ECT*

Annual Report

2007

European Centre for Theoretical Studies in Nuclear Physics and Related Areas
Trento
Institutional Member of the European Science Foundation Expert Committee NuPECC

Preface

This report reviews the scientific activities of ECT* during the year 2007. This concerns the international projects (workshops and collaboration meetings), the doctoral training programs, the visitor program, the postdoctoral program and local research. This report also describes the latest developments of the teraflop cluster (BEN) and the activities of the quantum computation group hosted at ECT*.

Sixteen projects were run in 2007 (14 workshops and 2 collaboration meetings). The topics spanned, as usual, a large variety of subfields, ranging from low to high energy nuclear physics; some of the workshops were directly connected to experimental projects, while others were centered on more theoretical subjects. Cross disciplinary workshops were also run. We have continued in 2007 to collect systematically copies of the talks, and make them available on the ECT* web site. The scientific reports written by the organizers are also available online shortly after each event. Electronic versions of the posters can be downloaded from the ECT* web site.

The training of young researchers has represented again in 2007 an important part of ECT*'s activities, with two training programs for PhD students. The by-now traditional spring doctoral training program has developed into a very successful format. Such a program offers a unique occasion for students coming from various countries in Europe and beyond, to get basic lectures from top level physicists, interact among themselves, as well as with workshop participants, and present their own work through seminars. The theme of this year's program, " Nuclear Structure and Reactions", was chosen by the Board to strengthen the activities in low energy nuclear physics at ECT*. A second training program, "Physics of Compact Stars" was run in the fall, for a shorter period of time (6 weeks). This latter program was partly self-supported. Georges Ripka had, this year again, agreed to come to ECT* and help supervising the training programs, in particular organizing tutorials and the student seminars. The success of these programs owes him a lot.

The research at ECT* is carried out by the postdocs, the director and the vice director, as well as by long term visiting scientists. Close contacts exist with the Physics Department of the University of Trento and the Center for Bose-Einstein Condensation. ECT* supports one or two PhD students at the Physics Department, and a common postdoc, Michael Schwamb, had been appointed in 2006, and has continued in 2007 to share his time between the Physics Department and the ECT*. Another appointment, that of Vladimir Pascalutsa, made also in 2006, has had a major impact on the local research group. Vladimir Pascalutsa occupies a position of a level equivalent to that of an assistant professor, that is jointly funded by ECT* and the European I3 Hadron Physics. He carries research of his own in hadronic physics, and contributes to the supervision of ECT* postdocs (in 2007 one postdoc was hired to work under his supervision). Actions have been taken to open another assistant professor level position in low energy nuclear physics. This position, to be occupied in 2008, will contribute to the development of the research group at ECT*, providing a broader basis for interactions with the workshop participants, as well as enhancing the attractiveness of the Center for visitors in various subfields of nuclear physics.

BEN, the Teraflop cluster is fully operational, and open to outside users. As will be seen from this report, a variety of projects have been run on the cluster: projects in nuclear physics, hadronic physics, gauge theory, but also molecular dynamic calculations applied to systems of biological interest.

During the year 2007, the ECT* was evaluated by a Commitee of independent experts representing the major sponsors of the Centre. This committee was chaired by F. Iachello

(representing the FBK), and composed of G. Baym (representing ECT*), H. Orland (CEA), P. Schuck (CNRS/IN2P3), E. Vigezzi (INFN), J. Wambach (GSI). Among its recommendations, the Committee underlined the need to strengthen, and broaden, the research activity. This recommendation has already been taken into account with the opening of a position in "Nuclear Many Body Physics". Another recommendation concerned the strengthening of the administrative support, which we could also realize with the help of the Bruno Kessler Foundation that allowed us to hire another assistant to the director. Finally, the Committe also suggested to extend the present agreements that guarantee the funding of the ECT*, from 3 year to five year periods. This is indeed necessary in order to envisage longer tems actions, such as the development of the researh group, and steps in this direction have been made. Changes in the local environment have taken place, with the creation of the Bruno Kessler Foundation (FBK) that has replaced the Istituto Trentino di Cultura. Discussions with the new management team of the FBK have been initiated in order to find the best arrangement for ECT* in this new envirenment.

Our scientific community is well aware of the generous and continuous support of the Autonomous Province of Trento, and the Bruno Kessler Foundation, which have made possible the creation of ECT* and its development throughout the years. Efforts to broaden the basis of the support that ECT* gets from various European countries has been continued, through various initiatives, involving the active help of NuPECC and its members. The coordinating action called NuPNET has been approved by the EC, and it is anticipated that, starting from 2010, it will be able to coordinate the support to ECT* coming from various European research councils. Aplications for support within the European framework program FP7 have been prepared. ECT* is well positioned within the two Integrated Infrastructure Initiatives Hadron Physics 2 and ENSAR (the successor of EURONS). For technical reasons, ECT* could apply for Transnational Access only within one I3 and, on the basis of reciprocity, it decided to join HadronPhysics 2, with however a clear understanding that all workshop activities can be supported, irrespective of the field. If these applications are successful, ECT* will receive, in addition to Access funds, also support for specific workshops and postdoc positions from Networking and Joint Reasearch Activities in both I3's.

In closing, I would like to express my appreciation and thanks to all the members of the ECT* staff, for their constant help and efforts to adapt to a continuously evolving environment. Particular thanks go to Susan Driessen and Barbara Currò Dossi for their help in the preparation of this report.

Jean Paul Blaizot
Director, ECT*

Contents

1 ECT* Board of Directors, Staff and Researchers

1.1 ECT* Board of Directors, Director, Vice Director and Scientific Secretary

Wanda Alberico (from September 2005)	University of Torino, Italy
Bengt Friman (from October 2006)	GSI, Darmstadt, Germany
Brian Fulton (from June 2006 - NuPECC)	University of York, UK
Hans Åke Gustafsson (from June 2006)	Lund University and CERN
Wick Haxton (from June 2006)	University of Washington
Paul Hoyer (from October 2004 - chairman)	University of Helsinki, Finland
Frithjof Karsch (until October 2007)	Bielefeld University, Germany
Friederich-Karl Thielemann (until October 2007)	Univ. of Basel, Switzerland
Piet Van Isacker (from September 2005)	GANIL, Caen, France

Honorary Member of the Board:

Ben Mottelson	NORDITA, Copenhagen, Denmark

ECT* Director:

Jean Paul Blaizot (from September 2004)	ECT* and CNRS, France

ECT* Vice Director:

Marco Traini (from October 2004)	ECT* and University of Trento

ECT* Scientific Secretary:

Renzo Leonardi	ECT* and University of Trento

1.2 ECT* Staff

Ines Campo	Technical Programme Co-ordinator
Stefania Campregher (until March 2007)	Programme Assistant
Corrado Carlin	Maintenance Support Manager
Cristina Costa	Technical Programme Co-ordinator
Serena Degli Avancini	Technical Programme Co-ordinator
Barbara Currò Dossi	System Manager
Susan Driessen (part time)	Assistant to the Directors
Gianni Fattore (part time)	System Manager
Domenico Gonzo (until November 2007, part time)	System Manager
Tiziana Ingrassia (part time)	Accounting Assistant
Mauro Meneghini	Driver and Maintenance Support Manager
Donatella Rosetti (part time)	Secretary Eurons
Luana Slomp (from April 2007)	Assistant to the Directors
Gianmaria Ziglio (part time)	Web Manager

1.3 Resident Postdoctoral Researchers and supported Students

- **ECT* postdocs:**

Andrea Beraudo (Italy)

Carlo Ewerz (Germany) (until October 2007)

Vadim Lensky (Russia) (from October 2007)

Taeko Matsuura (Japan)

Yacine Mehtar-Tani (Algeria) (until October 2007)

Claudia Ratti (Italy) (until August 2007)

Michael Schwamb (Germany)(Joint position with the Physics Department)

Dionysis Triantafyllopoulos (Greece)

- **Research Assistant Professor:**

Vladimir Pascalutsa (USA)(Joint position with I3 Hadron Physics (assistant professor level)

- **Quantum Computing Group (post-docs and students):**

Daniele Binosi (Italy) (from February 2005)

Tommaso Calarco (Italy) (from June 2003)

- **ECT* supported students:**

Marco Cristoforetti (Italy) (from July 2004, until October 2007)

- **Associate researchers:**

Daniele Binosi (from February 2005, part time)

- **Teraflop Cluster (special fellowships):**

Andrea Nobile (Italy)

Luigi Scorzato (Italy)

1.4 Visitors in 2007

This list includes Visiting Scientists (VS) who typically spent up to several weeks at the Centre, participants and lecturers of the Training Programme (TP).

Tan Ahn (07/03-10/06)	Technische Univ. Darmstadt, Germany (TP)
Roberto Anglani (19/09-06/10)	University of Bari, Italy (TP)
Benoit Avez (07/03-02/06)	Cea Saclay, France (TP)
Roger Balian (20-27/05)	Service de Physique Theorique, CEA-Saclay (VS)
David Blaschke (16/09-05/10)	University of Wroklaw, Poland (TP)
Yorick Blumenfeld (09-13/04)	Institute Physique Orsay, France (TP)
James Broomfield (06/03-11/06)	University of Surrey, UK (TP)
Giuseppina Burgio (30/09-06/10)	INFN Catania, Italy (TP)
Olga Liliana Caballero (17/08-06/10)	Nuclear Theory Center, Bloomington, US (TP)
Jorge Martin Camalich (18/11-01/12)	University of Valencia, Spain (VS)
Mark Caprio (29/05-21/06)	Yale University, USA (VS)
Fadi Castronovo (01/07-20/08)	College of Cooper Union, NY, US (VS)
Pavel Cejnar (03/05-31/07)	Charles University Prague, Czech Republic (VS)
Debarati Chatterjee (18/08-05/10)	Saha Institute, Kolkata, India (TP)
Antonella Colaiuda (23/09-06/10)	Inst. fuer Astronomie, Tuebingen, Germany (TP)
Marius Dan (19/08-07/09)	Jacobs University, Bremen, Germany (TP)
Dennis Dietrich (07-11/05)	University of Heidelberg , Germany (VS)
Anthea Fantina (19/08-06/10)	University of Milano, Italy (TP)
Angelo Raffaele Fazio (08/01-14/02)	University of Colombia, Bogota, Colombia (VS)
Sebastien Figerou (19/08-06/10)	Subatech, Nantes, France (TP)
Bert Tobias Fischer (18/08-05/10)	University of Basel, Switzerland (TP)
Hilmar Forkel (10/11-22/12)	Ift-Unesp So Paulo, Brazil (VS)
Johnaton Friedman (29/06-28/08)	College of Cooper Union, NY, US (VS)
Harald Fritzsch (3-5/09)	LMU Munich, Germany (VS)
Filippo Galeazzi (2-9/09)	A. Einstein Institut, Potsdam, Germany (TP)
Mikhail Gorshteyn (4-7/02)	California Institute of Technology, US (VS)
Pavlo Grygorov (16/09-06/10)	University of Tuebingen, Germany (TP)
Pawel R. Haensel (23-27/09)	N. Copernicus Astr. Center, Warsaw, Poland (TP)
Muhsin Harakeh (09-14/04)	KVI, The Netherlands (VS)
Kai Hebeler (03/09-31/12)	GSI, Germany (VS)
Matthias Hempel (18/08-07/10)	J.W. Goethe Institut, Frankfurt, Germany (TP)
Jillian Anne Henderson (11/09-06/10)	UNAM, Mexico (TP)
Morten Hjorth (15-21/04)	University of Oslo, Norway (TP)
Francesco Iachello (5-17/03)	Yale University, US (TP)
Andreas Ipp (27/03-09/04)	Max Planck Institute, Germany (VS)
David Jan Jones (26/08-02/09)	University of Southampton, UK (TP)
Mesut Karakok (07/03-09/06)	University of Erciyes, Turkey (TP)
Itakura Kazunori (14-19/01)	KEK, Japan (VS)
Thorsten Kellermann (26/08-08/09)	A.Einstein Institut, Potsdam, Germany (TP)
Elias Khan (9-13/04)	Institute de Physique Orsay, France (TP)

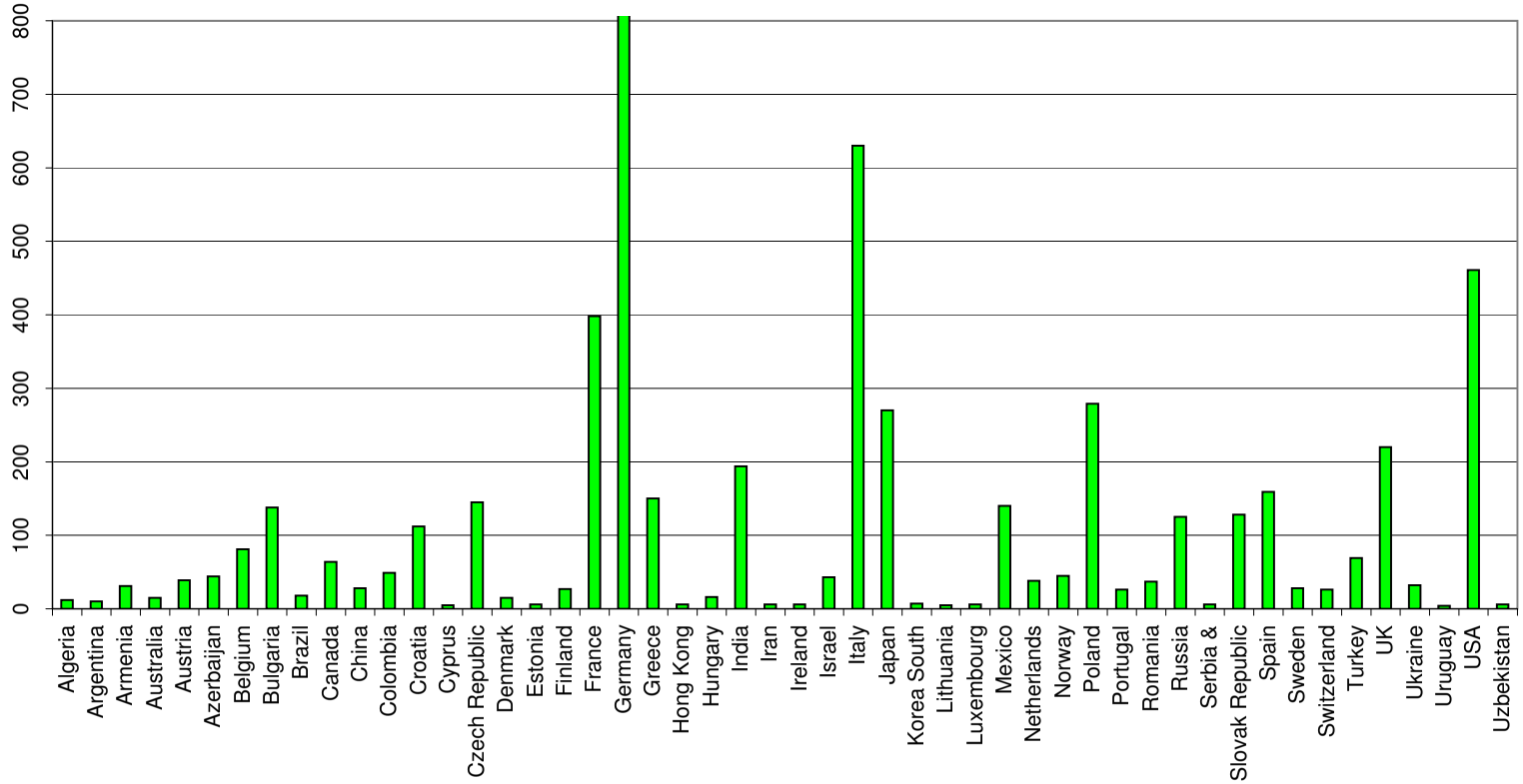
Timur Kolchinskiy (29/06-29/08)	College of Cooper Union, NY, US (VS)
Ritesh Kshetri (06/03-03/06)	Saha Institute Kolkata, India (TP)
Mikko Laine (19/02-16/03)	University of Bielefeld, Germany (VS)
Samuel Lander (22-29/09)	University of Southampton, UK (TP)
Karlheinz Langanke (27-31/05)	GSI, Germany (TP)
Vadim Lensky (24-26/01)	Forschungszentrum Juelich, Germany (VS)
Matthias Liebendorf (2-8/09)	University of Basel, Switzerland (TP)
Michal Macek (07/03-03/06)	Charles University Prague, Czech Republic (TP)
Tomislav Marketin (08/03-10/06)	University of Zagreb, Croatia (TP)
Sharon Markowitz (01/07-18/08)	College of Cooper Union, NY, US (VS)
Yacine Mehtar Tani (27/10-03/11)	Institut fur Theor. Physik Heidelberg, Germany (VS)
Ramon Mendez Galain (22-28/04)	University of Montevideo, Uruguay (VS)
Stephen Millmore (30/08-09/09)	University of Southampton, UK (TP)
Futoshi Minato (06/03-03/06)	Tohoku University, Japan (TP)
Stoyan R. Mishev (06/03-10/06)	BLPT Dubna, Russia (TP)
Irving Omar Morales (08/03-30/04)	University of Mexico (TP)
Enrique Moreno Mendez (19/08-06/10)	Stony Brook University, USA (TP)
Bernhard Mueller (3-8/09)	Max Planck Inst. fuer Astrophysik, Garching (TP)
Stefan Muenzel (02/07-28/08)	College of Cooper Union, NY, US (VS)
David Nummey (29/06-29/08)	College of Cooper Union, NY, US (VS)
Dany Pierre Page (16-22/09)	UNAM, Mexico (TP)
Vincenzo Palmisano (2-21/09)	University of Messina, Italy (TP)
Alessandro Pastore (22-28/04)	University of Milano, Italy (TP)
Dieter Pauwels (8-21/04)	Leuven University, Belgium (TP)
Dimitris Petrellis (06/03-02/06)	Centre Scientific Research, Athens, Greece (TP)
Konstantin Petrov (13-17/02)	Niels Bohr Institute, Copenaghen, Denmark (VS)
Pierre Pizzochero (25-28/09)	INFN Milano, Italy (TP)
Marek Ploszajczak (5-19/05)	Ganil, France (TP)
Jose Antonio Pons Potella (2-16/09)	University of Alicante, Spain (TP)
Sergey Popov (25/08-05/09)	University of Moscow, Russia (TP)
Michal Lukasz Rafalsky (07/03-10/06)	University of Warsaw, Polonia (TP)
Cesar Ramirez Fernandez (30/09-06/10)	UCM Madrid, Spain (VS)
Sanjay Reddy (02-16/09)	Los Alamos Laboratory, US (TP)
Luciano Rezzolla (19-26/08)	A. Einstein Institute Potsdam, Germany (TP)
Georges Ripka (01/03-30/06;05/08-31/10)	Cea Saclay, France (VS)
Oliver James Robertshaw (2-8/09)	University of Southampton, UK (TP)
Harmut Rosswog (18-26/08)	University of Bremen, Germany (TP)
Michael Ruzhansky (29-31/03)	Imperial College London, UK (VS)
Irina Sagert (18/08-06/10)	J.W. Goethe Institut, Franfurt, Germany (TP)
Natalij Severijns (1-6/04)	Leuven University, Belgium (TP)
Klara Shitikova (29/06-28/08)	College of Cooper Union, NY, US (VS)
Kamila Sieja (09/03-10/06)	University M. Curie of Lublin, Polonia (TP)
Vittorio Soma (19/08-06/10)	Institute of Nuclear Physics, Crakow, Poland (TP)
Irina Stefanescu (8-21/04)	Leuven University, Belgium (TP)
Pavel Stransky (07/03-03/06)	Charles University Prague, Czech Republic (TP)

Piet Van Isacker (08-16/03)	Ganil, France (VS)
Dimitri Voskresenskiy (16-23/09)	Moscow Institute of Physics/GSI (TP)
Dario Vretenar (22-28/04)	University of Zagreb, Croatia (TP)
Nicolas Wschebor Pellegrino (15-28/04)	University of Montevideo, Uruguay (VS)
Stanislav Yezhov (18-28/06)	University of Kiev, Ukraine (VS)
Daniel Zablocki (1-5/10)	University of Wroklaw, Poland (TP)
Maciey Zalewski (07/03-10/06)	University of Warsaw, Polonia (TP)

The figure next page provides a synthesis of the geographical origin of the participants to ECT* activities.

VISITOR DAYS spent at ECT* in 2007

Country



includes: Workshop Participants, Visiting Scientists,
Marie Curie Fellows and Lecturers

2 Scientific Projects run in 2007

2.1 Summary

Altogether, 18 projects have been run at ECT* in 2007: 14 workshops, 2 collaboration meeting and 2 doctoral training programmes. This chapter contains the scientific reports prepared by the organizers of each project. G. Ripka, who assisted the Director in the running of the doctoral training programmes, contributed to the preparation of the corresponding reports.

2.2 Workshops and Collaboration Meetings in 2007

9 – 13 Jan. **High Energy QCD: from RHIC to LHC**
Organisers:François Gelis (Co-ordinator) (*CEA-CERN*),
E. Iancu (*CEA*),
David d'Enterria (*CERN*) [p. 11]

15 - 19 Jan. **Photoproduction at collider energies: from RHIC and HERA to LHC**
Organisers: David d'Enterria (Co-ordinator) (*CERN*),
G. Bauer (*IKP Juelich*),
S. Klein (*LBL*),
J. Nystrand (*University of Bergen*) [p. 14]

8 Mar. - 1 Jun. **Nuclear Structure and Reactions**
(ECT* Doctoral Training Programme)
Piet Van Isacker (Co-ordinator) (*GANIL*),
Muhsin Harakeh (co-organiser) (*KVI*) [p. 54]

12 - 16 Mar. **Confinement: connecting the light- and heavy-quark domains**
Organisers: Andreas Krassnigg (Co-ordinator) (*Univ. Graz*),
G. Bal (*University of Regensburg*) ,
J. Wambach (*TU Darmstadt*) [p. 17]

19- 30 Mar. **The interface of quark-gluon-plasma physics and cold-atom physics**
Organisers: Gordon Baym (Co-ordinator) (*University of Illinois)*),
T. Matsui (*University of Tokyo*),
C. Pethick (*NORDITA*) [p. 20]

23 - 27 Apr. **Experiment – Theory Intersections in Modern Nuclear Structure**
Organisers: Achim Schwenk (Co-ordinator) (*Univ. of Washington*),
J. Dilling (*TRIUMF*),
R Kruecken (*TU Munich*) ,
T. Papenbrock (*University of Tennessee*) [p. 22]

14 - 18 May **Many-body open quantum systems: From atomic nuclei to quantum dots**
Organisers: M. Ploszajczak, Co-ordinator (*GANIL*),
K. Kato (*Hokkaido University*),
W. Nazarewicz (*University of Tennessee*),
I. Rotter (*Max-Planck-Institut*) [p. 24]

29 May - 1 Jun. **Nuclear Physics Data Compilation for Nucleosynthesis Modeling (Collaboration meeting)**
Organisers: Carmen Angulo, Co-ordinator (*Univ. de Louvain-la-Neuve*),
M. Wiescher (*University of Notre Dame*) [p. 28]

4 - 8 Jun. **Correlations in nuclei: beyond mean-field and shell model**
Organisers: Paul-Henri Heenen, Co-ordinator (*Univ. Libre Bruxelles*),
A. Poves (*Universidad Autonoma de Madrid*),
M. Bender (*SPhN CEA Saclay*),
T. Duguet (*Michigan State University*) [p. 31]

11 - 15 Jun. **Transverse momentum, spin, and position distributions of partons in hadrons**
Organisers: Andreas Metz, Co-ordinator (*Ruhr-Univ.*),
H. Avakian (*Jefferson Laboratory*) [p. 33]

18 - 22 Jun. **Electromagnetic Probes of Strongly Interacting Matter: The Quest for Medium Modifications of Hadrons**
Organisers: Burkhard Kampfer, Co-ordinator (*Inst. Rad. Phys.*),
R. Rapp (*Texas A&M University*),
J. Stroth (*J. W. Goethe-Universitt Frankfurt*) [p. 36]

25 - 29 Jun. **Fundamental symmetries: from nuclei and neutrinos to the universe**
Organisers: Cristina Volpe, Co-ordinator (*IPN, Orsay*),
B. Balantekin (*Univ. Wisconsin-Madison*) [p. 39]

2 - 6 Jul. **Advanced Many-body Methods for Nuclear Physics**
Organisers: C. Barbieri, Co-ordinator (*GSI*),
D. Dean (*Oak Ridge National Laboratory*),
R. Roth (*TU Darmstadt*) [p. 41]

16-20 Jul. **Hard QCD with Antiprotons at GSI FAIR**

Organisers: Bernard Pire, Co-ordinator (*CPhT, Ecole Poly.*),
S. Brodsky (*SLAC*),
M. Duren (*Giessen University*),
P. Lenisa (*University Ferrara*),
W. Vogelsang (*BNL*) [p. 43]

20 Aug. - 5 Sep. **Physics of Compact Stars)**
(Doctoral Training Programme
Organisers: David Blaschke, Co-ordinator (*Univ. Wroclaw*),
J. Pons (*University of Alicante*),
L. Rezzolla (*A. Einstein Inst. Potsdam*) [p. 57]

10 - 14 Sep. **Matter at Extreme Densities and Gravitational Waves from Compact Objects**
Organisers: Jos Pons, Co-ordinator (*University of Alicante*),
S. Reddy (*Los Alamos National Laboratory*) [p. 46]

8 - 12 Oct. **Exotic Modes of Excitation: from Nuclear Structure to Astrophysics**
Organisers: Gianluca Col, Co-ordinator (*Milan University*),
E. Kahn (*IPN*),
D. Vretenar (*University of Zagreb*) [p. 48]

26 - 30 Nov. **Electroweak interactions with nuclei and physics of the quark-gluon plasma : many-body techniques at high energies and temperature (Collaboration meeting)**
Organisers: A. Molinari, Co-ordinator (*Turin University*),
A. Barbaro (*University of Turin*),
T.W. Donnelly (*MIT*) [p. 51]

2.3 Reports on Projects and Collaboration Meetings

2.3.1 HIGH ENERGY QCD: FROM RHIC TO LHC

DATE: January 9-13, 2007

ORGANISERS:
François Gelis (Co-ordinator) (*CEA/SPhT - CERN*),
David D'Enterria (*CERN*),
Edmond Iancu (*CEA/SPhT*)

NUMBER OF PARTICIPANTS: 44

MAIN TOPICS:

- Experimental probes of parton saturation and of thermalization, Present status and predictions for the LHC
- Color Glass Condensate, Connections with statistical physics
- Initial particle production in heavy ion collisions, Thermalization, Plasma instabilities

SPEAKERS:

Fouad Rami (*IRES*),
Jamal Jalilian-Marian (*Baruch Coll.*),
Gregory Soyez (*LPTHE*),
Gunther Roland (*MIT*),
Yacine Mehtar-Tani (*LPT*),
Hirotsugu Fujii (*Tokyo Univ.*),
Yasushi Nara (*Frankfurt Univ.*),
Andre Utermann (*Amsterdam Univ.*),
Nestor Armesto (*Santiago Univ.*),
Eugenio Megias (*Granada Univ.*),
Edmond Iancu (*SPhT*),
Yoshitaka Hatta (*SPhT*),
Dionysis Triantafyllopoulos (*ECT**),
Arif Shoshi (*Bielefeld Univ.*),
Roy Lacey (*Stony-Brook Univ.*),
Kazunori Itakura (*KEK*),
Michael Kozlov (*Bielefeld Univ.*),
Bowen Xiao (*Columbia Univ.*),
Guilherme Milhano (*IST*),
Alfred Mueller (*Columbia Univ.*),
Michael Strickland (*Frankfurt Univ.*),
François Gelis (*CERN*),
Anton Rebhan (*Vienna Tech. Univ.*),
Kenji Fukushima (*RIKEN-BNL*),
Adrian Dumitru (*Franfurt Univ.*),
Kari Rummukainen (*Oulu Univ.*),
Martino Gagliardi (*Torino Univ.*),
Diego Stocco (*Torino Univ.*),
Cyrille Marquet (*BNL*),
Carlo Ewerz (*ECT**),
David D'Enterria (*CERN*),
Heribert Weigert (*Ohio State Univ.*),
Javier Albacete (*Ohio State Univ.*),
Boris Blok (*Technion*),
Leonid Frankfurt (*Tel Aviv Univ.*),
Beatriz Gay Ducati (*UFRGS*),
Konrad Tywoniuk (*Oslo Univ.*),
Daniel Litim (*Sussex Univ.*),
Andrea Beraudo (*ECT**),
Erik Wessels (*Amsterdam Univ.*),
Andrea Dainese (*INFN, Legnaro*)

SCIENTIFIC REPORT:

Aim and Purpose. The ongoing experiments at the Relativistic Heavy Ion Collider (RHIC, at the Brookhaven National Laboratory), as well as the forthcoming ones at the Large Hadron Collider (LHC, to start at CERN in 2007), have revived the interest in the theory of hadronic scattering at high energy, a longstanding problem for which no satisfactory solution has been given so far. Stimulated by this experimental conjuncture, new physical ideas have emerged, which suggest that the problem of high–energy scattering in Quantum Chromo-Dynamics (QCD) may lie within the realm of weak coupling techniques, and hence can be studied from first principles. Some of the phenomenological consequences of these ideas may have already been observed, such as the geometrical scaling in Deep Inelastic Scattering at HERA or the suppression of $p_\perp$-spectra at forward rapidities in deuteron-nucleus collisions at RHIC.

