxide and starts desorbing at 400K; at temperatures higher than 1000K both oxygen and lithium desorb, and the electronic structure of the pristine sample is recovered.

A comprehensive study on both chemical and electronic properties of N implanted SWCNT bundles [3] has provided us with a quite clear picture of the doping-induced effects on the nanotube network. After being accelerated toward the sample, N2 + ions break up, and highly energetic nitrogen atoms penetrate into the sample; ion irradiation produces defects and structural disorder, and strongly affects the 2p-π band structure. As for chemical properties, three possible configurations for N-C bond can be distinguished. Nitrogen atoms can interact with sp3-hybridized C in a tetrahedral configuration or take the place of carbon atoms. In the last case, N can form an sp2 bond with three carbon neighbours (substitutional doping) in a graphite-like arrangement, or with two carbon atoms in a defective pyridine-like structure. The total N atomic concentration is almost unaffected by heating at 650K, that however partially restores the CNT structure. Higher temperature (1200K) annealing induces the desorption of nitrogen placed in both tetrahedral an defective sites, while about 1% of substitutional nitrogen impurities still remains on the sample. Moreover, we have detected a noteworthy enhancement of the density of states near the Fermi level, which accounts for the charge transfer due to substitutional doping. Hence, according to our results, nitrogen ion implantation seems to be a promising technique to carry out CNT doping. Furthermore, this preliminary study suggests the opportunity of searching for the optimal value of beam energy, in order to reduce structural damages and maximize the concentration of substitutional impurities.

Raman measurements, performed on MWCNTs grown by arc discharge method in He atmosphere, have pointed out the occurrence of a band at 1780-1860 cm^{-1}, regardless of the use of a catalytic Ni-Cr alloy in the synthesis process [4]. This band has been attributed to the presence of carbon linear chains inside the innermost tube. The maximum Raman signal from the chain-related L bands is found inside a circular region, in correspondence with enhanced secondary electron emission, as evidenced by a strong white color in the SEM images. Furthermore, a temperature-dependent Raman study, up to about 1000K, has revealed for the first time a phase transition trend [5], which seems to be related to a strong, reversible reduction of the Peierls distortion at high temperatures.

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 due 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 π and π^* 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.

5.6 ION INTERACTION WITH NANOSTRUCTURES

The research has been focused on carbon nanotubes (CNTs) which show extraordinary optical, mechanical and electronic properties. The CNTs have a cylindrical structure with ends which can be either opened or closed and can be viewed as the roll-up of a single graphene layer (single wall carbon nanotube, SWNT) or of a few (10–12) coaxial layers (multi walled carbon nanotube, MWNT)

Preliminary studies 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 have been performed. 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. The electric resistivity 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 ρ decreases monotonously with increasing temperature without showing any sign of turn up. Our results can be well fitted with a power law of $T^{-\alpha}$ within the framework of one dimensional Luttinger liquid theory with α=0.13 or with a simple thermally activated inter shell hopping model.

Moreover we studied 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.

A different kind of sample (single wall carbon nanotubes) has been used to carry out X-ray photoemission and electron energy loss studies by 3 keV N_2^+ ion implantation in SWNTs. Our results show that nitrogen atoms can bind to carbon in tetrahedral sp^3, defects related pyridine-like, and triangular sp^2 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.

5.7 ION INTERACTION WITH SOLIDS

Energy distributions of electrons emitted in the interaction of Na^+ ions with Al surfaces as a function of incident ion energy in the range 300-2000 eV, have been measured. The Auger spectra of Sodium, which show several lines due to decay in vacuum of projectiles, singly and doubly excited in the 2p shell by electron promotion in close encounters with target atoms are discussed. Our results indicate that the double vacancy production is in close relation with the Al-2p electron excitation via an *autoexcitation* mechanism.

The energy distributions of electrons emitted in the interaction of Na+ with Al surfaces at incident ion energies have been measured in the range 150-4000 eV. The data allow to correlate emission intensities with spectral signatures of electron excitation processes. 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 Al-2p excitation via a vacancy transfer process. We observe that the total electron emission yields sharply increases by more than an order of magnitude at impact energies above the threshold for this process. Measurements of energy distributions and yields of electrons emitted in the interaction of slow singly charged Neon and Sodium ions with Al surfaces are reported. 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. These results indicate that the Auger decay of Al-2p excitations occurring in binary atomic collision between recoiling target atoms, is the dominant primary excitation mechanism. Measurements performed using sodium projectile show that a significant contribution to the total electron emission yield comes also from a vacancy transfer process that produce Al-2p excitation by a vacancy transfer process in asymmetric collisions between target atoms and incoming ions that have survived neutralization at the surface.

In addition energy distributions of electrons emitted in the interaction of slow Kr+ and Na+ with Al surfaces have been also measured. The data allow to correlate emission intensities with spectral signatures of electron excitation processes. Our results indicate that electron promotion processes leading to the excitation of Al target atoms plays the dominating role in kinetic electron emission from Al surfaces by slow ions. In the case of Kr+ ions, electron promotion occurs in close atomic collisions between recoiling target atoms. For Na+ projectiles, a significant

contribution to Al excitation comes also from a vacancy transfer process in asymmetric collisions involving ions that have survived neutralization in the interaction with the surface. In particular, experimental studies on electron emission in the interaction of 1-8 keV Kr+ ions with clean Al surfaces are reported. We observe that total electron emission yield depends exponentially on v(-1), the inverse of the velocity of the projectiles, rather than on the inverse of the component of v orthogonal to the surface, expected in the recently proposed surface-assisted kinetic electron emission. The energy distributions of emitted electrons show well-known features of kinetic electron emission: a broad continuum background with superimposed structures due to the decay of bulk plasmons and to Auger decay of Al-2p excitations produced by electron promotion. The close correlation of the intensities of electron emission from Auger and plasmon decay with the total electron yields leads to the conclusion that kinetic electron emission in Kr+ interactions with Al surfaces is dominated by electron promotion in close atomic collisions.

The interaction of 300 eV Na+ with Al surfaces, as a function of ion incidence angle supplied the distributions of emitted electrons. We observe that the intensity of electron emission shows the same dependence on ion incidence angle as the intensity of Auger electrons from decay of projectiles excited by electron promotion in collision with target atoms. It is concluded that electron emission is mainly determined in binary atomic collisions, similar to those that are clearly signaled by the observed Auger spectrum of sodium.

5.8 MULTIMEDIAL EDUCATION

The work in this section (tools for learning and teaching of physics) has produced new stimulating results with the publication of a text book. The book, adressed to the secondary school, is motivated by the recent indications about the new method in teaching physics. The contents are addressed to students and proposes homeworks and experimental activity to be carried out at home wit easy tools, more important the book supplies evaluation instruments set up by the student.In this direction a useful help is the DVD contained in the edition which presents animations, simulations, interactive tests all addressed to the auto-evaluation of students. The learning steps are also seen under a large point of view with continous connection to the history of physics and to other disciplines or to the evolution of theories in view of more uptodated experiments. Particular care has been taken in inserting good images and refined drwawings and graphs as a fundamental tool for an easier learning.

Moreover an interactive Java Applet has been developed, aimed at helping students in understanding the classical relative motions. The applet simulates the fall of a body from a plane either freely or under the air friction force. The learner is allowed to choose either the ground-fixed system of reference or the plane-fixed one. Preliminary results and future directions of the project are discussed. Concerning the photoelectric effect a learning object has been presented to virtually reproduce the main historical steps of the phenomenon. Such simulations allow to obtain virtual measurements and their evaluation in a sort of multimedial laboratory which is of good support to the real execution of the experiment.

The e-learning method has been presented as a new methodology which offers the possibility of supplying interactive tools. In particular such tools are addressed to the study of experimental sciences trying to overcome the difficulties and problems encountered by the student in approaching an experimental laboratory. Also the cycloid is presented by means of new multimedial technologies. The interactive and virtual laboratory is articulated through a MatCos programming tool orienting the student to the preparation and generalization of the different arguments, with practical and homemade activities. The cardiod is assumed as basis to build up a teaching path oriented to the use of graphic representation in treating the armonic motion. In particular using different phenomena, describing motion, it is shown that the same mathematical curve is obtained, but with different physical meaning since the graphic representation is linked to different physical quantities.

5.9 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 magnetic 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.

5.9.1 Quantum correlations and entanglement in many-body systems

We described the ground state entanglement of a bipartite system, composed by a two level system (qubit) strongly interacting with a single mode oscillator. The amount of entanglement present in the fundamental level has been evaluated as a function of the coupling strength, of the transition frequency and of the tunnelling amplitude (or level asymmetry) of the qubit. This has been done in the adiabatic regime, assuming that the evolution of the qubit is much faster than that of the oscillator. Within the adiabatic approximation, we found that both the spin magnetization and the amount of entanglement show a critical behavior in the case of symmetric qubit for a very strong interaction.
We recognized that this critical behavior is related to second order quantum phase transition displayed by the Dicke model (which describes the properties of an N qubit register coupled to an oscillator mode).

By employing the same techniques used for the single qubit case, we discussed the thermodynamic-limit and finite-size scaling properties of both quantum correlations (entanglement) and of the geometric (Berry's) phase in the

adiabatic Dicke model. In the thermodynamic limit, the entanglement shows a non-analytic behavior at the transition point and at the same time a nonzero Berry phase is obtained only if a path in parameter space is followed that encircles this critical point. Precursors of the critical behavior are present for a system with finite size. To show this, we evaluated the leading orders in the 1/N expansion of many observables which enabled us to obtain analytically various bipartite entanglement measures and the Berry phase, together with their critical exponents.

5.9.2 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. Finally, we showed that the impurity site behaves as an entanglement mirror and characterized the bouncing process in terms of reflection and transmission coefficients.

A. PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2006

1. M. Papagno, D. Pacilé, G. Caimi, H. Berger, L. Degiorgi and M. Grioni,
   Electronic structure of one-dimensional copper-oxide chains in $LiCu_2O_2$ from angle-resolved photoemission and optical spectroscopy,
   Phys. Rev. B 73, 115120 (2006).

2. D. Pacilé, C.R. Ast, M. Papagno, C. Da Silva, L. Moreschini, M. Falub, A.P. Seitsonen, and M. Grioni,
   Electronic structure of an ordered Pb/Ag(111) surface alloy: Theory and experiment,t
   Phys. Rev. B 73, 245429 (2006).

3. C.R. Ast, D. Pacilé, M. Papagno, T. Gloor, F. Mila, S. Fedrigo, G. Wittich, K. Kern, H. Brune, and M. Grioni,
   Orbital selective overlayer-substrate hybridization in a Pb monolayer on Ag(111),
   Phys. Rev. B 73, 245428 (2006).

