ECT*

Annual Report 2003

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

Preface

The year 2003 may well have been the most active one in the ten years' history of ECT*. A quick glance at the last page of this Annual Report, illustrating developments of the Centre's programmes in recent times, exemplifies the situation. In addition to the nineteen workshop projects, this year's Doctoral Training Programme on "Nuclear Structure" was generally considered a major success. Thanks go to Jacek Dobaczewski for the great intensity and the time he spent co-ordinating this programme together with colleagues in the Board.

The tenth anniversary of the Centre was celebrated in October with a symposium that reflected very well the broad scientific spectrum and the interdisciplinary character of ETC*. We are grateful to Gordon Baym who chaired a Board subcommittee co-ordinating the scientific programme of this memorable event (see section 4).

ECT*'s performance and infrastructure are monitored regularly through expert review pannels representing the users community and the funding agencies. In 2003 the Centre was under assessment by an international Review Committee chaired by Hans Weidenmüller (MPI Heidelberg). The Committee came to very positive conclusions and at the same time recommended improvements for the near future. One of those improvements concerns the necessity to strengthen the staff in response to the expansions of ECT* activities. Steps are being taken in this direction. Steps have also been taken in order to further improve and update the computing facilities and to strengthen the systems management at the Centre.

ECT* is entering its second decade with confidence. Nevertheless some concerns about the situation at the European level with respect to the Integrated Initiatives of the EC's 6th Programme cannot be denied. There has been an unfortunate splitting of the nuclear physics community into two such Initiatives: EURONS, representing nuclear structure and applications, and I3HP, representing the physics of hadrons and of matter under extreme conditions. This separation has a negative impact on ECT* which, by its mission, stands for the unity of these fields and encompasses both areas of research. One can hope that, should there be a 7th EC Programme in the future, the European nuclear physics community as a whole finds a way of acting together coherently in the spirit of the new NuPECC Long Range Plan.

In the very near future a new cornerstone of ECT* will be a cluster-based supercomputer in the Teraflop range, to be installed at the Centre's headquarters, Villa Tambosi. Following the initiative of Renzo Leonardi, the ECT* Scientific Secretary, this is a major joint venture in which the Province of Trento and the Istituto Trentino di Cultura, the Centre's generous local sponsor, act together with INFN, ECT* and the Exadron division of Eurotech, connecting basic science and high-tech industry.

This is the last Annual Report signed by the present director whose term ends in March 2004. Jean-Paul Blaizot (Saclay) will be the new director of ECT* starting from September 2004. Georges Ripka (Saclay and ECT*) will act as interim director from April 2004 until the end of August 2004. Marco Traini (Trento) has agreed to become vice director from spring 2004, strengthening the exchange between ECT* and the University of Trento. We are extremely glad to announce this smooth and efficient transition.

Last not least, I would like to express my sincere gratitude to the members of the ECT* team and their dedicated work that made the Centre run even in periods of extremely dense activities. Special thanks go to Francois Arleo, Luca Girlanda, Donatella Rosetti, Luana Slomp and Rachel Weatherhead for their assistance in preparing this report.

Wolfram Weise Director, ECT*

Contents

1 ECT* Board of Directors, Staff and Researchers

1.1 ECT* Board of Directors (BoD), Director and Scientific Secretary

ECT* Director:
Professor Wolfram Weise — ECT* and TU Munich

ECT* Scientific Secretary:
Professor Renzo Leonardi — ECT* and University of Trento

1.2 ECT* Staff

Ines Campo	Technical Programme Co-ordinator
Corrado Carlin	Maintenance Support Manager
Cristina Costa	Technical Programme Co-ordinator
Barbara Currò Dossi	System Manager
Tiziana Ingrassia	Accounts Assistant
Mauro Meneghini	Driver
Luana Slomp	Technical Programme Assistant
Rachel Weatherhead and Donatella Rosetti	Technical Programme Manager Assistant to the Directors
Gianmaria Ziglio	Web Manager

1.3 Resident Postdoctoral Researchers

François Arleo (France)

Tommaso Calarco (Italy) (from June 2003)

Pietro Faccioli (Italy)

Paolo Finelli (Italy)(from April 2003)

Luca Girlanda (Italy)

Daisuke Jido (Japan) (from April 2003)

Olivier Leitner (France) (from October 2003)

Barbara Pasquini (Italy) (until March 2003)

Francesco Pederiva (Italy)

Uffe Vestergaard Poulsen (Denmark) (from October 2003)

Akaki Rusetsky (Georgia) (until March 2003)

Dolores Sousa (Spain)

Pierfrancesco Zuccato (Italy) (from May 2003)

1.4 Marie Curie Fellows

Artur Blazkiewicz (USA/Poland)	University of Tennessee, Nashville
Stefan Fritsch (Germany)	Technical University of Munich
Uwe Heinzmann (Germany)	University of Mainz
Sara Perez Martin (Spain)	Autonomous University of Madrid
Cesar Fernandez Ramirez (Spain)	IEM Madrid
Ewan Roche (UK)	University of Edinburgh
Jorge Miguel Sampaio (Denmark/Portugal)	University of Aarhus

1.5 Visitors in 2003

This list includes Visiting Scientists (VS) who usually spend up to six weeks or longer at the Centre, Research Associates (RA) supported by other institutions, who visit ECT* regularly for joint projects, participants and lecturers of the Training Programme (TP – other than Marie Curie Fellows), and short-term visitors.

Jim Al-Khalili	University of Surrey, UK (TP)
Shufang Ban	University of Peking, China (TP)
Gordon Baym	University of Illinois at Urbana-Champaign, USA
Andrea Beraudo	University of Turin, Italy (TP)
Daniele Binosi	University of Valencia, Spain
Jean-Paul Blaizot	CEA Saclay, France
Mark Caprio	Yale University, USA (VS)
Greg Carter	University of Washington, Seattle, USA
Guy Chanfray	University of Lyon, France
Adriano Di Giacomo	University of Pisa, Italy
Jacek Dobaczewski	University of Warsaw, Poland (VS)
Magda Ericson	University of Lyon, France
Torleif Ericson	CERN, Geneva, Switzerland
Stefan Frauendorf	Notre Dame University, USA (TP)
Carla Fröhlich	University of Basel, Switzerland (TP)
Kalin Gladnishki	University of Sofia, Bulgaria (TP)
Arnaud Gnjady	IReS, Strasbourg, France (TP)
Maria Belen Gomez Hornillos	University of Liverpool, UK (TP)
Meinulf Göckeler	University of Leipzig, Germany
Harald Griesshammer	TU Munich, Germany (RA)
Ernest Grodner	University of Warsaw, Poland (TP)
Wick Haxton	University of Washington, Seattle, USA (TP)
Thomas Hemmert	TU Munich, Germany (VS)
Walter Henning	GSI, Darmstadt, Germany
Wolfgang Hillebrandt	MPI für Astrophysik, Garching, Germany
Jiri Hosek	Czech Academy of Sciences, Rez (Prague), Czech Republic
Francesco Iachello	Yale University, USA (VS)

Norbert Kaiser	TU Munich, Germany
Frantisek Knapp	University of Prague, Czech Republic (TP)
Evgeni Kolomeitsev	Niels Bohr Institute, Copenhagen, Denmark
Teiji Kunihiro	University of Kyoto, Japan
Ben Mottelson	NORDITA, Copenhagen, Denmark (TP)
Marco Martini	University of Torino, Italy (TP)
Gerald Miller	University of Washington, Seattle, USA (VS)
Alfredo Molinari	University of Torino, Italy (VS)
Jonathan Morris	Washington University, St-Louis, USA (TP)
Witek Nazarewicz	Oak Ridge National Laboratory, USA (TP)
Nicola Nikolov	University of Sofia, Bulgaria (TP)
Frédéric Nowacki	IReS, Strasbourg, France (TP)
Micaela Oertel	University of Lyon, France
Emma Maria Olsson	University of Uppsala, Sweden (TP)
Vijay Pandharipande	University of Illinois at Urbana-Champaign, USA (TP)
Barbara Pasquini	University of Pavia, Italy (VS)
Chris Pethick	NORDITA, Copenhagen, Denmark
Alberto Polleri	TU Munich, Germany (VS)
Massimiliano Procura	TU Munich, Germany and ECT* (RA)
Cesar Ramirez Fernandez	IEM, Madrid, Spain (TP)
Claudia Ratti	TU Munich, Germany and ECT* (RA)
Achim Richter	TU Darmstadt, Germany (TP)
Georges Ripka	CEA, Saclay, France (VS)
Jérome Roccaz	CSNSM, Orsay, France (TP)
Tomas Rodriguez	Autonomous University of Madrid, Spain (TP)
Gerrit Schierholz	DESY, Hamburg and Zeuthen, Germany
Leonid Schvedov	INS, Swierk, Poland (TP)
Norberto Scoccola	CNEA, Buenos Aires, Argentina (VS)
Sandro Stringari	University of Trento, Italy
Friedel Thielemann	University of Basel, Switzerland (TP)
Anthony W. Thomas	CSSM and University of Adelaide, Australia
Isaac Vidana	University of Pisa, Italy
Dario Vretenar	University of Zagreb, Croatia
Hans Weidenmüller	MPI für Kernphysik, Heidelberg, Germany
Michael Wiescher	Notre Dame University, USA (TP)
Nicolas Wschebor	CEA Saclay, France (VS)

2 Projects in 2003

24 Feb.–1 Mar. **Complex Systems of Hadrons and Nuclei: 6th Lecture Week of the European Graduate School Copenhagen-Giessen**
Organisers: V. Metag (Co-ordinator) (*Univ. Giessen*),
W. Cassing (*Univ. Giessen*) [p. 10]

3–4 Mar. **ALICE TRD collaboration meeting**
Organisers: J. Stachel (Co-ordinator) (*Univ. Heidelberg*),
P. Braun-Munzinger (*GSI Darmstadt*),
J. Wessels (*Univ. Münster*) [p. 11]

10–17 Mar. **Aspects of Confinement and Nonperturbative QCD**
Organisers: R. Alkofer (Co-ordinator) (*Univ. Tuebingen*),
E. Swanson (*Univ. Pittsburgh*),
A. W. Thomas (*Univ. Adelaide and CSSM*),
A. G. Williams (*Univ. Adelaide and CSSM*) [p. 12]

28–29 Mar. **BCPL collaboration meeting**
Organiser: L. Csernai (Co-ordinator) (*Univ. Bergen*) [p. 14]

31 Mar.–4 Apr. **Compton Scattering from Low to High Momentum Transfer**
Organisers: C. Weiss (Co-ordinator) (*Univ. Regensburg*),
B. Pasquini (*ECT* Trento*),
M. Vanderhaegen (*Univ. Mainz*) [p. 16]

19–23 May. **Transport Theories for Heavy-Ion Reactions**
Organisers: E. Kolomeitsev (Co-ordinator) (*NBI Copenhagen*),
J. Aichelin (*Subatech Nantes*),
H. Oeschler (*GSI Darmstadt*),
N. Xu (*LBNL Berkeley*) [p. 18]

26–30 May. **Random Matrices in Subatomic Physics**
Organisers: T. Guhr (Co-ordinator) (*Univ. Lund*),
T. Wettig (*Yale Univ.*) [p. 19]

2–6 Jun. **Contributions of Short and Long-range correlations, to Nuclear Binding and Saturation**
Organisers: W. H. Dickhoff (Co-ordinator) (*Washington Univ., St. Louis*),
A. Polls (*Univ. Barcelona*),
M. Baldo (*INFN Catania*) [p. 22]

16–21 Jun. **Weak Interactions in Nuclei and Astrophysics: Standard Model and Beyond**
Organisers: C. Volpe (Co-ordinator) (*IPN Orsay*),
B. Balantekin (*Univ. Wisconsin-Madison*),
S. Jullian (*LAL Orsay*) [p. 24]

22–29 Jun. **Color Glass Condensate and Parton Percolation**
Organisers: H. Satz (Co-ordinator) (*Univ. Bielefeld*),
L. McLerran (*BNL Brookhaven*), [p. 27]

29 Jun.–12 Jul. **Recent Advances in the Nuclear Shell Model**
Organisers: A. Zuker (Co-ordinator) (*IReS, IN2P3 Strasbourg*),
J. Dukelsky (*CSIC Madrid*),
S. Pittel (*Univ. Delaware*) [p. 28]

21–25 Jul. **Density Functional Theory in Nuclear Structure**
Organisers: P.G. Reinhard (Co-ordinator) (*Univ. Erlangen*),
M. Stoitsov (*Bulgarian Acad. of Sciences*) [p. 30]

1–6 Sept. **Critical Stability of Few-Body Quantum Systems**
Organisers: A. Jensen (Co-ordinator) (*Univ. Aarhus*),
J.M. Richard (*Univ. Joseph Fourier*) [p. 31]

14–20 Sept. **Nuclear Mean-Field: Symmetries and Spontaneous Symmetry Breaking**
Organisers: S. Frauendorf (Co-ordinator) (*Notre Dame Univ.*),
J. Dudek (*Univ. Strasbourg and IReS*) [p. 34]

21 Sept.–4 Oct. **Thermonuclear Supernovae and Cosmology**
Organisers: W. Hillebrand (Co-ordinator) (*MPI Munich*),
M. Turatto (*Padova Observatory*),
R. Canal (*Univ. Barcelona*) [p. 37]

13–17 Oct. **Hadronic Atoms**
Organisers: A. Rusetsky (Co-ordinator) (*ECT*, Univ. Bonn*),
L. Afanasyev (*CERN and Dubna*),
J. Gasser (*Univ. Bern*),
V. Lyubovitskij (*Univ. Tuebingen*),
L. Nemenov (*CERN and Dubna*),
J. Schacher (*Univ. Bern*),
H. Sazdijan (*IPN Orsay*),
D. Trautmann (*Univ. Basel*) [p. 40]

20–24 Oct. **Nuclear Response under Extreme Conditions**
Organisers: P.F. Bortignon (Co-ordinator) (*Univ. Milan*),
N. Van Giai (*IPN Orsay*),
H. Sagawa (*Univ. Aizu, Japan*),
G. Colo' (*Univ. Milan*) [p. 42]

10–14 Nov. **Role of Pions and Deltas in Nuclear Many-Body Dynamics (collaboration meeting)**
Organisers: A. Molinari (Co-ordinator) (*Univ. Turin*),
T. W. Donnelly (*MIT*) [p. 44]

26–28 Nov. **Shape Coexistence in Nuclei at High Angular Momentum (EUROBALL collaboration meeting)**
Organiser: H. Huebel (Co-ordinator) (*Univ. Bonn*) [p. 45]

3 Report on Scientific Activities

3.1 Summary

As in the previous years, ECT*'s scientific events in 2003 covered a wide range of research in nuclear physics and related areas. Altogether 19 projects were accepted, with a total of more than 800 participants. Active exchange between theory and experiment was a key feature of the majority of these programmes. All projects were performed by selected international groups of experts from Europe and around the world, and further efforts were made to support PhD students and young postdoctoral researchers.