At the heart of this theoretical progress, is the realization that, at high energy, a hadron wave–function develops a very high gluon density, which introduces a semi–hard scale in the problem — the so–called "saturation momentum". The novelty of this "saturated" regime is that it is characterized by strong color fields, contrary to the more conventional situations addressed in perturbative QCD. Therefore, it is the realm of strong non–linear effects, and its theoretical treatment requires elaborated resummations of the high density corrections.

These theoretical ideas have been fueled by the realization that this regime may be reached in ultra–relativistic heavy–ion collisions, where both the large collision energy and the large size of the colliding nuclei tend to increase the saturation scale. Thus, the advent of the LHC, with energies considerably larger than at RHIC, should give a novel dimension to the experimental study of the high–energy hadron–hadron collisions and provide a better playground for testing new ideas.

One should emphasize that the experimental situation in heavy ion collisions is extremely complex, due to the collective effects associated to the large number of intervening particles. A fundamental question in this respect is how to disentangle the 'initial state' effects — by that we mean the properties of the wave-functions of the hadrons before the collision — from the 'final state' interactions among the partons (quarks and gluons) liberated by the collision. Therefore, it seems useful to gather both theorists and experimentalists in order to identify the observables that are best suited to uncovering the physics of the initial state and of gluon saturation.

An equally fundamental issue in this context is that of the thermalization of the matter produced in a heavy–ion collision. Indeed, present experimental results suggest an early formation of an equilibrated quark-gluon plasma. Yet, such an early thermalization seems very difficult to achieve within standard scenarios based on perturbative QCD. There have been interesting developments in recent years on this question, based on the observation that plasmas with an anisotropic distribution of particles develop an instability that may accelerate the thermalization.

Results and Highlights. One of the main highlights of the workshop is the possible occurrence of a turbulent regime in the very early stages of heavy ion collisions, which may drive the produced system towards a relatively fast thermalization. This turbulent regime is closely related to the plasma instabilities observed in plasmas with an anisotropic distribution of particles, and has been observed both from analytic and numerical approaches. However,

it seems that its precise nature is still under debate, as well as its practical consequences for heavy ion collisions. It also seems that the instability that leads to this turbulent regime is also present in the Color Glass Condensate approach, which opens up the possibility to have a full description – including the effect of the plasma instabilities – of the initial instants of heavy ion collisions in a controlled framework.

Another important achievement of the last months, extensively discussed during the workshop, is the derivation of the corrections to the Balitsky-Kovchegov and JIMWLK evolution equations due to the running of the strong coupling constant. Three different approaches lead to equivalent results – and in cases where the details of the result differ, it is now understood that this is due to the fact that only a part of the complete Next-to-Leading Order has been calculated, which brings a certain scheme-dependence in the result. This will probably have important practical consequences, since it is known that the running coupling corrections are a large effect in the speed at which the solution of these equations evolve.

Conclusions. We think that this workshop was a success, and that it was very useful in order to make a status report on the field of high energy scattering in QCD and its applications to heavy ion collisions. It was also very useful in that it brought together both theorists and experimentalists, and each got to know better what the state of the art is on the theory side, and what can be measured experimentally – especially at the forthcoming LHC – and therefore what are the observables for which predictions would be most welcome. We expect that this will fuel research in directions that are most useful to RHIC and LHC experiments.

The talks can be browsed from the website:
www-spht.cea.fr/Images/Pisp/fgelis/Workshops/Trento2007

2.3.2 PHOTOPRODUCTION AT COLLIDER ENERGIES: FROM RHIC AND HERA TO LHC

DATE: January 15-19, 2007

ORGANISERS:
Gerhard Baur (*IKF-Jülich*), David d'Enterria (Co-ordinator) (*CERN*), Spencer Klein (*LBNL-Berkeley*), Joakim Nystrand (*Univ. Bergen*), and Mark Strikman (*Penn State Univ.*)

NUMBER OF PARTICIPANTS: 33

MAIN TOPICS:

- small-x QCD in photoproduction studies with protons and in electromagnetic (aka. ultraperipheral) nucleus-nucleus collisions
- hard diffraction physics at hadron colliders,
- photon-photon collisions at very high energies: electroweak and beyond the Standard Model processes

SPEAKERS:

L. Frankfurt (*Tel Aviv U.*),
R. Engel (*IKP Karlsruhe*),
S. J. Brodsky (*SLAC*),
V. Guzey (*Ruhr U. Bochum*),
H. Kowalski (*DESY*),
A. Baltz (*BNL*),
R. Vogt (*LBL and UC Davis*),
M. Machado (*U. Fed. do Pampa*),
U. Dreyer (*U. Basel*),
M. Yilmaz (*Istanbul Tech U.*),
O. Nachtmann (*Heidelberg U.*),
Z. Nagy (*CERN*),
G. Baur (*IKP Juelich*),
M. Klasen (*LPSC Grenoble*),
M. Strikman (*Penn State U.*),
C. Ewerz (*ECT**),

K. Itakura (*) (*KEK Tsukuba*),
K. Tywoniuk (*) (*U. Oslo*),
Y. Mehtar-Tani (*) (*LPT Orsay*),

K. Piotrzkowski (*UC Louvain, CMS*),
A. Hamilton (*Geneve U., CDF*),
S. Levonian (*DESY*),
A. Savin (*Wisconsin U., ZEUS*),
A. Valkarova (*IPNP & Charles U., H1*),
J. Butterworth (*Creighton U., STAR*),
Y. Gorbunov (*Creighton U., STAR*),
D. Silvermyr (*ORNL, PHENIX*),
R. Schicker (*Heidelberg U., ALICE*),
P. Ramalhete (*IST-Lisbon, NA60*),
D. d'Enterria (*CERN, CMS*),
J. Nystrand (*Bergen U., ALICE*),
C. Lourenco (*CERN, NA60*),
E. Scapparone (*U. Bologna, ALICE*)

(*) Participation only. No talk given.

SCIENTIFIC REPORT:

Aim and Purpose: Photon-induced collisions at high-energy are a fruitful tool to investigate strong and electromagnetic interactions. On the one hand, photon-hadron processes at the HERA *ep* collider have provided precise information on QCD – parton structure and evolution at low-x, partonic structure of the photon, measurement of the strong coupling constant, factorization breaking in diffractive processes, etc. – via measurements of inclusive hard photoproduction (heavy-flavour, (di)jets, prompt photons ...) and exclusive diffractive vector meson production. On the other hand, ultra-relativistic proton and heavy-ion beams accelerated at BNL-RHIC ($\sqrt{s_{_{NN}}} = 200$ GeV), FNAL-Tevatron ($\sqrt{s} = 1.96$ TeV) and CERN-LHC ($\sqrt{s_{_{NN}}} = 5.5$ – 14 TeV) energies generate strong electromagnetic fields which are equivalent to a flux of quasi-real photons with maximum energies in the range $E_\gamma^{max} \approx 3$ – 2000 GeV. At the LHC, these photons offer the opportunity to study $\gamma\, p$, $\gamma\, A$ and $\gamma\,\gamma$ processes at energies one order of magnitude larger than at previous colliders, probing parton distributions at still lower x values, and also opening interesting windows to electroweak and beyond the Standard Model physics.

At heavy-ion colliders, the electromagnetic field due to the coherent action of the $Z \approx 80$ proton charges (for lead or gold nuclei) results in photon beams fluxes $Z^2 \approx 7000$ times larger than those of corresponding electron or proton beams at the same energies. Photonuclear production of ρ and J/ψ, as well as e^+e^- pair production in two-photon collisions have been studied in "ultraperipheral collisions" (UPCs) of gold nuclei at RHIC. Studies of the small-x QCD regime accessible in $\gamma\, A$ processes with UPCs at LHC are of critical importance for the interpretation of heavy ion data, and provide a clean tool for the study of non-linear QCD effects in the nuclear wave-function. In addition, coherent $\gamma\,\gamma$ processes in UPCs at the LHC allow one to study QED in a very strong field regime ($Z\alpha_{\rm em} \approx 0.6$) as well to measure the couplings of the γ, Z and $W^\pm$ gauge bosons among themselves.

After 6 years of rich physics operation at HERA-II and RHIC, and less than one year before the start of LHC, it seemed a timely moment to have a workshop, gathering both theorists and experimentalists, to discuss the current status of investigations of photon-induced processes in *ep* at HERA and UPC ion-ion collisions at RHIC, and preparations for extension of these studies in PbPb and pp at LHC. There were 30 presentations of various lengths. Ample time was left for discussions after each talk. The talks and discussions were organized around the following main topics:

- Overview theoretical and experimental talks on photoproduction at RHIC, HERA, Tevatron and prospects for LHC.
- Inclusive and exclusive photoproduction at HERA: dijets, heavy-quarks, prompt photons, and vector mesons.
- Vector-meson and hard- photoproduction in UPC ion-ion at RHIC and LHC, with emphasis on the high gluon density regime at small-x in the nucleus.

- Photoproduction in $pp, p\bar{p}$ collisions at Tevatron and LHC: QCD (quarkonia, jets, top), electroweak (W, Higgs) and beyond the SM processes.
- Two-photon processes: studies of QED in strong field regime in UPCs, $\gamma\,\gamma \to l^+\,l^-$ as a luminometer at the LHC, triple and quartic gauge $WW\gamma\,(\gamma)$ couplings.

Results and Highlights: The workshop was extremely fruitful as it gathered theorists and experimentalists with different backgrounds (more $\gamma-$proton or $\gamma-$nucleus oriented) at various center-of-mass energies (from RHIC and HERA to Tevatron and LHC) but a common interest in the study of photon-induced processes. Many useful experiences were shared among the participants during and after the talks. New theoretical calculations have been provided to compare with existing data (and/or for use in experimental Monte Carlo simulations of future measurements). Continued professional contact exists today among various participants who met for the first time in the meeting. As a result of the workshop presentations and subsequent discussions, several new contributions were included in the topical review article "The Physics of Ultraperipheral Collisions at the LHC" (J. Phys. G. to be submitted).

Conclusions: The workshop was undoubtedly a success. It was not only very useful as a "status report" on the field of high energy photon-induced processes at current and future colliders but it brought together both theorists and experimentalists, and each got to know better what the state-of-the-art is on both sides, and what can be measured experimentally – especially at the forthcoming LHC. We believe that this was only the first workshop of this kind and look forward to similar meetings in the future.

The programme, list of participants and a one-page summary of each talk including a few relevant references are available in the "mini-proceedings" submitted to the pre-print server:

`http://arxiv.org/abs/hep-ph/0702212`

In addition, all the talks can also be downloaded from the workshop website:

`http://cern.ch/david.denterria/photoprod_ect07/`

2.3.3 CONFINEMENT: CONNECTING THE LIGHT- AND HEAVY-QUARK DOMAINS

DATE: March, 12-16

ORGANISERS:
C. D. Roberts (Co-ordinator) (*Argonne National Laboratory, USA*), A. Krassnigg (*University of Graz, Austria*), G. Bali (*University of Regensburg, Germany*), J. Wambach (*TU Darmstadt, Germany*)

NUMBER OF PARTICIPANTS: 34

MAIN TOPICS:

- topic 1 Confinement of quarks and gluons
- topic 2 Dynamical chiral symmetry breaking
- topic 3 Nonperturbative methods in QCD

SPEAKERS:

C. Alexandrou (*Univ. Cyprus*),
R. Alkofer (*Univ. Graz*),
G. Bali (*Univ. Regensburg*),
N. Brambilla (*INFN Milan*),
F. Bursa (*Univ. Regensburg*),
L. Chang (*Peking Univ.*),
I. Cloet (*Argonne*),
A. Di Giacomo (*Univ. Pisa*),
G. Eichmann (*Univ. Graz*),
B. El-Bennich (*UPMC Paris*),
P. Faccioli (*Trento Univ.*),
C. S. Fischer (*TU Darmstadt*),
J. Foley (*Swansea Univ.*),
A. Garcia-Garcia (*Princeton Univ.*),
J. Greensite (*SF State Univ.*),
M. Ilgenfritz (*Univ. Berlin*),
A. Krassnigg (*Univ. Graz*),
O. Lakhina (*Kent State Univ.*),
J.-P. Lansberg (*Ecole Polytechnique*),
A. Maas (*Slovak Acad. Sci.*),
D. Nickel (*TU Darmstadt*),
D. Nicmorus (*Univ. Tübingen*),
M. R. Pennington (*Univ. Durham*),
H. Reinhardt (*Univ. Tübingen*),
C. D. Roberts (*Argonne*),
B.-J. Schaefer (*Univ. Graz*),
W. Schleifenbaum (*Univ. Tübingen*),
T. Suzuki (*Kanazawa Univ.*),
C. Urbach (*Univ. Liverpool*),
A. Vairo (*INFN Milan*),
L. von Smekal (*Univ. Adelaide*),
R. D. Young (*JLab*),
D. Zwanziger (*New York Univ.*),

SCIENTIFIC REPORT:

Aim and Purpose

We held a one-week workshop to address the question of the connection between confinement and dynamical chiral symmetry breaking, and the interplay between dynamical quarks and the confinement mechanism. The workshop gathered more than thirty practitioners and early career-researchers with expertise in: the application of models to the spectrum and dynamics of light-quark hadrons; conjectures and models of a topological origin to confinement in pure-gauge QCD; effective field theories for heavy-quark systems; and the numerical simulation of lattice-regularised QCD in connection with gauge covariant Schwinger functions, topological features, and experimentally accessible observables. The goals were to initiate and build on communication across community barriers, and to foster cross-fertilisation between communities.

Results and Highlights

One view of confinement in pure-gauge QCD is that some special class of gauge field configurations come to dominate at long range. Candidates include merons, Abelian monopoles, and center vortices, and in this connection it is relevant that numerical techniques have recently evolved that enable the use of Monte-Carlo methods to search for such features in numerical simulations of lattice-regularised QCD. These studies were described.

From another point of view, signals and characteristics of confinement can be found in the properties of QCD's gauge- and ghost-field Schwinger functions, via Dyson-Schwinger equations and lattice-QCD. The outcomes agree and are complemented now by work using the exact renormalisation group. Thought no simple connection with the notions described in the preceding paragraph has been elucidated, contemporary attempts were described.

The picture becomes more complicated in the presence of dynamical quarks. Naturally, in their absence, it does not make sense to ask for the connection between confinement and dynamical chiral symmetry breaking, which is the keystone for so much of hadron physics. Moreover, their feedback into confinement scenarios in the gauge sector is largely unexplored. The current status of unquenching both studies of QCD was described.

A key goal of modern studies in QCD is to develop an understanding of the spectrum and interactions of light-quark hadrons, whose masses lie in the range 1-2 GeV, and connect this with a description of excited states and putative exotics and hybrids in the charm and bottom sector. Theory and phenomenology in this area was presented.

Conclusions

We brought together practitioners with expertise in:

- the application of QCD- and symmetry-based models to the spectrum and dynamics of light-quark hadrons, in particular excited states, exotics and hybrids, and extending also to the physics of charm states;
- conjectures and models of confinement in pure-gauge QCD;
- effective field theories for heavy-quarkonium systems;
- the numerical simulations of lattice-regularised QCD in connection with gauge covariant Schwinger functions, topological features, and experimental observables.

These practitioners elucidated the strengths of, and challenges for, their chosen tools, and got thinking and talking about the interplay between dynamical quarks and the problem of confinement. Each of the key participants addressed this charge.

The immediate goal of communication was met. In the longer term, we anticipate more discussion and collaboration between the participants. It was recognised that there is ample room for cross-fertilisation.

Presentations

The talks can be browsed from the website:
http://www.ect.it/Meetings/ConfsWksAndCollMeetings/
ConfWksDocument/2007/Talks/12_19_March_07/talks.htm

2.3.4 THE INTERFACE OF QUARK-GLUON-PLASMA PHYSICS AND COLD-ATOM PHYSIC

DATE: March 19-30, 2007

ORGANISERS:
Gordon Baym (Co-ordinator) (*University of Illinois*),
Tetsuo Matsui (*University of Tokyo*),
Christopher Pethick (*Nordita*)

NUMBER OF PARTICIPANTS: 34

MAIN TOPICS:

- Hydrodynamics and viscosity
- Crossover phenomena (BEC-BCS and hadron-quark)
- Infrared problems

SPEAKERS:

G. Baym (*Illinois*),
J.-P. Blaizot (*ECT**),
T. Hatsuda (*Tokyo*),
T. Hirano (*Tokyo*),
T.-L. Ho (*Ohio*),
M. Holzmann (*CNRS*),
R. Hulet (*Rice University*),
B. Jacak (*Stonybrook*),
C. Pethick (*NORDITA*),
P. Pieri (*Camerino, It.*),
T. Pohl (*Harvard*),
D. Rischke (*Frankfurt*),
T. Schaefer (*North Carolina*),
A. Schwenk (*TRIUMF*),
H. Stoof (*TRIUMF*),
G. Strinati (*Camerino, It.*),
S. Stringari (*Trento*),
A. Turlapov (*Russian Acad. of Sci.*),
M. Ueda (*Tokyo*),
S. Yip (*Taiwan*),
M. Zwierlein (*MIT*)

SCIENTIFIC REPORT:

There are many points of contact between the physics of ultrarelativistic heavy-ion collisions and the physics of cold atomic gases. One example is that in both fields experiments involve expansion of interacting material. In the case of heavy-ion collisions, the aim is to deduce the properties of matter in the initial fireball by study of the reaction products. For ultracold Fermi gases, information about states of atoms in a trap is deduced by releasing the atoms from the trap and measuring the momentum distribution of the atoms. Another similarity is that quark-gluon plasmas interact strongly and, for atoms, strong interactions can be induced with the help of molecular (Feshbach) resonances. In addition, one can explore crossover phenomena. For fermionic atoms with weakly attractive interactions, the system is a BCS superfluid state similar to that in a metallic superconductor, while for more strongly attractive interactions, the system becomes a Bose-Einstein condensate of diatomic molecules. In the case of nuclear physics, matter consisting of quarks at high densities becomes hadrons at lower densities. There are also similarities between the superfluid states with paired quarks and those with pairs of fermionic atoms.

The aim of the workshop was to bring together leading workers from the two communities to share their insights with each other. The workshop was very timely because of the rapid advances being made in understanding ultracold gases and heavy-ion collisions, and it brought together key theorists and experimentalists in the two areas. There has been rapid progress in investigating mixtures of fermionic atoms with different populations, and this has natural points of contact with dense matter with different populations of the various flavours of quarks, and the possible superfluid phases that have been proposed.

The workshop consisted of a number of general review talks whose purpose was to explain the essential issues in one area to physicists working in other areas. In addition, there were more specialized talks.

Results and Highlights

There was lively interchange on the subject of the viscosity of strongly-interacting Fermi gases, a subject of intense current interest to both communities. Another topic that received attention was the BEC-BCS crossover, and the possibility that the quark-hardon transition in cool dense matter could be of a similar nature. There was also much activity in trying to understand the apparently contradictory experimental results for atomic Fermi gases with unequal populations, and the possibility of observing phases with a spatially-varying order parameter, such as the Fulde-Ferrell and Larkin-Ovchinnikov states. Infrared problems in the two fields have much in common, and this was another major theme of the workshop.

Conclusions

In the opinion of the organizers and the participants, the workshop was very successful. The environment at ECT* provided an excellent venue and facilities for extended exchanges and collaboration.

Web site

All talks are available on the ECT* website.

2.3.5 EXPERIMENT-THEORY INTERSECTIONS IN MODERN NUCLEAR STRUCTURE

DATE: April 23–27, 2007

ORGANISERS:
Achim Schwenk (Co-ordinator) (*TRIUMF*)
Jens Dilling (*TRIUMF*)
Reiner Krücken (*TU Munich*)
Thomas Papenbrock (*University of Tennessee*)

NUMBER OF PARTICIPANTS:

36 plus 15 students from the ECT* Doctoral Training Program

(from 12 countries: Belgium, Canada, Finland, France, Germany, India, Italy, Japan, Poland, Spain, United Kingdom, USA)

MAIN TOPICS:
Structure of nuclei at the extremes of isospin
Nucleonic superfluidity/superconductivity
Ground states properties and density functional theory
Nuclei as laboratories for fundamental symmetries

SPEAKERS:

Yoram Alhassid (*Yale*)
Sonia Bacca (*GSI*)
Scott Bogner (*Ohio State*)
Pier Francesco Bortignon (*Milan*)
Ricardo Broglia (*Milan*)
Bradley Cheal (*Manchester*)
Jacek Dobaczewski (*Warsaw*)
Thomas Duguet (*MSU*)
Piet van Duppen (*Leuven*)
Thomas Fästermann (*TU Munich*)
Dieter Frekers (*Münster*)
Alexandra Gade (*MSU*)
Gerald Gwinner (*Manitoba*)
Gaute Hagen (*ORNL*)
Paul-Henri Heenen (*Brussels*)
Jason Holt (*TRIUMF*)
Andrea Jungclaus (*Madrid*)
Thorsten Kröll (*TU Munich*)
Ritesh Kshetri (*Saha Institute*)
Augusto Macchiavelli (*LBNL*)
Chiara Mazzocchi (*Milan*)
Gerda Neyens (*Leuven*)
Frederic Nowacki (*Strasbourg*)
Takaharu Otsuka (*Tokyo*)
Norbert Pietralla (*Darmstadt*)
Christoph Scheidenberger (*GSI*)
Juoni Suhonen (*Jyväskylä*)
Enrico Vigezzi (*Milan*)
Hans Wilschut (*KVI*)

SCIENTIFIC REPORT:

The aim of the workshop "Experiment – Theory Intersections in Modern Nuclear Structure" was to inform each other about the newest developments and the most recent progress in the field, to learn about experimental needs for theory and theoretical needs for data, and to foster discussions and collaborations on modern topics in nuclear structure physics and in fundamental symmetries investigated with nuclei as laboratory. The workshop brought together in a unique and informal way 36 junior and senior researchers from 12 countries. 17/18 of the participants were experimentalists/theorists and most radioactive ion beam facilities were represented.