4. R. Sanjinés, M. Benkahoul, M. Papagno, F. Lévy, and D. Music,
   Electronic structure of Nb_2N and NbN thin films,
   J. Appl. Phys. 99, 044911 (2006).

5. G. Liberti, R. Zaffino, F. Piperno and F. Plastina,
   Entanglement of a qubit coupled to a resonator in the adiabatic regime,
   Phys. Rev. A 73, 032346 (2006).

6. G. Liberti, F. Plastina, and F. Piperno,
   Scaling behavior of the adiabatic Dicke Model,
   Phys. Rev. A 74, 022324 (2006).

7. F. Plastina, G. Liberti, and A. Carollo,
   Scaling of Berry's Phase Close to the Dicke Quantum Phase Transition,
   Europhys. Lett. 76, 182 (2006).

8. T.J.G. Apollaro, and F. Plastina,
   Entanglement localization by a single defect in a spin chain,
   Phys. Rev. A 74, 062316 (2006).

A.1.2 Publications on international journals accepted in 2007

1. 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,
   Rad. Phys. and Chem. (2007) in press.

2. M. Barberio, M. Camarca, P. Barone, A. Bonanno, A. Oliva, F. Xu,
   Electric resistivity of multi-walled carbon nanotubes at high temperatures,
   Surf. Scie. (2007), accepted.

3. M. Barberio, P. Barone, A. Bonanno, M. Camarca, A. Oliva, F. Xu,
   Preliminary results on luminescence induced by thermal treatment and by N_2^+ ion bombardement on MWNT bundles,
   Radiation Physics and Chemistry (2007) in press.

4. M. Barberio, P. Barone, A. Bonanno, M. Camarca, F. Xu,
   Thermo- and iono- luminescence on MWCNT bundles,
   Radiation Physics and Chemistry (2007) in press.

5. F. Xu, M. Minniti, C. Giallombardo, A. Cupolillo, P. Barone, A. Oliva, L. Papagno,
   Nitrogen ion implantation in single wall carbon nanotubes,
   Surface Science, accepted.

6. 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, accepted.

7. 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, (2007) in press.

8. 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, accepted.

9. 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 slowIons,
Nuclear Instruments and Methods in Physics Research B, accepted.

10. 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 and Methods in Physics Research B, accepted.

11. A. Cupolillo, C. Giallombardo and L. Papagno,
Electronic properties of alkali-metal intercalated single walled carbon nanotubes,
Surface science, 2007, in press.

12. A. Sindona , F. Plastina , A. Cupolillo , C. Giallombardo , G. Falcone, L. Papagno,
Many body shake up in x-ray photoemission from bundles of lithium-intercalated single-walled carbon nanotubes,
Surface science, 2007, in press.

13. E. Cazzanelli, L. Caputi, M. Castriota, A. Cupolillo, C. Giallombardo, and L. Papagno,
Carbon linear chains inside multiwalled nanotubes,
Surface science, 2007, in press.

14. 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., 2007 in press.

15. 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 in physics research. Section B, 2007, in press.

16. A. Sindona, P. Riccardi, S. Maletta, S. A. Rudi, G. Falcone,
Negative ionization of the secondary ions of Silver and Gold,
Nuclear Instruments & Methods in physics research. Section B, 2007, in press.

17. A. Sindona, S.A.Rudi, S. Maletta, R.Baragiola, G.Falcone., P. Riccardi,
Fermi edge singularities in ion-induced electron emission from plane metal surfaces,
Nuclear Instruments & Methods in physics research. Section B, 2007, in press.

18. A. Sindona, S.A. Rudi, S. Maletta, R. Baragiola, G. Falcone, P. Riccardi,
Auger electron emission from metals induced by low energy ion bombardment: effect of the band structure and Fermi edge singularity,
Surface Science, 2007, in press.

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

A.2 Publications on national journals

A.2.1 Publications on national journals printed in 2006

1. P. Sapia , A. Oliva , A. Bonanno,

Un'applet Java per lo studio dei moti relativi,
La Fisica nella Scuola, XXXIX, 50-59, 2006.

2. P. Sapia, G. Falcone, A. Bonanno,
Un learning object multimediale per l'insegnamento/ apprendimento dell'effetto fotoelettrico,
Didattica e Didattiche Disciplinari **3**, 197-217 , 2006.

3. A. Bonanno, A. Oliva , P. Sapia, A. Milazzo,
Strumenti multimediali per l'insegnamento della fisica nell'ambito del progetto lauree scientifiche,
Didattica e Didattiche Disciplinari, Numero tematico: "Matematica, formazione scientifica e nuove tecnologie".
Cerasoli M., Costabile F.A., Mercuri E., Serpe A. (eds); 2006.

4. A. Milazzo, A. Bonanno,
Uno strumento interattivo per visualizzare il moto di un corpo su un piano orizzontale, o inclinato, scabro,
Scienzaonline, Anno 3, 17 Dicembre 2006.

A.2.2 Publications on national journals accepted in 2006

1. P. Sapia, A. Oliva, A. Bonanno
Un'applet Java per lo studio dei moti relativi,
to appear in La Fisica nella Scuola.

2. P. Sapia, G. Falcone, A. Bonanno,
Un learning object multimediale per l'insegnamento/apprendimento dell'effetto fotoelettrico,
to appear in Didattica e Didattiche Disciplinari.

3. A. Bonanno, M. Camarca, P. Sapia, M. Serpe,
Un learning object su una curva dalle proprietà sorprendenti: la cicloide,
Atti del congresso "DIDAMATICA 2007", in stampa.

4. B.M. Dibilio, P. Sapia, F. Sartogo,
Dal Fenomeno alla Legge Fisica - Percorsi d'Apprendimento per il Biennio della Scuola Secondaria di Secondo Grado,
Editrice "Il Capitello", Torino, 2007, in stampa.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2006

1. M. Barberio, M. Camarca, P. Barone, A. Bonanno, A. Oliva, F. Xu,
Preliminary results on transport properties of alkali-metal-doped Single-Wall carbon Nanotubes mats,
Ecoss 2006 (Paris, September - poster).

2. G. Acri, A. Oliva, M.B. Bitonti, A. Chiappetta, B. Testagrossa, G. Vermiglio, M.G. Tripepi,
Effects on Vegetable Seeds Due to Non Ionizing Radiation,
Convegno IRPA, Paris, May 19-22, 2006.

3. M. Barberio, A. Bonanno, G. Falcone, P. Sapia,
Tecnologie didattiche ed educazione alla salute: un'applet Java per l'esame audiometrico,
Didamatica 2006". (Cagliari, May 2006 – poster).

4. A. Sindona, S.A. Rudi, S. Maletta, R. Baragiola, G. Falcone, P. Riccardi,
Many body excitations in Auger electron emission,
IBMM 2006 (Ion Beam Modification in Materials), Taormina, 18-22 September, 2006.

C INVITED PRESENTATIONS
C.1 Invited presentations at international conferences in 2006
C.2 Invited presentations at national conferences in 2006

D PRESENTATIONS AT CONFERENCES
D.1 Presentations at international conferences in 2006

1. M. Barberio, M. Camarca, P. Barone, A. Bonanno, A. Oliva, F. Xu,
   Electric Transport Properties of Carbon Nanotubes mat,
   NanoSea 2006 (Aix en Provence, July 2006).

2. P. Sapia, A. Oliva, A. Bonanno,
   MM teaching the photoelectric effect in an italian school network: an early assessment,
   XI Workshop "Multimedia in Physics Teaching and Learning"- Szeged, September 20-22, 2006.

3. A. Milazzo, A. Bonanno,
   A Kinematics Learning Object,
   XI Workshop "Multimedia in Physics Teaching and Learning"- Szeged, September 20-22, 2006.

4. A. Sindona , F. Plastina , A. Cupolillo , C. Giallombardo , G. Falcone, L. Papagno,
   Many Body shake up in Carbon nanotubes,
   Oral Contribution to NANOSEA 2006, Aix-En-Provence (France), 2-6 July 2006.

5. F. Plastina,
   Entanglement localization by a single defect in a spin chain,
   Conference "Quantum mechanics: from fundamental problems to applications", 3/8-12-2006, Bertinoro (FC), Italy.

6. F. Plastina,
   Scaling of entanglement and Berry phase in the Dicke model,
   38 Symposium on Mathematical Physics", 6-06-2006, N. Copernicus University, Grudziadzka, Torun, Poland.

7. A. Sindona, P. Riccardi, S. Maletta, S.A. Rudi, G. Falcone,
   Negative ionization in sputtering of Metals: role of quasi-molecular interactions,
   Oral contribution to the XXI International Conference on Atomic Collisions in Solids(ICACS-22), Berlin, 21-26 July 2006.

8. A. Sindona, P. Riccardi, S. Maletta, S.A.Rudi, G. Falcone,
   Wave packet propagation approach in the study of secondary ion emission from sputtered materials,
   Oral contribution to the XVI International Workshop on inelastic Ion-Surface collisions (IISC-16), Wien (Austria), 17-22 September 2006.

D.2 Poster Presentations at international conferences in 2006

1. A. Sindona, S.A. Rudi, S. Maletta, R. Baragiola, G. Falcone, P. Riccardi,
   Many body excitations in Auger electron emission,
   IBMM 2006 (Ion Beam Modification in Materials), Taormina, 18-22 September 2006.

2. M. Barberio, M. Camarca, P. Barone, A. Bonanno, A. Oliva, F. Xu,
   Preliminary results on transport properties of alkali-metal-doped Single-Wall carbon Nanotubes mats,
   Ecoss 2006 (Parigi, September 2006).

3. M. Barberio, A. Bonanno, G. Falcone, P. Sapia,
   Tecnologie didattiche ed educazione alla salute: un'applet Java per l'esame audiometrico,
   Didamatica 2006". (Cagliari, May 2006)

4. T.J.G. Apollaro,
   Dynamics of Entanglement in XY Spin ½ Model in Presence of a Defect,
   38° Symposium on Mathematical Physics "Quantum Entanglement and Geometry", Torun (Poland), 4-7/6 2006.

5. T.J.G. Apollaro,
   Entanglement Properties in the XX Spin ½ Model in Presence of Defects,
   Symposium on Quantum Technologies (29/8-2/9 2006 Cambridge-UK).

D.2 Presentations at national conferences in 2006

1. A. Bonanno, M. Camarca, P. Sapia, M. Serpe,

La realtà fisica e la sua rappresentazione: un percorso integrato tra fisica, matematica ed informatica attraverso una cardioide,
Atti del congresso "DIDAMATICA 2006". Andronico A., Aymerich F., Fenu G. (eds); Cagliari 2006.