Present frontier developments and future perspectives were discussed and explored in the following fields:

Nuclear structure and reactions

The project on "Recent advances in the nuclear shell model" brought together the experts in this area of research and gave an impressive account on the state-of-the-art and the steadily increasing computational capacity of modern shell model calculations. The detailed understanding of "Contributions of short- and long-range correlations to nuclear binding and saturation" was in the focus of lively exchanges between the participants of this session which updated important developments in nuclear many-body theory. The projects on "Density functional theory in nuclear structure" and "Nuclear mean field: symmetries and spontaneous symmetry breaking" concentrated on theoretical concepts and computational methods under these headings, with special emphasis on fruitful interdisciplinary exchange. "Nuclear response under extreme conditions" reviewed theory and experiments investigating the response of exotic nuclear systems to various probes. Finally, an intense specialized meeting on "Shape coexistence in nuclei at high angular momentum" was held by the EUROBALL collaboration.

Astrophysics

The project "Weak interactions in nuclei and astrophysics: standard model and beyond" brought together experimentalists and theorists working on topics at the interface between nuclear physics, high energy physics and astrophysics. The extended programme on "Thermonuclear supernovae and cosmology" surveyed the rapid developments in this lively field. This project, through its combination of an active research group meeting and a high-level international workshop, figured as one of the highlights of the year.

QCD and hadron physics

ECT* hosted the European Graduate School "Complex Systems of Hadrons and Nuclei", jointly organized by institutions in Giessen and Copenhagen, on the occasion of their 6th lecture week. The project "Aspects of confinement and non-perturbative QCD" focused on recent progress and challenges including lattice gauge theory, QCD vacuum condensates, many-body and Schwinger-Dyson approaches, and modeling of non-perturbative phenomena, in active discussions involving both the leading experts in the field and young postdocs and graduate students. "Compton scattering from low to high momentum transfer" was an intense meeting which strengthened the cooperations between experimentalists and theorists in this area and beyond. "Hadronic atoms (HADATOM 03)", the fifth in a series of international workshops now held for the first time at ECT*, summarised current precision experiments investigating pionic and kaonic atoms and their theoretical understanding. The meeting on the "Role of pions and deltas in nuclear many-body dynamics" explored the importance of pions as Goldstone bosons and of the nucleon's spin-isospin excitations in the context of nuclear response functions.

Matter under extreme conditions

The project on "Transport theories for heavy-ion reactions" at high energies examined a variety of calculations by different groups as to their common theoretical basis and consistency. Proposed experimental signals for quark-gluon plasma formation were explored in a highly stimulating meeting on "Color glass condensate and parton percolation". Charmonium suppression, jet quenching and strangeness enhancement in nuclear collisions at the highest avaliable energies were discussed in this framework. A further project brought together members of the ALICE collaboration to elaborate the physics goals and the design of their transition radiation detector, aimed at reconstructing charmonium and bottomonium events in nuclear collisions at CERN LHC.

Related areas

As in previous years, the interdisciplinary component of ECT*'s activities was emphasised by several projects which promoted the exchange beyond the boarders of specialised subfields. Some programmes provided links between nuclear physics, subnuclear physics and astrophysics, others explored concepts in many-body theory common to nuclear and condensed matter physics. In a similar spirit, the project "Random matrices in subatomic physics" brought together researchers working on matrix models in nuclear physics, quantum chromodynamics, quantum gravity and string theory, and the meeting on "Critical stability of few-body quantum systems" attracted experts worldwide representing various fields of physics in which interesting few-body problems at the edge of stability are confronted.

3.2 Projects and Collaboration Meetings

1. COMPLEX SYSTEMS OF HADRONS AND NUCLEI: LECTURE WEEK OF THE EUROPEAN GRADUATE SCHOOL COPENHAGEN-GIESSEN

DATE: 24 Feb–1 March

ORGANISERS:
G. Metag (Co-ordinator) (*Univ. Giessen*), W. Cassing (*Univ. Giessen*), U. Mosel (*Univ. Giessen*)

NUMBER OF PARTICIPANTS: 44

MAIN TOPICS:

- RHIC Spin and the Spin Structure of the Proton (G. Bunce)
- Heavy Ion Physics at Collider Energies (A. Drees)
- Chiral Symmetry and the Partonic Structure of the Nucleon (K. Goeke)
- Baryon Resonance Structure and Transitions (D.O. Riska)
- Climate Variability during the last 1000 years (E. Bauer)

SPEAKERS:
E. Bauer (*La Plata Univ.*),
G. Bunce (*RIKEN BNL*),
A. Drees (*Brookhaven*),
K. Goeke (*Ruhr Univ. Bochum*),
D. O. Riska (*Helsinki Univ.*)

SCIENTIFIC REPORT:

The lecture week at the ECT* was part of the lecture weeks program of the European Graduate School Giessen-Copenhagen on 'Complex Systems of Hadrons and Nuclei', which are held twice per year in different locations. The central aim of these lecture weeks is the education of graduate students by leading scientists on actual fields of research as well as on a selected interdisciplinary topic, which was on 'Climate variability during the last 1000 years' this time. The graduate students from the Giessen-Copenhagen school as well as from outside institutions get the opportunity to discuss central questions as well as general concepts with the experts on the fields during the coffee breaks as well as the common lunches and dinners. In addition the graduates have the chance to present their own research results to an international audience and to introduce their own expertise to the participants. Furthermore, discussions (dominantly) between the lecturers and Professors are intended to map out the actual questions in more detail and set up future collaborations or common projects. We also point out, that the scientists from the ECT* frequently joined the lectures and very actively took part in the discussions. This created a very lively atmosphere that allowed to clarify a couple of scientific questions.

2. ALICE TRD COLLABORATION MEETING

(Collaboration Meeting)

DATE: 3–4 March

ORGANISERS:

J. Stachel (Co-ordinator) (*Univ. Heidelberg*), P. Braun Munzinger (*GSI Darmstadt*), J. Wessels (*Univ. Münster*)

NUMBER OF PARTICIPANTS: 43

MAIN TOPICS:

- Results from test beam measurements
- Gas properties
- Recent advances of read-out electronics
- Detector control and services
- Supermodule design and integration
- Status of chamber production
- Software status
- Planning

SPEAKERS:

A. Andronic (*GSI Darmstadt*),
V. Angelov (*Univ. Heidelberg*),
H. Appelshäuser (*Univ. Heidelberg*),
C. Blume (*Univ. Frankfurt*),
D. Bucher (*Univ. Münster*),
O. Busch (*GSI Darmstadt*),
V. Catanescu (*Univ. Heidelberg*),
S. Chernenko (*JINR Dubna*),
J. de Cuveland (*Univ. Heidelberg*),
V. Dodokhov (*JINR Dubna*),
D. Emschermann (*Univ. Heidelberg*),
C. Garabatos (*GSI Darmstadt*),
N. Herrmann (*GSI Darmstadt*),
T. Mahmoud (*Univ. Heidelberg*),
A. Marin (*GSI Darmstadt*),
V. Petracek (*Univ. Heidelberg*),
I. Rusanov (*Univ. Heidelberg*),
R. Schicker (*Univ. Heidelberg*),
M. Stockmeier (*Univ. Heidelberg*),
R. Tielert (*Univ. Kaiserslautern*),
G. Tsiledakis (*GSI Darmstadt*),
B. Vulpescu (*Univ. Heidelberg*),
B. Windelband (*Univ. Heidelberg*),
V. Yurevich (*JINR Dubna*),
Y. Zanevsky (*JINR Dubna*)

SCIENTIFIC REPORT:

The Transition Radiation detector for the ALICE experiment at the CERN LHC is the detector in the central barrel of ALICE to identify electrons. Its physics purpose is the reconstruction of charmonium and bottomonium states, of open charm and beauty, of the low mass vector mesons, of virtual photons and Drell-Yan electron pairs and to help in the identification of high momentum jets. A subset of the Alice collaboration with mainly groups from Germany but also collaborators from JINR Dubna and from Bucharest, Romania, is currently building the detector.

The collaboration has regular meetings, about twice per year, to assess the progree and status, to plan for the next year and to jointly discuss the solution of emerging problems. The meeting in Trento was such a meeting. It took place at a time when design of many components was near completion or completed and as various production readiness review were approached and construction of the detector proper was about to start. The meeting was considered very productive by all participant. At the following ALICE collaboration meeting a summary of the workshop was presented by J. Wessels. The presentations made at the workshop are accessible as files on the ALICE TRD web page to the entire collaboration.

3. ASPECTS OF CONFINEMENT AND NONPERTURBATIVE QCD

DATE: 10–17 March

ORGANISERS:
R. Alkofer (Co-ordinator) (*Univ. Tuebingen*), E. Swanson (*Univ. Pittsburgh*), A. W. Thomas (*Univ. Adelaide and CSSM*), A. G. Williams (*Univ. Adelaide and CSSM*)

NUMBER OF PARTICIPANTS: 34

MAIN TOPICS:

- Green's Function Methods and Dyson-Schwinger equations
- Lattice Gauge Theory
- Chiral Symmetry Breaking
- Light Cone Methods and Vacuum Models
- Experiment and Phenomenology

SPEAKERS:
R. Alkofer (*Univ. Tübingen*),
C. Amsler (*Univ. Zürich*),
M. Burkardt (*New Mexico State Univ.*),
W. Detmold (*Washington Univ.*),
R. Ent (*Jefferson Lab*),
P. Faccioli (*ECT**),
A. Feo (*Univ. Parma*),
C. Feuchter (*Univ. Tübingen*),
C. Fischer (*Univ. Tübingen*),
J. Greensite (*San Francisco State Univ.*),
H. Hueffel (*Univ. Wien*),
K.J. Juge (*Univ. Bern*),
A. Kalloniatis (*Univ. Adelaide*),
A. Kizilersu (*Univ. Adelaide*),
Y. Koma (*Max Planck Inst. für Physik*),
N. Ligterink (*Pittsburgh Univ.*),
A. Maas (*TU Darmstadt*),
P. Maris (*North Carolina State Univ.*),
D. Merten (*Univ. Bonn*),
M. Pepe (*Univ. Bern*),
H. Reinhardt (*Univ. Tübingen.*),
V. Sauli (*NPI Rez Prague*),
J. Skullerud (*Univ. Amsterdam*),
E. Swanson (*Pittsburgh Univ.*),
A. Szczepaniak (*Indiana Univ.*),
P.C. Tandy (*Kent State Univ.*),
A.W. Thomas (*Univ. Adelaide*),
P. van Baal (*Univ. Leiden*),

L. von Smekal (*Univ. Erlangen*),
A.G. Williams (*Univ. Adelaide*),
A. Wipf (*Univ. Jena*),
S. Wright (*Univ. Liverpool*),
D. Zwanziger (*New York Univ.*)

SCIENTIFIC REPORT:

Aim and Purpose: This workshop brought together a number of leading experts in the field of non-perturbative Quantum Chromo Dynamics (QCD) as well as postdoctoral researchers at the beginning of their career and a number of graduate students. The subfields of lattice gauge theory, Green's function methods, effective actions, topology of gauge fields, vacuum condensates, many-body approaches, Schwinger–Dyson formalism, chiral extrapolations, vacuum models, relativistic constituent gluon and quark models as well as quark-hadron duality have been represented.

Due to significant recent progress the exchange of experts as well as the dissimination of the most relevant results to young researchers has been one of the central focuses.

Most important results: As QCD is a Quantum Gauge Field Theory questions of gauge invariance and gauge fixing are of equally high importance to all of the above mentioned non-perturbative techniques. It is known now for more than twenty years that complete gauge fixing is practically impossible in QCD. Recent results of workshop participants that some of the related problems can be overcome (and in fact have been overcome already) have been presented and discussed in great detail. These results support the validity of calculations of QCD Green's functions in gauge-fixed lattice Monte Carlo simulations and methods based on Schwinger–Dyson equations.

First-principles lattice calculations of both the quark and gluon propagator as well as the quark-gluon vertex have been presented. Their use in verifying results from other approaches and in modeling hadron physics has been demonstrated. Chiral extrapolations of lattice data for several hadronic obeservables increased our understanding of the sensitivity of all hadron physics on the mass of the lightest hadron, the pion. Lattice calculations of electric and magnetic flux tubes provide not only an intuitive understanding of the QCD vacuum but have also proven to be important in developing further theoretical tools like effective actions or loop operators.

Studies of the system of Schwinger–Dyson and Bethe-Salpeter equations in the covariant gauge have increased our understanding of the infrared regime of QCD. Previous modeling assumptions have been refined, in several cases these assumptions have been replaced by definite results. E.g. dynamical chiral symmetry breaking can now be calculated from first principles in this approach. The comparison to lattice results hereby verifies the validity of the corresponding computations. Thus the basis for significantly improved calculations of form factors and hadron reactions has been laid out. It has been demonstrated that hadronic reactions like $\pi - \pi$ scattering are successfully described and provide a justification for meson-exchange models.

Many-body approaches to Coulomb gauge QCD have seen recent successes, e.g. an understanding of the difference between the asymptotic linear rising heavy-quark potential and its different contributions have been gained. The string tension produced by Coulomb gluons is hereby significantly larger than the asymptotic, i.e. phenomenological, one. Quark confinement can be obtained in a first-principle Green's function many-body calculation. Also here a refinement of respective models is to be expected in the near future. Lattice calculations, especially ones investigating the string picture of QCD, will provide further guidance. These will then help in the identification of glueballs. The latter is complicated by the fact that mixing between glueballs and ordinary mesons occur.

An analysis of a gauge theory based on the group $G(2)$ and its continueous deformation into QCD via a partial Higgs mechanism has been presented. Even before corresponding lattice simulations have started it provided already insight into the topological properties of some gauge field configurations, and here especially chromomagnetic monopoles and center vortices. An identification of the confining field configurations of QCD seems to arise via this method.

The understanding of nucleon spin asymmetries has been discussed in the light-front quantization. Furthermore, a physical interpretation of generalized parton distributions based on impact parameter dependent parton distributions along was presented.