The workshop focused on four themes: (i) Structure of nuclei at the extremes of isospin, (ii) nucleonic superfluidity/superconductivity, (iii) ground-state properties and density functional theory, and (iv) nuclei as laboratories for fundamental symmetries. It consisted of 29 scientific presentations. Each of the four major themes was introduced by a pair of 45-minute introductory talks that gave an experimental and theoretical overview. These talks were also aimed at and attended by the students of the ECT* Doctoral Training Program. All other talks were 30 minutes, with experimental and theoretical presentations mostly in alternating order. Each talk was accompanied by a 15-minute discussion period. This program, and the scheduled coffee and long lunch breaks offered ample opportunity for lively and in-depth discussions. Here, the confinement to the Villa Tambosi turned out to be very useful, as the interaction time between the participants covered a major fraction of the day. In particular, our schedule also permitted the students to interact with various participants of the workshop.

The exchange between experimentalists and theorists was very fruitful, and by all accounts the workshop was a great success. By the end of the week, many intersections between experiment and theory could be identified. As examples we mention, (i) the need for improved experimental data in the Nobelium region to further constrain single-particle aspects of the nuclear energy-density functional, (ii) the need to improve the theoretical calculations of nuclear matrix elements for the neutrino-less double-beta decay, for example for ^{76}Ge, (iii) the need to improve the theoretical corrections that enter the ft-values for a high-precision test of the unitarity of the Cabbibo-Kobayashi-Maskawa matrix, (iv) the constraints that data in the so-called island of inversion provide for tests of cross-shell interactions, (v) the experimental tests and theoretical studies of proton-neutron pairing at N=Z, and (vi) the tests of stability of known and the emergence of new shell closures in neutron-rich nuclei. Besides these challenges, collaborative efforts took place: Many participants used the meeting to advance existing collaborations, and new collaborations were started. The participants agreed that the exchange between experimentalists and theorists was very fruitful, and that more regular meetings in the spirit of this workshop are needed.

All talks are available on-line at the workshop website:
http://www.triumf.info/hosted/ECT07/.

2.3.6 MANY-BODY OPEN QUANTUM SYSTEMS: FROM ATOMIC NUCLEI TO QUANTUM DOTS

DATE: May 14-18, 2007

ORGANISERS:
Kiyoshi Kato (*Hokkaido Univ.*), Witek Nazarewicz (*Univ. of Tennessee/ORNL*), Marek Płoszajczak (Co-ordinator) (*GANIL*), Ingrid Rotter (*MPI-Dresden*)

NUMBER OF PARTICIPANTS: 43

MAIN TOPICS:

- Shell model description of open quantum systems
- Resonances and correlations in halo/few-body continuum
- Ab initio description of unstable systems
- Threshold effects in multichannel coupling
- Non-hermitian Hamilton operators
- Spreading of wave packets
- Quantum transport in mesoscopic systems and microwave billiards
- Laser induced continuum structures in atoms and molecules
- Dephasing in mesoscopic structures

SPEAKERS:

Rodolfo Id Betan (*Rosario*)
David Dean (*ORNL*)
Carla F.M. Faria (*CMS-London*)
U. Guenther (*FZ-Rossendorf*)
B. Gyarmati (*Debrecen*)
Shmuel Gurvitz (*Weizmann Inst.*)
Gaute Hagen (*ORNL*)
Naomichi Hatano (*Tokyo Univ.*)
Makoto Ito (*RIKEN*)
Felix Izrailev (*Puebla Univ.*)
Aksel S. Jensen (*Aarhus Univ.*)
Kiyoshi Kato (*Hokkaido Univ.*)
Andras Kruppa (*ATOMKI*)
Ulrich Kuhl (*Marburg Univ.*)
Horst Lenske (*Giessen Univ.*)
Roberto Liotta (*Stockholm*)
Rezso Lovas (*ATOMKI*)
Lubomir Majling (*Rez/Prague*)
Hiroshi Masui (*Hokkaido Univ.*)
Nicolas Michel (*Kyoto Univ.*)
Nimrod Moiseyev (*Technion-IIT*)
Takayuki Myo (*Osaka Univ.*)
Takashi Nakatsukasa (*Tsukuba*)
Witold Nazarewicz (*UT/ORNL*)
Jacek Okolowicz (*IFJ-Krakow*)
Nigel Orr (*LPC-Caen*)
Achim Richter (*TU-Darmstadt*)
Stefan Rotter (*Yale Univ.*)
Jimmy Rotureau (*ORNL*)
A.F. Sadreev (*IP-Krasnoyarsk*)
Wolfgang Schleich (*Univ. of Ulm*)
Eric Suraud (*IRSAMC-Toulouse*)
Jan S. Vaagen (*Bergen Univ.*)
Tamas Vertse (*ATOMKI*)
Alexander Volya (*FSU-Tallahassee*)
Masayuki Yamagami (*RIKEN*)
Kenichi Yoshida (*Kyoto Univ.*)

SCIENTIFIC REPORT:

Aim and Purpose: Today, much interest in various fields of physics is devoted to the study of small open quantum systems, whose properties are profoundly affected by environment, i.e., continuum of decay channels. Although every finite fermion system has its own characteristic features, resonance and threshold phenomena are generic; they are great interdisciplinary unifiers. It was therefore urgent to bring together scientists working on different many-body open quantum systems such as weakly bound/unbound atomic nuclei, atoms and molecules in strong external fields, quantum dots, microwave cavities , etc. to stimulate interdisciplinary contacts and contribute to exchange of ideas.

In the field of nuclear physics, the growing interest in theory of open quantum systems is associated with experimental efforts in producing weakly bound/unbound nuclei close to the particle drip-lines, and studying structures and reactions with those exotic systems. To this end, the major problem for nuclear theory is a unification of structure and reaction aspects of weakly-bound or unbound nuclei, based on the open quantum system many-body formalism. Solution of this challenging problem has been advanced recently through the new-generation continuum shell model approaches. These approaches can be used also for studies of other finite-size quantum many-body systems such as coupled quantum dots or atomic molecules which are easier to control experimentally than atomic nuclei.

Revival of the theory of open quantum systems is rooted in the work of Tore Berggren on the completeness of an ensemble consisting of resonant Gamow states and the complex-energy, non-resonant continuum of scattering states. One of the goals of the workshop was to celebrate the 40th anniversary of this seminal work which opened a window for the formulation of a comprehensive modern many-body theory of weakly bound/unbound states and henceforth put a foundation for the open quantum system community across the frontiers of various fields of physics.

Results and Highlights. Description of the dynamics of weakly bound and unbound many-body systems such as the atomic nuclei, clusters of neutral atoms, few-electron quantum dots, etc. close to the particle-emission thresholds became possible in the open quantum system formalism. This is one of the main highlights of the workshop. Few-body open quantum systems can be treated by solving Fadeev equations or using the Complex Scaling approach. Ab initio description of these systems is now also available using the Gamow Shell Model or the Coupled Cluster approach in Berggren ensemble, which can be applied to light and medium-mass nuclei. The development of the Density-Matrix Renormalization Group algorithms for open quantum systems enables presently a fully converged shell model calculations resolving the many-body completeness relation in Berggren ensembles.

Heavy atomic nuclei or atomic clusters, both bound and decaying, can be described in the density functional approach and the self-consistent Continuum-Hartree-Fock(-Bogoliubov) method. Collective excitations in those systems can then be studied using the self-consistent continuum QRPA.

Over last few years, one could notice an impressive development of the many-body techniques appropriate for studies of the dynamics of strongly correlated quantum many-body systems in the transitional region around the (multi-)particle emission threshold(s). Real-

istic applications, following an experimental progress in the fields of loosely bound atomic nuclei, atomic clusters, or cold atoms will be the challenge for future studies.

Deeper understanding of loosely bound or unbound many-body systems will help to identify salient features of the continuum coupling induced transition in the particle-particle coupling and its consequences for binding energy systematics, spectroscopic amplitudes, response functions, effective symmetries, reaction cross-sections, etc. To bridge the gap between configuration-interaction approaches with realistic interactions and the approaches rooted in the density functional theory is the long-term objective of those studies.

Many aspects of open quantum systems are generic and independent of the system dimensionality. These include: properties of the exceptional points and related topological phases, crossings and avoided crossings of resonance energies, redistribution of widths, symmetry-breaking effects in different regimes of resonance densities, S-matrix fluctuations, width distributions, etc. Those phenomena have been originally studied in nuclear reactions but it is not possible to experimentally control the behavior of the nuclear system by varying external parameters as in, e.g., atoms and molecules, quantum dots, or microwave resonators. In those systems, the new quality of precision table-top experiments have been recently achieved to study and prove fundamental quantum-mechanical laws that govern open quantum systems. Exact mapping between observed quantities and eigenfunctions of the Schrődinger equation, which is possible for example in microwave experiments (as well as in certain experiments in quantum optics), allow to view the microwave resonator as an analog computer solving Schrődinger equation in different regimes of level densities. This analogy can be further used, e.g., to test assumptions of the compound-nucleus reaction theory in the microwave resonator experiments.

Conclusions: The multi-configurational models based on the Berggren ensemble are tools of choice for the description of structure and reaction aspects of many-body systems that require microscopic treatment of open channels. A number of developments are on the way, primarily pertaining to nuclear physics; however, future applications to other systems (hypernuclei, molecules, dots) are envisioned.

Many experiments in quantum optics or in coupled quantum dots interacting with the environment, can be modelled by replacing degrees of freedom of the environment by the fluctuating force. Here the theoretical challenge are experimental results on decoherence (dephasing) and relaxation processes in open quantum systems generated by the fluctuating environment. It has been stressed that the formulation of a consistent quantum stochastic theory of such processes should be attempted also within the Berggren approach.

The participants have felt that discussions related to generic features of open systems were most stimulating and have led to excellent cross-fertilization. The topics of general interests included, among others,

- Properties of metastable states, resonances, and many-body continuum
- Threshold phenomena and channel coupling
- Channel alignment and clustering
- Statistical features of spectra; overlapping resonances

- Bound states in the continuum
- Nature of exceptional points
- Time evolution of wave packets and tunneling
- Rigged quantum mechanics and imaginary potentials
- Advanced computational techniques

It has been concluded that the inter-disciplinary workshops of this kind should definitely continue; a manifesto of the open-systems community is being drafted.

The talks can be browsed from the website:
`www.ect.it/Meetings/ConfsWksAndCollMeetings/ConfWksDocument/2007/Talks/14_19_May_07/talks.htm`

2.3.7. NUCLEAR PHYSICS DATA COMPILATION FOR NUCLEOSYNTHESIS MODELING

(Collaboration Meeting)

DATE: May, 29th. - June, 1st.

ORGANISERS:
C. Angulo (Co-ordinator) (*Universit de Louvain, Louvain-la-Neuve*), M.C. Wiescher (*University of Notre Dame*)

NUMBER OF PARTICIPANTS: 22

MAIN TOPICS:

- Nuclear Astrophysics

SPEAKERS:

R. Cyburt (*MSU, USA*),
I. Dillmann (*FZ Karlsruhe, DE*),
A. Kankaninen (*Univ. of Jyvaskyla, FIN*),
F. Kondev (*MSU, USA*),
H.-P. Loens (*GSI, Darmstadt,DE*),
P. Moller (*LANL, USA*),
B. Prytichenko (*BNL, USA*),
M. Smith (*ORNL, USA*)

SCIENTIFIC REPORT:

Aim and Purpose: Over the last decade the field of nuclear astrophysics has emerged as one of the most important subdisciplines of nuclear physics. The main goal of the field is to identify the most important nucleosynthesis sites and model the dominant nucleosynthesis processes which have led to the origin of the chemical elements in our universe. A further goal is to describe the nuclear burning processes which govern the different stages of stellar evolution and which drive a large variety of cataclysmic explosion processes observed in our universe. This effort requires both extensive observational data bases on elemental and isotopic abundances which represent the critical observables against which we can test the results of theoretical modeling efforts of the various nucleosynthesis sites. There is a large variety of stellar and explosive nucleosynthesis scenarios, ranging from charged particle induced hydrogen, helium, and carbon burning in stars to explosive hydrogen, helium and heavy ion burning in novae, cataclysmic x-ray bursts and type I supernovae explosions. Heavy elements beyond iron are produced by neutron induced processes such as the s-process in Asymptotic Giant Branch (AGB) stars or in core helium burning in massive red giant stars, or complementary to that by the r-process, a sequence of rapid neutron capture reactions which is expected to take place in the type II supernova shocks. These nucleosynthesis processes are complemented by photon induced processes such as Neon burning and Silicon burning during late stellar evolution and the p-process in the type I or type II supernovae. A reliable modeling and the identification of the associated astrophysical sites requires detailed nuclear reaction and decay data. Over the years a multitude of data libraries for nuclear astrophysics reactions has been developed (see http://www.nucastrodata.org). However, often the tabulated data are out-dated, sometimes contradictory, and the tabulations exist in a wide variety of formats which complicates the application for the astrophysics modeler.

CARINA (Challenges and Advanced Research In Nuclear Astrophysics,
http://www.cyc.ucl.ac.be/CARINA/) is a network of European research groups, supported by EURONS through the 6th EC Research Framework Program (FP6) from 2005 to 2008, with the goal of harmonizing nuclear astrophysics research in Europe. JINA (Joint Institute for Nuclear Astrophysics,
http://www.jinaweb.org/) represents a US collaboration between the University of Notre Dame, Michigan State University and the University of Chicago with several associated members in the US and Canada. JINA is funded through the Physics Frontier Center program of the National Science Foundation.

Results and Highlights: The goal of the collaboration meeting, jointly organized by CARINA and JINA, is to develop an updated and unified nuclear reaction data base for modeling a wide variety of stellar nucleosynthesis scenarios. The purpose of this first meeting was to develop strategies and techniques to update and eventually merge three of the presently most important data libraries, namely, the KADONIS, NACRE and REACLIB data bases. KADONIS is a data library for slow neutron capture reactions of relevance for the s-process. It is well maintained and the collaboration plans to expand it to also include photodisintegration reactions of relevance for the p-process; NACRE is the main data base for simulating stellar hydrogen and helium burning but is limited to low Z¡14. The present

data library needs to be up-dated since a multitude of new results has been obtained over the last ten years. It also needs to be expanded to include charged particle reactions for higher Z which are important for shell helium and hydrogen burning as well as for explosive hydrogen burning in novae; REACLIB combines experimental rates and theoretical predictions based on the statistical model. It can be utilized for hydrostatic stellar evolution and explosive events. Recent applications include explosive hydrogen and helium burning through the rp-process, as well as explosive carbon, neon, oxygen and silicon burning and the r-process. It needs updates from recent results of radioactive beam experiments and improved theoretical predictions. The library contains also a large number of decay data which need to be completed. The original authors of the three identified libraries are members of the CARINA-JINA collaboration and are taking a lead role in this project. A further goal of the meeting was the development and implementation of a central web access point in which the data of all libraries can be presented in a unified format and be used by the modeling community. It has been decided that this will be developed by the MSU JINA group and the ORNL nuclear astrophysics group. The data will be maintained and updated by the collaboration through databases, but will be made public through a central website provided and hosted by the ORNL nuclear astrophysics group. The importance for nuclear astrophysics of continued efforts in the compilation of nuclear masses (and fission barriers) was also recognized at the meeting. Where not experimentally available, far from stability, nuclear astrophysics relies on theory. This includes predictions for level densities, optical potentials as well as weak interaction decay rates and reactions with electrons/positrons and neutrinos. During a preliminary workshop, which has been the seed of this collaboration, at the University of Basel in June 2006, it was agreed on the goals and the procedure. The purpose of the ECT* meeting has been (i) to provide a one week closed working environment where subgroups of the participants have focused on reviewing and upgrading specific reaction information on the three identified libraries and (ii) to organize subgroups and to assess specific tasks (e.g. also how the astrophysics modeler can be pointed to available theory data bases). the existing KADONIS and JINA/REACLIB

Conclusions: A total of 22 participants from different groups in Europe and USA attended this meeting that was organized to have, each day, a general session in the morning, with introductory talks, and parallel working groups in the afternoon. The workshop developed very much in the way it has been foreseen and its goal was successfully achieved. The relaxing atmosphere at ECT* and the excellent local organization helped to the success of this meeting.

2.3.8 CORRELATIONS IN NUCLEI: BEYOND-MEAN-FIELD AND SHELL-MODEL APPROACHES

DATE: June 4-8

ORGANISERS:
P-H Heenen (Co-ordinator) (*ULB, Belgium*), M. Bender (*CENBG, France*), T. Duguet (*MSU, USA*) , A. Poves (*UAM, Spain*)

NUMBER OF PARTICIPANTS: 28 registered participants + 7 students from the previous school organized at ECT*

MAIN TOPICS:

- correlations in the shell model and self-consistent mean-field methods
- meaning of experimental and theoretical single particle energies
- signatures of correlations in the wave function: spectroscopic and transition moments

SPEAKERS:

Bender (*CENBG*),
Robledo (*UAM*),
Heenen (*ULB*),
Niksic (*Zagreb*),
Poves (*UAM*),
Zuker (*Strasbourg*),
Heyde (*RUGent*),
Goutte (*CEA*),
Rodriguez (*UAM*),
Lacrois (*LPC Caen*),
Reinhard (*Erlangen*),
Hjorth-Jensen (*Oslo*),
Horoi (*CMICH*),
Rotival (*CEA*),
Duguet (*MSU*),
Vretenar (*Zagreb*),
Rudolph (*Lund*),
Nowacki (*Strasbourg*),
Brown (*MSU*),
Bennaceur (*ULyon*),
Sorlin (*Ganil*),
Herzberg (*Liverpool*),
Signoracci (*MSU*),
Johnson (*San Diego*),
Dukelsky (*CSIC*),

SCIENTIFIC REPORT:

Aim and Purpose:

The aim of the workshop was to discuss the connection between mean-field based methods and the shell model, which kind of correlations they can easily describe in realistic applications and which ones they cannot, and to discuss the common challenges that are face for further developments.

The main topics covered by the workshop were

- correlations from exact diagonalization: shell model, truncation of the model space, coupled cluster methods, exactly solvable models
- correlations in and beyond the self-consistent mean-field: generator coordinate methods, symmetry restorations, treatment of pairing correlations
- correlations in the nuclear medium: construction of effective interactions for the shell model and for the mean-field-based approaches
- meaning of experimental and theoretical single-particle energies and role of the tensor force
- signatures of correlations in the wave function: spectroscopic and transition moments

Results and Highlights:

Despite of the fact that there were several other meetings at the same time as our workshop (INPC in Japan, Gordon Conference in the US), the workshop succeeded to attract people from most of the groups active in the field. There were 28 registered participants, with a mean attendance of 35 people during most of the sessions, several students participating to the school organized at the ECT* the weeks before being still present. Many discussions ran about the problems of interactions that have to be constructed for both mean-field based methods and the shell model, with several talks on the most recent developments on effective interactions based on effective field theory. It has also been shown that perturbative modifications of effective interactions, which are often performed to introduce new terms as the tensor interaction cannot be expected to lead to realistic results. The refit of the complete interaction including the new terms will soften their effects, making conclusions drawn from perturbative calculations overstated. The evolution of shell closures along isotopic and isotonic chains was also a central theme of the discussions. As very well put in evidence in the summary talk of M. Hjorth-Jensen, this problem will be the focus of joined experimental and theoretical efforts in the next years. The talks on experiments were mainly focussed on problems related to single particle levels in different region of the nuclear chart. Together with some theoretical talks, they put into evidence several strong disagreements between experimental data and theoretical calculations.

Conclusions: This workshop has reached its goal: to make an in depth comparison between the microscopic models aiming to describe exotic nuclei. The main conclusion of the workshop is that the efforts to strengthen the links between the microscopic models of nuclear structure physics should be a major objective of the coming years.

2.3.9 TRANSVERSE MOMENTUM, SPIN, AND POSITION DISTRIBUTIONS OF PARTONS IN HADRONS

DATE: June 11-15, 2007

ORGANISERS:
Harut Avakian (Jefferson Laboratory)
Delia Hasch (Co-ordinator) (LNF Frascati)
Andreas Metz (Bochum University)

NUMBER OF PARTICIPANTS: 40

MAIN TOPICS:

- Data on single spin asymmetries and related observables, as well as their interpretation and analysis
- Transversity, transverse momentum dependent parton distributions and fragmentation functions
- Factorization in terms of transverse momentum dependent correlators

SPEAKERS:
A. Afanasev (*Hampton Univ.*),
M. Anselmino (*Torino Univ.*),
H. Avakian (*Jefferson Lab*),
A. Bacchetta (*DESY*),
L. Bland (*BNL*),
M. Boglione (*Torino Univ.*),
F. Bradamante (*Trieste Univ.*),
G. Bunce (*BNL and RBRC*),
M. Burkardt (*NMSU*),
F. Ceccopieri (*Parma Univ.*),
J. Collins (*Penn State Univ.*),
U. D'Alesio (*Cagliari Univ.*),
P. Dalpiaz (*Ferrara Univ.*),
E. De Sanctis (*INFN Frascati*),
M. Diehl (*DESY*),
A. Efremov (*JINR Dubna*),
L. Gamberg (*Berks Univ.*),
Y. Goto (*Riken/RBRC*),
Ph. Haegler (*TU Munich*),
P. Hoyer (*Helsinki Univ.*),
X. Jiang (*Rutgers Univ.*),
A. Kotzinian (*INFN Torino*),
S. Liuti (*) (*Univ. of Virginia*),
Z. Lu (*Santa Maria Univ.*),
A. Martin (*Trieste Univ.*),
A. Miller (*TRIUMF*),
A. Mukherjee (*Bombay Univ.*),
P. Mulders (*VU Amsterdam*),
L. Pappalardo (*) (*Ferrara Univ.*)
B. Parsamyan (*INFN Torino*),
B. Pasquini (*Pavia Univ.*),
A. Prokudin (*Alessandria Univ.*),
M. Radici (*INFN Pavia*),
M. Schlegel (*Jefferson Lab*),
G. Schnell (*Gent Univ.*),
P. Schweitzer (*Bochum Univ.*),
R. Seidl (*Univ. of Illinois*),
W. Vogelsang (*BNL*)

(*) Participation only

SCIENTIFIC REPORT:

Aim and Purpose: Transverse momentum dependent parton distributions and fragmentation functions (TMDs) are currently under intense investigation both from the experimental and theoretical side. Of particular interest are those objects where the transverse parton momentum gets coupled to the transverse spin of the parton or the external hadron in a hard scattering process. These functions (like, e.g., the Sivers parton density and the Collins fragmentation function) can give rise to interesting single spin phenomena in semi-inclusive lepton- and hadron-induced processes. Experiments that aim at pinning down various TMDs are currently running at CERN (COMPASS Collaboration), DESY (HERMES Collaboration), Jefferson-Laboratory and RHIC. In addition, in the future this type of physics is likely to be studied through pp- and $\bar{p}p$-collisions (FAIR-project, J-PARC and U70), and through ep-collisions (at a facility like the proposed electron-ion collider). From the theoretical side the TMDs have many interesting features. In this context we only mention the possible information on the transverse position distribution of partons inside hadrons, as well as the need for unintegrated parton densities as their use typically considerable improves the convergence of calculations in perturbative QCD.

The main motivation to organize this workshop was to bring together world experts working in this field in order to discuss in detail the key physics issues of semi-inclusive reactions and TMDs. In more detail we had in mind to focus during the workshop on the p_T-behavior of semi-inclusive reactions, the role of soft gluon emission in unintegrated processes, QCD-evolution of TMDs, relation of TMDs to transverse position distribution of partons and to generalized parton densities. We also had the intention to shed more light on the dynamical origin of the observed large single spin asymmetries (in particular in single hadron production in hadron hadron collisions), and to intensively discuss the feasibility of a global analysis of TMDs using available and future measurements. The workshop showed a very close interplay of theorists and experimentalists.

We considered the workshop to be important and timely in order to augment the presently established role of semi-inclusive reactions as a tool for studying the hadron (most notably nucleon) structure in terms of TMDs. Such a meeting should, in particular, also help to identify directions for further development of this quickly emerging field.

Results and Highlights: First of all, during the workshop the state of the art for the entire field of transversity and transverse momentum dependent partonic correlators was presented at a high level by various speakers. Highlights were certainly the contributions on recent measurements of single spin and azimuthal asymmetries in electron-positron annihilation, electron-nucleon scattering as well as proton-proton collisions. The experimental talks made the tremendous progress in this field evident.
From the theoretical side, important results comprise the first extraction of the transversity, and also the fits of different TMDs like the Sivers parton distribution and the Collins fragmentation function. These achievements can be considered as milestones in the field, and they constitute the first step towards a complete description of the partonic structure of hadrons beyond the collinear parton model.
Also three dedicated discussion sessions (on Monte Carlo event generators, TMD factorization in hadron-hadron collisions, and global analysis for TMDs) were a crucial part of the workshop. The problems in these areas were pinned down, and directions for further mandatory work were defined.

Conclusions: The main conclusions of the workshop, relevant for the future of the field, are:

- the next steps towards a global analysis of hard semi-inclusive processes in terms of TMDs were discussed in detail and identified (key experiments and necessary theoretical work).

- it was generally agreed on that on a longer term a new Monte Carlo event generator, adapted to TMD effects, is needed for a quantitative global analysis of TMDs.

- a concise theoretical formalism, including soft gluon emission and energy evolution of TMDs, was discussed. The elements of the formalism, which already exists in the literature, have to be supplemented in order to make the formalism suitable for practitioners.

- the present and controversial status of TMD factorization in hadron-hadron collisions was discussed at length and future work in this field was identified.

- the origin of the large measured single spin asymmetries in hadron-hadron collisions was considered, and an alternative to the single parton scattering picture was presented. Future theoretical and experimental work will help to clarify the crucial question if the single spin asymmetries observed in hadron-hadron collisions and in lepton-hadron collisions have a common origin.

In general, the meeting can be considered as quite important and successful. It was necessary to sharpen the future directions of the very interesting field of hard semi-inclusive directions and transverse momentum dependent correlation functions. Very likely we are at the beginning of a new era in which the partonic structure of hadrons, inlcuding transverse paron momenta, will be explored on a quantitative level. We are quite confident that basically all participants left the workshop with new ideas and enthusiasm, and certainly new collaborations can be anticipated.