2. A. Milazzo, M. Camarca, A. Bonanno,
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Congresso "DIDAMATICA 2006"- Cagliari 11-13 maggio 2006.

6. MOLECULAR BIOPHYSICS

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Introduction

The Molecular Biophysics Group has essentially carried out, in the year 2006, research activity on two main topics. In particular, the first has concerned with the structure and dynamic properties of self assembled supramolecular lipid structures and their interactions with active biomolecules, while the second one has regarded the thermal stability and spectroscopic properties of metal-proteins with electron-transfer properties. Molecular Dynamics Simulation of the metal-protein, Azurin, has also been considered as well as the pro-oxidant properties of olive oil biomolecules. In the following the main results obtained in each field are reported.

6.1 DYNAMICS and MOLECULAR PROPERTIES in SELF ASSEMBLED LIPID STRUCTURES and INTERACTIONS at the LIPID/PROTEIN INTERFACE

6.1.1 Pulsed Electron Spin Resonance Studies of Spin-Labelled Lipids in Membranes

Recently, developments in time-resolved spin-label electron spin resonance (ESR) spectroscopy have contributed considerably to the study of biomembranes. Two different applications of electron spin echo spectroscopy of spin-labelled phospholipids are considered: 1. the use of partially relaxed echo-detected ESR (ED-ESR) spectra to study the librational lipid-chain motions in the low-temperature phases of phospholipid bilayers; and 2. the use of electron spin echo envelope modulation (ESEEM) spectroscopy to determine the penetration of water into phospholipid membranes. Results are described for phosphatidylcholine bilayer membranes, with and without equimolar cholesterol, that are obtained with phosphatidylcholine spin probes site-specifically labelled throughout the *sn*-2 chain.

6.1.2 Electron spin-echo studies of spin-labelled lipid membranes and free fatty acids interacting with human serum albumin

Human serum albumin (HSA) is an abundant plasma protein that transports fatty acids and also binds a wide variety of hydrophobic pharmacores. Echo-detected (ED) EPR spectra and D_2O-electron spin echo envelope modulation (ESEEM) Fourier-transform spectra of spin-labelled free fatty acids and phospholipids were used jointly to investigate the binding of stearic acid to HSA and the adsorption of the protein on dipalmitoyl phosphatidylcholine (DPPC) membranes. In membranes, torsional librations are detected in the ED-spectra, the intensity of which depends on chain

position at low temperature. Water penetration into the membrane is seen in the D_2O-ESEEM spectra, the intensity of which decreases greatly at the middle of the membrane. Both the chain librational motion and the water penetration are only little affected by adsorption of serum albumin at the DPPC membrane surface. In contrast, both the librational motion and the accessibility of the chains to water are very different in the hydrophobic fatty acid binding sites of HSA from those in membranes. Indeed, the librational motion of bound fatty acids is suppressed at low temperature, and is similar for the different chain positions, at all temperatures. Correspondingly, all segments of the bound chains are accessible to water, to rather similar extents.

6.2 MOLECULAR DYNAMIC SIMULATION and THERMAL STABILITY of METAL-PROTEIN with OXIDASE ACTIVITY

6.2.1 Thermal unfolding of pseudoazurin: calorimetric and spectroscopic studies

The thermal unfolding of pseudoazurin has been investigated by means of differential scanning calorimetry (DSC), optical density, fluorescence and electron paramagnetic resonance spectroscopy. The combination of these experimental techniques has allowed us to gain insight into the modifications of the copper site environment and of the whole protein structure, during the denaturation process.
The thermal transition from the native to the denaturated state results to be irreversible, on the whole, and occurs in the temperature range between 333.0 and 340.5 K, depending on the scan rate and the technique used.
The denaturation pathway of the pseudoazurin can be described in terms of the Lumry-Eyring model: $N \Leftrightarrow U \Rightarrow F$. The protein reversibly passes from the native (N) state to the unfolded (U) one, whereas the step towards the final (F) state is irreversible and kinetically controlled. This model has been checked by numerical simulation of the calorimetric thermograms. The thermodynamic parameters related to the reversible step (ΔH_U = 498 kJ·mol^{-1} and $T_{1/2}$ = 340.8 K) have been obtained by extrapolation of the DSC profile at infinite scan rate. These data together to the ΔCp value of 8.3 ± 0.9 kJ K^{-1} mol^{-1}, calculated by means two different theoretical methods, lead to a ΔG value of 39.2 kJ mol^{-1} at 298 K.
From the comparison of the data obtained by the different techniques used, it emerges that the thermal denaturation process of holo-pseudoazurin starts with the disruption of the copper active site and the destabilization of the hydrophobic core, and proceeds with the collapse of the whole protein. In addition, according to the EPR findings, the native type-1 copper ion, which is in a distorted tetrahedral configuration in the native state of the protein, shows type-2 copper features after the denaturation.
Finally the role of the copper on the thermal stability of pseudoazurin is also discussed. The unfolding of the apo-form of protein is a reversible process and occurs at 315 K.

6.2.2 A Comparative Investigation of the Thermal Unfolding of Pseudoazurin in the Cu(II)-Holo and Apo Form

The contribution of the copper ion to the stability and to the unfolding pathway of pseudoazurin was investigated by a comparative analysis of the thermal unfolding of the Cu(II)-holo and apo form of the protein. The unfolding has been followed by calorimetry, fluorescence, optical density and electron paramagnetic resonance (EPR) spectroscopy.
The thermal transition of Cu(II)-holo pseudoazurin is irreversible and occurs between 60.0 and 67.3 °C, depending on the scan rate and technique used. The denaturation pathway of Cu(II)-holo pseudoazurin can be described by the Lumry-Eyring model: $N \Leftrightarrow U \Rightarrow F$; the protein reversibly goes from the native (N) to the unfolded (U) state, and then irreversibly to the final (F) state.
The simulation of the experimental calorimetric profiles, according to this model, allowed us to determine the thermodynamic and kinetic parameters of the two steps. The □G value calculated for the Cu(II)-holo pseudoazurin is 39.2 kJ·mol^{-1} at 25 °C.
The sequence of events in the denaturation process of Cu(II)-holo pseudoazurin emerging starts with the disruption of the copper site and the hydrophobic core destabilization followed by the global protein unfolding.
According to the EPR findings, the native type-1 copper ion shows type-2 copper features after the denaturation.
The removal of the copper ion (apo form) significantly reduces the stability of the protein as evidenced by a □G value of 16.5 kJ·mol^{-1} at 25 °C. Moreover, the apo Paz unfolding occurs at 41.8 °C and is compatible with a two state reversible process $N \Leftrightarrow U$.

6.2.3 Calorimetric And Spectroscopic Studies of His306Ala Nitrite Reductase Mutant: Role of His306 in the Protein Thermal Denaturation

Nitrite reductase (NiR) is a very stable trimeric protein: its denaturation pathway can be satisfactorily described by a three state model, $N \Leftrightarrow U \Rightarrow F$ (N–native, U–unfolded and F–final), in which the oligomeric dissociation does not take place before the rate-determining step. To understand the role of the interfacial residues on the protein stability, the NiR

variant His306Ala, in which the type-2 copper His306 ligand has been site-directed mutated to an alanine, was calorimetrically and spectroscopically investigated.
The calorimetric study of this NiR mutant shows an endothermic irreversible profile, with maximum heat absorption at $T_m \approx 85$ °C, i.e. 15 °C lower than the value found for wild type protein. The replacement of the His306 with the alanine residue reduces the protein stability, as also optically evidenced. Moreover the denaturation pathway is also affected and can be described by the kinetic model $N_3 \overset{k}{\Rightarrow} F_3$, where the protein irreversibly passes from the native to the final state, without dissociation in monomers. Optical and magnetic data of the native state of the protein highlight that this mutation prevents type-2 copper ions from binding, suggesting that these copper sites, situated at the interface of two monomers, significantly affect both the stability and the denaturation mechanism of NiR. Finally, conformational changes of the type-1 copper sites precede the collapse of the whole protein structure, as evidenced by EPR results.

6.3 FREE RADICALS IN FOOD SCIENCE

6.3.1 Pro-oxidant Activity of Oleuropein Determined in Vitro by Electron Spin Resonance Spin-Trapping Methodology".

In this work, the pro-oxidant behavior of oleuropein (OLP, **1**) is characterized in a Fenton-like experiment by means of ESR spectroscopy using the spin trap system DMSO and 4-(pyridyl-1-oxide)-N-tert-butyl nitrone (POBN) in phosphate buffer (PB) solution. Ferrous ions in the absence of hydrogen peroxide cause the formation of the stable nitroxide species **4** and **5** through the intermediate perferryl species. OLP displays its antioxidant activity in vitro blocking the oxidation path that leads to methoxyl radicals hence to the formation of the stable radical species **5**. The role of the catechol moiety was proved when the perferryl experiments were repeated in the presence of the dimethylated oleuropein homologue (OLP-Met2, **2**). The dual behavior of oleuropein, similar to that ascertained for other catechol and non-catechol natural active species, should provide warnings for its use as nutraceutical or as drug with manifold healing effects.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2006

1. Bartucci R., Erilov D.A., Guzzi R., Sportelli L., Dzuba S.A, Marsh D.,
Time-resolved electron spin resonance studies of spin-labelled lipids in membranes,
Chem. Phys. of Lipids. 141, 142-157 (2006).

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Pro-oxidant Activity of Oleuropein Determined in Vitro by Electron Spin Resonance Spin-Trapping Methodology,
J. Agric. Food Chem.. 54, 7444-7449 (2006).

3. Stirpe A, Sportelli L., Guzzi R.,
A Comparative Investigation of the Thermal Unfolding of Pseudoazurin in the Cu(II)-Holo and Apo Form,
Biopolymers. 83, 487-496 (2006)

A.1.2 Publications on international journals accepted in 2006

1. B. Rizzuti, L. Sportelli, R. Guzzi,
Structural, dynamical and functional aspects of the inner motions in the blue copper protein azurin,
Biophys. Chemistry – on-line: November 23, 2006

2. M. Pantusa, R. Bartucci, L. Sportelli,
Calorimetric and spin-label ESR studies of PEG:2000-DPPE containing DPPC/lyso-PPC mixtures,
Coll. Polymer Science,. Accepted 12 October 2006 – on line: 20 Jan 2007

3. 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 – Biomembrane, Accepted.

4. A. Stirpe, L. Sportelli. H. Wijma, M. Ph. Verbeet, R. Guzzi,
Thermal stability effects of removing the type-2 copper ligand His-306 at the interface of nitrite reductase subunits,
Eur. Biophys. J. (2006), to appear.