Experimental evidence for quark-hadron duality has been presented. Data on electromagnetic form factors of the nucleon based either on polarized measurements or on the Rosenbluth separation are contradictory. Further theoretical insights into these form factors are certainly needed. This is complicated by the fact that non-perturbative contributions dominate the nucleon electromagnetic form factors even at momenta transfers of tens of GeV^2. It has been pointed out that our understanding of the nucleon depends crucially on the solution of this issue.

4. BCPL USER GROUP MEETING ON COMPUTATIONAL PHYSICS

(Collaboration Meeting)

DATE: 28–29 March

ORGANISERS:
L. Csernai (Co-ordinator) (*Univ. Bergen*),

NUMBER OF PARTICIPANTS: 11

MAIN TOPICS:

- Nuclear, particle, atomic and molecular reaction modelling
- Fluid- and continuum dynamics
- Quantum mechanical and quantum field theoretical dynamical modelling

SPEAKERS:
P. Bjorstad (*Univ. Bergen*),
L. Csernai (*Univ. Bergen*),
A.Keränen (*Univ. Oulu*),
P. Lichard (*Silesian Univ., Opawa*),
V. Magas (*IST Lisbon*),
Z. Neda (*Babes-Bolyai Univ., Cluj*),
G. Papp (*Eötvös Univ., Budapest*),
D. Strottman (*LANL, Los Alamos*),
Z. Stuchlik (*Silesian Univ., Opawa*),
M. Voit (*Univ. Bergen*),
G. Wolf (*KFKI RMKI, Budapest*)

SCIENTIFIC REPORT:

The Bergen Computational Physics Laboratory (BCPL) is an EU Research Infrastructure which offers scientific assistance and world class supercomputing power to researchers from EU member states and Associated states. The primary scientific target areas of the BCPL are nuclear, particle, atomic and molecular reaction modelling, using Monte Carlo transport theoretical descriptions, fluid- and continuum-dynamics, quantum mechanical and quantum field theoretical dynamical modelling.

Some scientific highlights from the workshop:

Particle Physics

In the project "Three-body initial states in charmonium dissociation" from Sylesian University, Czech Republic, led by P. Lichard, the main goal of the whole project was to calculate the contribution to the charmonium dissociation from the three-initial-meson reactions in a hadron gas.

High energy subatomic reactions

Several projects addressed these reactions with microscopic transport models, while others used continuum or CFD approaches to evaluate the collective effects in these reactions. These included Meson-Nucleon Scattering (KFKI, Budapest, by G. Wolf) and Meson Production (ELTE, Budapest, by G. Papp).

Another project, led by V. Magas, Lisbon, Portugal was working on the interface between the CFD module of the reaction simulation and of the so-called Freeze Out module. This module describes the stage of the reaction where mechanical, thermal and chemical equilibrium ceases to exist at the end of the reaction, and the final observables develop.

D. Strottman from Los Alamos National Laboratory held a presentation "Advances in Three-Dimensional Relativistic Hydro Codes". He discussed the progress arising from the exponentially increased computer memory and faster processing speed for fluid dynamical applications for high-energy subatomic physics.

Atomic Physics

Project no. 21 "Electron transitions in atoms and molecules" led by L. Nagy, Cluj, Romania addressed the problems of: 1. Inner-shell excitation and two-electron transitions in atoms. 2. Ionization and fragmentation of fullerenes by charged particle impact. 3. One and two-electron transitions in the hydrogen molecule.

Astrophysics

In the project on "Cooling of Extremely Compact Stars" led by Z. Stuchlik of Silesian University, Opava, Czech Republic, the study of neutron, quark, and hybrid stars was concentrated on diverse topics leading to the problem of cooling of extremely compact stars.

Statistical Physics

An interesting and very abstract idea is the base of a project by Z. Neda, of Cluj, Romania: "Statistical physics approach to clusterization phenomena in sociological systems".

Conclusion: The workshop objectives have been achieved and the workshop was a success. The participants could learn about each other's research activities and it can also be the foundation of future cooperation between various European physics projects.

5. COMPTON SCATTERING FROM LOW TO HIGH MOMENTUM TRANSFER

DATE: 31 March–4 April

ORGANISERS:
C. Weiss (Co-ordinator) (*Univ. Regensburg*), B. Pasquini (*ECT**), M. Vanderhaegen (*Univ. Mainz*)

NUMBER OF PARTICIPANTS: 54

MAIN TOPICS:

- Dispersion relations and sum rules: From real to virtual Compton scattering
- Generalized GDH sum rule: Theory and experiment
- Quark–hadron duality in Compton–like processes
- Generalized parton distributions and their uses
- Soft–pion theorems and chiral corrections in high–Q^2 processes
- Deeply–virtual Compton scattering: Status and prospects
- Crossed–channel Compton scattering: $\gamma\gamma \to$ hadron hadron
- Timelike processes and double deeply virtual Compton scattering
- Two-photon exchange processes in elastic electron-nucleon scattering
- High-energy ("small-x") limit of Compton-like processes

SPEAKERS:
P. Bertin (*Univ. B. Pascal, Aubiere*),
A. Braghieri (*INFN Pavia*),
M. Burkardt (*New Mexico Univ.*),
V. Burkert (*Jefferson Lab*),
J.P. Chen (*Jefferson Lab*),
M. de Jager (*Jefferson Lab*),
R. De Vita (*INFN Genova*),
N. d'Hose (*CEA Saclay*),
R. Ent (*Jefferson Lab*),
A. Fantoni (*LNF-INF Roma*),
L. Favart (*Univ. Bruxelles*),
H. Fonvieille (*Univ. B. Pascal, Aubiere*),
A. Freund (*Univ. Regensburg*),
M. Gorchtein (*Univ. Genova*),
H. Griesshammer (*TU Munich*),
M. Guidal (*IPN Orsay*),
R. Jacob (*Univ. Wuppertal*),
C.V. Kao (*Univ. Manchester*),
N. Kivel (*Univ. Regensburg*),
B. Krauss (*Univ. Erlangen*),
G. Laveissière (*Univ. B. Pascal, Aubiere*),
F. Maas (*Univ. Mainz*),
U. Meissner (*Univ. Bonn*),
W. Melnitchouk (*Jefferson Lab*),

H. Merkel (*Univ. Mainz*),
A. Mukherjee (*Univ. Dortmund*),
D. Müller (*Univ. Wuppertal*),
M. Osipenko (*INFN Genova*),
B. Pasquini (*Univ. Pavia*),
P. Pobylitsa (*Univ. Bochum*),
M. Radici (*INFN Pavia*),
M. Schumacher (*Univ. Göttingen*),
P. Schweitzer (*Univ. Pavia*),
B. Seitz (*Univ. Giessen*),
T. Spitzenberg (*Univ. Mainz*),
L. Tiator (*Univ. Mainz*),
M. Traini (*Univ. Trento*),
M. Vanderhaegen (*Univ. Mainz*),
A. Vassallo (*Univ. Genova and INFN*),
T. Walcher (*Univ. Mainz*),
C. Weiss (*Univ. Regensburg*),
B. Wojtsekhowski (*Jefferson Lab*),
Ji Xiangdong (*Univ. Maryland*)

SCIENTIFIC REPORT:

Aim and Purpose: Compton scattering - both real and virtual - has been one of the main sources of information about the structure of hadrons. This process has extensively been studied in various kinematical limits, using appropriate expansion techniques: Low energies (polarizabilities, chiral perturbation theory), high energies (Regge theory), and large momentum transfers (QCD factorization, generalized parton distributions). Progress in theory and experiment (MAMI, ELSA, JLAB, HERMES) requires increasing cooperation between these traditionally separate fields. The aim of the workshop is to bring together researchers working on low-energy, high-energy, and deeply-virtual Compton scattering. The common theme will be the (virtual) Compton amplitude and its rich physical properties. Particular emphasis will be put on approaches connecting different kinematical regions, such as dispersion relations, generalized GDH sum rule, quark-hadron duality, etc. The program includes review lectures on central topics as well as more specialized contributions.

Achievements:

- Reviewed current status of experimental investigation of Compton–like processes and their theoretical description
- Identified various direction for future studies; in particular, future experiments in real and deeply–virtual Compton scattering
- Strengthened cooperation between experimentalists and theorists
- Brought together researchers working on electron–beam (JLAB, HERMES, COMPASS, HERA) and hardon beam (GSI) experiments in order to create a new community
- Transferred expertise between various areas of specialization in the theoretical description of Compton–like processes: Dispersion relations, chiral perturbation theory, QCD factorization

6. TRANSPORT THEORIES FOR HEAVY-ION REACTIONS

DATE: 19–23 May

ORGANISERS:
E. Kolomeitsev (Co-ordinator) (*NBI Copenhagen*), J. Aichelin (*Subatech, Nantes*), H. Oeschler (*GSI, Darmstadt*), N. Xu (*LBNL*)

NUMBER OF PARTICIPANTS: 42

MAIN TOPICS:

- Recent achievements in transport theory and in the understanding of particle properties and reactions in dense and hot nuclear matter
- Detailed comparison of the available transport codes among each other and with the experimental data

SPEAKERS:
H. Barz (*FZ Rossendorf*),
E. Bratkovskaya (*Univ. Giessen*),
P. Danielewicz (*Michigan State Univ*),
T. Gaitanos (*LNS Catania*),
E. Kolomeitsev (*Univ. Copenhagen*),
S. Leupold (*Univ. Giessen*),
F. Liu (*Univ. Frankfurt*),
M. Nekipelov (*IKP Jülich*),
H.G. Ritter (*Berkeley*),
L. Tolos (*Univ. Barcelona*),
M. van Leeuven (*NIKHEF Amsterdam*),
N. Xu (*Berkeley*),
E. Zabrodin (*Univ. Tübingen*)

SCIENTIFIC REPORT:

Objectives: Advent of new experimental data gained at SIS and SPS facilities allows to put further constrains on the available transport programs. The initial stage of the collision at the beam energy about 1.5-2 GeV per nucleons is similar to the final stage of the collisions at about 200 GeV per nucleon. Therefore, it is important to control how the very same numerical codes are able to describe high-energy collisions at SPS and the low-energy energy collisions at SIS.

On the theoretical side, the substantial progress in the quantum kinetical theory has been achieved. The rigorous derivations of the "conserving" approximations to transport (kinetic) equations have been formulated for particles with a large width. Next step is to extend descriptions of particle propagation in hot and dense matter, formulated so far for systems in equilibrium, to dynamically evolving systems out of equilibrium.

Aim and Purpose: It was the purpose of this workshop to discuss the first benchmark tests for transport theories at SIS and SPS energies. In the past these theories have served the purpose to interpret the experimental results. This they did very successfully but they were never tested against each other. Consequently, there was never really verified that the programs which consist typically of several thousand lines give the same results if the same input (like cross sections and potentials) is employed. The homework, which all the groups accepted to do, showed that at SIS energies for the majority of observables the results are in between the errorbars. There remain, however, several more complex variables, like the yield of kaons and antikaons where the results still differ. This will be straightened out in near future. For the programs dealing with SPS physics the recent analysis of pp data present a challenge which is not met by all programs. It was the purpose of this meeting to discuss the experimental results and the theoretical improvements which will allow for an improvement of these simulation programs. A second round of homeworks have been discussed which will allow to nail down the differences in more detail.

Achievements: At low energies (SIS energies) the fact that all programs predict the same rapidity and transverse momentum distribution for protons and pions came as a surprise in view of the complexity of the different approaches. These results confirmed that the basic dynamics of heavy ion collisions is under control. The discrepancies in the kaon and antikaon yield has been discussed and possible sources have been identified. In a second round of homework assignments these differences will be addressed and most probably their physical origin will be understood. If this becomes true we are approaching the desired result that all the different simulation programs are validated and that discrepancies between prediction and experiment can be attributed to new physics. At SPS energies the situation is more complicated because there is much less consensus of how to treat the elementary reactions. Here models which use quantum mechanical amplitudes are confronted to other models which use convolutions of *pp* scattering or classical approaches. Nevertheless the discussion pointed out the range of applicability and the reason of failure of certain models in restraint regions of phase space. This allows for an improvement of these models. Here also a new homework assignment will help to clarify the situation and to discard insufficient models. Experts from the field of hadron physics and quantum transport theories have communicated in a series of contributions their point of view of how to improve the present models. Off shell propagation, unitarity and detailed balance in reaction in which a multitude of particles appear in the exit channels are keywords of some of these contributions. It is evident that these improvement on theoretical side will be soon realized in the simulation programs.

7. RANDOM MATRICES IN SUBATOMIC PHYSICS

DATE: 26–30 May

ORGANISERS:
T. Guhr (Co-ordinator) (*Univ. Lund*), T. Wettig (*Yale Univ.*)

NUMBER OF PARTICIPANTS: 34

MAIN TOPICS:

- Random matrices in nuclear physics, quantum chromodynamics, and quantum gravity/string theory

SPEAKERS:

S. Åberg (*Lund*),
G. Akemann (*Gif-sur-Yvette*),
B. Balantekin (*Madison*),
L. Benet (*Orsay*),
W. Bietenholz (*Berlin*),
O. Bohigas (*LPTMS Orsay*),
P. Damgaard (*København*),
J. de Boer (*Amsterdam*),
Y. Demasure (*København*),
Y. Fyodorov (*Uxbridge*),
T. Guhr (*Lund*),
A. Heine (*Darmstadt*),
F. Iachello (*Yale*),
E. Kanzieper (*Rehovot*),
C. Kristjansen (*København*),
D. Kusnezov (*Washington*),
H. Markum (*Wien*),
B. Mehlig (*Göteborg*),
G. Mitchell (*Raleigh*),
A. Monastra (*MPIK Dresden*),
T. Papenbrock (*Oak Ridge*),
M. Pato (*São Paulo/Orsay*),
A. Richter (*Darmstadt*),
T. Seligman (*Cuernavaca*),
S. Shcheredin (*Berlin*),
K. Splittorff (*København*),
B. Vanderheyden (*Liège*),
J. Verbaarschot (*Stony Brook*),
G. Vernizzi (*Gif-sur-Yvette*),
H. Weidenmüller (*MPI Heidelberg*),
W. Weise (*München/Trento*),
T. Wettig (*Yale*),
M. Zirnbauer (*Köln*)

SCIENTIFIC REPORT:

The aim of the workshop was to bring together researchers who use similar mathematical methods, in particular matrix models, in different areas of subatomic physics. This served a twofold purpose: One the one hand, the participants could learn about recent progress in fields that are related, but not identical, to their own fields of interest. On the other hand, they were exposed to new developments in matrix model "technology", which they could then use in their own research.