2.3.10 ELECTROMAGNETIC PROBES OF HOT AND DENSE MATTER: THE QUEST FOR MEDIUM MODIFICATIONS OF HADRONS

DATE: June 18 - 22, 2007

ORGANISERS:
Burkhard Kämpfer (Co-ordinator) (*Research Center Dresden-Rossendorf*),
Ralf Rapp (*Texas A&M University*),
Joachim Stroth (*University Frankfurt*)

NUMBER OF PARTICIPANTS: 48

MAIN TOPICS:

- Vector mesons at SIS/FAIR energies
- Dileptons at CERN-SPS
- Vector mesons in nuclear matter and nuclei
- Electromagnetic probes at RHIC
- Resonances and hard e.m. probes

SPEAKERS:

V. Metag (*Giessen*),
P. Salabura (*Cracow*),
G. Chanfray (*Lyon*),
S. Leupold (*Giessen*),
D. Cabrera (*Texas A&M*),
T. Renk (*Jyväskylä*),
S. Damjanovic (*CERN*),
H. J. Specht (*Heidelberg*),
C. Gale (*McGill*),
H. Appelshäuser (*Frankfurt*),
H. van Hees (*Texas A&M*),
R. Shahoyan (*CERN*),
K. Dusling (*Stony Brook*),
J. Ruppert (*McGill*),
C. Djalali (*South Carolina*),
M. Naruki (*RIKEN*),
C. Sasaki (*Munich*),
G. David (*Brookhaven*),
W. Cassing (*Giessen*),
B. Schenke (*Frankfurt*),
E.L. Brakovskaya (*FIAS*),
C. Höhne (*GSI*),
Y. Pachmeyer (*Frankfurt*),
M. Thomere (*SUBATECH*),
E. Santini (*Tübingen*),
T. Galattyuk (*GSI/Frankfurt*),
M. Bleicher (*Franfurt*),
O. Kaczmerek (*Bielefeld*),
P. Fachini-Laue (*Brookhaven*),
S. Vogel (*Frankfurt*),
A. Toia (*Stony Brook*),
J.-e Alam (*Kolkata*),
C. Vale (*Brookhaven*).

SCIENTIFIC REPORT:

This workshop was the third ECT* program on the topic of Electromagnetic Probes of Strongly Interacting Matter (first in March of 1999, second in June 2005). The main objectives were: (i) to facilitate the announcement, dissemination and in-depth discussion of recent important scientific results, (ii) to represent a forum for detailed discussions and exchanges between the experimental and theoretical communities (our field traditionally enjoys a high level of exchange between the two, owing largely to opportunities like the one provided by this workshop), and (iii) to develop a more coherent picture of medium modifications of ρ, ω, ϕ (e.g., light vector mesons in cold nuclear matter near its ground state vs. highly excited hot and dense matter in ultra-/relativistic heavy-ion collisions).

The workshop furthermore benefited from contacts between the high-energy (SPS, RHIC) and intermediate-energy (SIS) heavy-ion research communities, as well as researchers focusing on reactions of protons, photons or electrons with nuclei. The quality of the meeting was ensured by inviting a large group of leading scientists in the various fields.

Highlights:

- HADES results on di-electron data in heavy-ion collisions C+C at 1 and 2 AGeV, p+p at various energies (world premieres), and d+p, including a confirmation of the longstanding DLS puzzle. In particular, the importance of dilepton production in N-N Bremsstrahlung has been clearly identified.

- NA60 results on di-muon data allowing the identification and separation of early (possibly partonic) and late flow, as well as acceptance-corercted low-mass spectra (world premiere, confirming predictions from hadronic many-body ρ spectral functions).

- Long-awaited PHENIX di-electron spectra at RHIC energy for Au+Au at $\sqrt{s_{NN}} =$ 200 GeV (world premiere), showing a suprisingly large low-mass excess over expected sources.

Further highlights:

- Evidence of a dropping ω mass in photo-nuclear reactions by the CB-TAPS collaboration, consolidated in control experiments and by refined data analyses. This exciting result is subject of theoretical interpretations with respect to the onset of chiral symmetry restoration in nuclear matter and various quark condensates and their density dependence.

- CLAS g7/8 results for electro-excitation of ρ mesons in nuclei, showing a broadening of the ρ spectral shape but no "mass shift". Here, the crucial role of a careful and accurate determination of the background when using nuclear targets was demonstrated.

- Dedicated theory and model approaches to interpret HADES, NA60 and PHENIX data. The range covered approaches relying on local equilibrium up to advanced transport models.

- Connections between medium modifications and chiral symmetry restoration, in particular utilizing Weinberg and QCD sum rules.

Several (topical) discussion sessions were dedicated to scrutinize the status of the field which was surveyed with emphasis on direct evidence of medium modifications, most notably: differences in low-mass dilepton spectra from thermal fireball emission and late hadronic decays, the significance of NA60 slope analysis of lepton-pair p_t spectra (including hadronic slope systematics and the rapid variation of the slope from the ρ-mass to the continuum region), the sensitivity of medium effects in ω decays in nuclear matter vs. ρ decays in relativistic heavy-ion collisions, and disentangling related issues of "no evidence" vs. "inconclusive interpretations".

Conclusions:

The workshop was a resounding success with high-quality presentations and discussions. The degree of exchange in collaborations across the theoretical-experimental boundary has noticeably increased.

It was agreed to envisage a follow-up workshop on a 2-year timescale.

2.3.11 FUNDAMENTAL SYMMETRIES: FROM NEUTRINOS AND NUCLEI TO THE UNIVERSE

DATE: June, 25 - 29, 2007

ORGANISERS:
Volpe Maria Cristina (Co-ordinator) (*Institute de Physique Nucléaire Orsa*), Balantekin Baha (*University of Wisconsin-Madison, USA*)

NUMBER OF PARTICIPANTS: 31

MAIN TOPICS:

- CVC and superallowed beta-decays;
- lepton-number violating processes and double-beta decay;
- P,T and CP violation;
- neutrino masses and mixings;
- neutrino-nucleus interactions;
- precision measurements;
- neutrinos from core-collapse supernovae and gamma-ray bursts;
- nucleosynthesis;
- UHE neutrinos.

SPEAKERS:

E. Ben-Haim (*LAL Orsay,F*),
K. Blaum (*Univ. of Mainz,D*),
M. Breitenfeld (*Univ. of Greifswald,D*),
J.H. De Jesus (*Univ. of Wisconsin-Madison,USA*),
H. Ejiri (*Osaka Univ., Japan*),
J. Engel (*North Carolina Univ.,USA*),
V. Gudkov (*USA*),
J. Hardy (*Texas A-M,USA*),
B. Holstein (*Princeton Univ.,USA*),
N. Jachowicz (*Ghent Univ.,B*),
K. Jungmann (*KVI,NL*),
J. Ketelaer (*Mainz Univ.,D*),
H. Kosmas (*Ioannina Univ.,GR*),
R. Lazauskas (*IPN Orsay,F*),
A. Mirizzi (*Muenchen,D*),
A. Malkus (*Univ. of Wisconsin-Madison,USA*),
G. McLaughlin (*North Carolina Univ.,USA*),
M. Mezzetto (*INFN Padua,I*),
O. Naviliat-Cuncic (*LPC Caen,F*),
J. Ng (*Triumf,CA*),
N. Paar (*Univ. of Zagreb,HR*),
T. Pradier (*IRES Strasboug,F*),
N. Severijns (*Leuven Univ.,B*),
G. Sigl (*APC Paris,F*),
F. Simkovic (*Comenius Univ.,SK*),
S. Su (*Arizona Univ.,USA*),
J. Welzel (*IPN Lyon,F*).

SCIENTIFIC REPORT:

The study of fundamental interactions, their symmetries and symmetry breaking has brought major advances in our understanding of particles, the way they interact and decay as well as in the description of nuclei, how they decay or respond to various probes. These discoveries have had a clear impact in other fields, such as astrophysics and cosmology. At present, many experiments either running or under study will push tests of fundamental interactions and present sensitivities of their symmetry breaking to unpreceded precisions. An example is offered by the study of super-allowed beta-decay in nuclei which offers one of the crucial pieces of information to test the unitarity of the Cabibbo-Kobayashi-Maskawa matrix in the quark sector. On the other hand, the exploration of the CP and T violation in the lepton sector with pioneering experiments exploiting neutrino beams with boosted radioactive nuclei will open a completely new field of research. Another invaluable source of information concerning CP violation is the search for an electric dipole moment in leptons, neutrons and neutral atoms since this observation would indicate time-reversal violation. The quest for total lepton violation with nuclei or rare particle decays is also of outstanding importance. In this respect, the search for neutrinoless double-beta decay or of muon-electron conversion are very promising. In particular, the approved GERDA and CUORE experiments will test a claim for neutrino-less double-beta decay in nuclei while several other challenging measurements are expected to reach the tens of meV in the long term future.

The origin of the baryon asymmetry in the Universe remains to be an open problem. There is a reasonable consensus among the workers in the field that CP-violation is needed for a successful baryogenesis. In this regard a search for permanent dipole moments of electrons, neutrons, and neutral atoms can have potentially a huge impact on the baryon aymmetry of the Universe. A few decades ago Schiff showed that electric dipole moment of point-like, non-relativistic quanta as probed by an applied electric field exactly vanishes. Hence understanding finite size, relativistic, and magnetic corrections holds considerable potential towards baryogenesis.

The workshop has aimed at bringing together worldwide experts, experimentalists and theoreticians, working on these topics at the interface of nuclear physics, high energy physics and astrophysics. The exciting experimental discoveries and future challenging developments require to increase the synergy between these scientific communities. Having this in mind, we have devoted much time to informal discussions. The central goals of the workshop have been :

- to review the present experimental status and the plans for future developments (approved or under study) for the study of fundamental symmetries;
- to describe current developments in building nuclear structure models and open problems concerning the nuclear transition probabilities necessary for some of these experiments;
- to discuss the impact on astrophysical processes (nucleosynthesis and supernovae explosion) as well as on cosmology.

2.3.12 ADVANCED MANY-BODY METHODS FOR NUCLEAR STRUCTURE

DATE: July, 2-6, 2007

ORGANISERS:
C. Barbieri (Co-ordinator) (*GSI*), R. Roth (*TU Darmstadt*), D. Dean (*ORNL*)

NUMBER OF PARTICIPANTS: 36

MAIN TOPICS:

- nuclear forces and effective interactions
- *ab-initio* methods for many-body systems
- correlations in nuclei
- spectral functions in finite nuclei and spectroscopic factors

SPEAKERS:

S. Bacca (*GSI*),
S. Barbieri (*GSI*),
F. Barranco (*Seville*),
O. Benhar (*La Sapienza*),
R. Chatterjee (*Padova*),
G. Co' (*Lecce*),
L. Coraggio (*Napoli*),
S. Cowell (*LANL*),
W. Dickhoff (*Wash. U., St.Louis*),
E. Epelbaum (*Juelich*),
D. Fedorov (*Arhus*),
A. Gade (*MSU*),
H. Hergert (*TU Darmstadt*),
H. Feldmeier (*GSI*),
Y. Fujita (*RCNP*),
G. Hagen (*ORNL*),
G. I. Lykasov (*Dubna*),
N. Lo Iudice (*Napoli*),
T. Kroell (*Munich*),
P. Navrátil (*LLNL*),
T. Neff (*GSI*),
N. Paar (*Zagreb*),
P. Papakostantinou (*TU Darmstadt*),
P. Piecuch (*MSU*),
P. Polls (*Barcelona*),
F. Pederiva (*Trento*),
A. Rios (*MSU*),
R. Roth (*TU Darmstadt*),
I. Sick (*Basel*),
H. Simon (*GSI*),
Y. Utsuno (*JAEA*),
D. Van Neck (*Gent*),
K. Vantournhout (*Gent*),
E. Vigezzi (*Milano*),
P. von Neumann-Cosel (*TU Darmstadt*),
N. R. Walet (*Manchester*),

SCIENTIFIC REPORT:

The workshop "Advanced Many-Body Methods for Nuclear Physics" was intended to promote advances in many-body theory in ways supporting future progress in our understanding of atomic nuclei. Accurate predictions have so far been obtained for light nuclei with a variety of many-body approaches. Similar developments for medium and heavy nuclei are far more challenging, since the complexity of the many-body problem increases exponentially with the number of degrees of freedom. However, these developments are vital in view of the novel experimental domains accessible in modern radioactive beam facilities. Several groups have started to push the limits of *ab-initio* calculations for selected nuclei beyond the p shell. This is possible thanks to new ideas in the field of many-body theory, to modern effective interactions, and to improved computational resources. The aims of the workshop were *(i)* to stimulate discussions among the theorists engaged in *ab-initio* calculations and *(ii)* to identify microscopic approaches that can improve the accuracy in predictions of the larger body of experimental data.

The workshop has seen the active participation of about 40 scientists engaged at the forefront of nuclear structure (36 registered participants, plus other locals from the University of Trento). These included world leaders in both quantum many-body theory and experiment, as well as a number of young participants. A wide range of topics related to nuclear structure was discussed, ranging from modern nuclear forces to correlations and applications to collective modes and electroweak processes. Methods based on the concept of spectral functions have been proposed as the most natural tool for gaining insight into correlation phenomena. Of these, the Green's function formalism may provide a link between *ab-initio* theory and more phenomenological approaches. On the front of the pure *ab-initio* methods, strong focus was put on the recent attempts to compute convergent binding energies for closed shell nuclei beyond the p-shell. This will open the possibility of establishing benchmarks in the sd-shell for comparing different methods.

We think that the workshop was, by all accounts, a success. The different expertise among the participants—including quantum many-body experts in areas outside nuclear structure—fuelled several stimulating high level discussions. This constituted a major highlight of the meeting and we heard positive feedbacks from many participants. In our opinion, the meeting helped bringing closer the new generation of *ab-initio* practitioners with those traditionally interested in nuclear correlations. At the same time, the presence of experimentalists helped raising the awareness about most compelling issues in nuclear structure and about what computational theory can do to interpret modern experiments. We expect future collaborations and discussions among the participants to arise as consequence of this meeting.

The talks will be available from the following websites soon after the meeting:
http://theory.gsi.de/~barbieri/AdvManyBody/talks.html
and
http://www.ect.it/Meetings/ConfsWksAndCollMeetings/ConfWksDocument/ 2007/Talks/26 July/talks.htm

2.3.13 HARD QCD WITH ANTIPROTONS AT GSI

DATE: July, 16-20

ORGANISERS:
N.Nikolaev (Co-ordinator) (*IKP, FZJ Juelich*), Bernard Pire (*CNRS, CPHT Palaisseau*), S. Brodsky (*SLAC*), M. Duren (*Giessen University*), P. Lenisa (*Ferrara University*), W. Vogelsang (*BNL*)

NUMBER OF PARTICIPANTS: 30

MAIN TOPICS:

- FAIR: status of the project and the planned antiproton physics with PANDA and PAX
- Hard exclusive hadronic reactions and QCD
- Electromagnetic form factors at FAIR
- Spin in inclusive and exclusive reactions: theory and experiment
- Drell-Yan and transversity at FAIR
- Hidden and Open Charm Physics at FAIR

SPEAKERS:

I. Augustin (*GSI*) ,
F. Maas (*Orsay*),
M. Contalbrigo (*Ferrara U.*),
D. Bettoni (*Ferrara U.*),
P. Lenisa (*Ferrara U.*),
A. Lehrach (*Juelich*),
P. Kroll (*Uni. Wuppertal*),
P. Pakhlov (*ITEP, Moscow*),
D.S. Hwang (*Sejong U.*),
B. Pire (*CHPT Palaiseau*),
V. Braun (*Regensburg U.*),
S. Pacetti (*Frascati*),
E. Tomasi-Gustaffson (*DAPNIA, Saclay*),
H.-W. Hammer (*Bonn U.*),
D. Hasch (*LNF, Frascati*),
F. Bradamante (*Trieste U.*),
O. Teryaev (*JINR, Dubna*),
D. Boer (*Vrije U., Amsterdam*),
G. Goldstein (*Tufts U.*),
A. Bianconi (*Brescia U.*),
W. Vogelsang (*BNL*),
C. Cagliardi (*Texas A & M*),
J. Soeren Lange (*Univ.Giessen*),
N. Brambilla (*U. Milano*),
M. Lutz (*GSI*),

SCIENTIFIC REPORT:

Aim and Purpose: The FAIR facility at GSI, Darmstadt, Germany will dominate the intermediate-to-high energy nuclear and particle physics in Europe for decades to come. After the initial Core Project of FAIR has been formulated some 5 years ago, new ideas have been put forward especially regarding the polarized antiproton option for High Energy Storage Ring. On the theory side, there has been a tremendous development in the pQCD treatment of antiproton interactions. The objective of the Workshop was to discuss the changing landscape with a various aspects of hard-QCD processes that would be of interest at FAIR, which will be an unique facility for studying inclusive and exclusive hard reactions with unpolarized and polarized antiprotons. Regarding the transverse spin physics, FAIR will have no competitor in the world and will be an unique successor to 4 decades of deep inelastic scattering studies at FNAL, CERN, HERA DESY. This is new twist not anticipated in the FAIR Technical Design Report. The aim was to critically discuss the theoretical work that has been done so far for FAIR, and to identify directions in which future research is needed.

Results and Highlights:

- It was the first Workshop on the subject of hard QCD at FAIR.
- A thorough discussion of the fixed-target and collider options for HESR have been presented. The principal conclusion is that the target luminosity required for sound QCD, especially transversity, physics at FAIR is reachable.
- The scenarios for polarizing stored antiprotons have been presented and the progress with ongoing experiments at COSY in Juelich, and plans for the exploratory studies at the AD ring at CERN have been outlined. item A combined analysis of single spin asymmetries from HERMES, COMPASS and the first results on the Collins fragmentation function at BELLE give a strong evidence for the non-vanishing transversity distribution in the proton.
- A tremendous progress in the theoretical understanding of NLO corrections to transverse spin physics has been reviewed with the conclusion that Drell-Yan studies with PAX at FAIR would give an unambiguous determination of the transversity distribution of valence quarks in the proton - the last missing leading twist parton density of the proton.
- The stage of the phenomenology of the Collins, Sivers and transvesrity functinons is being superceded by a stage of dynamical models which aim at linking together different transverse spin phenomena. The first encouraging results in this direction have been reported at the Workshop.
- The modern theory of exclusive hard antiproton interactions is in good shape and the predicted cross sections are within the reach of PANDA and PAX experiments.
- A potential of polarization for crucial tests of predictions for time-like form factors of protons has been clarified. Polarization is a unique tool to measure the phase of the

time-like form factors. The ongoing discussion have already prompted a fresh view on the PANDA potential for the form factor physics.

- On the whole, the results of the Workshop will be an important input for drafting the final versions of the Technical Design Reports of PAX and PANDA collaborations.

Conclusions: The principal conclusion of the Workshop is that the polarized collider option for HESR at FAIR will extend the four decades of deep inelastic scattering studies at FNAL, CERN, HERA DESY into the as yet unexplored domain of transverse spin physics. In the both exclusive and inclusive reaction domains, polarized HESR at FAIL will be a unique facility and will have no competition from other acceleration centers. The workshop was undoubtedly a success. It was not only very useful discussion on the field of QCD in proton-antiproton collisions at medium-to-high energies but it brought together both theorists and experimentalists, and each got to know better what the state-of-the-art is on both sides, and what can be measured experimentally at the forthcoming GSI-FAIR. Having on average 6 to 7 invited review talks per day gave an ample opportunity for very active discussions which were a trademark of this Workshop. The participants have had already certain collaboration at early stages of the preparation of the PANDA and PAX proposals. All the initial targets of the Workshop have been fully met. There results of the Workshop will be be an important input for drafting the final versions of the Technical Design Reports of PAX and PANDA collaborations. At this stage, a close collaboration between theorists from BNL, Ferrara, Frascati, Saclay, Palaisseau, Darmstadt and the ongoing modeling of specific reaction channels accessible with PANDA and PAX detectors is being established. We believe that this was only the first workshop of this kind and look forward to similar meetings in the future.

The Workshop talks: The talks can be browsed from the website
http://www.fz-juelich.de/ikp/pax

2.3.14 MATTER AT EXTREME DENSITIES AND GRAVITATIONAL WAVES FROM COMPACT OBJECTS

DATE: September 10-14, 2007

ORGANISERS:
José A. Pons (*University of Alicante, Spain*), Sanjay K. Reddy (*LANL, New Mexico, USA*)

NUMBER OF PARTICIPANTS: 33

MAIN TOPICS:

- Gravitational Wave detectors and data analysis
- Gravitational Waves from rotating neutron stars
- r–modes and superfluid instabilities
- Core collapse Supernovae
- Gravitational Waves from magnetars
- Neutron Star structure and evolution
- The equation of state in neutron stars: imprint on the GW emission

SPEAKERS:

Deborah Aguilera *(Alicante)*
Debades Bandyopadhyay *(Saha Institute)*
David Blaschke *(Wroclaw)*
Pablo Cerdá *(MPA-Garching)*
Joseph Carlson *(LANL)*
Bruno Giacomazzo *(MPG-AEI)*
Leonardo Gualtieri *(Roma)*
Badri Krishnen *(MPG-AEI)*
Christian Ott (AEI - Potsdam)
Andrea Passamonti *(AUTH, Greece)*
Luciano Rezzolla *(MPG-AEI)*
B. Sathyaprakash *(Cardiff)*
Andrew Steiner *(Michigan State)*
Andrea Viceré *(Urbino)*
Marcello Baldo *(Catania)*
Omar Benhar *(Roma)*
Fiorella Burgio *(Catania)*
Simone Dall'Osso *(Roma)*
Harald Dimmelmeier *(MPA-Garching)*
Kostas Glampedakis *(SISSA)*
Charles Horowitz *(Indiana)*
James Lattimer *(Stony Brook)*
Benjamin Owen *(Penn. State)*
Angeles Pérez–García *(Salamanca)*
Lars Samuelsson *(Nordita)*
Simon Scheidegger *(Basel)*
Luigi Stella *(Roma)*

SCIENTIFIC REPORT:

Aim and purpose

Unraveling the structure of matter at extreme densities through observations of neutron stars, core collapse supernova and gamma-ray bursts is a fundamental goal that brings together nuclear theorists, astrophysicists, experimentalists and observers. Radio, X-ray and neutrino astronomy have already provide interesting glimpses into the structure of compact objects. Gravitational wave astronomy promises to provide a new window to the universe. The first generation of ground based laser interferometers is already a reality - LIGO and VIRGO are working at near nominal sensitivity, and GEO600 and TAMA300 have been operational for several years. The prospect of detecting gravitational radiation from compact objects, binary mergers and core collapse supernova in the new millennium are therefore very promising. The workshop hosted at the ECT addressed the physics potential of such observations. In particular, we addressed how these observations would impact our understanding of matter at extreme densities and thus the structure and composition of compact stars. The workshop succeeded in bringing together theorists, experimentalists and observers working on nuclear physics, high-energy physics, and gravitational physics to fully explore the full spectrum of physics issues relating to gravitational waves from compact objects.

Results and Highlights

A central focus was the equation of state of dense matter and its role in the structure, dynamics and quasi-normal mode gravitational-wave spectrum. The development and suppression of dynamical instabilities such as the bar-mode instability or the r-mode instability was another key question during the workshop. The current status of core collapse Supernovae was review in several talks, with special attention to the effects of magnetic fields and convection. The gravitational wave signal from a future galactic Supernova will be recorded and its analysis will prove useful in our understanding of properties of matter at high density and temperature.

Conclusions

The workshop was undoubtedly a success. It was very useful as a status-report of the field, but more interestingly it provided a rather unique opportunity for nuclear and particle theorists to meet and discuss with astrophysicists and gravitational-wave physicists working on the modeling of compact stars, supernova and binary mergers. We believe that the interaction between specialists from different fields is necessary in such a complex problem and this event helped to increase our knowledge from each other point of view. All talks are available and can be downloaded from the ECT* website.

2.3.15 EXOTIC MODES OF EXCITATION: FROM NUCLEAR STRUCTURE TO ASTROPHYSICS

DATE: October, 8-12

ORGANISERS:
Gianluca Colò (Co-ordinator) (*University of Milano, Italy*), Dario Vretenar (*University of Zagreb, Croatia*), Elias Khan (*IPN Orsay, France*)

NUMBER OF PARTICIPANTS: 34

MAIN TOPICS:

- Theoretical issues: Comparison of physical contents, predictions, and results of various models that are being used in the description of exotic modes of excitation in nuclear systems (interacting shell-model, time-dependent self-consistent mean-field framework, semi-classical approaches, theories beyond mean field). Discussion of future developments of modern theoretical tools for nuclear structure physics.
- Experimental studies: Present and future experiments on the multipole response of nuclei far from stability using radioactive beam facilities. Comparison of available data with theoretical predictions, and open questions in the interpretation of the dynamics of exotic modes (collectivity of low-energy dipole strength, vortex modes, spin-isospin modes). Discussion on exotic modes which could be measured at the next generation radioactive beam laboratories (SPIRAL2, FAIR, EURISOL, RIBF).
- Nuclear astrophysics applications: Role of exotic modes of nuclear excitation in the r-process nucleosynthesis, photodisintegration of Ultra-High Energy Cosmic Rays, exotic modes in neutron stars, weak-interaction processes (beta-decay rates, neutrino-induced reactions on stable and neutron-rich nuclei).