A.2 Publications on national journals

A.2.2 Publications on national journals printed in 2006

1. A. Stirpe, R. Guzzi,
Thermal unfolding of holo and apo pseudoazurin,
Il Nuovo Cimento C, 29, 351-360 (2006).

C INVITED PRESENTATIONS

C.1 Invited presentations at international conferences in 2006

1. R. Bartucci,
Interaction of PEG-grafted membranes with spin-labelled Human Serum Albumin,
Workshop on Lipid – Protein Interactions; April 28-29, 2006, Murcia (Spain).

C.2 Invited presentations at national conferences in 2006

1. B. Rizzuti,
Functional aspects of inner motions in the blue copper protein azurin,
SIF 2006 – 92nd National congress of SIF (Società Italiana di Fisica), Section: Biophysics and Medical Physics, Comprensorio di Chimica e Fisica – September 22, 2006 – Torino, Italy.

2. R. Guzzi,

Calorimetric and spectroscopic studies of His306Ala nitrite reductase mutant: role of His306 in the protein thermal denaturation,
XVIII Congresso Società Italiana di Biofisica Pura ed Applicata, Palermo, September 17-21, 2006.

D PRESENTATIONS AT CONFERENCES

D.1 Presentations at international conferences in 2006

1. M. Pantusa, R. Bartucci, L. Sportelli,
Interaction of PEG-grafted membranes with spin-labelled Human Serum Albumin,
Workshop on Lipid – Protein Interactions; April 28-29, 2006, Murcia (Spain).

2. F. De Simone, R. Guzzi, R. Bartucci, L. Sportelli,
Echo-detected spectra and ESEEM spectroscopy of spin-labelled stearic acids in human serum albumin,
6th European Federation of EPR Group Meeting, Madrid, September, 4-8, 2006.

D.2 Presentations at national conferences in 2006

1. M. Pantusa, R. Bartucci, L. Sportelli,
Thermotropic behaviour of PEG:2000-DPPE containing DPPC/lyso-PPC mixtures: spin-label ESR and calorimetric studies,
SIBPA 2006 – XVIII Italian conference of SIBPA (Società Italiana di Biofisica Pura e Applicata) – September, 17-21, 2006 – Palermo, Italy.

2. F. De Simone, R. Guzzi, R. Bartucci, L. Sportelli,
Spin-labelled stearic acids interacting with human serum albumin: pulsed electron spin-echo studies,
SIBPA 2006 – XVIII Italian conference of SIBPA (Società Italiana di Biofisica Pura e Applicata) - September, 17-21, 2006 – Palermo, Italy.

3. A. Stirpe, R. Guzzi, L. Sportelli,
Calorimetric and spectroscopic studies of His306Ala nitrite reductase mutant: role of His306 in the protein thermal denaturation,
SIBPA 2006 – XVIII Italian conference of SIBPA (Società Italiana di Biofisica Pura e Applicata) - September, 17-21, 2006 – Palermo, Italy.

4. B. Rizzuti,L. Sportelli, R. Guzzi,
Functional aspects of inner motions in the blue copper protein azurin,
SIF 2006 – 92nd National congress of SIF (Società Italiana di Fisica), Section: Biophysics and Medical Physics, Comprensorio di Chimica e Fisica – September 22, 2006 – Torino, Italy.

7. PHYSICS AND APPLICATIONS OF THE SOFT MATTER

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Introduction

The research activity in 2006 has been concerned with the following subjects: PDLC e POLICRYPS, liquid crystals, nonlinear optics, electrooptics, electrodynamical instabilities, oxide thin films, polymer, nonlinear dynamics, nanoscience of soft matter, vibrational spectroscopy

7.1 SOFT MATTER

Ferroelectric Liquid Crystal Composed Of Non-Chiral Bent-Shape

In collaboration with the group of the Institute of Crystallography, Russian Academy of Science (Moscow) there has been obtained an important result. A ferroelectric liquid crystal composed of non-chiral bent-shape (banana) molecules has been prepared in the form of the Langmuir Blodgett films with evaporated top Al electrodes. In this sandwich geometry, typically used in semiconductor electronics, the 20-70 nm thick layers of the liquid crystal material show both ferroelectric and electrooptical properties. Therefore, a new ultrathin film liquid crystal technology has been suggested.

PDLC

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. Moreover, planar nematic layers of 5CB oriented by “sliding on” nanolayer of PTFE were studied by electrooptic methods. Deposited layer were characterized by AFM and spectroscopic ellipsometry. It was found that at 100 °C presumably single PTFE chain (4 nm thickness) are deposited. By ellipsometry measurements c. 0.1° pretilt angle of the nematic layer was determined. An overall 1/f shape of the oscillation spectrum was found in the range 1 to 1000 Hz, giving no evidence of a surface viscosity effect in this range.

7.2 NANOSCIENCE AND PHOTONIC

Random Laser Action In Highly Anisotropic And Partially Ordered NLC

Random laser action in highly anisotropic and partially ordered NLC has been observed in several confined geometries as well as in freely suspended films. The underlying mechanism is mainly based on interference effects which survive to recurrent multiple scattering driven by nematic director fluctuations. Coherent backscattering experiments performed on similar systems have already proven that interference effects leads to weak localization of light waves. Weakly localized light waves into dye doped nematic sample are responsible for amplification while the resonance frequencies are selected through interference phenomena of the counter-propagating light waves within the localized loops. For the sake of simplify, photons spontaneously emitted by the fluorescent guest molecules are launched at random directions from random positions within the excited volume. Because of the recurrent multiple scattering the probability to trace reciprocal paths by these photons is not null, as demonstrated by coherent backscattering experiments, thus resulting in equal phase accumulation during these open loops. Being the gain length comparable with the transport mean free path the emission of other photons is stimulated before the recurrently scattered photons leave the sample, triggering a coherent chain reaction. When the balance gain-loss becomes positive the optically excited dye doped nematic start to lase. Unlike distributed feedback mirror-less laser, this system can be considered as a cavity-less microlaser where the disorder unexpectedly plays the most important role, behaving as randomly distributed feedback laser. We found that the dye transition dipole moments adopt in some degree the orientational order parameter of the nematic director, resulting in a control of the emission intensity by varying the polarization of the pump beam. In addition, the evaluated β-factor for the presented system yields an intermediate value with respect to the random and fully ordered systems, suggesting that the order parameter drives the amount of spontaneous emission radiated into the lasing modes. Many further studies will be needed in order to gain full understandings of the diffusive laser action in nematic samples, indeed a wide series of experiments; simulations and

extensive investigations have been planned. The aim of this work is to gain understandings of mechanisms behind random lasing in nematics in order to enlighten the intriguing world of the partially ordered systems, and its peculiar emission properties when doped with gain media. Clearly, this could represent an exceptionally promising route for fundamental prospective studies with strong technological implications for integrated optical systems, nanophotonic and optoelectronic fields.

Liquid Crystal Diffraction Gratings

The experimental study and modeling of the field behavior of liquid crystal diffraction gratings have been performed, which showed the way for optimization of the grating recording process.

Mirrorless Clc Laser

The super-molecular helical structure, gives to cholesteric liquid crystals (CLCs) particular properties. Bragg reflection of light at a wavelength comparable to the helical pitch and the presence of a photonic band-gap allows to use these materials as photonic crystals. Doping CLCs with photo-luminescent dyes we are able to obtain laser emission from these mixtures. Tuning the helical pitch length, a modulation of the laser emission can be obtained. Considerable miniaturization and fiber optics technology offer very promising developments related to technological applications for these kind of systems.

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.

The manipulation of the topography in thin films of azo-benzene based dyes and polymers has been achieved and formation of the surface relief gratings has been reported for the first time with polarization holography in systems without azo-compounds.

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. Photoisomerization of the azo- or azoxy-nematic components of the cholesteric mixture was exploited in order to perform reversible tuning, instead of the phototrasformation of the chiral dopants. Two LEDs emitting at wavelength of 405nm and 466nm respectively, induce trans-cis and cis-trans isomerization of nematic components resulting in a tuning range of 70nm. The new line of research was initiated related to lasing in the in-plane waveguiding geometry for nematic and cholesteric liquid crystals. The new regime of the waveguide feedback has been found and explained and its importance for lasing efficiency in cholesterics was underlined. A new type of voltage tunable DFB laser is suggested that operates on high Bragg diffraction orders of a periodic shadow mask.

7.3 NANOSCIENCE OF SURFACES

Vibrational Spectroscopy

In the year 2006 continued the extensive scientific and technological work of synthesis and characterization of thin solid film, to be used for electrochromic devices and for asymmetric nematic liquid crystal cells. Beside the materials research, development and testing of electrochromic devices, based on both organic and inorganic films, were performed. A new activity has been developed on ferroelectric crystals, in particular PZT, to be used as substrate in liquid crystal cells: a Raman characterization on nanocrystals grown by other groups in confined environments (nanopores) has been carried out; later, new sol-gel methods and different post deposition thermal treatments for growing PZT film have been tested by using various techniques.

Moreover, some research of Raman spectroscopy on particular materials has been made in collaboration with other groups of this Department, of others Department of this University, and of other Italian and foreign universities and research centers. To be pointed out the works on mixed films of Re-Ta, in collaboration with Trento and Riga (Latvia) University, the paper on polymeric blend, made in collaboration with a group of the Chemistry Department, and finally the research on TiO_2 powders specially synthesized for deposition on thin films, made in collaboration with a group of Palermo University.

The temperature dependence of Raman scattering from linear carbon chains inside multiwalled nanotubes has been analysed and interpreted in terms of a reversible reduction of the Peierls distortion of the chains at high temperatures. Such results have been presented to international conferences and submitted to high level journals.

Finally, the applications of the micro-Raman Spectroscopy to the study of archaeological handiworks have been developed, on the fresco “Trapasso della Vergine” of a church “S. Giovanni Battista” at Paterno Calabro. This study was associated to a dissertation of a student of the specialistic degree in Restoration and Conservation of the Cultural Heritage, successfully defended in October 2006; the results were also presented in an international meeting and submitted to a specific journal on the cultural heritage.

Nematic Order Reconstruction And Nanoscopic Surface Interactions.

Recently, we presented the first time resolved experimental characterization of the biaxial switching between two topologically distinct textures of a nematic liquid crystal cell under strong applied electric field. This fast electro-optical effect is governed by the electric induced order reconstruction in the nematic bulk, which continues to be a relevant challenge for a complete theoretical description of the nematodynamics. At present, the average molecular orientation change is obtained without any local director rotation, but with a suitable deformation of the ellipsoid which represents the nematic order. We developed an improved bi-dimensional numerical model using the Q-tensor description that gives good agreement with experimental data. With respect to the previous one-dimensional dynamical model we solve now the bi-dimensional cases, adding to the elastic energy always 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.