The first three days of the workshop started with overview talks about the applications of matrix models in nuclear physics (Weidenmüller), in quantum chromodynamics (Verbaarschot), and in quantum gravity and string theory (de Boer). Matrix model applications in nuclear physics were further discussed in talks by Richter, Mitchell, and Åberg. Benet, Seligman, and Papenbrock discussed new results on the embedded random matrix ensembles. The latter are random matrix models with a fixed k–body character of the interaction. This is much more realistic than standard random matrix models which contain all k–body interactions. Unfortunately, the embedded ensembles still resist an analytical treatment. Progress in quantum chromodynamics was addressed in talks by Damgaard, Markum, Vanderheyden, Akemann, and Shcheredin; and the applications in quantum gravity and string theory were further expounded by Kristjansen, Demasure, and Bietenholz.

There were also a number of talks about the use of random matrix theories in related areas. Bohigas and Monastra discussed the interplay of regular and chaotic motion in fermionic many body systems. They combine periodic orbit theory with random matrix approaches and arrive, among other things, at a remarkably improved understanding of nuclear masses. Fyodorov reviewed the use of random matrices in scattering theory. This has applications ranging from nuclear physics to mesoscopic systems and even to signal processing. Kusnezov spoke about driven non-equilibrium systems, and Mehlig about stochastic processes and random walks. Heine presented experimental results on microwave billiards which considerably help to understand the role of symmetries and invariances in chaotic systems and, in extension, in random matrix models. Pato introduced new ensembles of random matrices based on the concepts of Tsallis' entropy.

One of the highlights of the workshop was the talk by Zirnbauer who presented a new approach to a 10-year old idea known as "induced QCD". The idea here is to dynamically generate a Yang-Mills action by adding extra matter degrees of freedom to the theory. In the past, the only known way to do this was to introduce a large number N_f of heavy fermions with mass m and to take the rather inconvenient limits $N_f \to \infty$ and $m \to \infty$ such that N_f/m^4 is fixed. Zirnbauer showed how the same Yang-Mills action can instead be generated by adding a very small number of bosons that are coupled to the gauge field in a certain (local) way. This discovery is important since it will allow approaches based on the color-flavor transformation (which is intimately related to matrix model technology) to be applied to lattice quantum chromodynamics.

Talks about new developments in matrix model technology were given by Kanzieper, Splittorff, and Vernizzi. In particular, Kanzieper and Splittorff presented the solution to a long-standing problem concerning the replica trick. In this approach, one computes quantities for integer n and then needs to take the limit $n \to 0$. Analytical continuation is ambiguous in this case, and the procedure is known to fail in certain instances, usually when nonperturbative quantities are to be computed. The solution to this problem was found by identifying the mathematical structures arising in the course of the calculation with the Toda lattice equation, which allows analytic continuation to noninteger n and leads to a correct replica limit.

Finally, group theoretical methods were covered in the talks by Iachello, Balantekin, and Seligman. Iachello spoke about the interacting boson model and supersymmetry in this context. Balantekin and Seligman presented new approaches for the calculation of group integrals. This is of high practical relevance for random matrix applications. Balantekin introduced the character expansion. This is a powerful method which already led to a series of new results. Seligman presented an asymptotic method in which the full measure on the group is generated around the δ-functions fixing the orthonormality relations.

A number of important open problems were identified and discussed in the talks and discussions. Let us mention some examples:

- What is the systematics of the spectral fluctuations in low energy nuclear physics? — As Richter showed, there is, contrary to common belief, a high degree of regularity even in situations where traditionally a doorway picture is used.
- Can one analytically derive the fluctuation properties of the embedded random matrix ensembles? — This would enormously improve our understanding of why random matrices are so powerful in many body systems.
- The results presented by Bohigas and Monastra are a breakthrough for many body physics. Can they lead to a periodic orbit description of general many body systems? — This would yield a much better understanding of collective versus single particle effects.
- The mapping of the replica solution to the Toda lattice equation leads to the correct

final result, but it is not yet clear why. A firmer mathematical basis for this approach is needed.

- Zirnbauer's promising new approach to lattice gauge theory needs to be worked out in four dimensions and to be generalized to gauge group SU(3) to be applicable to real QCD. The color-flavor transformation also leads to a complex action problem that needs to be solved.
- Balantekin's and Seligman's approaches to group integrals could yield more explicit results, highly appreciated by the large community working with matrix models. However, both approaches need to be developed further: Can one extend Balantekin's approach to the most relevant case of other symmetric spaces? Can Seligman's approach be made exact by resumming the asymptotic expansion?
- Akemann and Vernizzi's calculation of the microscopic spectral correlations of the QCD Dirac operator at nonzero chemical potential should be generalized to include dynamical fermions.

The workshop was attended both by experienced researchers and by younger postdocs and graduate students. There was plenty of time for discussions, of which good use was made. The participants found the workshop very educating and stimulating. In other words, the goal of the workshop has been reached.

8. CONTRIBUTIONS OF SHORT AND LONG-RANGE CORRELATIONS TO NUCLEAR BINDING AND SATURATION

DATE: 2–6 June

ORGANISERS:
W.H. Dickhoff (Co-ordinator) (*Washington Univ., St. Louis*), A. Polls (*Univ. Barcelona*), M. Baldo (*INFN, Catania*)

NUMBER OF PARTICIPANTS: 36

MAIN TOPICS:

- Many-body theory of nuclei
- Many-body theory of nuclear and neutron matter
- Chiral perturbation theory and three-body forces
- Latest data on $(e, e'p)$ reactions and deep hole states
- Single-nucleon strength function, self-consistent approximation and binding energy of finite nuclei and nuclear matter
- Long-range correlations and binding
- Pionic modes in nuclear matter and nuclei, the role of the Δ-isobar, the Gamow-Teller excitation mode and the density dependence of the Landau parameters g'
- The relevance of three-body forces in nuclear matter and finite nuclei and constraints from phenomenology
- LDA in nuclei from nuclear matter
- Long-range correlations in neutron matter

SPEAKERS:

M. Baldo (*INFN Catania*),
C. Barbieri (*TRIUMF Vancouver*),
O. Benhar (*INFN Roma*),
P. Bozek (*Univ. Crakow*),
B. V. Carlson (*Univ. Sao Paulo*),
J. W. Clark (*Washington Univ.*),
L. Coraggio (*Univ. Naples*),
Y. Dewulf (*Univ. Gent*),
W. H. Dickhoff (*Washington Univ.*),
A. Dieperink (*KVI Groningen*),
T. Duguet (*Argonne*),
D. Entem (*Univ. Salamanca*),
A. Fabrocini (*Univ. Pisa*),
S. Fantoni (*SISSA Trieste*),
T. Frick (*Univ. Tübingen*),
F. Frömel (*Univ. Giessen*),
N. Kaiser (*TU Munich*),
L. Lapikas (*NIKHEF Amsterdam*),
U. Lombardo (*Univ. Catania*),
M. F. M. Lutz (*GSI Darmstadt*),
A. Polls (*Univ. Barcelona*),
D. Rohe (*Univ. Basel*),
H. Sakai (*Tokyo Univ.*),
D. Sarchi (*Univ. Milan*),
K. Schmidt (*SISSA Trieste*),
P. Schuck (*IPN Orsay*),
H. Schulze (*INFN Catania*),
A. Sedrakian (*Univ. Tübingen*),
I. Sick (*Univ. Basel*),
D. Van Neck (*Univ. Gent*),
I. Vidaña (*Univ. Pisa*),
T.Wakasa (*Kyushu Univ.*)

SCIENTIFIC REPORT:

Aim and Purpose: The main purpose of the workshop was to discuss the recent progress in nuclear many-body theory and the theory of nuclear forces. Recent (e,e') and (e,e'p) data were to be discussed with special emphasis on the emerging complete picture of the properties of the proton in the nucleus. Recent work at the RCNP was to be represented to clarify the pionic and Gamow-Teller response. Specific goals of the workshop were to clarify and discuss recent results on the saturation properties obtained with Green's function methods. The role of pion-exchange interactions in nuclear matter was also to be discussed in detail. The latter was to be addressed from the perspective of its contribution to binding, three-body forces, and its recent evolution as described by chiral perturbation theory. Properties of neutron stars were also on the program.

Report: The consensus of the participants was that a successful exposure to recent theoretical and experimental work was achieved during the workshop. A comprehensive overview of recent work on the saturation properties of nuclear matter was obtained since most contributors to this field were present. General consensus of results and conclusions about the role of short-range correlations to nuclear binding and the properties of protons in the nucleus was achieved. A clear picture emerged from the experimental data from (e,e'p) which clarify now completely the properties of correlated protons in the nucleus. This accomplishment appears to be unique among all fields of physics in that for the first time a complete experimental description of a correlated consituent of a many-body system has been established. The role of pions in nuclei and nuclear matter was debated in considerable detail.

New insights into the possible spurious role of pionic excitations to the binding of nuclear matter were discussed whilc making contact with the experimental data obtained at RCNP for the pionic and Gamow-Teller response. Recent results for neutron matter calculations revealed some interesting discrepancies between various stochastic approaches and illustrated the potentially huge role of three-body forces in this system. Other properties of neutron star matter were also successfully discussed. On the final day of the workshop recent work on chiral perturbation theory was presented as it pertains to nuclear forces and the description of nuclear matter. One of the central achievements of this workshop was that it brought together a large number of young participants who were very enthusiastic and eager to learn about recent work in this important area of nuclear many-body theory.

9. WEAK INTERACTIONS IN NUCLEI AND ASTROPHYSICS: STANDARD MODEL AND BEYOND

DATE: 16–21 June

ORGANISERS:
C. Volpe (Co-ordinator) (*IPN, Orsay*), B. Balantekin (*Univ. Wisconsin, Madison*), S. Jullian (*LAL, Orsay*)

NUMBER OF PARTICIPANTS: 32

MAIN TOPICS:

- Neutrino masses and oscillations
- Standard and non-standard weak processes in nuclei
- Double beta decay
- Muon-electron conversion
- Second-class currents
- Neutrino-nucleus interactions
- Nuclear matrix elements
- Supernova neutrinos
- Supernova and big-bang nucleosynthesis

SPEAKERS:
C. Augier (*LAL Orsay*),
B. Balantekin (*Univ. Wisconsin Madison*),
J. Bouchez (*CEA Saclay*),
O. Civitarese (*Univ. La Plata*),
G. Co' (*Univ. Lecce*),
J. Conrad (*Columbia Univ.*),
G. Drexlin (*Forschungszentrum Karlsruhe*),
K. Eitel (*Forschungszentrum Karlsruhe*),
A. Faessler (*Univ. Tübingen*),
J. Formaggio (*Univ. Washington*),
Y. Fujita (*Osaka Univ.*),
C. Horowitz (*Indiana Univ.*),
N. Jachowicz (*Univ. Gent*),
H. Kosmas (*Univ. Ioannina*),

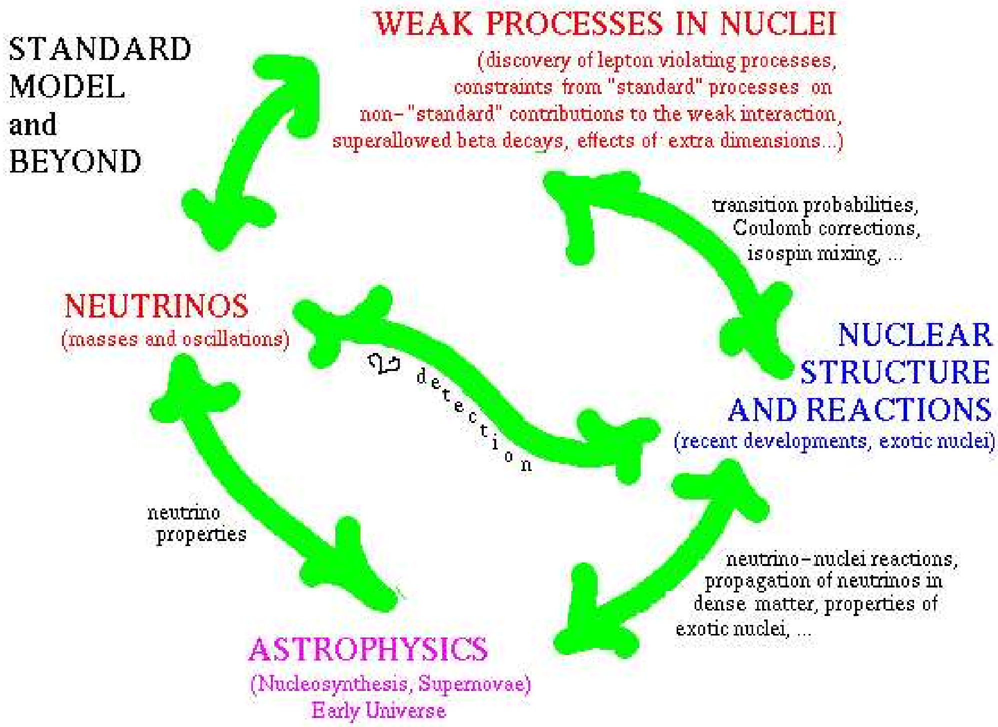
G. Lykasov (*JINR Dubna*),
M. Lindroos (*CERN Geneva*),
G. McLaughlin (*North Carolina Univ.*),
M. Mezzetto (*INFN Padova*),
O. Naviliat-Cuncic (*LPC/Univ. Caen*),
S. Pascoli (*UCLA Los Angeles*),
G. Raffelt (*MPI für Physik München*),
S. Schönert (*MPI für Physik Heidelberg*),
N. Severijns (*Katholieke Univ., Leuven*),
F. Simkovic (*Comenius Univ.*),
N. Smirnova (*Univ. Gent*),
J. Suhonen (*Univ. Jyväskylä*),
E. Truhlik (*INP Rez/Prague*)

SCIENTIFIC REPORT:

The experimental and theoretical discoveries in weak interactions of mesons and nuclei have been milestones for the developments of the $SU(3) \times SU(2) \times U(1)$ Standard Model. The Standard Model is now confirmed with a high precision. Nevertheless, it still contains conceptual problems like the hierarchy problem and requires a number of input parameters. At the present time there is no convincing experimental evidence for the necessity of going beyond the standard model with one exception: The recent discovery of neutrino oscillations. This discovery has considerable impact on different domains of physics: - in astrophysics, on the comprehension of astrophysical phenomena (nucleosynthesis, supernovae explosion), both for the modelling of processes in stars and for the terrestrial detection of neutrinos emitted by stars (sun, supernovae); - in high energy physics, where we need to extend the Standard Model to describe non-zero neutrino masses and mixings; - in cosmology, in the search for dark matter.