SPEAKERS:

B. Balantekin (*Univ. Winsconsin*),
D. Allard (*APC, Paris*),
T. Suzuki (*Nihon Univ.*),
N. Van Giai (*IPN, Orsay*),
M. Matsuo (*Univ. Niigata*),
H. Sagawa (*Univ. Aizu*),
T. Marketin (*Univ. Zagreb*),
R. Surman (*Union College, Schenectady*),
C. Volpe (*IPN, Orsay*),
M. Grasso (*IPN, Orsay*),
Y. Blumenfeld (*IPN, Orsay*),
A. Bracco (*Univ. Milano*),
U. Garg (*Univ. Notre Dame*),
J. Li (*Univ. Milano*),
G. Colò (*Univ. Milano*),
E. Litvinova (*GSI, Darmstadt*),
V. Ponomarev (*TU-Darmstadt*),
G. Blanchon (*Univ. Pisa*),
S. Grévy (*GANIL, Caen*),
E. Vigezzi (*INFN, Milano*),
C. Ducoin (*INFN, Catania*),
T. Aumann (*GSI, Darmstadt*),
S. Frauendorf (*FZD-Rossendorf, Dresden*),
D. Savran (*TU-Darmstadt*),
J. Terasaki (*UNC, Chapel Hill*),
N. Paar (*Univ. Zagreb*),
S. Peru (*CEA/DAM, Bruyeres*),
K. Yoshida (*Univ. Kyoto*),
D. Pena (*TU-Muenchen*),
H. Sakurai (*RIKEN, Japan*),
I. Hamamoto (*Univ. Lund*),
P. Ring (*TU-Muenchen*)

SCIENTIFIC REPORT:

Aim and Purpose: The multipole response of nuclei far from the beta-stability line and the possible occurrence of exotic modes of excitation presents a very active field of research. The unique structure properties which characterize nuclear systems far from stability (weak binding of the outermost nucleons, coupling between bound states and the particle continuum, formation of nuclei with very diffuse neutron densities, occurrence of neutron skin and halo structures) have a pronounced effect on the multipole response of unstable nuclei. For instance, several theoretical analyses have predicted the occurrence of the pygmy dipole resonance (PDR) in medium-mass and heavy nuclei. The interpretation of the dynamics of the observed low-lying E1 strength in nuclei with a pronounced neutron excess is currently very much under discussion. Several new theoretical approaches have recently been developed, providing a fully microscopic description of low-lying collective excitations in weakly bound nuclei. The Workshop has been intended to provide an opportunity to compare results and predictions of various models, and to discuss the future development of modern theoretical tools based on the interacting shell-model, the time-dependent non-relativistic and relativistic mean-field models, as well as various extensions which go beyond the mean-field framework. The measurement of exotic modes is also a rapidly expanding field and many new experiments are being planned and designed at existing or future radioactive beam facilities. The purpose of the Workshop is to provide a strong interplay between theorists and experimentalists on current and future research projects. The emphasis is on the theoretical guidance and support for experimental studies of exotic modes of excitation. Exotic modes of excitation might play an important role in nuclear astrophysics: the occurrence of PDR has a pronounced effect on neutron capture rates in the r-process nucleosynthesis. The ability to model the Gamow-Teller response is also essential for reliable predictions of β-decay rates in neutron-rich nuclei along the r-process path. Assessing the quality of calculations at mean field level and/or beyond mean field, as far as nuclear astrophysics applications are concerned, is one of the goals of the present Workshop. Other applications such as the photodisintegration of Ultra-High Energy Cosmic Rays (UHECR) or excitations in neutron stars crust should also be investigated.

Results and Highlights: A large fraction of the talks have been focused on the use of mean field models, which are currently viewed as approximate, yet increasingly accurate, realizations of a Density Functional Theory for atomic nuclei. The nonrelativistic (Skyrme or Gogny) or relativistic functionals have been shown to be reliable in reproducing ground-state nuclear properties, in keeping with the fact that binding energies are accounted for within errors of 1 MeV or less (i.e., less than 0.1%). In the Workshop, new results have shown how the inclusion of a tensor component is crucial to improve the functionals, when the trend of s.p. states along isotope or isotone chains need to be understood. The same functionals are suitable for the study of excitation modes within the time-dependent framework, i.e., within the Quasiparticle Random Phase Approximation theory. It has been shown that applying this theory to the study of the giant monopole resonance (GMR) has improved our understanding of the nuclear matter incompressibility, K_∞, and of the asymmetry part of the finite nucleus incompressibility, K_τ. Large, systematic QRPA calculations done without any serious approximation are nowadays possible, also because of the availability of powerful

computers. Exotic nuclei can be treated either by the direct inclusion of the continuum coupling or by employing very large basis. Not only the (relatively) known neutron pygmy modes have been object of study, but other exotic modes as well (proton pygmy modes, toroidal and twist modes). The unifying perspective according to which the study of all excitations should coherently contribute to a better theoretical assessment of the nuclear functionals has been a strong guideline. We mention in this respect that the possibility to extract, from the E1 pygmy excitations, constraints on the symmetry energy (a key quantity in nuclear physics, which controls also the stability of neutron stars), has been elucidated for the first time. At the same time, new experimental results, for instance from $(\alpha, \alpha', \gamma)$ still challenge our understanding of the isospin quantum numbers of the low-energy dipole modes. A large blooming of deformed QRPA calculations has been evident: by using them, it is possible to test in details the performance of existing functionals on a very large set of nuclei. In keeping with the interplay with nuclear astrophysics, a number of talks have been concerned with charge-exchange modes. The knowledge of these modes can allow progress in the understanding of key questions in physics, like those associated with the elusive neutrino properties. In the Workshop it has been possible to have perspective talks addressing in detail the question on which nuclear structure inputs are crucial for the progress in nuclear astrophysics, as well as specific talks reporting on improved calculations of β-decay and new consistent calculations of neutrino-nucleus interaction. Energy functionals include a part related to pairing: new results have shown how it is possible to simplify the treatment of pairing without loosing accuracy, and how it is possible to connect the effective pairing forces with more *ab-initio* approaches. Methods beyond the mean field approximation have also been extensively discussed. Particle-vibration coupling and corrections to the single-particle states, widths of the vibrational excitations, shape coexistence of nuclei characterized by very flat energy surfaces, are topics which have been treated in the past only phenomenologically but can at present be attacked by using nonrelativistic or relativistic functionals consistently, without the need of *ad-hoc* parameters.

Conclusions: The workshop presented a wealth of new and interesting results, both experimental and theoretical. The very detailed presentations stimulated many lively discussions during the sessions, as well as in smaller informal groups of researchers interested in more specific aspects. Many details of various calculations were addressed, model predictions were compared with data, and possible applications to astrophysical problems were discussed in a way that would not have been possible in a larger meeting or conference. As a specific outcome we expect a concentrated effort towards a more detailed microscopic description of the onset and evolution of exotic modes of excitations in nuclei far from stability, as well as a number of new experiments that should resolve open issues and eventually disclose new phenomena in these systems. We also foresee the development of new theoretical approaches and models that will provide accurate global microscopic calculations of nuclear structure input for astrophysical applications, in particular neutrino-nucleus reactions, beta-decay and electron-capture rates. As has been noted by a number of participants, exotic modes of excitations in atomic nuclei and possible astrophysical applications present an emerging field of experimental and theoretical research, and there is an obvious need for more regular topical meetings between the nuclear structure and nuclear astrophysics communities.

Talks: The talks of the workshop are available on
http://ipnweb.in2p3.fr/ PhT-IPN/EME/program.html, as well as on the ECT* web site.

2.3.16. ELECTROWEAK INTERACTIONS WITH NUCLEI AND PHYSICS OF THE QUARK-GLUON PLASMA: MANY-BODY TECHNIQUES AT HIGH ENERGIES AND TEMPERATURES

(Collaboration Meeting)

DATE: November, 26-30

ORGANISERS:
Maria B. Barbaro (*Turin University*), Thomas W. Donnelly (*MIT*), Alfredo Molinari (*Turin University*)

NUMBER OF PARTICIPANTS: 31

MAIN TOPICS:

- Superscaling analysis of electroweak physics in nuclei
- Microscopic relativistic models for the superscaling function
- Superscaling induced connection between electron- and neutrino-nucleus scattering
- Correlations among quarks, correlations among hadrons
- Potential models for the heavy quark interaction
- Effective Lagrangians for the QGP
- The QGP out of equilibrium: the problem of viscosity

SPEAKERS:

L. Alvarez-Ruso (*Valencia*),
J.E. Amaro (*Granada*),
A. Beraudo (*Trento*),
G. Bertaina (*Turin*),
J.A. Caballero (*Sevilla*),
R. Cenni (*Genova*),
S. Chiacchiera (*Turin*),
P. Czerski (*Krakow*),
D. Davesne (*Lyon*),
A. De Pace (*Turin*),
T.W. Donnelly (*MIT*),
C. Fernandez (*Madrid*),
M. Gaidarov (*Sofia*),
G. Garbarino (*Turin*),
C. Giusti (*Pavia*),
M. Ivanov (*Sofia*),
C. Maieron (*Lecce*),
C. Martinez (*Madrid*),
M. Martini (*Lyon*),
A. Meucci (*Pavia*),
M. Nardi (*Turin*),
F. Palumbo (*LNF, Frascati*),
C. Ratti (*Stony Brook*),
J.M. Udías (*Madrid*)

SCIENTIFIC REPORT:

Aim and Purpose

The aims of the workshop followed the model of the two previous workshops held by the organizers and many of the same participants in Fall 2003 and Fall 2005. Namely, intersections of the areas of research centered, on the one hand, on studies of electroweak interactions with nuclei, especially those studies where superscaling occurs, and on the other, on the use of many-body techniques in descriptions of the quark-gluon plasma provided the dual foci. In both areas the progress in recent years has been very rapid, with many new insights from a variety of theoretical approaches (for example, the use of various models to explore the superscaling behaviour and the violations of scaling these may entail) and with new connections with experiment (for example, with the asymmetric flow in peripheral relativistic heavy collisions and the implications for shear viscosity in the QGP phase). Some aspects of these advances are summarized below. The motivations for holding this type of workshops, in addition to having the two individual communities meet and exchange ideas in their own respective area, are also to have some interchange between the two communities and, in particular, to exploit theoretical many-body techniques which have a common basis.

Results and Highlights

In the area of electroweak interactions with nuclei (electron scattering and both charge-changing and neutral-current neutrino reactions) much of the workshop was devoted to discussions of the state of the art in studies of superscaling. At energies of order 1 GeV the basic superscaling behaviour is well established, although some scale-breaking is clearly seen in this energy domain in comparisons with electron scattering data, and these now form a major thrust of the on-going investigations. Various models are being applied to explore the reasons for the scale-breaking, whether of the 0th, 1st, 2nd or 3rd kind: these include perturbative expansions based on the relativistic Fermi gas including nucleons, pions and deltas as degrees of freedom; relativistic mean field theory with strong scalar and vector potentials; semi-relativistic approaches with relativized currents and kinematics and Dirac equivalent potentials; in the deep negative so-called scaling region the role played by correlations; and, at low energies where the scaling approach is less applicable, many-body resummations such as RPA. In context, these inclusive reaction studies were also cross-compared with studies of semi-inclusive processes and with two-nucleon knockout reactions. The goals in this area are several, certainly to explore scaling and scaling violations and to arrive at a robust understanding of the electromagnetic response for the purpose of making predictions for CC and NC neutrino reactions with relevance for modern neutrino experiments such as MiniBooNE and K2K whose aims are to investigate neutrino oscillations as well as the weak interaction nucleonic and nuclear responses.

The workshop provided the opportunity for the participants to inform their collaborators of the latest results from these theoretical studies and to discuss some of the future steps that are foreseen as forming the near-term efforts in the area of superscaling.

In the area of QGP search, several talks were devoted to interesting and challenging items related to the extraction of the quark-antiquark potential from lattice data at finite temperature, to the theoretical justification of this approach starting from Bethe-Salpeter-like equations, to the thermodynamics of QGP and to the investigation of the shear viscosity of the QGP within various theoretical frameworks. This last topic appears to be particularly controversial at face with recent experimental data.

Conclusions

Within the area of superscaling the short-term goals of the workshop were met: the subject was thoroughly updated and the on-going work reviewed. The collaborators clearly identified several avenues to follow in the next year to two years and tentative ideas on how to interconnect some of the various approaches emerged. It was agreed that the mild scale-breaking seen experimentally should be incorporated using the models where such effects are also present, although clearly some issues still remain to be addressed, specifically, to clarify the reasons for the differences found in using different models and thereby to ascertain which is the most robust approach. Where forming new collaborations is concerned, the most likely new link to emerge may be to marry the high-energy superscaling approach with low-energy approaches in which more sophisticated (albeit, non-relativistic) many-body physics can be incorporated. Concerning the quark gluon plasma important presentations and in depth discussions were performed. The theoretical community involved in this type of research is unfortunately still rather small and one of the goals of the meeting was precisely to spread knowledge and interest in its development, closely connected to the advancements of many-body techniques and to the implementation of fundamental symmetries. In this respect it was commonly felt that the meeting was successfull. It was also agreed that under specific conditions, throughout analyzed in many occasions, the physics addressed by the two fields should much benefit from each other.

The talks can be browsed from the website: http://www.ect.it

2.4 ECT* Doctoral Training Programme "Nuclear structure and reactions"

The 2007 ECT* Doctoral Training Programme was held at ECT* during the 13 week period extending from March 8 to June 1, 2007. It was devoted to Nuclear Structure and Reactions. The Programme Coordinator was Piet Van Isacker (GANIL, France) and he was assisted by Muhsin Harakeh (KVI, Groningen, the Netherlands). ECT* covered the financial support for 8 lecturers and 15 participants.

The Doctoral Training Programme consisted of 8 lecture series, each (except one) given by one lecturer and lasting for one week. One lecture series was given by two lecturers from the University of Trento. Each student was asked to give a seminar which was announced on the ECT* Web page. In addition some lecturers scheduled occasional afternoon tutorial sessions.

The Doctoral Training Programme was attended by 11 full-time participants. Some lectures were attended by a handful of students from the University of Trento and several lectures were attended by ECT* post-docs. Two students who were participating in an on-going ECT* workshop, attended one lecture series. Among the full time students, 5 were in the 1st year of their PhD, 1 was in his 2nd year, 2 in the 4th year and 2 had completed their PhD. One student was still preparing his MSc. The list of full time students is given below.

The students were each given a desk to work on and those which did not use their personal laptops were given ECT* desk computers, running either on Unix or on Windows. They all had access to Internet. In addition, they had access to an ECT* wiki page, from which they could download the lecture notes delivered by the lecturers.

During the stay of the students, five workshops were held at ECT*:

- Confinement: connecting the light- and heavy-quark domains (March 12-16, 2007)
- The interface of quark-gluon-plasma physics and cold-atom physics (March 19-23, 2007)
- Experiment–Theory Intersections in Modern Nuclear Structure (April 23-27, 2007)
- Many-body open quantum systems: From atomic nuclei to quantum dots (May 14-18, 2007)
- Nuclear Physics Data Compilation for Nucleosynthesis Modeling (May 29-June 1, 2007)

Only the first two workshops were of direct interest to the students. One student (Swagato Mukherjee) gave a talk in the second workshop.

The duration of the course, namely 11 weeks seems to be good. The students had time to work both on the lectures and on their research projects. In addition, the lecturers remained at ECT* in the afternoons, and several students chose that opportunity to discuss with them.

2.4.1 Lecture Series

The following series of lectures were presented at the Centre (see also section 3.4.1):

- **Symmetries in nuclei**
  Lecturer: Francesco Iachello (Yale University, USA)
- **Mean-field methods in nuclei and beyond**
  Lecturer: Dario Vretenar (University of Zagreb)
- **Weak interactions in nuclear systems**
  Lecturer: N. Severijns (University of Leuven, Belgium)
- **Exotic Beam Physics**
  Lecturer: Y. Blumenfled and Elias Khan (IPN, Orsay, France)
- **Nuclear Shell Model**
  Lecturer: M. Hjorth-Jensen (University of Oslo, Norway)
- **Many-body open quantum systems**
  Lecturer: M. Ploszajczak and W. Nazarewicz (GANIL, France and University of Tennessee, USA)
- **Nuclear astrophysics**
  Lecturer: K. Langanke (GSI, Germany)

2.4.2 Participants

Tan Ahn	Technische Universitaet Darmstadt,
Benoit Avez	CEA, Saclay, France,
James Michael Broomfield	University of Surrey,
Mesut Karakoc	Erciyes University, Turkey
Ritesh Kshetri	Saha Institute of Nuclear Physics,
Michal Macek	Charles University, Prague
Tomislav Marketin	University of Zagreb,
Futoshi Minato	Tokohu University,
Stoyan Raykov Mishev	BLTP JINR,
Irving Omar Morales Agiss	Universida Necional Autonoma de Mexico,
Dimitris Petrellis	National Centre for Scientific Research
Michal Rafalski	University of Warsaw,
Kamila Sieja	University of M. Curie Sklodowka,
Pavel Stransky	Charles University Prague,
Maciej Zalewski	University of Warsaw

2.4.3 Further scientific activities of the Training Programme

In addition to the lectures listed above, further scientific activities consisted of seminars given at ECT* by the participants, and various tutorials.

Seminars given at ECT* by the students

Michal MACEK: 15th of March, 2007, "Order-to-chaos transition within the symmetry triangle of the IBM 1".

Dimitris PETRELLIS: 16th of March, 2007, “Special solutions of the Bohr Hamiltonian in the context of critical point symmetries”.

Pavel STRANSKY: 20th of March, 2007, “The interface of quark-gluon-plasma physics and cold-atom physics”.

Kamila SIEJA: 27th of March, 2007, “Extended approach to correlations beyond mean-field in atomic nuclei”.

Benoit AVEZ: 28th of March, 2007, “Pairing vibrations: an outlook for a mean field study”.

Irving Omar MORALES AGISS: 3rd of April, 2007, “Nuclear Forecasting as Pattern Recognition”.

Tomislav MARKETIN: 4th of April, 2007, “Effective mass in a relativistic mean field model”.

Tan AHN: 10th of April, 2007,“Search for mixed-symmetry states using Coulomb excitation”.

Ritesh KSHETRI: 12th of April, 2007, “High spin spectroscopy of using clover detectors”.

Stoyan Raykov MISHEV: 17th of April, 2007,“Ground state correlations and the structure of odd-even nuclei”.

Ritesh KSHETRI: 19th of April, 2007,“Evolution of collectivity in neutron-rich nuclei in the 132 Sn region”.

Maciej ZALEWSKI: 8th of May, 2007,“Terminating states as a laboratory for testing energy density functional”.

James Michael Alexander BROOMFIELD: 22th of May, 2007, “Two-body observables using the Balian-Veneroni variational method”.

Michal RAFALSKI: 24th of May, 2007, “Symmetry energy and pairing in the Woods-saxon model”.

Futoshi MINATO: 29th of May, 2007,“Environmental effects on the neutrino-nucleus reaction”.

Mesut KARAKOC: 31st of May, 2007, “Analysis of the system using folding potentials”.

2.5 ECT* Doctoral Training Programme "Physics of Compact Stars"

The Doctoral Training Programme on Physics of Compact Stars was held at ECT* during 7 weeks, from August 20 to October 5, 2007. The Programme was organized by David Blaschke, Jose Pons and Luciano Rezzolla.

The programme was attended by 10 full time students and 12 part-time students. Among the full-time students:

- 6 students were just beginning their PhD project; however, among these, some had already worked on deep-inelastic scattering for their Diploma
- 2 students were in the first year of their PhD project;
- 4 students were in the second year of their PhD project;
- 1 student was in the fourth year of his PhD project.

Five of the full-time students were engaged in an experimental research project. The list of students is attached to this report.

The students were each given a desk to work on and those which did not use their personal laptops were given ECT* desk computers, running either on Unix or on Windows. They all had access to Internet. In addition, they had access to an ECT* wiki page, from which they could download the lecture notes delivered by the lecturers.

2.5.1 Lecture Series

The following series of lectures were presented at the Centre (see also section 3.4.1):

- **Computational Relativistic Astrophysics**
  Lecturer: Luciano Rezzolla (AEI Potsdam, Germany)
- **Computational Relativistic Astrophysics**
  Lecturer: Stephan Rosswog (Jacobs University Bremen, Germany)
- **Compact Star Phenomenology**
  Lecturer: David Ian Jones (University of Southampton, UK)
- **Compact Star Phenomenology**
  Lecturer: Sergey Popov (Moscow State University, Moscow)
- **Supernovae and Protoneutron Stars**
  Lecturer: Matthias Liebendoerfer (University of Basel, Switzerland)
- **Supernovae and Protoneutron Stars / Matter at Extreme Densities and Gravitational Waves from Compact Objects**
  Lecturer: Jose Antonio Pons (Universidad de Alicante, Spain)
- **Matter at Extreme Densities and Gravitational Waves from Compact Objects**
  Lecturer: Sanjay Reddy (Los Alamos National Laboratory, Mexico)
- **Neutrino Processes and Compact Star Cooling**
  Lecturer: Dany Pierre Page (UNAM, Mexico)
- **Neutrino Processes and Compact Star Cooling**
  Lecturer: Dmitri Voskrensensky (GSI Darmstadt, Germany)

- **Physics of Neutron Star Crust**
  Lecturer: Pawel Haensel (CAMK Warsaw, Poland)
- **Physics of Neutron Star Crust**
  Lecturer: Pierre Pizzocchero (INFN Milano)
- **EoS for Compact Star Interiors**
  Lecturer: David Ian Blaschke (University of Wroclaw, Poland)
- **EoS for Compact Star Interiors**
  Lecturer: Fiorella Burgio (INFN Catania)

2.5.2 Participants

Roberto Anglani	INFN, Bari
Olga Caballero	Nuclear Theory Center, Bloomington, USA
Debarati Chatterjee	Saha Institute of Nuclear Physics, India
Antonella Colaiuda	Institut fur Astronomie und Astrophysik, Tbingen
Marius Dan	Jacob University, Bremen
Anthea Fantina	Universit degli Studi di Milano
Sebastien Figerou	Subatech, Nantes, France
Tobias Fischer	University of Basel, Switzerland
Filippo Galeazzi	Albert Einstein Institut, Potsdam
Pavlo Grygorov	Institute of Theoretical Physics, Tbingen
Matthias Hempel	Institut fur Theoretische Physik, Frankfurt
Jillian Anne Henderson	Instituto de Astronomia, UNAM, Mexico
Thorsten Kellermann	Albert-Einstein Institut, Potsdam
Samuel Lander	University of Southampton, UK
Stephen Millmore	University of Southampton, UK
Enrique Moreno-Mendez	Stony Brook University, USA
Bernhard Mueller	Max-Planck-Institut fuer Astrophysik, Garching
Vincenzo Palmisano	Universit degli Studi di Messina
Oliver Robertshaw	University of Southampton, UK
Irina Sagert	Institute of Theoretical Physics, Frankfurt
Vittorio Soma	Institute of Nuclear Physics, Krakow
Daniel Zablocki	University of Wroclaw, Poland

2.5.3 Further scientific activities of the Training Programme

A total of 12 seminars were given by the students during the programme (two seminars each week). They covered research projets which the students were engaged in. Several students placed their seminar presentations on the Wiki page.

Seminars given at ECT* by the students

Enrique MORENO-MENDEZ: 22nd of August, 2007, “Black hole binaries as sources of -ray bursts and hypernova explosions”.

Olga CABALLERO: 23rd of August, 2007, “Molecular-dynamic simulation of multicomponent plasmas”.

Roberto ANGLANI: 29th of August, 2007, “Inhomogeneous colour superconductivity in compact stars?”.

Irina SAGERT: 30th of August, 2007, “Asymmetric neutrino emission in quark matter and pulsar kicks”.

Vittorio SOMA: 4th of September, 2007, “Thermodynamics of nuclear matter”.

Thorsten KELLERMANN: 6th of September, 2007, “Methods for numerical relativity”.

Tobias FISHER: 18th of September, 2007, “Where do we come from? 1d general relativistic core collapse simulations and the expected neutrino signal”.

Debarati CHATTERJEE: 20th of September, 2007, “Exotic matter in neutron stars and r-modes”.

Anthea FANTINA: 25th of September, 2007, “Type II supernovae: weak processes and dynamics of gravitational collapse”.

Matthias HEMPEL: 26th of September, 2007, “A statistical model for hot hadronic matter below saturation density”.

Sbastein FIGUEROU: 2nd of October, 2007, “Structural transitions in the neutron star crust”.

Daniel ZABLOCKI: 5th of October, 2007, “BEC-BCS crossover in quark matter”.

3 Research at ECT*

This chapter summarizes the scientific activities of researchers who are hosted at ECT*. This concerns the Director and the Vice Director, the postdoctoral fellows and PhD students. Strong collaborations exist within the research group, as can be seen from this report. However, because of the particular structure of the ECT*, with very few senior scientists present, several of the postdocs maintain strong collaborations with colleagues outside ECT*. The arrival in 2006 of Vladimir Pascalutsa, on an assisant professor level position jointly supported by the European I3 "Hadron Physics" and the ECT*, has contributed to revitalize the scientific life of the group. In 2007 Vadim Lensky was hired to work in close collaboration with V. Pascalutsa. Michael Schwamb is jointly supported by the Physics Department and the ECT* where he spends part of his time. Andrea Nobile and Luigi Scorzato have special followships and are responsible for the running of the Teraflop cluster. Daniele Binosi has special responsibility in the coordination of a large European consortium on quantum computing (see the sections concerning QUROPE and the ERA-pilot).

Below, one can read the reports written by the researchers on their activities in 2007, and find the list of publications from ECT* reseachers (and some long term visitors), as well as the list of seminars and lectures given at ECT* in 2007.

3.1 Projects of ECT* Researchers

• Andrea Beraudo

My research activity was mainly devoted to investigate some properties of the Quark Gluon Plasma, which is the high-temperature phase of QCD. In particular I studied some aspects of the behavior of light and heavy mesons in such a hot environment. The goal is to compare my findings with the finite-temperature lattice-QCD calculations and (possibly) with the data coming from the heavy-ion collision experiments. I discuss below the two main issues of my research which have already led to publications.