Effect Of Nanometer-Scale Roughness On The Adhesion And Friction Between Surfaces

Friction and adhesion measurements between surfaces of cross-linked, stiff polymers of varying roughness against smooth, bare mica surfaces were carried out in dry air as well as in the presence of lubricating oil. The nominal (macroscopic) contact area varies with the applied load according to the Johnson, Kendall and Roberts (JKR) theory, yet shows significant hysteresis due to the irreversibility arising from the loading/unloading curves of multiple asperities. Upon introducing the oil between the surfaces, the critical shear stress is reduced to zero due to the elimination of the adhesion force. However, the effect is less noticeable on the friction coefficient. Lastly, the effect of increasing the (RMS) roughness was greatest over the first few nanometers due to the diminution of the adhesion-controlled contribution to the friction, after which a further increase in roughness had less dramatic effects. A model is presented to account for the observed adhesion hysteresis during repeated loading/unloading cycles of purely elastically deforming rough surfaces.

Changes Of The Electro-Optic Response Of Nematic Liquid Crystal Cells

Thin film of PZT (lead zirconium titanate oxide [(Pb(Zr 0.47Ti 0.53)O3]) are of great interest for their application in non volatile memories, then, the interest in physical and electric properties of such materials has been considerable in the last 10 years, moreover, the problem, associated with application of ferroelectric materials such as polarisation fatigue, ageing and field and frequency dependence of the piezoelectric, elastic and dielectric properties, generated intensive research of the fundamental properties of ferroelectrics. In this work we have provided to the application of PZT thin film in asymmetric nematic liquid crystal cells. The electro-optical response of asymmetric nematic liquid crystal cells has been studied in the lasts years for the insertion of various kind of oxide layers having mixed conduction properties (Tungsten Trioxide, Titania Vanadia oxide, etc). These devices show a particular polarity sensitive electro-optical response and this behaviour has been related to the ionic charge migration into the oxide film. The possibility to introduce PZT (lead zirconate titanate) thin film has been taken into account more recently. Such films have been obtained via sol-gel and deposited on ITO substrate as electrode of asymmetric nematic liquid crystal cells. The ferroelectric properties of PZT allow us to obtain a polar reorientation in the liquid crystal films in the way as the ions migration in the previously used oxides. In the PZT case we obtain a considerable improvement in term of contrast as well as of response time.

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 cm^2/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 $130cm^{-1}$

Spectroscopic Ellipsometry Study Of The Soft Condensed Matter

a - Thin PTFE films

We studied by electrooptic methods planar nematic layers of 5CB oriented by ‘‘sliding on’’ nanolayers of PTFE . 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 15 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.

Important result of this work is the finding of the pretilt angle and the tilt orientation of the nematic director on PTFE films. With some loosely PTFE covered glass substrates an unusual static modulated domain pattern was observed for the first time. These static domains are memorized for several hours. Tentative mechanism of this modulating instability could be an escape of director field from a planar, but splayed configuration to a non-planar but twisted configuration, which is of a lower elastic energy as the twist elastic constant is lower than the splay one. Noteworthy, this study represents the first experimental determination of such properties for PTFE oriented 5CB films.

b- Structural and morphological characterization by VASE technique of lead zirconae-titanate thin films.

We studied the optical and morphological properties of transparent thin films of $Pb(Zr_{0.47}Ti_{0.53})O_3$ (PZT) by Variable Angle of incidence Spectroscopic Ellipsometry technique (VASE) in the spectral range from 250nm to 1000nm. The sol gel technique by spin coating deposition was used to obtain thin films on various substrates: intrinsic silicon wafers, soda-lime float glasses and soda-lime float glasses covered by indium tin oxide (ITO). The PZT films have been annealed at different temperatures in the range between 100°C and 700°C. The ellipsometric investigation allowed us to estimate the composition, the thickness, and the roughness of the samples and the comparison of the different used optical models are objects of the present work.

We have observed a structural rearrangement of the PZT thin films when the annealing temperature is in the range among 500 – 600 °C.

The structural properties of the PZT films are not influenced by the substrates when the annealing temperature is smaller than 500 – 600 °C.

The substrates are important for structural rearrangement of PZT films when the annealing temperature is greater than 500 – 600 °C.

7.4 SENSORS

Uv Sensors

The Erythemal Response Spectrum is a scientific expression that describes the sensitivity of the skin to the ultraviolet radiation. The skin sensitivity strongly depends on the UV wavelength: a long exposure to UV radiation causes erythema once a threshold dose has been exceeded. In the past years several devices, able to mimic the human skin behaviour under UV radiation, have been developed. We are working on a new device based on liquid crystals technology. The sensor is based on a liquid crystalline mixture that absorbs photons at UV wavelength and emits them at a longer one. This system presents several innovative features: the absorption range of the mixture can be varied to be sensitive to different wavelengths and to be similar to the Erythemal Response Spectrum, the luminescence intensity can be tuned, the system can be implemented on flexible devices.

7.5 BIONANOTECHNOLOGY

Scanning Probe Microscopy And Modelling In Ophthalmologic Surgery

We are interested in the modelling of the biomechanical response of the cornea following different surgical techniques: corneal photoablation or corneal transplantation. The optical quality of the modified cornea and the simulation of visual quality after surgery are also investigated. The aim is to determine the impact of corneal surgery on vision and further analyse new visual metrics for clinical purpose.

The research group is also involved in the analysis of the nano-topography in native and photoablated corneas using Atomic Force Microscopy (AFM) in liquid environment. We aim to widen the current knowledge of the biophysical response of the cornea to surgery either at micro- and at nano-scales. This could definitely lead to more predictable surgical results and to further optimize visual performance for the individuals after the surgery.

The study of the biophysical properties of the intra-ocular lenses (IOLs) is a another field of research. IOLs are biomaterials widely used to replace the crystalline lens after cataract surgery. The work aims to determine the optimal surface properties of IOLs, which could be worthy for minimizing the incidence of posterior capsular opacification, that is the main postoperative complication.

Boundary Biolubrication Articular Joints

Using a Surface Forces Apparatus, we have measured the normal and friction forces between layers of the human glycoprotein lubricin, the major boundary lubricant in articular joints, adsorbed from buffered saline solution on various hydrophilic and hydrophobic surfaces: (i) negatively charged mica, (ii) positively charged poly-lysine and aminothiol, and (iii) hydrophobic alkanethiol monolayers. On all these surfaces lubricin forms dense adsorbed layers of thickness 60−100 nm. The normal force between two surfaces is always repulsive and resembles the steric entropic force measured between layers of end-grafted polymer brushes. This is the microscopic mechanism behind the anti-adhesive

properties showed by lubricin in clinical tests. For pressures up to about 6 atm, lubricin lubricates hydrophilic surfaces, in particular negatively charged mica (friction coefficient $\mu = 0.02\text{-}0.04$), much better than hydrophobic surfaces ($\mu > 0.3$). At higher pressures, the friction coefficient is higher ($\mu > 0.2$) for all surfaces considered and the lubricin layers rearrange under shear. However, the glycoprotein still protects the underlying substrate from damage up to much higher pressures. These results support recent suggestions that boundary lubrication and wear protection in articular joints are due to the presence of a biological polyelectrolyte on the cartilage surfaces.

Conformational Change Of Cavitands By Sum-Frequency Vibrational Spectroscopy

Biomolecules that undergo conformational changes in response to external perturbations are everywhere in nature, and there is great interest in developing biomimetic molecules that mimic biological function. Cavitands are synthetic receptors that exhibit molecular–recognition properties because of a combination of shape selection and specific interaction with the guest. They present the peculiar property of a temperature or pH driven conformational switch between a closed vase and an open kite shape which offers the potential of selective binding/releasing a guest molecule. In this context, we monitored in situ these molecular scale conformational changes at the air-water interface. Sum-Frequency Vibrational Spectroscopy (SFVS) gave direct structural information, such as average orientation of selected moieties through their vibrational spectra, providing the first quantitative molecular-level description of a vase-kite conformational change of a cavitand monolayer.

7.6 OPTICAL

Depolarizing Optical Systems

In the last few years the scientific and technological interest in light depolarizing system is continuously growing, our activity in this field concerns light depolarization in turbulent media and light depolarization in liquid crystals composite systems, we studied the light depolarization in the disorder evolution that occurs during the Fréedericksz transition in homeotropically aligned nematic liquid crystals films. The study was carried out by measuring by means of a four-detectors polarimeter the Stokes parameters of the light transmitted by the sample during the transient. 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.

There is a substantial difference between the homeotropic and planar cases of initial configuration of nematic film. The depolarization effects during Fréedericksz transition occurs only in the homeotropic case. In the planar case the orientational director dynamics is established by the geometry of the system, which unambiguously fixes the initial and the final directions of the director. In homeotropic case only the initial director orientation is fixed (perpendicular to the cell plates), than, during the transition, the director is free to revolve in all the directions around the initial one. This is a further degree of freedom which is not present in the planar case. This symmetry breaking produces a local director orientation which is different in the various points of the cell. As a consequence the wave front of the transmitted light undegoes a local phase displacement and we have light depolarization. The average size of this domains is about 5 μ m for ε =0,07 until 1 μ m for ε =0,7.

Moreover there is evidence of other depolarization effects in presence of the defects. We have observed that the depolarization did not occur when the defects disappear for the defect-antidefetc annihilation mechanism. So we could suppose that the presence of defects could select some modes in the orientation perturbation. We have so a director orientation pattern that continuously varies and weak-defects between domains boundaries.

Electrohydrodynamic Instabilities In Doped M5 Nematic Liquid Crystals

We have studied M5 with different concentrations of salt and acid dopants by various analysis. We obtained that the clearing point temperatureTC decreases when the salt concentration increases. On the contrary TC is almost independent from the acid concentration, meanwhile increasing the acid concentration we observed an increasing of both the perpendicular resistivity and the cutoff frequency. The perpendicular dielectric constant doesn't change significantly in any case. The mixtures with SALT ¼ 8wt%_12 wt% and ACID ¼ 2wt%_ 175 6wt% are good candidates to replace MBBA for electroconvenction experiments but we must be able to reach greater ions concentration and it's not possible by our dopants. In particular the impurities present in M5 preparations (in presence of the acid and salt dopants) could play a fundamental role for this purpose but more studies are required.

7.7 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 (2006), our interest has been devoted to the following arguments:

a) In situ optical control and stabilization of the curing process of POLICRYPS gratings.