The study of weak processes in nuclei contribute significantly to the search for physics beyond the Standard Model in several ways. First, with the search for processes which are not allowed in the Standard Model. Muon-electron conversion and neutrinoless double beta decay are examples of this type. Second, with the study of "standard" processes to give constraints on non-standard components of the weak interaction, such as beta decay of polarized and unpolarized nuclei or muon capture. Third, in the study of reactions induced by neutrinos on nuclei. They are necessary to interpret current experiments on neutrinos or to evaluate the feasibility of new projects. They are also of direct astrophysical interest, for the understanding of nucleosynthesis and supernovae explosion. Finally, the study of weak processes in nuclei offers possibilities for more "exotic" searches, such as the search of supersymmetric particles or the effects of extra dimensions.

In the near future, experiments on neutrinos and weak processes in nuclei will aim at challenging sensitivities and projects under study for the long term, if approved, will achieve outstanding ones. Nuclear structure transition probabilities are crucial in the interpretation of many of these experiments. These calculations often present disagreements that need to be better understood. For example, the charged-current $\nu-{}^{12}$C reaction, used in the recent LSND and KARMEN experiments on neutrino oscillations, has been extensively investigated because of discrepancies between experiment and theory (up to a factor of 4 !). Recent studies show that nuclear structure effects are at the origin of this disagreement. Another case of interest is the $\nu-{}^{208}$Pb reaction for which there are no experimental data. Lead will be used in new projects, such as OMNIS and LAND, to detect neutrinos emitted in a supernova explosion. Finally, future experimental data on the 2ν double beta decay in various nuclei will reach error bars of 10% whereas the theoretical predictions on the transition probabilities



still often differ by a factor 2 and more.

The workshop has brought together worldwide experts, experimentalists and theoreticians, working on these topics at the interface of nuclear physics, high energy physics and astrophysics. The program of the workshop has offered a review of the present experimental status and the plans for future developments (approved or under study) both in the field of neutrinos and of weak processes in nuclei. A description of current developments in building nuclear structure models and open problems concerning the nuclear transition probabilities has been given. The connection of these topics with astrophysical processes, in particular nucleosynthesis and supernovae explosion, has been discussed. In addition to the talks there were intense discussions on these issues which require the synergy between the above-mentioned communities.

The performance of all the ECT* staff and support from the Director was excellent by any criteria. They were very helpful both during the workshop and in the preparation stage. The director and his dedicated staff should be congratulated for their skillful management, cooperative attitude, and providing an excellent environment in which participants could work and interact productively.

10. COLOR GLASS CONDENSATE AND PARTON PERCOLATION

DATE: 22–29 June

ORGANISERS:
H. Satz (Co-ordinator) (*Univ. Bielefeld*), L. McLerran (*BNL Brookhaven*)

NUMBER OF PARTICIPANTS: 19

SPEAKERS:
N. Arnesto (*CERN Geneva*),
R. Baier (*Bielefeld*),
K. Golec-Biernat (*Cracow/DESY*),
S. Fortunato (*Bielefeld*),
E. Iancu (*Saclay*),
D. Kharzeev (*BNL Brookhaven*),
A. Krasnitz (*Faro*),
T. Lappi (*Helsinki*),
L. McLerran (*BNL Brookhaven*),
B. Mueller (*Duke Univ.*),
M. Nardi (*Torino*),
C. Pajares (*Santiago de Compostela*),
P. Petreczky (*Brookhaven*),
K. Redlich (*Wroclaw*),
H. Satz (*Bielefeld*)

SCIENTIFIC REPORT:

In recent years it has become increasingly clear that high energy nuclear collisions are to a large extent determined by the initial state parton configurations of the colliding nuclei. The incident nuclei are Lorentz-contracted to thin discs in the transverse plane; each nucleus contains in this plane a "frozen" parton configuration which during the collision is activated. After the collision, we thus find in the transverse collision plane various clusters of partons. When the density of partons becomes so high that one large overlapping and hence interacting cluster spans the entire transverse plane, we have parton saturation and a new state is formed: the color glass condensate. The transition to this condensate of partons is specified by percolation theory in terms of the partonic transverse sizes and densities.

Since color connection is a pre-requisite for subsequent thermalization, the color glass condensate is a necessary precursor for the subsequent formation of quark-gluon plasma. It is quite possible, however, that observable features in nuclear collisions originate already from the early initial state and do not require thermalization.

Parton percolation determines the transition from individual partons to a connected cluster of colored constituents and thus the onset of color glass formation. The critical point is specified as function of the effective transverse parton size and of the parton density achieved in nuclear collisions. In the workshop, we have discussed to what extent these quantities can be specified, how that effects the transition point, and to what extent finite size effects soften the critical behavior.

Pressing issues discussed for the color glass condensate were: How does one compute approximate analytic and numerical solutions to the renormalization group equations which determine the effective Hamiltonian for the CGC? Can total hadronic cross sections be computed from the CGC? How does one compute diffractive and inclusive distributions in AA, pA and eA collisions? How do we compute and measure the transverse distribution of matter inside of hadrons? What are the definitive signatures for the Color Glass Condensate in proposed and existing experiments at RHIC, HERA and eRHIC?

Several of the proposed experimental signals for quark-gluon plasma formation can presumably occur already as consequence of parton percolation and color glass formation. In the workshop, we have studied in this context in particular charmonium suppression, jet quenching and strangeness enhancement, to see if initial state color connection and the resulting color glass condensate are sufficient for their occurrence. We have also looked for definitive signatures for color glass formation in existing and proposed experiments at RHIC, LHC, HERA and eRHIC.

The meeting lasted for six days, with arrival of the participants on Sunday, June 22, and departure on Sunday, June 29. Each day, there were two plenary presentations of about one hour length in the morning and two in the afternoon. This provided for each talk at least half an hour of discussion, and this time was in almost all cases used fully. It was the general opinion of the participants that this extensive discussion time made the meeting particularly fruitful and stimulating.

11. RECENT ADVANCES IN THE NUCLEAR SHELL MODEL

DATE: 29 June–12 July

ORGANISERS:
A. Zuker (Co-ordinator) (*IReS, IN2P3 Strasbourg*), J. Dukelsky (*CSIC Madrid*), S. Pittel (*Univ. Delaware*)

NUMBER OF PARTICIPANTS: 52

SPEAKERS:
F. Andreozzi (*Univ. Napoli*),
B. R. Barrett (*Univ. Arizona*),
M. A. Bentley (*Keele Univ.*),
R. Bijker (*UNAM Mexico*),
O. Bohigas (*LPTMS Orsay*),
J. Boronat (*Univ. Pol. Catalunya*),
E. Caurier (*IReS Strasbourg*),
D. J. Dean (*ORNL*),
J. Dobaczewski (*ITP Varsaw*),
J. Draayer (*Louisiana Univ.*),
A. Gniady (*IReS Strasbourg*),
H. Grawe (*GSI Darmstadt*),
J. Gu (*Kyoto Univ.*),
R. Guardiola (*Univ. Valencia*),
J. Heisenberg (*Univ. New Hampshire*),
G. Hirsch (*UNAM Mexico*),
M. Hjorth-Jensen (*Univ. Oslo*),
M. Horoi (*C. Michigan Univ.*),
N. Itaco (*Univ. Napoli*),
H. Laftchiev (*INRNE*),
K. Langanke (*Arhus Univ.*),
S. M. Lenzi (*Univ. Padova*),
R. Liotta (*RIT Stockholm*),
T. Luu (*Univ. Washington*),
R. Machleidt (*Univ. Idaho*),
B. Mihaila (*LANL*),
T. Mizusaki (*Senshu Univ.*),
R. Molina (*SPEC-CEA Saclay*),
F. Nowacki (*IReS Strasbourg*),
T. Otsuka (*Univ. Tokyo*),

T. Papenbrock (*ORNL*),
F. Perrot (*IReS Strasbourg*),
S. C. Pieper (*ANL*),
S. Pittel (*BRI Delaware*),
M. Ploszajczak (*GANIL Caen*),
A. Poves (*UAM Madrid*),
P. Ring (*Tech. Univ. Munich*),
S. Rombouts (*Ghent Univ.*),
B. Rubio (*IFIC Valencia*),
Y. Sun (*Notre Dame Univ.*),
T. Suzuki (*Nihon Univ.*),
Y. Utsuno (*JAERI*),
P. Van Isacker (*GANIL Caen*),
J. P. Vary (*Iowa Univ.*),
R. B. Wiringa (*ANL*),
V. Zelevinsky (*NSCL*)

SCIENTIFIC REPORT:

Everything went according to plan. So much so, that this report is a lightly edited version of the Scientific Proposal originally presented. Senior and junior speakers were given essentially the same time, and though the scope and quality of the talks varied, practically all of them were either good or excellent, and consistently enlivened by discussions.

The workshop was quite a success an—in one word often heard—*timely.*

As few as ten years ago, exact solutions of the many-body problem were restricted to 4 particles and exact shell model (SM) diagonalizations to model spaces of dimensionality 10^5. In time this number has grown to 10^9 – and sometimes larger – and exact solutions are now available for 10 particles. Simultaneously, methods have been developed, or extended, to deal with even larger problems: The coupled cluster formalism has made it possible to obtain high quality wavefunctions for ^{16}O, no-core shell model calculations have been shown to converge to the exact GFMC (Green's Function Monte Carlo) values, while Shell Model Monte Carlo (SMMC) and Quantum Monte Carlo (QMCD) methods can provide accurate approximations to exact diagonalization and be applied in much larger spaces.

These developments have had important conceptual consequences that promise to be far reaching. In particular, the exact solutions indicate the necessity to introduce three-body interactions, thus invalidating the long held assumption that the two particle system alone provides all the necessary information about the nuclear forces. The implications of this state of affairs was a key topic amply discussed at the workshop.

In addition to advances in exact solution of the Schrödinger equation and in exact SM calculations, there have been significant advances in the development of appropriate truncation strategies to use in even larger systems. The coupled cluster formalism had opened the way, next came two of the Monte Carlo approaches noted above, now followed by the Density Matrix Renormalization Group Method, borrowed from the study of quantum lattices in condensed matter. Several talks provided an up-to-date review of the various methods for solving the shell model, either exactly or with reliable precision.

The emergence of weakly-bound nuclei as a new research pole thanks to radioactive beams has enormously stimulated the development of shell model techniques in the neighborhood of the continuum. Though they were the subject of a workshop few weeks earlier, they obviously had their place in ours.

Another area of rapid progress that was touched upon concerns the study of random Hamiltonians and chaos in the SM. features have a more general origin than hitherto suspected.

The recent SM advances have much increased the number of nuclei accessible to reliable analysis and predictions. Ample time was devoted to talks in which experimentalists and theoreticians focusing on measures that have led or could lead to fruitful collaborations. They included evidence for isospin violating nuclear forces, drip-line studies, and superdeformation in medium-light nuclei.

Large-scale microscopic studies of quantum systems is of great interest not only in nuclear physics but in many other domains as well. If we have one regret, it is that we could not include many topics. The choice was restricted to the one closest to nuclear physics: liquid Helium and Helium droplets, treated in two talks that whetted our appetite for more.

12. DENSITY FUNCTIONAL THEORY IN NUCLEAR STRUCTURE

DATE: 21–25 July

ORGANISERS:
P.G. Reinhard (Co-ordinator) (*Univ. Erlangen*), M. Stoitsov (*Bulgarian Acad. of Sciences*)

NUMBER OF PARTICIPANTS: 33

MAIN TOPICS:

- DFT in General
- Nuclear DFT - Basics and Extensions
- Relativistic Nuclear DFT
- Many-Body Calculations
- Input from QCD
- Microscopic Description of Nuclear Collective Motion
- Correlations

SPEAKERS:
M. Bender (*Bruxelles*),
P. Bonche (*Saclay*),
D. Brink (*Oxford*),
A. Bulgac (*Seattle*),
T. Bürvenich (*Los Alamos*),
G. Colo (*Milano*),
T. Cornelius (*Frankfurt*),
S. Dimitrova (*Sofia*),
J. Dobaczewski (*Warsaw*),
T. Duguet (*Argonne*),
H. Flocard (*Orsay*),
E. Gross (*Berlin*),
K. Hagino (*Kyoto/Paris*),
P. H. Heenen (*Bruxelles*),
N. Kaiser (*München*),
S. Kümmel (*Dresden*),
J. Maruhn (*Frankfurt*),
M. Pearson (*Montreal*),
M. Ploszajczak (*Caen*),
P. Ring (*München*),
L. Robledo (*Madrid*),
M. Samiyn (*Bruxelles*),
G. Stoitcheva (*ORNL*),
E. Suraud (*Toulouse*),
D. Vretenar (*Zagreb*),
W. Weise (*München/Trento*),
M. Yamagami (*Kyoto*)

SCIENTIFIC REPORT:

Density functional theory (DFT) is a framework for a systematic formulation of effective interactions for the purpose of self-consistent mean field calculations. It is a much scrutinized and widely used method in the physics of electronic systems (atoms, molecules, clusters, solids). Effective interactions are invoked in various different fashions in nuclear physics too, with more or less consciousness of the theoretical impications of such practical schemes. It was the aim of this workshop to bring together experts from the various mean field models and thus to foster mutual awareness of comparable developments in seemingly different applications. We have been able to gather speakers from the areas of the Skyrme-Hartree-Fock approach, the relativistic mean-field model, the Nambu and Jona-Lasinio model, effective QCD Lagrangians, and from electronic DFT. The mean-field bias had been enriched by contributions about detailed correlations, the unavoidable ones from collective modes as well as those from fully fledged nuclear many-body theory. We admit, that some aspects were missing, as e.g. the Gogny force, applications of DFT to liquid ^{3}He, or contributions from plasma physics. It was our original intention to have also these pieces in our mosaic. But dating problems at the side of the invited speakers hindered us to deliver a more complete bundle of topics. Nonetheless, the program was sufficiently diverse that our main goal of mutual inspiration across the borders of the models was nicely achieved. We had many responses from participants expressing that they have learned a lot from others areas.

In order to stimulate discussions, we have allocated for each talk 40 minutes speaking time and 20 minutes for discussions. That worked out very well in most cases. We had plentiful of inspired discussions.