- **Meson Screening Masses** [*Meson Screening Masses in the Interacting QCD Plasma*, W.M. Alberico, A. Beraudo, A. Czerska, P. Czerski and A. Molinari, Nucl. Phys. A792, 152 (2007).]
  The screening mass of a meson is the quantity which controls the exponential decay of the spatial correlations between the fluctuations of two mesonic currents in a hot medium. They are of particular interest for lattice-QCD calculations, since they are relatively easy to extract and provide information on the active degrees of freedom in the QGP. I followed an approach based on the HTL resummation scheme and, from the in-medium quark propagator I evaluated the finite momentum meson correlation function (in the pseudoscalar channel). From the latter, through a fitting procedure it was possible to get the screening mass of the meson.

- **Quarkonium correlators from potential models** [*Potential models and lattice correlators for quarkonia at finite temperature*, W.M. Alberico, A. Beraudo, A. De Pace

and A. Molinari, to appear in Phys. Rev. D, e-Print: arXiv:0706.2846 [hep-ph].] Screened potential model calculations represent an important tool to study the sequential melting of the different states of charmonium and bottomonium in the QGP. On the other hand the full physical information on the in-medium properties of the above states is encoded in their spectral function, which is obtained from the imaginary-time correlator of meson currents. Comparing the correlators and spectral functions measured on the lattice with the ones arising from a potential model calculation represents an important numerical check of the consistency of the latter and of its capability of catching the relevant physical processes involved.

The most important problem I'm presently addressing, in collaboration with Jean Paul Blaizot and Claudia Ratti, concerns the first principle calculation of the propagator of a quark pair in a hot-dense medium. The final goal is to provide a consisent treatment of its evolution in real and imaginary time, the latter being of importance for the calculation of the free-energy of the pair. We also wish to give a solid theoretical basis to screened potential calculations and to include in a consistent way the effects of collisions.

An independent line of research, in collaboration with Claudia Ratti and Nicolao Fornengo (Turin University) is related to the study of the decoupling of possible candidates of Cold Dark Matter occuring for values of the temperature close to the QCD deconfinement transition, for which a reliable model of the QCD Equation of State is required.

• Daniele Binosi

During the year 2007 my activity has been focused on two fronts. On the one hand I have continued my activity in coordinating the work of the European projects ERA-Pilot QIST and QUROPE. In particular I have been responsible for the updating the roadmap-type document Quantum Information Processing and Communication: strategic report on current status, visions and goals for research in Europe, which has the purpose of promoting QIPC in Europe, strengthening its image and expressing it in a coherent way, unifying the research community, elaborating a common European strategy and setting the agenda for its short- and long-term goals, and, finally, reaching in an appropriate way decision makers. In particular, in order to expand the vision of the field, in v.1.4 an appendix discussing Entanglement-enabled Quantum Technologies has been added. ERA-Pilot QIST has expired the past December, and the project final review will be held on March. Starting the past September, and following the moving of Dr. Tommaso Calarco to Ulm, I have been appointed Work-package leader of the QUROPE WP4. I will thus supervise the development and management of its website, as well as helping WP2 in writing all position documents that the community might need. For more information see the projects websites http://qist.ect.it (ERA-Pilot QIST) and http://www.qurope.net (QUROPE).

On the other hand I have continued my research in the high energy physics, which included the following projects:

- In [*The effect of electromagnetic fields on the lifetime of unstable particles"*, D. Binosi and V. Pascalutsa, arXiv:0704.0377 hep-ph] we have investigated how the decay properties of an unstable particle are affected by the presence of an external magnetic field. The effect on the lifetime can be in fact assessed by observing that the magnetic

moment of an unstable particle has an absorptive contribution, which in an external field induces a shift in the absorptive part of the energy, namely the width. We computed this effect for the case of the muon and the neutron at the leading order in the electroweak coupling (two-loop order) and found respectively a relative shift of the lifetime 10^{-15} and 10^{-14}. Notwithstanding its smallness, this effect can have important implications in astrophysical process.

- In [*Increasing entanglement through engineered disorder in the random Ising chain*, D. Binosi, G. De Chiara, S. Montangero and A. Recati, Phys. Rev. B 76, 140405(R) (2007)], we studied the properties of the entanglement entropy in a disordered spin chain by means of numerical simulations. It has been demonstrated that the entanglement entropy of a block of an infinite homogeneous spin chain diverges logarithmically with the length of the block if the model of the spin chain is critical. This is a consequence of the divergence of the correlation length in critical models. It has been predicted for specific models that also the average block entropy of a disordered spin chain follows the same divergence but with a different prefactor. This prefactor for the random Ising model is $\ln 2$ times the prefactor of the corresponding homogeneous Ising model. In this work we studied the random Ising model and we confirmed this prediction using exact numerical simulations. We then considered a modified random Ising model in which for a given site the local transverse magnetic field and the coupling with the neighboring spin are taken randomly but with a certain tunable correlation. We studied the scaling of the block entropy and we found again a logarithmic divergence with the length of the block. However this time the prefactor is an increasing function of the correlation. This result shows that for random models the association of a universal prefactor is ambiguous. Moreover we showed that for high correlation the prefactor of the entanglement entropy in the random model is larger than that of the corresponding homogeneous model. Thus correlated disorder may increase entanglement with respect to translational invariant systems. Apart from quantum information applications, our calculations reveal that the ground state of the system when the couplings are correlated is structurally different from the ground state of the standard random Ising model. This is best understood when studying the probability distribution of the von Neumann entropy between two halves of the chain for different samples. The random non correlated Ising model exhibits a narrow peak around 1 bit of entropy meaning that a singlet state between a random pair of spins is broken for this partition of the chain. For the model with correlated disorder instead we found a broader peak meaning that the ground state possesses a more complicated structure.

- In [*Guage-invariant truncation scheme for the Schwinger-Dyson equations of QCD*, D. Binosi and J. Papavassiliou, arXiv:0712.2707 hep-ph] we presented a new truncation scheme for the Schwinger-Dyson equations of QCD that respects gauge invariance at any level of the dressed loop expansion. When applied to the gluon self-energy, it allowed for its non-perturbative treatment without compromising the transversality of the solution, even when entire sets of diagrams (most notably the ghost loops) are omitted, or treated perturbatively. This result is of particular relevance, for it represents the culmination of my research on the Pinch Technique subject. In particular there will be a longer version of this paper coming out soon, as well as an application

to the solution of the QCD Schwinger-Dyson equations for the gluon propagator.

From the "work in progress" side

- I am preparing a Physics Reports with the (provisory) title "Pinch Technique: Theory and Application" to be (hopefully) delivered in June 2008;
- I am in the process of writing a monograph together with Prof. J. M. Cornwall and Dr. J. Papavassiliou with the (provisory) title "Pinch Technique". The publisher will be Cambridge University Press;
- Last but not least, we are now finalizing version 2.0 of the code `JaxoDraw`.

• Jean-Paul Blaizot

Together with collaborators at Montevideo and Paris, I have pursued the developments of approximations to the exact renormalization group in view of applications to non perturbative problems. Much efforts have been devoted to the numerical implementation of a method proposed two years ago by R. Mendez-Galain, N.Wschebor and myself (when R. Mendez-Galain and N. Wschebor were visitors at ECT*). We have obtained excellent results for the critical behavior of simple field theories (publications are being written). Applications of the method to finite temperature problems are underway in collaboration with Andreas Ipp (a former ECT* postdoc).

Together with Taeko Matsuura, I have started to apply the non perturbative renormalization group to the problem of the BCS-BEC crossover. This is a long term project in which we have gathered partial results. Publications are expected to appear in 2008.

With Andrea Beraudo and Claudia Ratti I have started giving a solid basis to the calculation of heavy quark bound states in a medium (see the reports by A. Beraudo and C. Ratti and [*Real and imaginary time Q Qbar correlators in a thermal medium, arXiv:0712.4394*]).

• Tommaso Calarco

- In *Structural phase transitions in low-dimensional ion crystals* (S. Fishman, G. De Chiara, T. Calarco, G. Morigi, arXiv:0710.1831) we considered a structural phase transition in a 1D Coulomb crystal of trapped ions, demonstrating that this transition is of second order in agreement with the results found in numerical simulations and in experiments. Structural transitions in ion crystals are induced by changing the aspect ratio of the ion trap, i.e. the ratio of the axial to transverse confinement. When the aspect ratio is above a certain critical value, the ions arrange in a planar zigzag configuration breaking spontaneously the translational invariance. We studied the transition by means of a classical mean field treatment of the Coulomb chain. We computed the normal modes of the linear and zigzag chains in the thermodynamic limit, fixing the interparticle distance as the number of ions was let to infinity. We identified the soft mode with the transverse zigzag mode at highest momentum, whose frequency approaches zero close to the critical point and which drives the transition. We identified

the order parameter as the distance of the ions from the trap axis. We then studied the phase transition by developing a Landau theory and calculating the Landau potential for the order parameter. We thus demonstrated that this transition is of second order confirming the results found in numerical simulations and in experiments.

- In *Optimal control atom transport for quantum gates in optical lattices* (G. De Chiara, T. Calarco, M. Anderlini, S. Montangero, P. J. Lee, B. L. Brown, J. V. Porto, and W. D. Phillips, to be submitted) we showed that Quantum Optimal Control techniques could improve the speed and fidelity of transport of atoms in an optical lattice. We modeled and studied numerically the transport process used to affect this two-qubit quantum gate and found that it gives an accurate description of the evolution measured in the experiment. We then applied quantum optimal control theory to the transport process of the atoms, both with and without interactions, to show how to increase the speed of the gate by a factor of three and maintaining a high fidelity. This result represents a relevant improvement in terms of scalability of the number of gates that can be performed before the system decoheres due to the coupling to its environment. The success of this method in this specific problem demonstrates the promise of optimal control for coherent manipulation of a diverse class of quantum systems.

- In *Decoherence induced by interacting quantum spin baths* (D. Rossini, T. Calarco, V. Giovannetti, S. Montangero, R. Fazio, Phys. Rev. A 75, 032333 (2007)), we study decoherence induced on a two-level system coupled to a one-dimensional quantum spin chain. We consider the cases where the dynamics of the chain is determined by the Ising, XY, or Heisenberg exchange Hamiltonian. This model of quantum baths can be of fundamental importance for the understanding of decoherence in open quantum systems, since it can be experimentally engineered by using atoms in optical lattices. As an example, here we show how to implement a pure dephasing model for a qubit system coupled to an interacting spin bath. We provide results that go beyond the case of a central spin coupled uniformly to all the spins of the bath, in particular showing what happens when the bath enters different phases, or becomes critical; we also study the dependence of the coherence loss on the number of bath spins to which the system is coupled and we describe a coupling-independent regime in which decoherence exhibits universal features, irrespective of the system-environment coupling strength. Finally, we establish a relation between decoherence and entanglement inside the bath. For the Ising and the XY models we are able to give an exact expression for the decay of coherences, while for the Heisenberg bath we resort to the numerical time-dependent Density Matrix Renormalization Group.

- In *Photon storage in Lambda-type optically dense atomic media. IV. Optimal control using gradient ascent* (Alexey V. Gorshkov, Tommaso Calarco, Mikhail D. Lukin, Anders S. Sorensen, arXiv:0710.2698v1 [quant-ph]) we use the powerful numerical gradient ascent methods from optimal control theory to extend efficient photon storage in Lambda-type atomic media (including those based on Electromagnetically Induced Transparency, off-resonant Raman processes, and photon-echo) to regimes inaccessible via the optimization techniques of the preceding papers and to provide simple intuitive explanations for our optimization techniques. In particular, by using gradient

ascent to shape classical control pulses used to mediate photon storage, we open up the possibility of high efficiency photon storage in the non-adiabatic limit, in which analytical solutions to the equations of motion do not exist. This control shaping technique enables an order-of-magnitude increase in the bandwidth of the memory. We also demonstrate that the often-discussed connection between time-reversal and optimality in photon storage follows naturally from gradient ascent. Finally, we discuss the optimization of controlled reversible inhomogeneous broadening.

- In *Wigner crystals of ions as quantum hard drives* (J.M. Taylor and T. Calarco, arXiv:0706:1951 [quant-ph]), we developed an approach to quantum memory and entanglement generation that takes full advantage of the advances in ion trap technology for building large Wigner crystals of ions in Penning traps. Using a modulated-carrier "push" gate adapted from linear ion trap quantum computing schemes we found a fast but adiabatic method for building small clusters of entanglement that is insensitive to thermal phonons in 2D and 3D Wigner crystals. We took advantage of some of the unique features of Penning traps, such as rotation of the crystal, to provide simplifications in the necessary hardware to implement these ideas in 2D Wigner crystals. We then considered extensions of our approach to the fast generation of large cluster states, and a non-local architecture using an asymmetric entanglement generation procedure between a Penning trap system and well-established linear Paul trap designs.

• Carlo Ewerz

In collaboration with A. von Manteuffel and O. Nachtmann (Univ. Heidelberg) I have continued to investigate the color dipole picture of high energy scattering. We have in particular derived new bounds on correlated ratios of various deep inelastic proton structure funcitons from the dipole picture. By confronting these bounds with measured data we have been able to restrict the range of applicability of the dipole picture. Conclusions drawn from any description of the data based on the dipole picture can now be made more reliable by restricting that description to the range resulting from our study.

In collaboration with Jean-Paul Blaizot (ECT*) I have started to investigate the properties of Yang-Mills theories at finite temperature using the framework of the Anti-de-Sitter/conformal field theory (AdS/CFT) correspondence. In this formalism one can use a (relatively simple) calculation in a supergravity background in order to learn something about a strongly coupled gauge theory (which is difficult to investigate otherwise). Starting form existing calculations of the static potential and the screening length in a hot plasma of $\mathcal{N} = 4$ supersymmetric matter we study the effects of deformations of the dual gravitational theory on these quantitites. Eventually, one can hope to find deformations which correspond to real-world QCD, or at least come close to it. As a first step, we currently try to understand the systematics of suitable deformations of the AdS background.

Together with J. Bartels and M. Hentschinski (Univ. Hamburg) I have completed a study of the high energy limit of general Yang-Mills theories containing fermions in the adjoint representation. We have considered explicitly the amplitudes for the exchange of up to five gluons in high energy scattering using the framework of perturbative resummation. The main finding is that these amplitudes have a structure of an effective conformal field theory

— similar to the one found earlier in QCD with quarks in the fundamental representation. With fermions in the adjoint representation, however, we find a new element in this effective theory. A particularly interesting application of this study is to $\mathcal{N} = 4$ supersymmetric Yang-Mills theory which is now widely used as a model for the transition from perturbative to nonperturbative dynamics of gauge theories.

I have furthermore continued my work on the conformal properties of Pomeron vertices in high energy QCD in collaboration with T. Bittig (Max-Planck-Institut für Physik komplexer Systeme, Dresden), G. Korchemsky and S. Wallon (both at LPT, Univ. de Paris XI, Orsay).

• Vadim Lensky

During the time I have spent at the ECT*, I have been doing research in the field of chiral effective field theory (EFT). In collaboration with V. Pascalutsa, we started studying of the real Compton scattering on the nucleon within the EFT, and also started a project aimed at an understanding of nucleon–nucleon forces within EFT (in collaboration with M. Schwamb). Along with these projects, I have been continuing investigations of pion production in nucleon–nucleon collisions (and also related dispersion and adsorption corrections to the pion–deuteron scattering length), in collaboration with V. Baru, J. Haidenbauer, and other researchers from FZ Jülich and ITEP Moscow.

• Taeko Matsuura

In 2007 I have continued our investigation on BCS-BEC crossover with Jean-Paul. Blaizot and A. Ipp. We study the BCS and BEC limit of the BCS-BEC crossover with the exact renormalization group. As a first step, we consider the flows of BCS and Bogoliubov theories in parallel, getting the flow equations from the variational principle. We study how the effective potential, the gap, the number density, and the quantum depletion from the condensate flow with the IR scale. The results of the Bogoliubov theory are also compared with those of a more elaborate treatment of the exact RG flow equations.
In collaboration with E. Nakano(Taiwan, Natl. Taiwan U. & NCTS, Taipei) and M. Nitta(Keio U.), I also have studied the interaction among vortices in color superconductivity at high baryon density and in the chiral phase transition.
The most fundamental strings in color superconductivity are the Non-Abelian semi-superfluid strings which have color gauge flux tube but behave as superfluid vortices in the energetic point of view. We show that in addition to the usual translational zero modes, these vortices have normalizable orientational zero modes in the internal space, associated with the color-flavor locking symmetry broken in the presence of the strings. The interaction among two parallel Non-Abelian semi-superfluid strings is derived for general relative orientational zero modes to show the universal repulsion. This implies that the previously known superfluid vortices, formed by spontaneously broken $U(1)_B$, are unstable to decay. Moreover, our result proves the stability of color superconductors in the presence of external color gauge fields.
Non-Abelian strings are also expected to form during the chiral phase transition. They have orientational zero modes in the internal space, associated with the vector-like symmetry $SU(N)_{L+R}$ broken in the presence of strings. The interaction among two parallel Non-Abelian global strings is derived for general relative orientational zero modes, giving a

Non-Abelian generalization of the Magnus force. It is shown that when the orientations of the strings are the same, the repulsive force reaches the maximum, whereas when the relative orientation becomes the maximum, no force exists between the strings. We also show the marginal instability of the previously known Abelian eta' strings.

• Andrea Nobile

My research is focused on developing efficient Lattice QCD code for the next generation of supercomputers. By the use of a performance model we are able to estimate the sustained performance of a given algorithm on a given machine before writing the code. Through the use of specific microbenchmarks we are able to understand the maximum theoretically achievable performance for a given implementation of an algorithm. This approach is valuable for the design of new efficient machines, as a tool to write optimized code and to choose or design algorithms. Currently I'm working on the QPACE project, a special porpouse machine based on the Cell BE processor designed for lattice QCD calculations.

• Vladimir Pascalutsa

Together with M. Vanderhaeghen (JLab), we have recently completed a theoretical study of the radiative pion photoproduction on the nucleon ($\gamma N \to \pi N \gamma'$) in the Δ-resonance region, with the aim to determine the magnetic dipole moment (MDM) of the $\Delta^+(1232)$. A paper on this subject is accepted for publication in Physical Review D.

The study is done within the framework of chiral effective-field theory (EFT), where the expansion is performed (to next-to-leading order) in the δ power-counting scheme, an extension of chiral perturbation theory to the Δ-resonance energy region. We obtained the results for the absorptive part of the Δ MDM, as well as perform a sensitivity study of the dependence of $\gamma N \to \pi N \gamma'$ observables on the real part of the Δ MDM. We find that an asymmetry for circular polarization of the photon beam may provide a model-independent way to measure the Δ MDM. This work proved to be relevant to the ongoing measurements of the Δ-resonance MDM at the MAMI facility in Mainz.

In a subsequent publication, we establish new relations among the three $N \to \Delta$ transition form factors and the nucleon form factors. These relations are based on the known large-N_c relation between the $N \to \Delta$ electric quadrupole moment and the neutron charge radius, and a newly derived large-N_c relation between the electric quadrupole ($E2$) and Coulomb quadrupole ($C2$) transitions. Namely, in the large-N_c limit we find $C2 = E2$. We show that these relations provide predictions for the $N \to \Delta$ electromagnetic form factors which are found to be in very good agreement with experiment for moderate momentum transfers. They also provide constraints for the $N \to \Delta$ GPDs.

Together with K. Orginos (JLab) et. al., we have initiated lattice QCD calculations of the Δ-resonance properties. Extending the CHROMA software of LHPC to include external electromagnetic fields, we are able to compute a number of electromagnetic properties of the nucleon and the $\Delta(1232)$-resonance, in both quenched and full QCD. The range of available pion masses in our calculations is between 300 MeV and 776 MeV. To connect to the physical value of 140 MeV, we compute the pion-mass dependence using the framework of chiral EFT.

It is in this synergy of EFT and lattice QCD methods one is able at present to compute hadronic properties from first principles.

An interesting spinoff of the chiral EFT calculation of the Δ-resonance magnetic moment was the observation that quantum corrections give rise to an absorptive (imaginary) part of the magnetic moment, the effect that is expected to change the width of the resonance in an external magnetic field. This effect should be generic for any unstable particle. Together with D. Binosi (ECT*) we have investigated this effect for the case of the muon and the neutron, where it arises at the two-loop level. We have that this effect is very small in moderate magnetic fields (e.g., in the field of 1 Tesla the relative change in the muon lifetime is of order of 10^{-14}). However, we plan to exploit this effect in lattice QCD calculations, where external fields of arbitrary strength can be simulated, to assess the absorptive part of the magnetic moment of hadron resonances.

For the group of undergraduate students from Cooper Union College (NYC, USA), who were visiting ECT* for the period of two months, I have done a number of lectures and research projects in the field of quantum mechanics and field theory. The subject of the projects were (i) calculation of the decay widths of resonances, such W and Z bosons, and (ii) statistical analysis of hadron spectra, with the aim of determining the chaoticity of the underlying dynamics. All the students have completed a paper and gave a talk on the subject of their research.

Together with V. Lensky (ECT*), we have initiated a chiral EFT calculation of the nucleon Compton scattering. The calculation is being done to order p^3 in the covariant baryon chiral perturbation theory, which requires consideration of one loop graphs, including several box graphs. So far calculations to this order were done only using the so-called heavy baryon approach, which in many cases is poorly convergent. We hope our study will resolve the long-standing puzzle of nucleon polarizabilities in chiral perturbation theory.

• Claudia Ratti

A field theoretical quasiparticle approach for QCD thermodynamics

In collaboration with S. Rößner and W. Weise (Technical University of Munich)

A relevant part of my recent research activity is focused on the study of QCD thermodynamics in the framework of a field theoretical model. The motivation for using a quasiparticle approach in this investigation is twofold: it provides an interpretation of the available lattice results in terms of effective degrees of freedom, and it can be used to explore regions of the phase diagram that cannot be reached on the lattice yet.

The model which I have been developing recently, in collaboration with Professor Wolfram Weise, combines the Nambu Jona-Lasinio type of interaction with the nonlinear dynamics involving the Polyakov loop (PNJL model) [C. Ratti, M. A. Thaler and W. Weise, Phys. Rev. **D73**, 014019 (2006)].

The finite μ lattice results which we use for reference are obtained through a Taylor expansion of the thermodynamic grand canonical potential in powers of μ/T around $\mu = 0$. Within our model, we have performed a comparison between full and truncated results at

finite μ; this has allowed us to draw conclusions about the convergence properties of the Taylor series [C. Ratti, S. Roessner, M. A. Thaler and W. Weise, Eur. Phys. J **C49**, 213 (2007). C. Ratti, S. Roessner and W. Weise, Phys. Lett. **B649**, 57 (2007)]. The model has also been extended to larger chemical potentials, with the incorporation of diquark condensation [S. Roessner, C. Ratti and W. Weise, Phys. Rev. **D75**, 034007 (2007).]. The phase diagram in the (T, μ) plane has been obtained, and its quark mass dependence has been investigated, including the position of the critical endpoint [S. Roessner, C. Ratti and W. Weise, Phys. Rev. **D75**, 034007 (2007)].

Another interesting application of the PNJL model, in which I have been involved, is the study of mesonic properties in a hot/dense medium [H. Hansen *et al.*, Phys. Rev. **D75**, 065004 (2007).]. In particular, we have analized the pion and sigma spectral functions with varying temperature and quark chemical potential. We have showed that the introduction of the Polyakov loop in the standard NJL model does not spoil the nice features related to chiral symmetry restoration, and it improves some of the shortcomings of the NJL model concerning confinement.

Recently, we have been working on the improvement of the approximation that we use [S. Roessner, T. Hell, C. Ratti, W. Weise, Preprint December 2007.]; we calculated corrections beyond the mean field results, taking into account both Polyakov loop and mesonic fluctuations. We showed that the corrections that we introduce are small, leading to a convergent procedure.

$Q\bar{Q}$ correlators in a thermal medium

In collaboration with A. Beraudo and J.-P. Blaizot (ECT)*

Recently, in collaboration with Professor Jean-Paul Blaizot and with Dr. Andrea Beraudo, I have been investigating the behaviour of a heavy $Q\bar{Q}$ pair in a hot/dense medium [A. Beraudo, J.-P. Blaizot, C. Ratti, in preparation.]. In particular, we have showed that its large-time temporal evolution is governed by an effective potential emerging naturally from our calculation. In the study that we have performed so far, we have considered some simple models: the heavy fermion pair interacts either by means of an instantaneous potential, or through the exchange of a scalar meson, or finally through the exchange of photons, which belong to a hot medium in which also light fermions can propagate. In all these cases, we have derived the equations governing the temporal evolution of the two-particle propagator, and compared them with recent results referring to the $Q\bar{Q}$ real-time propagator in the Quark-Gluon Plasma. In particular, we have discussed the connection between real and imaginary time propagation, since this can be very useful for the interpretation of the available lattice results, obtained in Euclidean time.

• Michael Schwamb

My research activities in 2006 at ECT, in collaboration with the Trento group (W. Leidemann, G. Orlandini), concentrate on the study of few-nucleon systems. In the long term run, a unified description of corresponding hadronic and electromagnetic reactions is planed to be realized for energies up to the D-region at least. It is based on one common Hamiltonian which has to consider therefore not only nucleons, but also mesons and resonances as

explicit degrees of freedom. In the past, this ambitious aim has already been realized in the two-nucleon sector for not less than seven reactions. Furthermore, in 2006, it has formally been worked out also for the three-nucleon sector. In consequence, my work at ECT in 2007 has been devoted mainly to the development of appropriate computer codes for inclusive reactions on the A=3 system in terms of a partial wave decomposition within the framework of the Lorentz Integral method (LIT). The latter has been developed by the Trento group in collaboration with V.D. Efros (Moscow) and requires only bound state techniques for the calculation of observables in scattering processes, yielding a considerable simplification of the numerical challenges. These studies, where first numerical results can be expected soon, go conceptually far beyond standard Faddeev-techniques due to the nonperturbative treatment of the D-isobar and mesons. They allow not only a profound study of nuclear dynamics in general, but they are also of specific importance for a better understanding of He as an effective neutron target. This knowledge is necessary for various experimental activities in the field. In the present parametrization, the basic ingredients of the hadronic interaction are standard meson-nucleon-nucleon and meson-nucleon-D vertices known from potential theory. With respect to further conceptual improvements in the long term run, I have started in 2007 with a systematic study of already existing field theory approaches in the few-nucleon sector, which are presently limited to rather low energies close to pion-threshold at most. As a further application, the experience on few-nucleon systems turns out to be very helpful for the study of electromagnetic reactions on more complex targets. In collaboration with the Pavia group (S. Boffi, C. Giusti, F.D. Pacati), an improved theoretical understanding of electromagnetic two-nucleon knockout off O has been obtained. The (g,NN)- and (e,e'NN)-reactions constitute a unique tool for the study of correlations in atomic nuclei going beyond the standard single particle picture. They tackle therefore one of the central challenges of nuclear physics, namely a more profound understanding of the structure of complex atomic nuclei. This successful work nicely illustrates the fundamental character of studies on few-nucleon systems for nuclear physics in general.