We have realized a new holographic setup for the fabrication of polymer liquid-crystal polymer-slice (POLICRYPS) diffraction gratings, which utilizes an optical-feedback-driven nanopositioning technique. We have increased the stability of the interference pattern by means of a simple piezomirror used in a feedback configuration to keep constant the phase of the interferometer. The feedback system is driven by a proportional, integral, derivative control software, and the stability degree is controlled by the reference signal coming from a standard test grating. A preliminary experimental characterization indicates that good control and stabilization of parasitic fluctuations of the interference pattern are obtained.

b) Investigation of two - wave coupling during the formation of POLICRYPS gratings.

We have studied the beam coupling effect that occurs during the formation of POLICRYPS diffraction gratings. We have also implemented a complete theoretical model which accounts for the main experimental features of the effect. Numerical solutions confirm the observed absence of any energy transfer process for unit ratio of the impinging beam intensities. When this ratio is not unit, the transfer is instead present and tends to equalize the beam intensities during the curing process; the capability of performing this equalization is strongly related to the grating diffraction efficiency. Furthermore, in this case, numerical simulations enable also to visualize the final (distorted) morphology of the fabricated structure.

c) POLICRYPS switchable holographic grating utilized as an electro-optical Pixel for high resolution display application.

We have investigated the possibility of utilizing a micrometric sized POLICRYPS grating as an "electro-optical pixel" for high resolution display application. We have shown that this utilization of the POLICRYPS is a quite promising possibility for the following reasons:

- the POLICRYPS is very versatile and can be used to obtain both transmission and reflection diffraction gratings;
- there are no mechanical parts and the fringe spacing can be reduced to about 0.3 μm, with a first order diffraction efficiency as high as 98%; this means that micrometric pixels can be fabricated without affecting the grating features, with a consequent high resolution of the image;
- availability of a satisfactory chemical diffusive model for the sample realization enables to choose the best conditions of curing temperature and UV intensity for realizing a sharp structure with a high diffraction efficiency;
- availability of a satisfactory Kogelnik-like model for determination of the diffraction efficiency enables to choose the best values of sample thickness and material parameters for the realization of gratings whose optical characteristics remain almost constant in the whole range of operation temperature;
- switching voltages, of the order of few V/μm are already satisfactory and can be further reduced;
- the cost is really low.

7.8 REALIZATION OF PARTICULAR LIQUID CRYSTAL CELLS FOR PROPAGATION AND CHARACTERIZATION OF OPTICAL SPATIAL SOLITON

We have designed, fabricated and characterized liquid crystal cells for investigation of optical spatial solitons. Controlling of the director orientation at the input interface, as well as in the bulk, allows to obtain configurations that can produce distinct optical phenomena in a light beam propagating in the cell. For a particular director configuration, it is possible to produce two waves inside the nematic liquid crystal cell: the extraordinary and the ordinary one. With a different director configuration, the extraordinary wave only is obtained, which propagates inside the cell at an angle of more than 7° with respect to the impinging wave vector direction. Under this peculiar configuration and by applying an external voltage, it is possible to have a good control of the propagation direction of the optical spatial soliton.

7.9 DFB MICRO-LASER ARRAY: HELIXED LIQUID CRYSTALS: EMBEDDED IN HOLOGRAPHICALLY SCULPTURED POLYMERIC MICROCAVITIES

We have performed a detailed physical characterization of a novel array of organic DFB microcavity laser possessing a high ratio between the quality factor Q of the resonant cavity and its volume V. The optical microcavity was obtained by confining self-organized mesophases doped with fluorescent guest molecules into holographically patterned polymeric microchannels. The LC microchannels act as mirror-less cavity lasers, where the emitted laser light propagates along the liquid crystal superhelical axis behaving as Bragg resonator. This miniaturization process allows to obtain a micro-laser array possessing an ultralow lasing threshold (25nJ/pulse)

while having directional control on the lasing emission, a fine wavelength tunability and the control over the emission intensity.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2006

1. L.M. Blinov, S.P. Palto, A.R. Geivandov, V.V. Lazarev and S.G. Yudin,
   Antiferro- and Ferroelectric Switching of a Liquid Crystal Under Strong Confinement Conditions in Langmuir-Blodgett Films,
   Kristallografiya 51, 898-905 (2006).

2. A.R. Geivandov, S.P. Palto, S.G. Yudin, L.M. Blinov, G. Pelzl, W. Weissflog,
   Ferro- and antiferroelectric properties of Langmuir-Blodgett films composed of mesogenic bent-core molecules,
   Ferroelectrics 344, 1-8 (2006).

3. L.M. Blinov, G. Cipparrone, A. Mazzulla, C. Provenzano, S.P. Palto, M.I. Barnik, A.V. Arbuzov, B. A. Umanskii,
   A nematic liquid crystal as an amplifying replica of a holographic polarization grating,
   Mol. Cryst. Liq. Cryst. 449, 147-160 (2006).

4. S.P. Palto, M.I. Barnik, A.V. Arbuzov, B.A. Umanskii, L.M. Blinov,
   A nematic replica of a holographic polarization grating: Modeling of the ideal and a corrugated surface,
   J. Nonlinear Opt. Phys. & Mat. 15, 23 (2006).

5. L.M. Blinov, G. Cipparrone and P. Pagliusi, V.V. Lazarev and S.P. Palto,
   Mirrorless lasing from nematic liquid crystals in the plane waveguide geometry without refractive index or gain modulation,
   Appl. Phys. Lett. 89, 0311114 (2006).

6. S.P.Palto, N.M. Shtykov, B.A.Umansky, M.I. Barnik and L.M.Blinov,
   General Properties of Lasing Effect in Chiral Liquid Crystals,
   Opto-Electronics Review 14, 323-8 (2006).

7. I. Nicotera, L. Coppola, C. Oliviero, M. Castriota, E. Cazzanelli,
   Investigation of ionic conduction and mechanical properties of PMMA-PVdF blend based polymer electrolytes,
   Solid State Ionics 177, 581-588 (2006).

8. ED. Mishina, N.É. Sherstyuk, V.O. Val'dner, A.V. Mishina, K.A. Vorotilov, V.A. Vasil'ev, A.S. Sigov, M.P. De Santo, E. Cazzanelli, R. Barberi and T.H. Rasing,
   Nonlinear-optical and micro-Raman diagnostics of thin films and nanostructures of ABO(3) ferroelectrics,
   Physics of the Solid State 48 (6), 1210-1213 (2006).

9. J. Purans, A. Kuzmin, R. Kalendarev, E. Cazzanelli and M. Castriota,
   Structural Characterization of Mixed Ta-Re Oxide Films,
   Solid State Ionics 177**,** 1887–1891 (2006).

10. G. Strangi, S. Ferjani, V. Barna, A. De Luca, C. Versace, N. Scaramuzza, and R. Bartolino,
    Random lasing and weak localization of light in dye-doped nematic liquid crystals,
    Optics Express 14 (17), 7737-7744 (2006).

11. S. Ferjani, V. Barna, A. De Luca, N. Scaramuzza, C. Versace, R. Bartolino, G. Strangi,
    Thermal Behaviour of Random Lasing in Dye Doped Nematic Liquid Crystals,
    Applied Physics Letters 89**,** 121109 (2006).

12. Y. Marinov, S. D'Elia, L. Todorova, A.G. Petrov, C. Versace, N. Scaramuzza,
    Orientation Effects of PTFE Nanolayers Upon the Nematic 5CB,
    Liquid Crystals 33(10), 1219-1225 (2006).

13. A. Chanishvili, G. Petriashvili , G. Chilaya, R.C. Barberi, M.P. De Santo, M.A. Matranga, F. Ciuchi,
    Lasing in an intermediate twisted phase between cholesteric and smectic,
    Applied Physics Letters 88 (10), 101105 (2006).

14. R. Barberi, F. Ciuchi, H. Ayeb, G. Lombardo, R. Bartolino, and G. E. Durand,

Reply to the comment on "Time Resolved Experimental Analysis of the Electric Field Induced Biaxial Order, Reconstruction in Nematics,
Physical Review Letters 96 (1), 019802 (2006).

15. G. Chilaya, A. Chanishvili, G. Petriashvili, R. Barberi, R. Bartolino, M.P. De Santo, M.A. Matranga, P. Collings,
Light control of cholesteric liquid crystals using azoxy-based host materials,
Molecular Crystals and Liquid Crystals, 453, 123-140 (2006).

16. E.D. Mishina, N.K. Sherstyuk, V.O. Val'dnera, A.V. Mishina, K.A. Vorotilov, V.A. Vasil'ev, A.S. Sigov, M.P. De Santo, E. Cazzanelli, R. Barberi, T. Rasing,
Nonlinear-optical and micro-raman diagnostics of thin films and nanostructures of ABO(3) ferroelectrics,
Physics of the Solid State, 48 (6), 1210-1213 (2006).

17. M. Lombardo, M.P. De Santo, G. Lombardo, R. Barberi, S. Serrao,
Analysis of intraocular lens surface properties with atomic force microscopy,
Journal of Cataract and Refractive Surgery 32 (8), 1378-1384 (2006).

18. O.M. Zhigalina, E.D. Mishina, N.E. Sherstyuk, K.A. Vorotilov, V.A. Vasiljev, A.S. Sigov, O.I. Lebedev, Y.V. Grigoriev, M.P. De Santo, R. Barberi, T. Rasing,
Crystallization of PZT in porous alumina membrane channels,
Ferroelectrics 336, 247-254 (2006).

19. M. Lombardo, M.P. De Santo, G. Lombardo, R. Barberi, S. Serrao,
Atomic force microscopy analysis of normal and photoablated porcine corneas,
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20. G. Pucci, M.P. De Santo, G.Carbone, R. Barberi,
A novel method to prepare probes for atomic force spectroscopy,
Digest Journal of Nanomaterials and Biostructures, 1 (3), 99-103 (2006).

21. G. Chilaya, A. Chanishvili, G. Petriashvili, R. Barberi, M.P. De Santo, M.A. Matranga,
Enhancing cholesteric liquid crystal laser stability by cell rotation,
Optics Express 14 (21), 9939-9943 (2006).

22. C. Provenzano, A. Mazzulla, G. Cipparrone,
Photopolarimeter based on two gratings recorded in thin organic films,
Applied Optics, 45, 3929-3934 (2006).

23. C. Provenzano, P. Pagliusi, G. Cipparrone,
Highly efficient liquid crystal based diffraction grating induced by polarization holograms at the aligning surfaces,
Applied Physics Letters 89, 121105 (2006).

24. G. Barbero, G. Cipparrone, O.G. Martins, P. Pagliusi, A.F.M. Neto,
Electrical response of a liquid crystal cell: The role of Debye's layer,
Applied Physics Letters 89, 132901 (2006);

25. P. Pagliusi, F. Lagugné-Labarthet, D.K. Shenoy, E. Dalcanale, Y. R. Shen,
Sensing vase-to-kite switching of cavitands by sum-frequency vibrational spectroscopy,
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26. P. Pagliusi, C.Y. Chen, Y.R. Shen,
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Journal of Chemical Physics 125, 201104 (2006).