13. CRITICAL STABILITY OF FEW-BODY QUANTUM SYSTEMS

DATE: 1–6 September

ORGANISERS:
A. S. Jensen (Co-ordinator) (*Univ. Aarhus*), J. M. Richard (*Univ. Joseph Fourier*)

NUMBER OF PARTICIPANTS: 41

MAIN TOPICS:

- Weakly Coulomb-bound few-body states
- Weakly strong-interaction bound few-body states
- Weakly power-law-potential bound few-body states
- Continuum structure and few-body decay properties
- Time dependent few-body problems near instability
- Correlation in boson-fermion systems confined by external fields
- Few-body correlations in condensates
- Exotic structures: Efimov, tango, Borromean, halo states

SPEAKERS:

S. Adhikari (*Sao Paulo*),
P. Barletta (*Pisa*),
R. O. Barrachina (*CA Rio Negro*),
D. Blume (*Washington Univ.*),
D. Bressanini (*Como*),
Ph. Briet (*Toulon/Marseille*),
J. Dalibard (*LKB Paris*),
B. Danilin (*Kurchatov Inst., Moscow*),
P. Duclos (*Toulon/Marseille*),
N. Elander (*Stockholm*),
D. Fedorov (*Aarhus*),
P. Froelich (*Uppsala Univ.*),
H. O. U. Fynbo (*Aarhus*),
E. Garrido (*Madrid*),
J. Gómez-Camacho (*Sevilla*),
E. Hiyama (*KEK Tsukuba*),
H. Hogreve (*IFISR N.Y./Hildesheim*),
Y. Kanada-En'yo (*IPNS Tsukuba*),
A. Karmanov (*Lebedev Inst., Moscow*),
O. I. Kartavtsev (*Dubna*),
A. Kievsky (*Pisa*),
R. Lazauskas (*Grenoble*),
J. L. Lecouey (*Caen/East Lansing*),
R. Liotta (*Stockholm*),
V. Mandelzweig (*Jerusalem*),
S. Mattiello (*Rostock*),
S. Moszkowski (*UCLA*),
D. Oelkrug (*Tuebingen*),
S. Oryu (*Tokyo Univ. of Science*),
F. Peeters (*Antwerpen*),
J. M. Rost (*Dresden*),
J. P. Schermann (*Paris-Nord*),
O. Sørensen (*Aarhus*),
L. Tomio (*Sao Paulo*),
A. Voronin (*Lebedev Inst., Moscow*),
L. Wiesenfeld (*Grenoble*)

SCIENTIFIC REPORT:

Aim and Purpose: Almost all subfields of physics are confronted with interesting problems related to few-body physics at the edge of stability as demonstrated at previous meetings at ECT* in 1997 and Les Houches in 2001. The feedback from these workshops was very positive both during the workshops and afterwards when participants expressed views on successful and less successful meetings. The participants had apparently lots of relevant information to exchange with each other.

This encouragement is one reason why we followed up by organizing the present workshop on similar topics and appealing to similar, but not identical, groups of people. The other convincing reason for taking the trouble to organize a new workshop were the developments in the field of few-body physics at the edge of stability. Almost all subfields of physics contribute with interesting problems of this nature. The concepts, ideas, methods and techniques are often similar or identical in the different subfields, but not equally well-known and not developed to the same degree of refinement. The usual meetings do not often appeal to the interdisciplinary aspects or at least bringing people together from rather separated physics communities is not often successfully achieved.

The idea of the present meeting was to bring together people with overlapping interests and supplementary knowledge from fields ranging from quantum chemistry via condensed matter, molecular, atomic, nuclear to mathematical physics. We wanted contributions within the main theme of critical stability from as many subfields as possible and with a significant number of both topics and participants in common with the previous workshops. This more or less adiabatic development ensures both continuity and renewal. We wanted to allow the participants to present the work they find most interesting. In this way we wanted to encourage enthusiastic contributions and a workshop influenced by the actual participants. The theme still remains as spelled out in the title.

The participants should present a relatively broad distribution in age reflecting a mixture of experience and youthful energy, but all eager to learn. The level of the meeting should accordingly not be too technical unless the basis is presented at the meeting. Knowledgeable Phd-students and post docs must be able to follow the essential pieces.

Difficulties and achievements: The difficulties are the superficial differences in different subfields like notation, specific units, unessential simplifying assumptions invalid for other applications. The common features are too easily hidden. Much is known in one field and not in another and exchange of information would speed up the research. However, to identify similarities of approaches in different fields may be very difficult but also very useful. Progress would clearly be faster if we could "speak the same language" and immediately distribute the knowledge from one field to another. Collaboration across subfield barriers would be welcome and an efficient method to transmit new insight.

We started by inviting about 20 key speakers, then made one general announcement of the meeting and asked for applications to attend. The final selection resulted in 40 participants. This is an ideal number covering many different subfields still with several individuals within each. This number also allowed time for an oral presentation for each participant. To focus and get acquainted with the topic we asked for abstracts containing references for distribution in advance. This was not meant to tie down the speakers to exactly those topics, but such written information is a very useful tool for communication between physicists and subfields of physics.

To prevent evaporation of the information after the last day of the workshop we decided to produce proceedings. This is especially useful to look up references and to refresh the memory in relatively unknown fields of interest. Often the proceedings are produced too late and with too little new content to be of any value. Traditionally proceedings have also been blamed for preventing free discussion, but this certainly has not been and observable effect at these workshops. The proceedings are scheduled to appear as regular refereed papers in Few-Body Systems in January 2004.

The scientific program is reflected in the above schedule and titles of the talks presented. Every speaker had 30 minutes to give the talk and the 15 minutes reserved for discussions afterwards were often fully exploited. The discussions included surveys and examples of a number of methods as well as precise experimental and theoretical investigations of various extremely weakly bound few-body systems very close to the threshold of stability. Specific applications to problems distributed throughout physics were addressed, i.e., antimatter-matter, small molecules, ultracold atomic condensed gasses, nanostructure in semiconductor layers, chemical reactions like hydrogen on molecular hydrogen, hypernuclei exploiting the lesser known strange sector of the basic nucleon-nucleon interaction, more mathematical questions about exciton models, structure of the few-body continuum, Dirac-Coulomb operators and the nodal structure of the wave function describing few-body fermionic systems.

The meeting was very lively with lots of discussion and many pieces of useful information were exchanged. Future research projects will be affected and probably new collaborations initiated.

14. NUCLEAR MEAN-FIELD: SYMMETRIES AND SPONTANEOUS SYMMETRY BREAKING

DATE: 14–20 September

ORGANISERS:
S. Frauendorf (Co-ordinator) (*Notre Dame Univ.*), J. Dudek (*Univ. Strasbourg and IReS*)

NUMBER OF PARTICIPANTS: 31

MAIN TOPICS:

- Chirality of nuclei/Frauendorf
- Axial vector deformations/Dudek
- Breaking of reflection symmetry/Dudek
- Point group symmetries in Nuclear Physics/Frauendorf
- New symmetries of the pair field/Dudek
- Triaxial density distributions/Frauendorf

SPEAKERS:
D. Almehed (*UMIST Manchester*),
K. Arita (*Nagoya Inst. of Technology*),
A. Bulgac (*Washington Univ.*),
N. Dubray (*IReS Strasbourg*),
J. Dudek (*Univ. Strasbourg and IReS*),
J.-B. Faes (*IReS Strasbourg*),
S. Frauendorf (*Univ. Dresden*),
A. Gozdz (*Univ. Lublin*),
E. Grodner (*Univ. Warsaw*),
G. Hageman (*Niels Bohr Inst., Copenhagen*),
I. Hamamoto (*Univ. Copenhagen*),
M. Horoi (*Michigan State Univ.*),
T. Koike (*SUNY, Stony Brook*),
P. Magierski (*Univ. Warsaw*),
K. Matsuyanagi (*Kyoto Univ.*),
J. Meng (*Peking Univ.*),
M. Miskiewicz (*Univ. Lublin*),
H. Molique (*IN2P3 Strasbourg*),
M. Oi (*Univ. Surrey*),
P. Olbratowski (*Univ. Warsaw*),
J. Peng (*Peking Univ.*),
A. Petrovici (*Univ. Tübingen*),
W. Satula (*Univ. Warsaw*),
N. Schunck (*Univ. Surrey*),
Y. R. Shimizu (*Kyushu Univ.*),
J. Srebrny (*Univ. Warsaw*),
K. Starosta (*Michigan State Univ.*),
S. Tabor (*Florida State Univ.*),
M. Wiedeking (*Florida State Univ.*),
K. Yabana (*Tsukuba Univ.*)

SCIENTIFIC REPORT:

We discussed possible symmetries of the nuclear mean field, their manifestation through the nuclear spectra and through other observables. Special attention has been devoted to the new ideas of a possible existence of high-order point-group symmetries such as tetrahedral and octahedral ones - as well as symmetry breaking effects caused by coupling with collective vibrations and/or through long-range force polarization mechanisms. We have also discussed the calculation techniques involving restoration of broken symmetries by means of many-body methods beyond the mean-field approach. We focussed on symmetries that arise from the combination of the deformed density distribution with the angular momentum vector in rotating nuclei and the symmetries of the pair field (both proton-neutron and like particle).

Chirality and magnetic rotation: Possible experimental signatures of chirality in energies and electromagnetic transitions have only been derived from studies of the particle rotor model so far. For several of the indicated signatures one has not yet found convincing experimental evidence so far. Specific, dedicated experiments are needed. A more microscopically founded description of the dynamics of chirality is needed. There is a rich experimental evidence for magnetic rotation, which is overall well reproduced by the Tilted Axis Cranking in its standard (pairing+QQ, Strutinsky) versions. More detailed comparisons point to deviations that call for a more sophisticated mean-field functionals. Olbratowski and Meng reported first results from Tilted Axis Cranking calculations on the basis of the Skyrme and relativistic Mean-Field energy density functionals.

Tetrahedral and octahedral symmetries: An important new line of development are possible nuclear shapes with tetrahedral symmetry. As demonstrated by Dudek, mean-field calculations suggest such shapes in several mass regions. The corresponding symmetries carry unusual four-fold degeneracies of nucleonic levels in nuclei and several other quantum 'exoticities' that were so far not observed. Several talks discussed the possible spectral consequences of such exotic shapes. Further theoretical analysis seems necessary for formulating clear cut experimental evidence. Tabor and Wiedeking addressed the experimental search for tetrahedral shapes. The missing theoretical predictions of the consequences of tetrahedral shape hamper the search. Only evidence for deviations from reflection symmetry is available in various mass regions.

Reflection asymmetry, projection techniques: Matsuyanagi reported on pronounced octupole shapes in light nuclei, obtained in HF calculations. Horoi demonstrated that going beyond the mean-field approximation by projecting on good parity gives a substantial stabilization of the reflection asymmetric shapes. This seems important for other weakly broken symmetries as chirality. Visualization is important when a number of multipoles are combined. Dubray demonstrated an important visualization device developed in Strasbourg.

Pairing - New concepts and new approaches: Bulgac reported on a new energy density functional that gives a very good description of pair correlation energies all over the mass table. Reliable predictions of nuclear binding energies are expected. Satula compared mean-field calculations of the proton-neutron pairing with available experimental binding energies and claimed evidence for the presence of strong isoscalar pair correlations. Frauendorf offered an alternative explanations in terms of a pure isovector pair field. A detailed discussion of the pro and cons of the two competing views followed. Molique has presented new methods for solving the pairing problem by using the symmetries of the nuclear system expressed directly in the Fock space. This allows to apply e.g. shell model diagonalization techniques to hamiltonians with originally unprecedented dimensionalities varying from $10^9 \to 10^{12}$, in realistic nuclear context. Another very important step forward in understanding of very basic aspects in the nuclear quantum mechanics has been reported by Faes who has showed the solution to the nuclear mean-field Schrödinger equation using the Markov chain concept and stochastic techniques. The corresponding random-walk techniques offer for the first time the possibility of overcoming the limitation due to prohibitive sizes of the hamiltonian matrices since, as showed by the present-day calculations, the random-walk simulation needs only very limited computer resources.

Triaxiality and nuclear wobbling motion: Our understanding of the wobbling motion of triaxial nuclei mainly relies on on studies of the particle rotor model. A good description of both energies and electromagnetic transition probabilities seems rather problematic. Probably, only a more microscopically founded description of the dynamics of wobbling can overcome the problem. The combination of RPA with the mean-field solution was discussed. It seems to reconcile energies and transition rates to some extend. At the moment it is not clear if the remaining discrepancies are of systematic nature. There was a lively discussion of the interpretation of the microscopic RPA results.

Special sessions: The participants particularly appreciated the opportunity of having long, often very lively but at the same time constructive discussions. Important open questions have been revealed through those discussions; they were elaborated during the evenings by concerned participants and the following day special sessions have been intertwingled with the scheduled presentations, allowing for extensive clarifications. Several participants have stressed the extreme usefulness of these opportunities: our workshop could provide them only thanks to the actual 'mode of operation' of the Centre in Trento.

Summarizing remarks: The program of the workshop have revealed an important number of *new ideas and concepts related to the nuclear structure physics* ranging from the genuinely new symmetries, both in the Cartesian and in the abstract Fock spaces, through stochastic concepts applied to nuclear quantum mechanics, ending at the difficult problems of the experimental verifications of these new ideas. Once again, it has been possible to gather the leading theorists and experimentalists in Trento, organize the brain-storming discussions, so that, as one young participant has put it 'many of us have learned a lot'.

The importance of the achieved result can be best of all summarized by the wish expressed by many: *"It will be extremely useful and important to organize a similar brain-storming meeting to attack the nuclear structure problems of actuality in about two-years time"*.

15. THERMONUCLEAR SUPERNOVAE AND COSMOLOGY

DATE: 21 September–4 October

ORGANISERS:
W. Hillebrandt (Co-ordinator) (*MPI, Munich*), M. Turatto (*Padova Obervatory*), R. Canal (*Univ. Barcelona*)

NUMBER OF PARTICIPANTS: 61

MAIN TOPICS:
More than 60 scientists from 13 countries participated in the program. About half of them were graduate students and recent postdocs. Also about one half of the participants stayed for the full duration of the program, and the other half came for a three days workshop only that was devoted to the same topics, but aimed at a broader attendance.