• Luigi Scorzato

Computer Systems for Scientific applications: (In collaboration with Eurotech, INFN, IASMA, ATreP, Universities of TN, MI-Bic, PR, FE, PD) We are currently carring out the preliminary studies of a project that aim at developing a new computational system optimized for scientific applications. The collaboration includes experts of various fields, from hardware development to optimization of scientific application software.

Computing corrections to Instantons Liquid with Stochastic PT: (in coll. with P.Faccioli, R.Millo and F.Di Renzo) By means of Stochastic Perturbation Theory we are computing the quantum corrections around a background of diluted Instantons and/or Instantons pairs. This would allow to promote the Instantons Liquid Model into a systematic expansion, where QCD corrections are computed in PT via NSPT.

Ben cluster with APE3D: (In collaboration with A. Nobile (ECT*), INFN-APE group in Roma 2 and Exadron) I am developing and testing the software interface between MPI the APE3D network cards. This is needed to ensure stability and good performances of the APENet system.

Numerical Stochastic Perturbation Theory: (In Collaboration with F. Di Renzo (Parma U.) and C. Torrero (Bielefeld U.)). I am computing renormalization factors and improvement coefficients in Lattice Perturbation Theory. These quantities are needed to improve the precision of phenomenological predictions that can be extracted from Non-perturbative QCD Lattice calculations.

Unquenched Lattice QCD: (within the ETM Collaboration). I am doing Lattice QCD calculation of hadron masses and decay constants. We use the "twisted mass" regularization for the sea quarks and also the "overlap" regularization for the valence quarks. This choice is done in order to optimize symmetry properies and computational cost. Computations are done, in part, also on the ECT* BEN cluster.

Study of the Delta-resonance: (In collaboration with K. Orginos, M. Vanderhaeghen (JLab), and V. Pascalutsa (ECT*)). We started a project to study the properties of the Delta-resonance with Lattice QCD computations. Calculation will be performed on the teraflop cluster BEN of ECT*.

• Marco Traini

In collaboration with Marco Cristoforetti and Pietro Faccioli I studied the Interacting Instanton Liquid Model to explore the role of instanton induced dynamics in hadron structure. To support the validity of the model in the chiral regime, the quark mass dependencies of several properties have been investigated and shown to agree with chiral perturbation theory, including the density of eigenmodes of the Dirac operator and the masses of the pion and nucleon.
A quark mass m* = 80 MeV emerging naturally from the model has been shown to specify the mass scale above which the fermion determinant is suppressed, the zero modes become subdominant, and the density of quasi-zero modes become independent of the quark mass.
The Interacting Instanton Liquid Model (IILM) has also been used as a tool to study the role played by the chiral interactions in the lowest-lying vector and axial vector meson resonances.
We find that narrow a1 and rho meson resonances can be generated by instanton-induced chiral forces, even in the absence of confinement. In the IILM, these hadrons are found to have masses only about 30experimental value and small width ¡10-50 MeV. This result suggests that chiral interactions are very important in these systems and provide most of their mass. We have explored the decaying patterns of the rho meson, in the absence of confinement. We argued that, in our model where only chiral forces are switched on, this meson decays dissociating into its quark anti-quark constituents.

Also scalar glueball have been recently included in our studies.

• Dionysis Triantafyllopoulos

Quantum Chromodynamics at High Energy

A main active field of research within QCD is the study of its behavior in the high energy limit. In this regime, and due to the triple-gluon coupling, the wavefunction of a hadron is dominated by a dense system of gluons. When the energy of the hadron becomes sufficiently high, one expects the gluon density to reach its asymptotic limit ($1/\alpha_s$) and the wavefunction to exhibit saturation. In particular, but not necessarily, this phenomenon is enhanced for large nuclei due to the large number of valence quarks. With increasing energy, more and more gluonic modes saturate and the dynamically generated "saturation scale" is an increasing monotonic function of the energy. The QCD coupling constant becomes small and the problem can be approached by analytical methods. Over the recent years it has been possible to describe the energy evolution of all the moments of the gluon density through a system of coupled equations.

There are two main sources of "higher-order" corrections to the "standard" QCD non-linear equations: (i) the low-density fluctuations of the hadronic wavefunction which eventually lead to the formation of Pomeron loops and (ii) the genuine NLO corrections of resummed perturbation theory. Each effect can be described by more general evolution equations, but equations that treat properly both of them at the same time are not available. However, we have been able to construct a realistic model which achieves to contain both elements and we found and understood that, even though the contributions from the low density fluctuations are parametrically more important, numerically it is the corrections due to the running coupling that dominate.

Then, since fluctuations are small and we can use mean field equations (with running coupling), we expect inclusive and semi-inclusive cross sections to exhibit geometrical scaling, that is, to be functions of Q^2/Q_s^2, where Q is a characteristic momentum of the process and Q_s is the saturation scale. We have discussed the possibility that the phenomenon be important for pA collisions at LHC, where it is believed to produce significant suppression of the spectra at relatively high transverse momenta. Currently, we are finishing a work where we show that the scaling should be expected to appear in the description of pp collisions when two produced jets are widely separated in rapidity. Such jets, the so-called Mueller-Navelet jets, are expected to be produced at LHC.

3.2 Publications of ECT* Researchers

W.M. Alberico, A. Beraudo, A. Czerska, P. Czerski and A. Molinari
Meson Screening Masses in the Interacting QCD Plasma
*Nucl. Phys. A***792***, 152 (2007)*

W.M. Alberico, A. Beraudo, A. De Pace and A. Molinari
Potential models and lattice correlators for quarkonia at finite temperature
to appear in Phys. Rev. D, e-Print: arXiv:0706.2846 [hep-ph]]

D. Binosi and J.Papavassiliou
Pinch-Technique for Schwinger-Dyson equations
JHEP 0307:041 (2007) [*arXiv:hep-ph/0611354*]

Jean-Paul Blaizot, Andreas Ipp, Ramon Mendez-Galain, Nicolas Wschebor
Perturbation theory and non-perturbative renormalization flow in scalar field theory at finite temperature
Nucl. Phys. A784:376-406,2007 [*hep-ph/0610004; ECT*-06-15*]

J.-P. Blaizot, E. Iancu, U. Kraemmer, A. Rebhan
Hard thermal loops and the entropy of supersymmetric Yang-Mills theory
JHEP 0706:035,2007 [*hep-ph/0611393;ECT*-06-22*]

A. Beraudo, J.-P. Blaizot, C. Ratti
Real and imaginary time Q Qbar correlators in a thermal medium
to appear in Nucl. Phys. A [*arXiv:0712.4394*]

J.-P. Blaizot
Non perturbative renormalization group and Bose-Einstein condensation
Lecture notes [*arXiv:0801.0009;ECT*-07-22*]

D. Rossini, T. Calarco, V. Giovannetti, S. Montangero, R. Fazio
Decoherence induced by interacting quantum spin baths
Phys.Rev. A **75***, 032333 (2007).*

S. Montangero, T. Calarco, R. Fazio
Robust optimal quantumgates for Josephson charge qubits
Phys. Rev. Lett. **99***,170501(2007).*

Z. Idziaszek, T. Calarco, P. Zoller
Controlled collisions of a single atom and ion guided by movable trapping potentials
Phys. Rev. A 76, 033409 (2007).

J. M. Taylor, T. Calarco
Wigner crystals of ions as quantum hard drives
arXiv:0706.1951.

S. Fishman, G. De Chiara, T. Calarco, G. Morigi
Structural phase transitions in low-dimensional ion crystals
arXiv:0710.1831.

D. Binosi, G. De Chiara, S. Montangero and A. Recati
Increasing entanglement through engineered disorder
Phys. Rev. B **76***, 140405(R) (2007).*

D. Rossini, T. Calarco, V. Giovannetti, S. Montangero, R. Fazio
Decoherence by engineered quantum baths
J. Phys. A: Math. Theor. **40** *(2007) 8033-8040.*

G. De Chiara, M. Rizzi, D. Rossini and S. Montangero
Density Matrix Renormalization Group for Dummies
J. of Comp. and Theor. Nanosc. (in press).

B. Zhao, Z.-B. Chen, J.-W. Pan, J. Schmiedmayer, A. Recati, G. E. Astrakharchik, T. Calarco
Deterministic Entanglement via Molecular Dissociation in Integrated Atom Optics
Phys. Rev. A **75***, 042312 (2007).*

C. Ewerz, A. von Manteuffel, O. Nachtmann
On the Limitations of the Color Dipole Picture - Talk presented by C. E. at the 12th International Conference on Elastic and Diffractive Scattering (EDS07), DESY Hamburg, May 2007
arXiv:0710.2796, to appear in the proceedings [*ECT*-07-18, HD-THEP-07-29*]

C. Ewerz, A. von Manteuffel, O. Nachtmann
On the Range of Validity of the Dipole Picture
arXiv:0708.3455, submitted to Phys. Rev. **D** [*ECT*-07-15, HD-THEP-07-17*]

C. Ewerz, O. Nachtmann
Diffractive Neutral Pion Production, Chiral Symmetry and the Odderon Invited talk presented by C. E. at XVth International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS 2007), and by O. N. at the 12th International Conference on Elastic and Diffractive Scattering (EDS07), DESY Hamburg, May 2007
arXiv:0707.1507, to appear in the proceedings [*ECT*-07-14, HD-THEP-07-15*]

C. Ewerz, O. Nachtmann
Bounds on Ratios of DIS Structure Functions from the Dipole Picture

Phys. Lett. **B 648** *(2007) 279 [hep-ph/0611076]* [*ECT*-06-18, HD-THEP-06-29*]

C. Ewerz, O. Nachtmann
Chiral Symmetry and Diffractive Neutral Pion Photo- and Electroproduction
Eur. Phys. J. **C 49** *(2007) 685 [hep-ph/0608082]* [*ECT*-06-10, HD-THEP-06-16*]

C. Ewerz, O. Nachtmann
Towards a Nonperturbative Foundation of the Dipole Picture: II. High Energy Limit
Annals of Physics **322** *(2007) 1670, [hep-ph/0604087]* [*HD-THEP-04-18, IFUM-790-FT, ECT*-05-19*]

J. Bartels, **C. Ewerz**, M. Hentschinski
High Energy Behavior of Yang-Mills Theories with Adjoint Fermions
ECT-07-07*

V. Baru, J. Haidenbauer, C. Hanhart, A. Kudryavtsev, V. Lensky and U.-G. Meissner
Pion–deuteron scattering length in Chiral Perturbation Theory up to order $\chi^{3/2}$
arXiv:0711.2743 [nucl-th]

V. Baru, J. Haidenbauer, C. Hanhart, A. Kudryavtsev, V. Lensky and U.-G. Meissner
Progress in NN $\to$ NNpi
arXiv:0711.2748 [nucl-th]

V. A. Gani, N. B. Konyukhova, S. V. Kurochkin and V. A. Lensky
Study of Stability of a Charged Topological Soliton in the System of Two Interacting Scalar Fields
USSR Comput. Math. Math. Phys. J. 44, 1968 (2007) [*arXiv:0710.2975 [hep-th]*]

V. Baru, J. Haidenbauer, C. Hanhart, A. Kudryavtsev, V. Lensky and U.-G. Meissner
Role of the Delta(1232) in pion-deuteron scattering at threshold within chiral effective field theory
Phys. Lett. B659, 184 (2008) [*arXiv:0706.4023 [nucl-th]*]

V. Lensky, V. Baru, E. Epelbaum, C. Hanhart, J. Haidenbauer, A. Kudryavtsev and U.-G. Meissner
Neutron neutron scattering length from the reaction gamma d –¿ pi+nn employing chiral perturbation theory
Eur. Phys. J. A33, 339 (2007) [*arXiv:0704.0443 [nucl-th]*]

E. Nakano, M. Nitta and T. Matsuura
Non-Abelian Strings in High Density QCD:Zero Modes and Interactions
arXiv:0708.4096 [*ECT*-07-16*]

E. Nakano, M. Nitta and T. Matsuura
Interactions of Non-Abelian Global Strings

arXiv:0708.4092 [*ECT*-07-17 Title*]

Belletti, F.,Bilardi, G., Drochner, M., Eicker, N., Fodor, Z., Hierl, D., Kaldass, H., Lippert, T., Maurer, T., Meyer, N., Nobile, A., Pleiter, D., Schaefer, A., Schifano, F., Simma, H., Solbrig, S., Streuer, T., Tripiccione, R., Wettig, T.
"QCD on the Cell Broadband Engine"
arXiv:0710.2442v1 (2007) [*URLhttp://arxiv.org/abs/0710.2442*]

V. Pascalutsa
The Delta(1232) Resonance in Chiral Effective Field Theory
Prog. Part. Nucl. Phys. (in press) [*arXiv:0712.3919 [nucl-th]*]

V. Pascalutsa and M. Vanderhaeghen
Large-N_c relations for the electromagnetic N to Delta(1232) transition
Phys. Rev. D **76**, *111501[RC] (2007)* [*arXiv:0711.0147 [hep-ph]*]

V. Pascalutsa and M. Vanderhaeghen
Chiral effective-field theory in the Delta(1232) region: II. Radiative pion photoproduction
Phys. Rev. D (in press) [*arXiv:0709.4583 [hep-ph]*]

D. Binosi and V. Pascalutsa
The lifetime of unstable particles in electromagnetic fields
[*arXiv:0704.0377 [hep-ph], submitted for publication*]

V. Pascalutsa
Chiral effective field theory in the Delta-resonance region
In Proc. 5th International Workshop on "Chiral Dynamics, Theory and Experiment (CD2006)" (World Scientific, Singapore, 2007)

V. Pascalutsa and M. Vanderhaeghen
The $\gamma N \to \Delta$ transition in chiral effective-field theory
AIP Conf. Proc. **904**, *158 (2007)*

V. Pascalutsa, M. Vanderhaeghen and S.-N. Yang
Electromagnetic excitation of the $\Delta(1232)$ resonance
Phys. Rept. **437**, *125 (2007)*

C. Ratti, S. Roessner and W. Weise
" Quark number susceptibilities: Lattice QCD versus PNJL model"
Phys. Lett. **B649**, *57 (2007).* [*ECT* preprint number: ECT*-07-01*]

W. Weise, C. Ratti and S. Roessner
"Phases of QCD, Polyakov loop and quasiparticles"

To appear in Prog. Theor. Phys. Suppl. e-print archive: 0704.3585. [*ECT* preprint number: ECT*-07-09*]

C. Ratti, S. Roessner and W. Weise
"A field theoretical model for QCD thermodynamics"
J. Phys. **G34**, *s647 (2007).*

M. Schwamb
Electromagnetic Reactions on Few-Nucleon Systems., published in .Theoretical Nuclear Physics in Italy, Proceedings of 11th Conference on Problems in Theoretical Nuclear Physics
Editors A. Covello, L.E. Marcucci, S. Rosati and I. Bombaci. World Scientific (2007), 57-64 [*ECT-06-029*]

C. Giusti, F. D. Pacati, M. Schwamb and S. Boffi
Center-of-mass effects in electromagnetic two-proton knockout reactions
The European Physical Journal A 31 (2007) 155-162 [*ECT-07-04*]

C. Giusti, F. D. Pacati, M. Schwamb and S. Boffi
Electromagnetic proton-neutron knockout off O: new achievements in theory.
The European Physical Journal A 33 (2007) 29-38 [*ECT-07-11*]

M. Schwamb, G. Orlandini, W. Leidemann
The three-nucleon system above pion-threshold with explicit pionic and D-degrees of freedom., Proceedings of Meeting Few-Body Systems (Initiative PD32)
published in .Few-Body Systems in Nuclear and Hadronic Physics: Results and Perspectives of the Research Initiative IS PD32., Editors L. Canton and A. Pascolini, Universit degli Studi di Padova (2007), 15-25 [*ECT-07-24*]

M. Schwamb
Unified description of pion production processes on few-nucleon systems, Proceedings of International Workshop on the Physics of Excited Nucleons (NSTAR 2007), Bonn 2007
to be published [*ECT-07-25*]

M. Schwamb
Few-nucleon systems with explicit pionic and D-degrees of freedom., Proceedings of 20th European Conference On Few-body Problems In Physics (EFB 20), Pisa 2007
to be published [*ECT-07-26*]

C. Giusti, F. D. Pacati and M. Schwamb
Recent Advances in the Description of Electromagnetic Two-Nucleon Knockout Reactions., Proceedings of XVII International School on Nuclear Physics, Neutron Physics and Application, Varna 2007
to be published

F. Di Renzo, V. Miccio, L. Scorzato, C. Torrero
High-loop perturbative renormalization constants for Lattice QCD (I): finite constants for Wilson quark currents
Eur.Phys.J. C 51 (2007) 645 [*ECT*-06-28*]

ETM Collaboration
Dynamical twisted mass fermions with light quarks
Phys.Lett.B 650 (2007) 304 [*ECT*-07-29*]

F.Di Renzo, L.Scorzato and C.Torrero
High loop renormalization constants by NSPT: a status report
arXiv:0710.0552 [hep-lat] [*ECT*-07-30*]

N.Garron and L.Scorzato
Results from overlap valence quarks on a twisted mass sea
arXiv:0710.1582 [hep-lat] [*ECT*-07-31*]

M. Cristoforetti, P. Faccioli, M.C. Traini and J.W. Negele
Exploring the Chiral Regime of QCD in the Interacting Instanton Liquid Model
Phys.Rev. D75 (2007) 034008 [*ECT*-06-06*]

M. Cristoforetti, P.Faccioli and M. Traini
Instantons, Chiral Dynamics and Hadronic Resonances
Phys. Rev. D75 (2007) 054024 [*ECT*-07-02*]

A. Dumitru, E. Iancu, L. Portugal, G. Soyez and D.N. Triantafyllopoulos
Pomeron Loop and Running Coupling Effects in High Energy QCD Evolution
JHEP **08** *(2007) 062 [arXiv:0706.2540]* [*ECT*-07-10*]

E. Iancu and D.N. Triantafyllopoulos
R_{pA} Ratio: Total Shadowing due to Running Coupling
arXiv:0707.0204 [To appear in Jour. Phys. **G***]* [*ECT*-07-12, contribution to the proceedings of "Heavy Ion Collisions at the LHC: Last call for Predictions"*]

E. Iancu, M.S. Kugeratski and D.N. Triantafyllopoulos
Geometric Scaling in Mueller-Navelet Jets
[*ECT*-07-27*]

3.3 Seminars and Presentations at International Conferences by ECT* researchers

- **Andrea Beraudo**

  Rapidity evolution of particle production in DIS
  High energy QCD: from RHIC to LHC (ECT*)
  January 2007, Trento, Italy

  Rapidity evolution of particle production in DIS
  Quark Gluon Plasma and Heavy Ion Collisions: past, present, future
  February 2007, Torino, Italy

  Quarkonia propagation in a hot-dense medium
  Electroweak interactions with nuclei and physics of the quark-gluonplasma: many-body techniques at high energies and temperatures (ECT* and Univ. of Trento)
  Nov. - Dec. 2007, Trento, Italy

- **Jean-Paul Blaizot**

  Infrared problems in cold atoms and quark-gluon plasmas
  The interface of quark-gluon-plasma physics and cold-atom physics
  March 21, ECT, Trento, Italy*

  Infrared problems in cold atoms and quark-gluon plasmas
  Seminar at the University of Tokyo
  June 21, Tokyo, Japan

  Hot and dense QCD matter
  Lectures given at the European Graduate School "Complex systems of hadrons and nuclei"
  September 1-5, Obergurgl, Austria

  The transition temperature of the weakly repulsive Bose gas
  Seminar at the Tata Institute for Fundamental Research
  November 22, Mumbai, India

  The transition temperature of the weakly repulsive Bose gas
  Seminar at the University of Montevideo
  December 7, Montevideo, Uruguay

- **Carlo Ewerz**

  How and Where to use the Dipole Picture
  High Energy QCD: from RHIC to LHC, ECT*
  January 2007, Trento, Italy

  Energy Loss and Jet Quenching in AdS/CFT
  High Density QCD', Galileo Galilei Institute
  March 2007, Florence, Italy

  Odderon Searches at LHC
  Invited talk at HERA-LHC Workshop, DESY
  March 2007, Hamburg, Germany

  Diffractive Neutral Pion Photoproduction and the Odderon
  Invited talk at DIS2007, 'Workshop in Deep-Inelastic Scattering and Related Subjects'
  April 2007, München, Germany

  High Energy Scattering: From Gluons to Strings
  Universität Giessen
  May 2007, Giessen, Germany

  On the Limitations of the Color Dipole Picture
  12th Int. Conference on Elastic and Diffractive Scattering
  May 2007, Hamburg, Germany

  From Soft QCD to String Theory
  Invited talk at 31st Johns Hopkins Workshop
  August 2007, Heidelberg

- **Vadim Lensky**

  Neutron-neutron scattering length from the reaction $\gamma d \to \pi^+ nn$
  11th International Conference on Meson-Nucleon Physics and the Structure of the Nucleon (MENU 2007)
  September 2007, Jülich, Germany

- **Taeko Matsuura**

  A study of BCS and Bogolyubov theories with the exact renormalization group
  Ruperto Carola Symposium on Ultracold Quantum Gases
  July 2007, Heidelberg, Germany

- **Vladimir Pascalutsa**

  Exciting Hadrons
  talk at the NuPECC Meeting, ECT*
  March 2007, Trento, Italy

  Unstable particles, EFTs, and the Δ-resonance magnetic moment
  Physics **Colloquium**, University of Mainz
  April 2007, Mainz, Germany

  Unstable particles, EFTs, and the Δ-resonance magnetic moment
  JLab Theory Center Seminar, Jefferson Laboratory
  May 2007, Newport News VA, USA

  Electromagnetic moments of the Δ resonance
  invited talk at the Crystal Ball Collaboration Meeting
  June 2007, Mainz,Germany

  Chaos in the N* spectrum
  invited talk at the Workshop for Excited Baryons (NSTAR 2007)
  September 2007, Bonn, Germany

  The nucleon to Delta transition
  invite talk at the 5th International Conference on Meson-Nucleon Physics (MENU 07)
  September 2007, Juelich, Germany

  Resonances in chiral EFT and lattice QCD
  invited seminar at the 29th Erice School on "Quarks in Nucleons and Nuclei"
  September 2007, Erice, Italy

  Chaos in Hadrons
  JLab Theory Center Seminar, Jefferson Laboratory
  November 2007, Newport News VA, USA

- **Claudia Ratti**

  Phases of QCD: lattice thermodynamics, quasiparticles and Polyakov loop
  Invited seminar at Brookhaven National Laboratory
  January 2007, Brookhaven, USA

  Phases of QCD: lattice thermodynamics, quasiparticles and Polyakov loop
  Invited seminar at the State University of New York at Stony Brook
  January 2007, Stony Brook, USA

A field theoretical model for QCD thermodynamics
Talk at the International School "Quark-gluon plasma and relativistic heavy ions: past, present and future"
February 2007, Torino, Italy

A field theoretical model for QCD thermodynamics
Invited seminar at the Collaboration meeting "Electroweak interactions with nuclei and physics of the quark-gluon plasma: many body techniques at high energies and temperatures", ECT*
November 2007, Trento, Italy

A field theoretical model for QCD thermodynamics
Invited seminar at Kent State University Kent
December 2007, Ohio, USA

- **Michael Schwamb**

The three-nucleon system above pion-threshold with explicit pionic and D-degrees of freedom
Meeting Few-Body Systems (Initiative PD32)
October 2007, Padova, Italy

Unified description of pion production processes on few-nucleon systems
International Workshop on the Physics of Excited Nucleons (NSTAR 2007), Bonn 2007
September 2007, Bonn, Germany

Few-nucleon systems with explicit pionic and D-degrees of freedom
20th European Conference On Few-body Problems In Physics (EFB 20), Pisa 2007
September 2007, Pisa, Italy

- **Luigi Scorzato**

Results from Twisted Mass QCD
Talk presented at: Nineth Workshop on Non perturbative QCD
June 2007, Paris, France

Results from overlap valence quarks on a twisted mass sea
Talk presented at: XXV International Symposium on Lattice Field Theory. Lattice 2007
July - August 2007, Regensburg, Germany

- **Marco Traini**

  Light Hadron Spectrum in the Instanton Liquid Model
  Talk presented at: HADRON07: XII International Conference on Hadron Spectroscopy
  October 2007, Frascati, Italy

  Exploring the Chiral Regime of QCD in the Interacting Instanton Liquid Model
  Lattice 2007: the XXV International Symposium on Lattice Field Theory
  August 2007, Regensburg, Germany

- **Dionysis Triantafyllopoulos**

  Boost invariance and Multiple Scattering: Modeling QCD
  Talk given at Workshop "High Energy QCD: From RHIC to LHC" at ECT*
  January 2007, Trento, Italy

  QCD and Unitarity at Small-x
  Seminar given at CERN
  February 2007, Geneva, Switzerland