27. V. Barna, R. Caputo, A. De Luca, N. Scaramuzza, G. Strangi, C. Versace, C. Umeton, G.N. Price and R. Bartolino,
Distributed feedback micro-laser array: helixed liquid crystals embedded in holographically sculptured polymeric microcavities,
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28. R. Caputo, L. De Sio, A. Veltri, C. Umeton, A.V. Sukhov,

POLICRYPS Switchable Holographic Grating: A Promising Grating Electro-Optical Pixel for High Resolution Display Application,
J. Display. Tech., 2, 38 (2006).

29. L. De Sio, R. Caputo, A. De Luca, A. Veltri, C. Umeton,
In-situ Optical Control and Stabilization of the Curing Process of Holographic Gratings with a nematic film–polymer-slice sequence structure,
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30. G. Assanto, C. Umeton, M. Peccianti and A. Alberucci,
Nematicons and Their Angular Steering,
J. Nonl. Opt. Phys. Mat., 15, 33 (2006).

31. A. De Luca, G. Coschignano, C. Umeton, M. Morabito,
Realization of particular liquid cells for propagation and characterization of optical spatial solitons,
Optics Express, 14, 5548 (2006).

32. D.K. de Boer, R. Caputo, H.J. Cornelissen, C.M. van Heesch, E.J. Hornix, M.J. Jak,
Diffractive grating structures for colour-separating backlights,
Proc. of SPIE, 6196, 241 (2006).

A.1.2 Publications on international journals accepted in 2006

1. L.M. Blinov, G. Cipparrone, A. Mazzulla, P. Pagliusi, V. Lazarev,
Lasing in a cholesteric liquid crystal cell: a competition of Bragg- and leaky modes,
J. Appl. Phys. (accepted).

2. L.M. Blinov, S.P. Palto and V.V. Lazarev, G. Cipparrone, A. Mazzulla and P. Pagliusi,
Quasi-In-Plane Leaky lasing modes from thin waveguiding layers of nematic and cholesteric liquid crystals,
Mol. Cryst. Liq. Cryst. (accepted).

3. E. Cazzanelli, L. Caputi , M. Castriota, A. Cupolillo, C. Giallombardo, L. Papagno,
Carbon Linear Chains Inside Multiwalled Nanotubes,
Surface Science (accepted).

4. E. Cazzanelli, M. Castriota, S. Marino, N. Scaramuzza, J. Purans, A. Kuzmin, R. Kalendarev, G. Mariotto, G. Das,
Characterization of rhenium oxide films,
Solar Energy Materials and Solar Cells (accepted).

5. 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 (accepted).

6. 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 (accepted).

7. B. Zappone, K. J. Rosenberg, J. N. Israelachvili,
Role of nanometer roughness on friction: a rough polymer surface sliding on a smooth mica surface,
Tribology Letters (accepted).

8. B. Zappone, M. Ruths, G.W. Greene, G.D. Jay, J.N. Israelachvili,
Adsorption, lubrication and wear of Lubricin on model surfaces: Polymer brush-like behavior of a glycoprotein,
Biophysical Journal, (accepted).

9. 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 (accepted)

10. C. Provenzano, P. Pagliusi, G. Cipparrone,
Electrically tunable two-dimensional liquid crystals gratings induced by polarization holography,

Optics Express (accepted)

11. C. Vena, C. Versace, G. Strangi, S. D'Elia, R. Bartolino,
Depolarization Effects During the Freèdericksiz Transition,
Submitted to Phys. Rev. E (accepted)

12. C. Vena, C. Versace, G. Strangi, S. D'Elia, R. Bartolino,
Electrohydrodynamic instabilities in doped M5 Nematic Liquid Crystals,
Mol. Cryst. Liq. Cryst. (accepted).

13. A. Di Paola, M. Addamo, M. Bellardita, E. Cazzanelli and L. Palmisano,
Preparation of photocatalytic brookite thin films,
Thin Solid Films (accepted).

14. 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 (accepted).

15. R. Caputo, L. De Sio, M.J.J. Jak, E.J. Hornix, D.K.G. de Boer, H.J. Cornelissen and M.P.C. Krijn,
New *System Concept for Colour Separating Backlights*,
J. Soc. Inf. Disp. (SID) (accepted).

16. A. Veltri, A.V. Sukhov, R. Caputo, L. De Sio, C. Umeton,
Two - wave coupling during the formation of POLICRYPS diffraction gratings: Experimental results and theoretical model,
Mol. Cryst. Liq. Cryst. (accepted).

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.1 Publications on international conference proceedings in 2006

1. A. Chanishvili, G. Petriashvili, G. Chilaya, R.C. Barberi, M.P. De Santo, M.A. Matranga, F. Ciuchi,
UV sensors based on liquid crystals mixtures,
Organic Optoelectronics and Photonics II, Proc. of SPIE, vol. 6192, 619226 (2006) ISBN: 0-8194-6248-9.

2. P. Pagliusi, C.Y. Chen and Y.R. Shen,
Surface vibrational spectroscopic studies of rubbed polyvinyl cinnamate for liquid crystal alignment,
Proc. of SPIE, 6332, 63320X (2006).

C INVITED PRESENTATIONS

C.1 Invited presentations at international conferences in 2006

1. G. Cipparrone, C. Provenzano, P. Pagliusi, L.M. Blinov,
Polarization dependent LC diffraction gratings exploiting holographic techniques and external fields,
SICL-JLCS Italian Japanese Liquid Crystals Societies Workshop, Castiglioncello, Italy, 4-7 June 2006.

2. P. Pagliusi, C.Y. Chen, Y.R. Shen,
Surface vibrational spectroscopic studies of rbbed and photo-irradiated polyvinyl cinnamate for liquid crystal alignment,
SPIE Optics & Photonics 2006, San Diego (CA), 13-17 August 2006.

3. L.M. Blinov,
Lasing from Liquid Crystals,
International Doctorate Workshop, Cetraro (Italy), Sept. 2006.

4. E. Cazzanelli, M. Castriota, S. Marino, N. Scaramuzza, J. Purans, A. Kuzmin, R. Kalendarev, G. Das, G. Mariotto,
Characterization of Rhenium oxide films,
7th International Meeting on Electrochromism, Istanbul, Turkey, September 03 – 07, 2006.

5. G. Strangi, S. Ferjani, V. Barna, A. De Luca, C. Versace, N. Scaramuzza, R. Bartolino,
Random Lasing and Weak Location of Light in Nematic Liquid Crystals,

21st International Liquid Crystal Conference Keystone, Colorado (USA), July 2 - 7, 2006.

6. V. Barna, G. Strangi, R. Caputo, A. De Luca, C. Versace, N. Scaramuzza, C. Umeton, R. Bartolino, and G.N. Price, *Distributed feedback micro-laser array: Helixed liquid crystals embedded in holographically sculptured polymeric microcavities,*
21st International Liquid Crystal Conference Keystone, Colorado (USA), July 2 - 7, 2006.

7. G. Strangi,
Random Lasing and Weak Localization of Light in Nematic Liquid Crystals,
SPIE Photonics 2006, August 13-17, 2006, San Diego, CA (USA).

1. A. d'Alessandro, D. Donisi, R. Beccherelli, R. Asquini, L. De Sio, R. Caputo and C. Umeton,
Tuneable guided wave components using POLICRYPS holographic gratings,
7th Italian Liquid Crystal Society (SICL) National Meeting, Castiglioncello (LI), Italy (2006).

9. R. Caputo, D.K.G. de Boer, H.J. Cornelissen, C.M. van Heesch, E.J. Hornix, M.J.J. Jak,
Diffractive structures for efficiency enhancement of backlight display systems,
5th ODIMI workshop (Ottiche Diffrattive, Microottica e Microsistemi), Applied Physics Institute "Nello Carrara" (IFAC), CNR, Florence, Italy (2006).

10. D.K.G. de Boer, H.J. Cornelissen, R. Caputo,
Polarised colour separation by diffractive gratings based on liquid-crystalline materials,
Int. Workshop on Liquid Crystals for Photonics, Gent University, Gent, Belgium (2006).

11. A. De Luca, G. Coschignano, L. Pezzi, A. Veltri, C. Umeton, A. Alberucci, C. Conti, M. Peccianti, and G. Assanto,
Liquid crystal cells for generation and propagation of optical spatial solitons,
21th International Liquid Crystals Conference, Keystone, Colorado, USA (2006).

D PRESENTATIONS AT CONFERENCES

D.1 Presentations at international conferences in 2006

1. L.M. Blinov, V.V. Lazarev, S.P. Palto, G. Cipparrone, P. Pagluisi (oral),
Lasing from a nematic liquid crystal in the plane waveguide geometry,
Int. Conf. on Photonics of Liquid Crystals, Gent, 24-28 April 2006;

2. L.M. Blinov, G.Cipparrone, A. Mazzulla, P. Pagliusi, V. Lazarev and S. Palto (Invited),
Lasing in cholesteric liquid crystal cells: competition between Bragg- and Leaky modes,
Meeting of Italian Liquid Crystal Society, SICL-06, Castiglioncello, 7-9 June, 2006.

3. M. Giocondo, L. Blinov, A. Mazzulla, F. Ciuchi, A. Pane,
Electro-optical properties of defect mode photonic structures using polymeric cholesteric liquid crystals layers,
Meeting of Italian Liquid Crystal Society, SICL-06, Castiglioncello, 7-9 June, 2006.

4. 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,
13th Solid State Proton Conductors Conference, St Andrews, Scotland, UK, 03/09 – 06/09/2006

5. E. Cazzanelli, M. Castriota, A. Cupolillo, L. Caputi and L. Papagno,
Carbon linear chains inside multiwalled nanotubes,
24th European Conference on Surface Science, ECOSS 24", Paris, France, 04/09 – 08/09/06.

6. E. Meduri, M. Castriota and E. Cazzanelli,
Micro-Raman spectroscopic investigations of the pigment of the fresco "Trapasso della Vergine" present in the Church of "S. Giovanni Battista" of Paterno Calabro, in southern Italy,
3rd International Workshop on: Science, Technology and Cultural Heritage", Cassino (FR), Italy, 04/10-06/10 2006.

7. S. D'Elia, E. Bruno, S. Marino, C. Vena, M. Castriota, M. De Santo, C. Versace, E. Cazzanelli and N. Scaramuzza,

Structural and morphological characterization by VASE technique of lead zirconate-titanate (PZT) thin films deposited by sol-gel method,
1st International Symposium on Transparent Conducting Oxides", Crete, Greece, 23/10 – 25/10/06.