- Supernova rates and statistics
- Supernova progenitors and pre-supernova stellar evolution
- Supernova spectroscopy and photometry
- General properties: homogeneity vs. diversity
- The ignition of thermonuclear supernova explosions
- Physics of thermonuclear burning and explosion models
- Radiation transport: synthetic lightcurves and spectra
- Nuclear physics and nucleosynthesis aspects
- Cosmological and particle physics implications

SPEAKERS:
G. Blanc (*INAF Padova*),
S. Blinnikov (*ITEP Moscow*),
S. Blondin (*ESO Garching*),
S. Bongard (*IPNL Villeurbanne*),
R. Canal (*Univ. Barcelona*),
Z. Han (*Yunnan Observatory*),
W. Hillebrandt (*MPI Garching*),
P. Hoeflich (*Univ. of Texas*),
D. Kasen (*Berkeley*),
A. Khokhlov (*Univ. of Chicago*),
P. Lesaffre (*Oxford and Cambridge Univ.*),
C. Lidman (*Eur. South. Observ., Santiago*),
P. Lundquist (*Stockholm Observatory*),
P. Mazzali (*Osservatorio di Trieste*),
S. Nobili (*Univ. Stockholm*),
K. Nomoto (*Tokyo Univ.*),
R. Pain (*IN2P3*),
F. Roepke (*Max Planck Inst.*),
P. Ruiz-Lapuente (*Univ. Barcelona*),
D. Sauer (*Max Planck Inst.*),
W. Schmidt (*Max Planck Inst.*),
B. Schmidt (*Nat. Univ.of Australia*),
W. Satula (*Univ. Warsaw*),
N. Schunck (*Univ. Surrey*),
M. Stehle (*MPI Garching*),
M. Stritzinger (*MPI Garching*),
C. Tout (*Univ. Cambridge*),
C. Travaglio (*MPI Garching*),
L. Zampieri (*INAF Padova*)

SCIENTIFIC REPORT:

Objectives of the Program: Systematic studies of type Ia supernovae at high red-shifts between z $\simeq$ 0.3 and 1 give increasing evidence that we are living in an expanding universe which began to *accelerate* its expansion when it was somewhat older than half its present age. This finding is commonly interpreted as being due to a finite positive cosmological constant Λ (interpreted as the energy density of the vacuum) or, alternatively, attributed to a new form of yet unidentified energy density with negative pressure.

This interpretation leaves one with several questions: First, if there is a positive cosmological constant: Why is it so small, but not zero? Also, it requires extreme fine-tuning of the initial conditions to have the cross-over between matter domination and vacuum domination at a red-shift of about 0.5. As far as a new "dark" energy is concerned the situation is not much better. It would also be rather unpleasant if we would have to invent yet another unknown into cosmology in order to salvage the standard model. Moreover, the "dark" energy needs to have a very specific equation of state in order to be in agreement with the supernova data, but still requires extreme fine-tuning of the initial conditions.

Therefore the question has to be addressed: Can we find out whether or not there exist loop-holes in the theoretical arguments through which models could predict systematically dimmer type Ia supernovae at high red-shifts, preferentially by leaving the Phillips-relation (e.g. the observed correlation between peak luminosity and light-curve shape) intact.

Currently, our understanding of the supernova physics is the major systematic uncertainty of this result. The distant supernovae exploded at a time when our solar system was just forming. There is no guarantee that these distant explosions are the same as the nearby ones on which the empirical relations are based. Only once we understand the physics of the explosions will we be able to assess whether they can be used as distance indicators reliably, and whether we have to search for new physics beyond the standard models of particle physics and cosmology.

Over the last couple of years several workshops have been devoted to Type Ia supernovae and their role in cosmology, including an extended program at ECT* in 2000. At most of these meetings the major emphasis was on observations and not so much on theory. On the other hand, theory has progressed well, and we are approaching the situation that theory begins to develop predictive power. Moreover, these workshops were attended mainly by senior researchers and to a lesser extend by graduate students and recent postdocs.

Therefore it was timely to discuss all aspects of thermonuclear supernovae, including models of the progenitors, the physics of thermonuclear burning, radiation transport, light-curves and spectra, and the cosmological and particle physics aspects, at a program that brought together theory and observations, and experts in the field with young researchers. A European Research Training Network on type Ia supernovae that has started its operation in July of 2002 provided the appropriate platform.

Participation and Scientific Program: More than 60 scientists from 13 countries participated in the program. About half of them were graduate students and recent postdocs. Also about one half of the participants stayed for the full duration of the program, and the other half came for a three days workshop only that was devoted to the same topics, but aimed at a broader attendance.

Results and Highlights: The program developed very much in the way it had been envisioned. In particular, splitting the program into two parts, a regular workshop with review talks by senior scientists and somewhat shorter presentations by postdocs and students, and a second part with more informal discussions and ample time for collaborations and interactions, worked out fine. There was active collaboration work from the beginning, even leading to presentations of results that were obtained by computer simulations performed at ECT* during the program. Publications were finished and submitted to journals, and new proposals for getting observing time at several telescope sites were discussed, written, and finally submitted during the program.

The scientific highlights presented at the "workshop within the workshop" included the discovery of polarized radiation from a few Ia supernovae during the early phase of the explosion, indicating partial shielding of processed material by clumps of cool matter moving with high velocity. These findings seem to favour explosion models with deflagration-to-detonation transitions. Several talks were devoted to SN 2002ic, the first type Ia supernova for which hydrogen lines have been seen in early spectra, shedding light on the circum-stellar matter and, thus, the nature of the progenitor star. First results of monitoring nearby type Ia supernovae by the European Supernova Collaboration were presented, as well as recent numerical simulations of both, the thermonuclear explosion and synthetic lightcurves and spectra. It was shown that we are approaching a stage in which at least the basic features of these supernovae are being understood. In fact, it is now generally accepted that exploding white dwarfs composed of carbon and oxygen near or at the critical Chandrasekhar mass can explain most of the observed properties very well.

Consequently, because it seems that the absolute luminosity of type Ia supernovae can indeed be calibrated, it also seems that they are dimmer at high redshifts than in our local Universe. This effect is interpreted as being caused by a non-zero positive cosmological constant or a new "dark energy" with negative pressure. Supernovae, in principle, can constrain the properties of this unknown form of energy, but this will be a difficult task. In fact, systematic uncertainties in their luminosity distances will have to be reduced below a tenth of a magnitude!

16. HADRONIC ATOMS (HADATOM03)

DATE: 13–17 October

ORGANISERS:
A. Rusetsky (Co-ordinator) (*Bonn/Tbilisi*), L. Afanasyev (*Dubna*), J. Gasser (*Bern*), V. Lyubovitskij (*Tübingen*), L. Nemenov (*CERN-Dubna*), H. Sadzijan (*Orsay*), J. Schacher (*Bern*), D. Trautmann (*Basel*)

NUMBER OF PARTICIPANTS: 46

MAIN TOPICS:

- Hadronic atoms: production, interaction with matter, energy levels, decays
- Meson-meson and meson-baryon scattering
- Experiments: DIRAC at CERN, DEAR at DAPHNE, Pionic Hydrogen Collaboration at PSI, Experiment on deeply bound pionic atoms at GSI, Others
- Lattice calculations and effective theory of QCD
- Chiral Perturbation Theory and nuclear many-body systems: nuclear matter, finite systems, spectrum and decays of π-nucleus, K-nucleus bound states

SPEAKERS:
L. Afanasyev (*Dubna*),
V. Brekhovskikh (*Protvino*),
P. Buettiker (*Bonn*),
M. Cargnelli (*Vienna*),
A. Dax (*PSI*),
S. Duerr (*Zeuthen*),
T. Ericson (*CERN*),
E. Friedman (*Jerusalem*),
J. Gasser (*Bern*),
L. Girlanda (*ECT**),
D. Gotta (*Jülich*),
K. Hencken (*Basel*),
S. Hirenzaki (*Nara*),
A. N. Ivanov (*Vienna/St.Petersburg*),
T. Jensen (*Paris*),
D. Jido (*ECT**),
K. J. Juge (*Dublin*),
E. Kolomeitsev (*NORDITA*),
S. Krewald (*Bonn*),
V. Lyubovitskij (*Tuebingen*),
H. Nagahiro (*Nara*),
L. Nemenov (*CERN/Dubna*),
C. Petrascu (*LNF-INFN*),
A. Rusetsky (*Bonn*),
M. Sainio (*Helsinki*),
H. Sazdjian (*Orsay*),
J. Schacher (*Bern*),
J. Schweizer (*Bern*),
L. Simons (*PSI*),
J. Stern (*Orsay*),
K. Suzuki (*München*),
A. Tarasov (*Dubna*),
W. Weise (*München/Trento*),
A. Wirzba (*Bonn*),
P. Zemp (*Bern*)

SCIENTIFIC REPORT:

Aim and Purpose: The programme HadAtom03, which took place on 13-17 October in Trento, Italy, is a continuation of the regular series on hadronic atoms, that have started in 1998. Previous workshops were held at:

1. Workshop "Hadronic atoms and Positronium in the Standard Model", 26-31 May 1998, JINR, Dubna, Russia
2. Workshop HADATOM99, 14-15 October 1999, Bern, Switzerland
3. Workshop HADATOM01, 11-12 October 2001, Bern, Switzerland
4. Workshop HADATOM02, 14-15 October 2002, CERN, Switzerland

The HadAtom series have been inspired by latest experimental and theoretical progress achieved in the investigation of the bound states of strongly interacting particles – hadronic atoms. The energy spectrum and decays of different hadronic atoms have recently been measured by several experimental collaborations. These measurements yield an extremely valuable piece of information about the behavior of QCD at a very low energy, which is hardly accessible with a different experimental technique. In particular, the measurement of the $\pi^+\pi^-$ atom decay width by DIRAC collaboration at CERN, which will result in the determination of the difference $a_0 - a_2$ of the S-wave $\pi\pi$ scattering lengths at a 5 % precision, would allow one to directly test the large/small condensate scenario of chiral symmetry breaking in QCD with two flavors. Further, the Pionic Hydrogen collaboration at PSI intends to extract the S-wave πN scattering lengths from the ongoing measurement of the spectrum and transition energies between $3p - 1s$ levels in pionic hydrogen at a remarkable 1 % accuracy. One may expect, that this will yield a more precise value of the πNN coupling constant and of the πN σ-term. Finally, the DEAR collaboration at the DAFNE facility plans to measure the energy level shift and lifetime of the $1s$ state in K^-p and K^-d atoms - with considerably higher precision than in the previous experiment carried out at KEK for K^-p atoms. It is expected that this will result in an accurate determination of the $I = 0, 1$ S-wave scattering lengths. It will be a challenge for theorists to extract from this new information on the $\bar{K}N$ amplitude at threshold a more precise value of e.g. the KN σ-term and of the strangeness content of the nucleon.

In order to fully exploit the high-precision experimental data and to perform this beautiful test of QCD at low energy, it is however imperative to design the theoretical framework for the analysis of these data, which would describe this sort of bound states in the accuracy that matches the experimental precision. There has been a substantial progress in this direction during the recent years. The effective Lagrangian techniques have shown to be very efficient also here: Bound state calculations - in particular the determination of energy levels and decay widths - can now be performed with surprising ease.

The project was aimed at the detailed discussion of both the experimental and theoretical aspects of the hadronic atom problem. The results of the latest measurements by DIRAC, Pionic Hydrogen and DEAR collaborations have been presented. On the theoretical side, the substantial progress has been reported, in particular, in understanding the spectrum and decays of pionic hydrogen and the πK atom. In a large part, the discussions during the workshop have been focused on the hadronic atoms containing strange hadrons (πK atom, kaonic hydrogen). It is hoped, that the study of this sort of bound systems will eventually lead to a deeper understanding of the flavor-dependence of the parameters of QCD at low energies.

A topic of strong current interest, also considered during the workshop, are deeply bound states of pionic atoms formed with heavy nuclei. Such states have recently been observed at GSI and initiated an active experimental programme. The data analysis for Pb and Sn isotopes were reviewed, and new theoretical developments on S-wave pion-nucleus interactions with respect to chiral dynamics (in particular, concerning the issue of the in-medium chiral restoration) were discussed.

We wish to mention that, as an experiment, for the first time during the HadAtom workshops we have allocated free slots for informal discussions, particularly useful for not being restricted with strict time limits and the detailed program. The topics and the coordinators of the discussions were announced in advance. In total, three discussions took place during the workshop.

As for the previous workshops (see hep-ph/9911339, hep-ph/0112293, hep-ph/0301266), mini-proceedings will be published. These contain one-page excerpts submitted by the speakers. We combine these contributions into a single file, which is submitted to the hep-archive.

17. NUCLEAR RESPONSE UNDER EXTREME CONDITIONS

DATE: 20–24 October

ORGANISERS:
P. F. Bortignon (Co-ordinator) (*Univ. Milan*), N. Van Giai (*IPN, Orsay*), H. Sagawa (*Univ. Aizu*), G. Colo' (*Univ. Milan*),

NUMBER OF PARTICIPANTS: 36

MAIN TOPICS:

- Giant Resonances and Pygmy Resonances
- Multi-Phonon Excitations
- Response in Very Isospin-Asymmetric Matter
- Continuum and Pairing Effects on the Low-Energy Response Near the Threshold
- Unified Structure plus Reaction Models for New Experiments

SPEAKERS:

T. Aumann (*GSI Darmstadt*),
F. Barranco (*Univ. Seville*),
Y. Blumenfeld (*IPN Orsay*),
P. F. Bortignon (*Univ. Milan*),
A. Bracco (*Univ. Milan*),
P. Chomaz (*GANIL Caen*),
G. Colo' (*Univ. Milan*),
H. Emling (*GSI Darmstadt*),
M. Fallot (*GSI Darmstadt*),
U. Garg (*Notre Dame Univ.*),
G. Gori (*INFN Milano*),
I. Hamamoto (*Univ. Copenhagen*),
M. Harakeh (*KVI Groningen*),
S. Kamerdshiev (*Univ. Obninsk*),
E. Khan (*IPN Orsay*),
D. Lacroix (*LPC Caen*),
E. Litvinova (*Univ. Obninsk*),
Z. Ma (*Beijing Univ.*),
J. Margueron (*GANIL Caen*),
M. Matsuo (*Niigata Univ.*),
T. Motobayashi (*Saitama Univ.*),
J. Piekarewicz (*Florida State Univ.*),
J. Rong (*Beijing Univ.*),
H. Sagawa (*Aizu Univ.*),
H. Sakaguchi (*Kyoto Univ.*),
N. Sandulescu (*Univ. Bucarest*),
S. Shlomo (*Texas Univ.*),
T. Suzuki (*Tokyo Univ.*),
M. Thoennessen (*Michigan State Univ.*),
N. Van Giai (*IPN Orsay*),
E. Vigezzi (*INFN Milano*),
A. Vitturi (*Univ. Padova*),
D. Vretenar (*Univ. Zagreb*),
M. Yamagami (*Kyoto Univ.*)

SCIENTIFIC REPORT:

Aim and Purpose: The main project objectives were to review the experimental landscape concerning the nuclear response in exotic systems, and to discuss problems and future perspectives of the models used to explain the experimental data or to make predictions. In particular, a question to be addressed was to what extent the new experiments will be able to provide detailed spectroscopic information on exotic systems. From the theory side, the emphasis had to be on the status of mean field theories, both in the non-relativistic and relativistic frameworks, and the comparison with models which include important correlations beyond mean field.