  Open Questions on Fluctuations in Small-x QCD
  Talk given at Workshop "High Density QCD" at GGI
  February 2007, Florence, Italy

  Running Coupling Effects in Small-x QCD
  Lectures given at "School on QCD, Low-x Physics, Saturation and Diffraction"
  July 2007, Copanello (Calabria), Italy

  Parton Saturation in Quantum Chromodynamics
  Seminar given at National Technical University
  October 2007, Athens, Greece

3.4 Lectures and Seminars at ECT*

3.4.1 Lectures

- Symmetries in nuclei
  (March 12 - 16)
  Lecturer: Francesco Iachello (Yale University)
- Introduction to mean field theory and deformations in nuclei
  (March 26 - 30)
  Lecturer: Georges Ripka (CEA Saclay)
- Weak interactions in nuclear systems
  (April 2 - 6)
  Lecturer: N. Severijns (University Leuven)
- Exotic beam physics
  (April 9 - 13)
  Lecturer: Y. Blumenfeld (IPN Orsay)
- Nuclear shell model
  (April 9 - 13)
  Lecturer: M.Hjorth-Jensen (University of Oslo)
- Nuclear shell model
  (April 23 - 27)
  Lecturer: D. Vretenar (University of Zagreb)
- Nuclear reaction theory
  (April 30 - May 4)
  Lecturer: J.A.Tostevin (University of Surrey)
- Solving a model to understand the quantum theory of measurement
  (May 21 - 25)
  Lecturer: R. Balian (CEA)
- Nuclear Astrophysics
  (May 28 - June 1)
  Lecturer: K. Langanke (GSI)
- Series of lectures
  (August 20 - 24)
  Lecturer: L.Rezzolla - S.Rosswog (AEI Potsdam - Jacobs University Bremen)
- Neutron Star Phenomenology
  (August 27 - 29)
  Lecturer: D.I.Jones - S.Popov (University of Southampton - University of Moscow)
- Supernovae and Protoneutron stars
  (September 3 - 7)
  Lecturer: M.Liebendorfer - J.Pons (University of Basel - University of Alicante)
- Neutrino processes and compact star cooling
  (September 17 - 21)
  Lecturer: D.Page - D.N.Voskresensky (UNAM, Mexico - Moscow Institute of Physics/GSI)

- Physics of the neutron star crust
  (September 24 - 28)
  Lecturer: P.Haensel - P.Pizzochero (N. Copernicus Astr. Center, Warsaw - INFN Milano)
- EoS for compact star interiors
  (October 1 - 5)
  Lecturer: D.Blaschke - F.Burgio (University of Wroklaw - INFN Catania)

3.4.2 Seminars

11.01
Physics and radiation oncology: current status and (a few) open issues
M. Schwarz (*ATreP*)

25.01
Elastic and inelastic pion reactions in few nucleon systems
V. Lensky (*Forschungszentrum Juelich*)

05.02
Model independent naturalness bounds on neutrino magnetic moments
M. Gorshtein (*California Institute of Technology*)

15.02
Heavy quark Thermodynamics: life after deconfinement
K. Petrov (*Niels Bohr Institute*)

06.03
Hot QCD and sterile neutrino dark matter
M. Laine (*University of Bielefeld*)

15.03
Order-to-chaos transition within the symmetry triangle of the IBM 1
M. Macek (*Charles University Prague*)

16.03
Special solutions of the Bohr Hamiltonian in the context of critical point symmetries
D. Petrellis (*National Center for Scientific Research, Greece*)

20.03
Order and Chaos in the Geometric Collective Model
P. Stransky (*Yale University*)

27.03
Extended approach to correlations beyond mean-field in atomic nuclei
K. Sieja (*University M. Curie of Lublin*)

28.03
Pairing vibrations: an outlook for a mean field study
B. Avez (*Cea Saclay, France*)

30.03

Differentiation with symmetries
M. Ruzhansky (*Imperial College London*)

03.04
Nuclear Forecasting as Pattern Recognition: Can we predict Nuclear Masses?
I.O. Morales Agiss (*University of Mexico*)

04.04
Effective mass in a relativistic mean field model
T. Marketin (*University of Zagreb*)

10.04
Search for mixed-symmetry states using Coulomb excitation
T. Ahn (*Technische Univ. Darmstadt*)

12.04
High spin spectroscopy of 35 CL using clover detectors
R. Kshetri (*Saha Institute of Nuclear Physics*)

13.04
Effective theories, quantum chaos, unstable particles (Journal club seminar)
V. Pascalutsa (*ECT**)

17.04
Ground state correlations and the structure of odd-even nuclei
S.R. Mishev (*BLPT Dubna*)

19.04
Evolution of collectivity in neutron rich nuclei in the 132Sn region
R. Kshetri (*Saha Institute Kolkata*)

08.05
Terminating states as a laboratory for testing energy density functionals
M. Zalewski (*University of Warsaw*)

22.05
Two-body observables using the Balian-Veneroni variational method
J.M.A. Broomfield (*University of Surrey*)

23.05
Lattice QCD with Fermions (Journal club seminar)
L. Scorzato (*ECT**)

24.05
Symmetry energy and pairing in the Wood-Saxon model
M. Rafalski (*University of Warsaw*)

29.05
Environmental effects on the neutrino-nucleus reaction
F. Minato (*Tohoku University*)

31.05
Analysis of the 12C + 24Mg system using folding potentials
M. Karakoc (*Erciyes University - Turkey)*)

13.06
Lattice QCD on the Playstation 3 (Journal club seminar)
A. Nobile (*ECT**)

20.06
Mirror matter and the extinction of dinosaurs (Journal club seminar)
C. Ewerz (*ECT**)

27.06
Pinching (Journal club seminar)
D. Binosi (*ECT**)

03.07
Glueball enhancement by color deconfinement
V. Vento (*Universidad de Valencia*)

04.07
QCD Phase Diagram: Facts and Speculations (Journal club seminars)
C. Ratti (*ECT**)

22.08
Black hole binaries as sources of y-ray bursts and hypernova explosions
E. Moreno-Mendez (*Max Planck Inst. fuer Astrophysik*)

23.08
Molecular-dynamic simulation of multicomponent plasmas
O. Caballero (*Nuclear Theory Center, Bloomington*)

29.08
Inhomogeneous colour superconductivity in compact stars?
R. Anglani (*University of Bari*)

29.08
Few Nucleon Systems, for Few ¡ 13 (Journal club seminar)
Michael Schwamb (*ECT**)

30.08
Asymmetric neutrino emission in quark matter and pulsar kicks
I. Sagert (*J.W. Goethe Institut*)

04.09
Constitutent Quarks and the internal structure of the nucleon and the nucleon spin
H. Fritzsch (*LMU Munich*)

04.09
hermodynamics of nuclear matter
V. Soma (*Institute of Nuclear Physics, Crakow*)

06.09
Methods for numerical relativity
Kellermann (*A.Einstein Institut*)

18.09
Pinching Techniques (Journal club seminar)
D. Binosi (*ECT**)

18.09
Where do we come from? 1d general relativistic core collapse simulations and the expected neutrino signal
T. Fischer (*University of Basel*)

20.09
Exotic matter in neutron stars and r-modes
D. Chatterjee (*Saha Institute, Kolkata*)

25.09
Type II supernovae: weak processes and dynamics of gravitational collapse
A. Fantina (*University of Milano*)

26.09
Non-perturbative aspects of BCS-BEC crossover (Journal club seminar)
T. Matsuura (*ECT**)

26.09

A statistical model for hot hadronic matter below saturation density
M. Hempel (*J.W. Goethe Institut*)

2.10
Structural transitions in the neutron star crust
S. Figerou (*University of Wroklaw - INFN Catania*)

3.10
Spectral-fluctuations test of the quark-model baryon spectrum
C. Fernandez-Ramirez (*MIT,Cambridge*)

5.10
BEC-BCS crossover in quark matter
D. Zablocki (*University of Wroklaw*)

9.10
Renormalization Group Approach to Superfluid Neutron Matter
K. Hebeler (*GSI*)

27.11
Lattice Hamiltonian Effective Field Theory for Nuclear Physics
P. Faccioli (*University of Trento*)

29.11
Nucleon-to-Delta axial-vector transition form factors up to NNLO in relativistic chiral effective theory
J.M. Camalich (*University of Valencia*)

18.12
Glueballs as holograms
H. Forkel (*Ift-Unesp So Paulo*)

4 The Quantum Information Processing Group at ECT*

The Quantum Information Processing Group has been presented in previous reports. Let us recall that T. Calarco (now based at Ulm University) and D. Binosi are responsible of the update of the "QIPC Strategic Report", a roadmap-like document that is being used to provide input to the EC Future and Emergin Technologies (FET) Unit for the preparation of the Call 4 of the 7th Framework Programme. This is done in the framework of two different European projects: the ERA-Pilot Project and the coordination action QUROPE. In what follows we will review the Work Packages (WP) of the aforementioned projects that are under the direct responsibility of the QIPC group at ECT* (a detailed description of the projects can be found in the ECT* 2006 Report.)

- **ERA-Pilot QIST WP1 (Drawing a European Guideline for Quantum Information Sciences and Technologies)**
  WP leaders: R. Fazio (Pisa) and T. Calarco (Ulm); WP members: D. Binosi (Trento)

  The ERA-Pilot WP1 aimed both at surveying European QIST related structures, as well as at the elaboration of guidelines for future funding and research developments in the area of QIST in Europe. To achieve the first goal (survey of structures) it has been essential to produce a description of QIST topics called Quantum Information Classification Scheme or QICS that defined what techniques are part of QIST, where the border lies with other scientific areas, etc. The second goal has been instead achieved by writing the position document Quantum Information Processing and Communication: strategic report on current status visions and goals for research in Europe. As already said, this is a roadmap-type document which has the goal of promoting QIPC research in Europe, strengthen its image and express it in a coherent way, unify the research community and elaborate a common pan European strategy and goals, provide input for the European Commission for the preparation of the Seventh Framework Programme and reach in an appropriate way decision makers, and, finally, expand and strengthen activities at the European level. WP1 results have been disseminated through the website `http://qist.ect.it` hosted at the ECT* servers.

  The ERA-Pilot project ended the 31st of December 2007, and it will undergo its final review the 4th of March of 2008, where all the project results will be presented.

- **QUROPE WP2 (Develop a common vision, strategy and goals)**
  WP leaders: T. Calarco (Ulm) and P. Zoller (Innsbruck); WP members: D. Binosi (Trento)

  WP2 is designed to develop a common European vision, strategy and goals. It formally takes over the development and regular updates of the European QIPC Strategic Report from the ERA-Pilot QIST WP1 described earlier. Other reports and position papers are also within the scope of work. The goal is to provide input for the preparation of the upcoming 7th Framework Program, and of other strategy/policy documents which could help the EC to shape the research programme in the field of IST. The organization of working Expert groups in various sub-fields, their interaction and integration is also an important part of the work.

- **QUROPE WP4 (Electronic Information Infrastructure and Information Exchange)**
  WP leaders: E. Polzik (Copenhagen) and D. Binosi (Trento); WP members: L. Theussl (Trento)

  QUROPE WP4 is in charge of establishing and maintaining an Electronic Information Infrastructure to support the efficient service of all the coordination action objectives. The centerpiece is a comprehensive website constituting (*i*) the project portal through which all the relevant information are distributed, exchanged and disseminated, and (*ii*) the feedback channel that the QIPC community uses to provide direct input to the QUROPE members thus influencing on the fly the future actions taken by the coordination action.
  The QUROPE website `http://www.qurope.net` is hosted at Copenhagen with part of the database infrastructure hosted at the ECT* servers.

5 BEN, the ECT* teraflop cluster

This section provides a detailed technical status of the machine, as well as the list of the projects that have been running in 2007.

5.1 Report of the Cluster Management

Group	No. jobs	days	Percent	Average No. nodes	kCPUh granted	kCPUh used
AFDMC	27193	7012.94	39.36	5.18	300	336
thermqcd	1218	3967.98	22.27	13.91	240	190.5
NSPT	11114	2437.13	13.68	5	120	117.0
NLMCHPF	245155	1239.48	6.96	1	60	59.5
molcp	345	914.41	5.13	12.07	31	43.9
pH2wave	3344	855.68	4.80	1.74	1	41.0
BECPCF	1755	566.37	3.18	1.09	30	27.2
qnsu	116	524.08	2.94	20.85	42	25.2
lattham	842	207.30	1.16	1.09	150	9.9
QCDFF	458	37.43	0.21	6.82	100	1.8
Delta	9	24.59	0.14	41.60	600	1.2

Table 1: Granted CPU time refers to the whole year. All the other figures refer to the period 1/3/07 - 27/12/07. Total ideal available CPU time for one year is 1682k CPUh.

Status of the computing nodes

The table shows the resources used by the jobs running under the queue system (i.e. excluding APE3D) in 2007 (from 1/3/2007 to 27/12/2007). It also compares the granted CPU time with the one actually used until now (in thousands of CPU hours). This should also be compared with the total ideally available CPU hours which amount to 1682k per year. Because of many reasons (optimal parallel jobs use 1CPU/node; uptime of the machine; queueing of larg jobs) a more realistic figure is about the half. In 2007 the machine was used mainly by the following projects: AFDMC[1], thermqcd[2], NSPT[3], NLMCHPF[4], molcp[5], pH2wave[6], BECPCF[7], qnsu[8], lattham[9]. The others are mainly test runs. The only new entry in this list is the project "lattham", which was evaluated last October. The projects

[1]F.Pederiva and S.Gandolfi. Study of ground state properties of light nuclei and neutron matter with the Auxiliary Field Diffusion Monte Carlo (AFDMC) method.

[2]F.Karsch and M.Kitazawa. First principle calculation for spectral properties of quarks in the quark-gluon plasma.

[3]C.Torrero et al. NSPT for 3d gauge theories.

[4]P.Verocchio. Non-local Monte Carlo algorithm for highly polydisperse fluids

[5]V.Minicozzi et al. The role of metals on protein aggregation processes. Prion protein and beta-Amyloids

[6]F.Pederiva and F.Operetto. Study of high pressure properties of defective solid pH2 with Shadow Wave Functions.

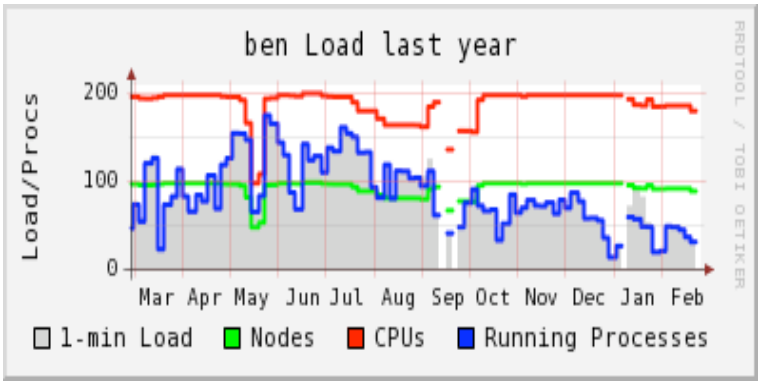
[7]D.Binosi et al. Increasing entanglement through noise.

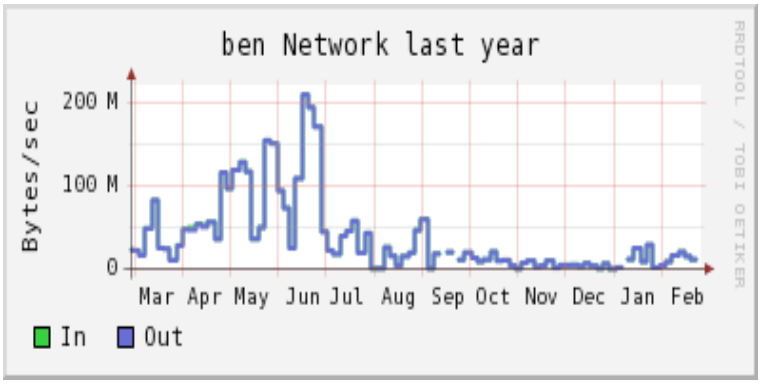
[8]A.Ipp et al. Quark-gluon-plasma instabilities in discretized hard-loop approximation.

[9]P.Faccioli, F.Pederiva, S.Gandolfi. Nuclear Physics in Lattice Hamiltonian Effective Field.

"AFDMC" and "molcp" have recently exceeded the CPU time which was granted to them and applied for an estension that was accepted by the Board in the January 2008 meeting.

The first of the two figures below shows the usage of the cluster. It also indicates the period (about 2 weeks in september 2007) when the cluster was not available due to a failure of the cooling system. This is discussed below. The second figure shows the internal communication flow, which depends very much on the application (and it does not include APE3D communications).





5.2 Network connection with the external world

The network band available with the external world amounts presently at 4Mb/sec. In fact it was upgraded from 2Mb/sec last summer. Although this is still not optimal for the large amount of data that are expected to be exchanged in a cluster like BEN, it seems that this is currently sufficient.

Cooling system. The last failure of the cooling system happened last September, as already reported to the Board meeting in October. The temperature went above the limit and the machine shutted down authomatically. That caused a serious failure of an important disk. However, everything was recovered and the full machine was up again after a couple of weeks.

File System and Queue System. This year the behaviours of the file system and the queue system were quite stable. That means that the problems that we had in 2006 are essentially solved, as we hoped at the end of 2006.

Front-end machine. The front-end machine experienced a few unexpected crashes. If this phenomenon should be more frequent we will have to consider the substitution of the front-end.

New users approved by the Borad in October 2007. The only new project approved by the Board on October 2007 is "lattham". The principal investigator (P.Faccioli) has already good experience with the BEN cluster.
New software. No new software was installed in 2007.
APE3D network cards. Last year the INFN group of Roma and Eurotech collaborated to implement a version of MPI which is fully MPI compatible and also stable. This is very important for the use of the APE3D network in this cluster. Since november 2007 the final version is available. We ported such implementation in our system and also adapted the firwmare of one rack to this purpose. All tests were positive.

5.3 Overview of the projects running in 2007.

The table above shows the resources used by the jobs running under the queue system (i.e. excluding APE3D). The machine was used mainly by 9 groups: AFDMC, thermqcd, NSPT, NLMCHPF, molcp, pH2wave, BECPCF, qnsu and lattham. The others are mainly test runs. I report below some informations about each of these groups.

5.4 Abstracts from the projects

Group: AFDMC

- [People:] Francesco Pederiva, Stefano Gandolfi

- [Title:] Study of ground state properties of light nuclei and neutron matter with the Auxiliary Field Diffusion Monte Carlo (AFDMC) method.

- [Abstract:] We perform calculations of nuclear systems with the Auxiliary Field Diffusion Monte Carlo method. The aim of AFDMC technique is to solve the many-body Schrodinger equation for A nucleons interacting with realistic NN-potential (of the Argonne-type). In particular, we studied the equation of state of symmetric nuclear matter with the Argonne v_6' interaction (Phys.Rev.Lett. 98 (2007) 102503) and the properties of several nuclei. We also performed calculations to study properties of neutron rich isotopes of calcium (nucl-th/0605064 to be published in EPJA). At present we are working to include three-body and spin-orbit forces in the nuclear Hamiltonian, and we are studing properties of three-body forces in pure-neutron systems (neutron drops).

Group: thermqcd

People: Frithjof Karsch, Masakiyo Kitazawa

Title: First principle calculation for spectral properties of quarks in the quark-gluon plasma

Abstract: Hot hadronic matter undergoes a phase transition to the quark- gluon plasma (QGP) phase at high temperature. We explore the quasi-particle picture of quarks, the most basic degrees of freedom in Quantum Chromodynamics (QCD), in the QGP phase using the lattice QCD Monte Carlo simulations. We intend to determine the quasi-particle

mass of quarks in the QGP phase for the first time. This study utilizes existing lattice gauge configurations generated for the analysis of hadron spectral functions earlier. Still a sizable amount of CPU time is needed to analyze these data sets within our project.

Group: NSPT

People: Y. Schroeder , F. Di Renzo, M. Laine, C. Torrero, V. Miccio

Title: NSPT for 3d gauge theories.

Abstract: Three-dimensional (3d) gauge theories are interesting for several independent reasons. Theoretically, they are simpler than four-dimensional (4d) theories in that they are superrenormalisable, yet equally non-trivial in that they display confinement and other nonperturbative phenomena. Phenomenologically, they describe the thermodynamic properties of 4d physical theories, particularly QCD, at very high temperatures. Motivated by the latter aspect, namely the reliable determination of the pressure of hot QCD at very high temperatures, we wish to make use of the former aspect, namely the possibility to obtain non-perturbative results from lattice Monte Carlo simulations of 3d gauge theories, if the perturbative ultraviolet divergences are computed up to a sufficient loop order. More precisely, we wish to determine the renormalisation constants needed for certain effective gluon condensates, by using numerical stochastic perturbation theory (NSPT). Part I of the project has been completed, and it has demonstrated that BEN meets the demands of this project in an optimal way. In Part II we wish to determine the renormalisation constants for the remaining effective gluon condensates. With the help of BEN, we have published a proof-of-concept of our strategy. For precision results, we would need to run our codes for a larger set of parameters.

Group: NLMCHPF

People: Paolo Verrocchio.

Title: Non-local Monte Carlo algorithm for highly polydisperse fluids.

Abstract: We aim to study the freezing transition in a polydisperse model which is well suited to describe both colloids and glass-formers. The numeric simulation will be based on the local swap Monte Carlo algorithm, which turned out to reduce dramatically both the relaxation time and the freezing time. Focusing on the frozen phase, we shall investigate the structural differences between the solid with small polydispersity and the highly polydisperse one.

Group: molcp

People: V. Minicozzi, F.Stellato, G. La Penna, S. Morante, G.C. Rossi

Title: Study of aggregation processes in proteins: Prion Protein and beta-Amyloid peptides

Abstract: By using first principle ab initio Molecular Dynamics simulations of the Car-Parrinello type, the coordination modes of Cu and Zn to the binding sites of the prion and $\beta-$ Amyloid proteins are investigated. Despite the large amount of available experimental data, many details of structural modifications involved in the aggregation process in the presence of metals are still unclear. *Ab initio* quantum mechanical simulations are a unique tool for a parameter-free investigation of such problems. Since large numbers of atoms with many electrons are involved, investigations of this type are well suited for a Linux Cluster architecture, owing to the existence of high-performance libraries and well adapted codes.

Group: pH2wave

People: Francesco Pederiva, Francesco Operetto

Title: Study of high pressure properties of defective solid pH2 with Shadow Wave Functions.

Abstract: We employ the SWF formalism in conjunction with variational Monte Carlo methods to study high pressure properties of solid pH2 at temperature T=0 in presence of vacancies and impurities. In particular we want to address the destructuring of the crystal due to the presence of vacancies, the vacancy-vacancy correlation, and the possible phase separation in the solid with impurities when the impuruty concentration increases.

Group: BECPCF

People: D. Binosi, G. de Chiara, S. Montangero and A. Recati

Title: Increasing entanglement through noise.

Abstract: The ground state entanglement entropy between block of sites in the random Ising chain is studied by means of the Von Neumann entropy. We show that in presence of strong correlations between the disordered couplings and local magnetic fields the entanglement increases and becomes larger than in the ordered case. The different behavior with respect to the uncorrelated disordered model is due to the drastic change of the ground state properties. The same result holds also for the random 3-state quantum Potts model.

Group: qnsu

People: Andreas Ipp, Maximilian Attems, Anton Rebhan, Paul Romatschke, Michael Strickland

Title: Quark-gluon-plasma instabilities in discretized hard-loop approximation

Abstract: This work will be a memory- and calculation-intensive extension of a work by AR, PR, and MS [1, 2] where the real-time evolution of instabilities in non-Abelian plasmas with a momentum-space anisotropy has been studied using a hard-loop e ective theory that is discretized in the velocities of hard particles. Previous results on the evolution of unstable modes in the gauge groups SU(2) and SU(3) in 1+1-dimensional and 3+1-dimensional simulations were limited only by the main memory of a desktop computer.

This constraint shall be avoided by splitting the simulation domain into smaller pieces that t into the main memories of the nodes of a calculation cluster. Finer discretization and larger lattice sizes will allow to more accurately study the late-time behavior of anisotropic systems.

Group: lattham

People: P.Faccioli, S.Gandolfi, F.Pederiva.

Title: Nuclear Physics in Lattice Hamiltonian Effective Field Theory.

Abstract: The goal of this research line is to develop an ab-initio theoretical and computational framework to determine ground-state properties of nuclei and nuclear matter directly from the low-energy chiral Effective Field Theory (EFT) of QCD, using Montecarlo techniques. At present, calculations of nuclear binding energies based on the EFT framework are extremely challenging and therefore limited to very light nuclei. For example, lattice calculations of Borasoy and collaborators of the He-4 binding energy required a huge computational time on $\mathcal{O}(10^3)$ parallel CPUs.

6 ECT* Computing Facilities

6.1 Available computing resources

2 license servers:	2 PC (MATHEMATICA) [10 concurrent users] 1 PC (MATLAB) [2 concurrent users]
server:	6 Dell Intel Xeon 3GHz
computation servers:	1 Dell Intel Xeon 3GHz 1 AMD Opteron 2GHz
26 PC for staff and local research:	Pentium III up to 866 MHz Pentium IV up to 2.8 GHz BI-PROC. Pentium III up to 1 GHz BI-PROC. Pentium IV up to 1.6 GHz RACK
31 PC for users:	Pentium III up to 866 MHz Pentium IV up to 3 GHz BI-PROC. Pentium III up to 650 MHz Workstation Dell Optiplex GX280 Workstation Dell Optiplex GX620
1 Supercomputer EXADRON:	1 Front/End and 99 computers Communication Band width Gbit/second
1 cluster ALPS:	1 Front/End and 36 CPU Communication Band width Gbit/second
1 DELL:	Power Edge 1850 Bi-Processore Xeon 3 GHz