8. S. Marino, E. Bruno, M. Castriota, E. Cazzanelli, G. Strangi, C. Versace and N. Scaramuzza,
Characterisation of PZT thin film on ITO substrate obtained by sol-gel route: their applications in asymmetric nematic liquid crystal cells,
1st International Symposium on Transparent Conducting Oxides", Crete, Greece, 23/10 – 25/10/06.

9. F. Santoro, G. Lombardo, R. Barberi,
Portable multichannel waveform generator for liquid crystal direct or multiplexed addressing,
3rd Italian-Japanese Workshop on Liquid Crystals, 4-7 June 2006, Castiglioncello (Livorno, Italy).

10. A. Habib, F. Ciuchi, G. Lombardo, R. Barberi,
Experimental investigations on the electric field induced nematic order reconstruction,
3rd Italian-Japanese Workshop on Liquid Crystals, 4-7 June 2006 Castiglioncello (Livorno, Italy).

11. F. Ciuchi, M. Giocondo, R. Barberi, R. Bartolino,
Creation of electrically controlled defects in liquid crystal mixture,
SICL 2006 Castiglioncello (Livorno, Italy) 7-9 June 2006.

12. M. Lombardo, M.P. De Santo, G. Lombardo, R. Barberi,
Surface Analysis of Intraocular Lenses with Atomic Force Microscopy,
3rd European Meeting in Physiological Optics, 7- 9 September 2006, City University, London (UK).

13. M.A. Matranga, H. Sellame, R. Barberi, M.P. De Santo, F. Ciuchi, G. Chilaya, A. Chanishvili, G. Petriashvili,
Mirror-less microlaser a cristallo liquido colesterico,
II Scuola sui Materiali Molecolari per Fotonica ed Elettronica e V Convegno Nazionale Materiali Molecolari Avanzati per Fotonica ed Elettronica, Tortolì (Nuoro, Italy), 18-24 June 2006.

14. A. Chanishvili, G. Petriashvili, G. Chilaya, R.C. Barberi, M.P. De Santo, M.A. Matranga, F. Ciuchi,
UV sensors based on liquid crystals mixtures,
Organic Optoelectronics and Photonics II, SPIE Europe Conference on Photonics, Strasburgo (Francia) 3-7 April 2006.

15. M.A. Matranga, R. Barberi, M.P. De Santo, F. Ciuchi, H. Sellame, G. Chilaya, A. Chanishvili, G. Petriashvili,
Lasing in dye doped cholesteric liquid crystals,
IX Scuola Nazionale "Chimica dei materiali inorganici", Arcavacata (CS) 26-30 November 2006.

16. B. Zappone,
Lubrication by glycoprotein brushes,
American Physical Society Meeting, Baltimore (USA), March 13-17 2006.

17. B. Zappone,
SFA Conference 2006,
Cancun (Mexico) May 2006.

18. P. Pagliusi, C.Y. Chen and Y.R. Shen,
Sum-frequency Vibrational Spectroscopy on Rubbed Poly(vinyl cinnamate) Films for Liquid Crystal Alignment,
American Physical Society Meeting, Baltimore, March 13-17 2006.

19. P. Pagliusi, C.Y. Chen and Y.R. Shen,
Sum-frequency Vibrational Spectroscopy on Poly(vinyl cinnamate) Surfaces: toward Molecular-level Understanding of the Liquid Crystal Alignment,
SICL-JLCS 2006, Castiglioncello, Italy, June 4-9 2006.

20. P. Pagliusi, C. Provenzano and G. Cipparrone,
All-optical Control of Photorefractive Gain in Twisted Nematic,
European Optical Society Meeting 2006, Paris, October 16-19 2006.

21. Veltri, R. Caputo, C. Umeton and A.V. Sukhov,

Model for Inhomogeneous Photo-polymerization Processes in Multicomponent Media,
7th Italian Liquid Crystal Society (SICL) National Meeting, Castiglioncello (LI), Italy (2006).

22. R. Caputo, L. De Sio, A.V. Sukhov, A Veltri, C. Umeton,
POLICRYPS Gratings: Theory & Practice,
7th Italian Liquid Crystal Society (SICL) National Meeting, Castiglioncello (LI), Italy (2006).
23. R. Caputo, D.K. de Boer, H.J. Cornelissen,
Diffractive grating structures for colour-separating backlights,
2nd Marie Curie conference: "Putting the Knowledge Based Society into Practice", Manchester University, Manchester, United Kingdom. (2006).

24. D.K. de Boer, R. Caputo, H.J. Cornelissen, C.M. van Heesch, E.J. Hornix, M.J. Jak,
Diffractive grating structures for colour-separating backlights,
Photonics Europe (SPIE international symposium), Palais de la Musique et des Congres, Strasbourg, France (2006).

8. GEOPHYSICS

Professors and Researchers:	Ignazio Guerra
Postdoc fellows	Anna Gervasi (*from National Institute of Geophysics and Volcanology (INGV), Center for Seismology and Seismic Engineering*)
Collaborators	P. Harabaglia and M. Mucciarelli (*Basilicata University, Potenza, Italy*) M.R. Gallipoli (*CNR – Tito Scalo (PZ), Italy*) A. Moretti (*Univ. of L'Aquila, L'Aquila, Italy*) G. Neri, B. Orecchio and D. Presti (*Univ. of Messina, Messina, Italy*) J. Armbruster, W.J. Kim, A. Lerner-Lam, L. Seeber e M. Steckler *(Lamont Doherty Observatorv, Columbia Univ., New York, USA*)

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.

8.1 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, Rom (INGV); the second is the basic instrument to conduct seismotectonic investigations.

During 2006, the operation continued of fifteen seismic stations installed since 2003 in the frame of the CAT/SCAN project in cooperation with the Lamont-Doherty Earth Observatory (Columbia University. New York). With this institution a formal agreement has been signed and a new program (called CALARCO) started.

8.2 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 modeling the pattern of seismic occurrence The main result is the retrieval of a

relation that describes the pattern of both of main events and seismic sequences. A fall-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.

8.3 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.

8.4 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}Rn 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 2006 by means of the prototype of the gas monitoring station built in the frame of the CIPE Project completed in 2004.

8.5 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 modern, GPS techniques can ne applied.

In 2006, two different field experiments were carried out.

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 the observation sites are connected to the web and will remain operational for some years.

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 was scheduled for the spring 2007. Three pre-existing planimetric networks were integrated by newly established benchmarks and measured contemporeaneously by temporary GPS observations. This work, when completed, will lead to a network of more than 30 sites in Central and Southern Calabria.

8.6 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. Presently two of them are operating since about three years.

In 2006 a meeting was organized for the presentation and diffusion of a book on the great Calabrian earthquake of 1905. This work contains 22 scientific contributions by 38 different authors from several Italian Universities and research institutes. It was designed and edited by the Geophysics Group keeping in mind its destination to pre-university teachers.

A PUBLICATIONS ON SCIENTIFIC JOURNALS

A.1 Publications on international journals

A.1.1 Publications on international journals printed in 2006

1. Carbone V., Sorriso-Valvo L., Vecchio A., Lepreti F., Veltri P., Harabaglia P e Guerra I., *The clustering of polarity reversals of the geomagnetic field* – Phys. Rew. Lett., 96, 128501, 2006.

B PUBLICATIONS ON CONFERENCE PROCEEDINGS

B.2 Publications on national conference proceedings in 2006

1. Guerra I., Harabaglia P. e Moretti A.: *La sismicità della Calabria nel contesto geodinamico del Mediterraneo – in Guerra I. e Savaglio A,.* (a cura di): 8 settembre 1905 Terremoto in Calabria – Rende, Univ. della Calabria, Dip. di Fisica, 352 pp.

2. Guerra I., De Rose C., Gervasi A., Neri G., Orecchio B., Presti D.: *Attività sismica recente in Calabria Centro-Meridionale – in Guerra I. e Savaglio A,.* (a cura di): 8 settembre 1905 Terremoto in Calabria – Rende, Univ. della Calabria, Dip. di Fisica, 352 pp.

D PRESENTATIONS AT CONFERENCES

D.1 Presentations at international conferences in 2006

1. Gervasi A., Guerra I., Neri G., Orecchio B. e Presti D.: *Crustal seismotomography and shallow earthquake locations in Southern Italy* - Abstract number: EGU06-A-02687

2. Sorriso L., Carbone V., Guerra I., De Rose C. e Harabaglia P.*: Non-Poisson statistics of quiet times in seismic time series: a local test* - Abstract number: EGU06-A-08451

3. Gervasi A., Guerra I., Moretti A., Neri G., Orecchio B., Presti D., Valensise G.: *Shallow earthquake activity vs. geological features in the Calabrian Arc region, Southern Italy* - Abstract number: EGU06-A-02772

4. Carbone V., Sorriso L., Vecchio A., Lepreti F., Veltri P., Guerra I., Harabaglia P.: *The clustering of polarity reversals of the geomagnetic field: a constraint for geodynamic modeling* - Abstract number: EGU06-A-08064

D.2 Presentations at national conferences in 2005

1. Barba S., Caporali A., Braitenberg C., Guerra I. e Sepe V., 2006: *Caratterizzazione geofisica delle principali strutture sismogenetiche (Task 3 - Progetto S2*) – 25° Conv. Ann. GNGTS, Roma.

2. Caputo R., De Rose C., Gallipoli M., Gervasi A., Guerra I., Harabaglia P., 2006: *Il terremoto di Ferrandina (MT) del 7 Settembre 2006* - 25° Conv. Ann. GNGTS, Roma GNGTS 2006

3. Guerra I., De Rose C., Gervasi A., Harabaglia P., Kim W., Rosa A., 2006: *Sismicità recente in Lucania: una mappatura delle strutture attualmente attive* – 25° Conv. Ann. GNGTS, Roma

4. Kossobokov V., Lepreti F., Carbone V., Harabaglia P. e Guerra I., 2006*: Complessità nelle serie temporali di eventi sismici e brillamenti solari* – 25° Conv. Ann. GNGTS, Roma

5. Orecchio B., Gervasi A., Guerra I., Moretti A., Neri G, Presti D. e Valensise G., 2006: *Confronti fra sismicità crostale e dati geologici per l'individuazione di strutture sismogenetiche in Calabria: l'esempio della sequenza di Rogliano (Ottobre 2001*) – 25° Conv. Ann. GNGTS, Roma

ORGANIZATION OF CONFERENCES

8 settembre 1905: terremoto in Calabria – Rende, 7-8 giugno 2006

BOOK ORGANIZATION AND EDITING

Guerra I. and Savaglio A. (eds): *1905: terremoto in Calabria* – Rende, Univ. della Calabria, Dip. di Fisica, 352 pp.