Main Achievements The large (36) participation of colleagues very active in their field, who gave extremely clear and stimulating talks (34) in the unique atmosphere of ECT*, allowed matching the main objectives of the project in a very encouraging way. There was enough time for discussions outside the sessions, an important complement to the many questions asked during the talks, in which detailed issues were faced with a full and frank exchange of ideas. From the talks of the experimentalists, a stimulating picture of the middle- and longe-range plans for accelerator and detection systems in Europe, Japan and USA emerged, supplemented by the most recent spectroscopic results obtained at the existing facilities. To what extent theory can help to solve the ambiguities of the experimental results, was carefully debated. The first self- consistent Quasi-particle Random Phase Approximation calculations were presented, which allow preserving all symmetries. Coupling the results of such calculations with the reaction models permits direct comparisons with the experimental cross sections, in the inelastic, charge-exchange and particle-transfer channel. Progress can be foreseen in the extension beyond mean-field of these calculations, since the efforts of different groups were confronted. The microscopic mechanisms at work in the pairing channel and its properties far from stability were addressed, with still many open questions. Decay studies of giant- resonance (GR) structures were shown to be instrumental to gain a deeper undestanding of the properties like the anharmonicities of the two- and three-GR states. The still existing discrepancy between the results obtained for the nuclear incompressibility in the relativistic and non-relativistic approaches was a highly debated subject, asking for new calculations and experiments in very exotic nuclei. The talks about neutrino propagation in the very extreme neutron star conditions represented one of the intellectual challenges of the workshop.

18. ROLE OF PIONS AND DELTAS IN NUCLEAR MANY-BODY DYNAMICS

DATE: 10–14 November

ORGANISERS:
A. Molinari (Co-ordinator) (*Univ. Turin*), T. W. Donnelly (*MIT*)

NUMBER OF PARTICIPANTS: 20

MAIN TOPICS:

- Fingerprints of pions and Delta in nuclei
- Theory of the electroweak interaction with nuclei at high energy
- Scaling and superscaling
- The nuclear many-body problem and QCD
- Chiral perturbation theory
- Items in the physics of the quark-gluon plasma
- Mesonic and correlation currents in inclusive and semi-inclusive nuclear responses
- Higher nucleonic resonances and 2p-2h excitations: role in the response functions
- The pion in hypernuclear physics

SPEAKERS:
W. M. Alberico (*INFN Torino*),
L. Alvarez-Ruso (*Univ. Giessen*),
J. E. Amaro (*Univ. Granada*),
M. B. Barbaro (*Univ. Torino*),
A. Beraudo (*Univ. Torino*),
J. A. Caballero (*Univ. Sevilla*),
R. Cenni (*Univ. Genova*),
A. De Pace (*INFN Torino*),
T. W. Donnelly (*MIT*),
P. Finelli (*Univ. Bologna*),
S. Fritsch (*ECT*/TU Munich*),
G. Garbarino (*Univ. Barcelona*),
M. Martini (*Univ. Torino*),
A. Molinari (*Univ. Torino and INFN*),
E. Moya De Guerra (*CSIC Madrid*),
M. Nardi (*Univ. Torino*),
F. Ramirez (*IEM Madrid*),
I. Sick (*Univ. Basel*),
W. Weise (*ECT*/TU Munich*)

SCIENTIFIC REPORT:

The pion field displays a complex nature in nuclei: on the one hand its effect are evident in the meson-exchange-currents, for example in the so-called dip region of inclusive inelastic electron scattering on nuclei and can be brought to evidence, e.g., via parity-violating polarized electron scattering which disentangle the isoscalar from the isovector correlations. Indeed the pion role is strongly felt in the former: as a consequence the pv longitudinal response is expected to be substantial, owing to the action of the pion, whereas it almost vanish in an uncorrelated Fermi gas. On the other hand the long sought after enhancement of the pion field in the spin-longitudinal response function or in the EMC effect (via the depletion and enhancement of the number of quarks at various momentum scales) has never been observed. From the above one is thus lead to conclude that the pion field is quenched at short nucleon-nucleon distances inside nuclei and the related physics is expected to be described by QCD. The workshop focused on this complex pion/delta physics in nuclei with the aim of exploring, in this field, mutually beneficial overlapping concepts stemming both from the high-energy perturbative point of view (an approach pursued, e.g., by Donnelly and Molinari) and from the chiral perturbation theory point of view (an approach pursued by Weise and collaborators). The former relates to the conventional hadronic degrees of freedom of matter and attempts to establish how far one can go on this basis in describing the physics of the electroweak nuclear responses fully respecting Lorentz, gauge and translational invariance. The latter is more directly related to the fundamental degrees of freedom of QCD and has been vigorously pushed by Weise and collaborators from the low energy regime to the one of the so-called chiral gap. From this intercomparison we expect the emergence of potentially very useful "cross-over" ideas: actually this has already occurred during several discussions who took place during the worshop. Indeed the themes of the latter centered precisely on how to harmonize the chiral framework taken at relatively low energies, but at high densities and temperatures, with the standard perturbative one taken at high energies (short wavelengths and high frequencies of the probe exploring the matter of nuclei).

19. SHAPE COEXISTENCE IN NUCLEI AT HIGH ANGULAR MOMENTUM

DATE: 26–28 November

ORGANISERS:
H. Hübel (Co-ordinator) (*Bonn*)

NUMBER OF PARTICIPANTS: 39

MAIN TOPICS:

- Search for Hyperdeformation
- Jacobi Shape Transition
- Superdeformation
- Triaxiality and Wobbling Excitations
- Chirality in Nuclei
- Feeding and Decay out of Superdeformed Bands
- Future Perspectives

SPEAKERS:

A. AlKhatib (*Bonn*),
G. Benzoni (*Milan*),
P. Bringel (*Bonn*),
T. Dossing (*Copenhagen*),
S. Frauendorf (*Notre Dame*),
A. Görgan (*Saclay*),
G.B. Hagemann (*Copenhagen*),
B. Herskind (*Copenhagen*),
R.M. Lieder (*Jülich*),
A. Lopez-Martens (*Orsay*),
P. Mason (*Milan*),
A. Maj (*Cracow*),
A. Neusser (*Bonn*),
B.M. Nyako (*Debrecen*),
S.W. Odegard (*Oslo*),
A.A. Pasternak (*Jülich*),
C. Petrache (*Camerino*),
A.N. Petrovici (*Tübingen*),
I. Ragnarsson (*Lund*),
A. Saltarelli (*Camerino*),
S. Siem (*Oslo*),
A.K. Singh (*Bonn*),
G. Sletten (*Copenhagen*)

SCIENTIFIC REPORT:

The EUROBALL spectrometer array is the most efficient instrument in Europe for the investigation of γ-ray transitions emitted from high-spin states in nuclei. In recent years the EUROBALL collaboration has studied a wide variety of nuclear structure topics using the array. A large number of these studies was devoted to the investigation of shape coexistence in nuclei at high angular momenta. Spherical or normal deformed states are known to coexist with superdeformed and triaxial states. In addition, theory predicts hyperdeformed states. These are excitations with axis ratios expected to approach 3:1, much larger than for the long-known superdeformed states with axis ratios up to 2:1.

The EUROBALL collaboration has performed several experiments devoted to the search for hyperdeformation. One of the aims of the workshop was to review the results of these experiments and to plan the further steps of the analysis and the experimental work. In particular, a four weeks long experiment was carried out at IReS, Strasbourg, to search for hyperdeformation in the ^{64}Ni + ^{64}Ni reaction. At the workshop progress reports were given on the analysis of the different aspects of this investigation. A first interesting result is the identification of ridges in coincidence matrices of the γ-ray continuum that could be due to hyperdeformed rotational bands. A statistical analysis of these ridges revealed that these bands have intensities in the 10^{-6} range. The discrete γ-ray spectra show weak structures in the same energy region, compatible in intensity with that of the ridges. The analysis of the discrete spectra is in progress.

A second prominent topic of the workshop was triaxiality in nuclei. Triaxiality was predicted theoretically for a long time, but only recent experimental results obtained with the EUROBALL array provided firm evidence for this exotic shape. The unique fingerprint is the 'wobbling mode' which was observed for the first time in several Lu isotopes. Another fingerprint are 'chiral' bands which occur when nucleons align along different axes of a triaxial nucleus. The theoretical predictions and the experimental evidence were discussed at the workshop.

The excellent statistical accuracy obtained in experiments with EUROBALL allows very detailed spectroscopic investigations of high-spin states. Several cases of such investigations were discussed at the workshop. Prominent examples are ^{125,126}Xe, ^{124}Ba and ^{140}Nd. In these nuclei new very high-spin bands were found, extending into the spin region above 50 $\hbar$, which are built on multi-quasiparticle excitations.

The workshop ended with a discussion of the future perspectives. For the search for hyperdeformation, the further steps of the analysis of existing data were divided among the members of the collaboration and new experiments were discussed. It was als emphasized that new, more powerful coincidence spectrometer arrays and accelerators with high-intensity stable beams are required for the future.

It was a very fruitful workshop with an intensive interaction between experimental and theoretical nuclear-structure physicists. It resulted in many new ideas and plans for future work. The meeting of groups from different laboratories working on the analysis of common experiments provided a chance to compare results and plan the next steps of the work.

3.3 ECT* Doctoral Training Programme

The second Doctoral Training Programme at ECT* as a Marie Curie Training Site was held in the period June-October 2003 under the title:

Nuclear Structure Co-ordinator: Jacek Dobaczewski (Warsaw)

It offered a unique combination of lecture series and workshops, summarising theoretical and experimental research focused on nuclear structure, nuclear reactions and nuclear astrophysics to a group of altogether 22 advanced doctoral students and young postdocs from all over Europe and beyond.

3.3.1 Lecture Series

The following series of lectures were presented at the Centre (see also section 3.7.1):

- **Neutrino Nuclear Astrophysics**
  Lecturer: Wick Haxton (INT, Seattle, USA)
- **Effective Theory Applications**
  Lecturer: Wick Haxton (INT, Seattle, USA)
- **The Shell Model as a unified view of Nuclear Structure**
  Lecturer: Frederic Nowacki (IReE, Strasbourg, France)
- **Many-Body Theory of Nuclei, Nuclear and Neutron Star Matter**
  Lecturer: Vijay Pandharipande (University of Illinois, Urbana, Champaign, USA)
- **Structure of Heavy Nuclei**
  Lecturer: Witek Nazarewicz (Oak Ridge National Lab, USA, and Univ. Warsaw, Poland)
- **Studies of Spectral Properties of Stable and Unstable Nuclei**
  Lecturer: Achim Richter (Technical University of Darmstadt, Germany)
- **Few-Body Models of Direct Nuclear Reactions**
  Lecturer: Jim Al-Khalili (University of Surrey, UK)
- **How do Nuclei Rotate?**
  Lecturer: Stefan Frauendorf (Notre Dame University, USA)
- **Topics in Laboratory Nuclear Astrophysics**
  Lecturer: Michael Wiescher (Notre Dame University, USA)
- **Nuclear Reactions, Nuclear Structure, Nuclei far from Stability and their Role in Astrophysics**
  Lecturer: Friedel Thielemann (University of Basel, Switzerland)
- **The Origin of Independent Particle Motion**
  Lecturer: Ben Mottelson (NORDITA, Copenhagen, Denmark)

The following workshop projects were also open to the participants of the Training Programme:

- **Recent Advances in the Nuclear Shell Model**
- **Density Functional Theory in Nuclear Systems**
- **Critical Stability of Few-Body Quantum Systems**
- **Nuclear Mean Field: Symmetries and Spontaneous Symmetry Breaking**
- **Thermonuclear Supernovae and Cosmology**
- **Nuclear Response under Extreme Conditions**

3.3.2 Participants

On the basis of their academic and scientific profiles and achievements, 22 advanced doctoral students were selected as participants of the Training Programme. Seven of those participants were eligible for Marie Curie Fellowships[1]. These fellowships enabled them to spend extended periods (3-6 months) at ECT* conducting their own research and entering into new collaborations. All Training Programme participants were furnished with standard working conditions at the Centre, including full access to the ECT* computing facilities.

List of participants (Marie Curie Fellows are indicated by *):

Shufang Ban	(Univ. of Peking),
Andrea Beraudo	(Univ. Torino),
Artur Blazkiewicz*	(Univ. of Tennessee, Nashville),
Stefan Fritsch*	(TU Munich),
Carla Frölich	(Univ. Basel),
Kalin Gladnishki	(Univ. Sofia),
Arnaud Gnjady	(IReS Strasbourg),
Uwe Heinzmann*	(Univ. Mainz),
Maria Belen Gomez Hornillos	(Univ. Liverpool),
Ernest Grodner	(Univ. Warsaw),
Frantisek Knapp	(Univ. Prague),
Marco Martini	(Univ. Torino),
Jonathan Morris	(Washington University, St. Louis),
Nikola Nikolov	(Univ. Sofia),
Emma Maria Ollson	(Univ. Uppsala),
Sara Perez Martin*	(Univ. Madrid),
Cesar Fernandez Ramirez*	(IEM Madrid),
Jerome Roccaz	(CSNSM, Orsay),
Ewan Roche*	(Univ. Edinburgh),
Tomas Rodriguez	(Univ. Madrid),
Jorge Miguel Sampaio*	(Univ. Aarhus),
Leonid Schvedov	(INS, Swierk)

[1] According to EC rules, Italian participants are non-eligible for Marie Curie Fellowships at ECT* as the Centre is based in Italy.

3.4 Projects of ECT* Researchers

• François Arleo

Quenching of hadron spectra in DIS on nuclear targets

The multiple scatterings incurred by a hard quark produced in a nuclear medium induce the emission of soft gluons which carry a fraction of the quark energy and eventually affect the hadronization process. The depletion of semi-inclusive hadron spectra in DIS on various nuclei (N, Ne, Cu, Kr) has been computed as a function of ν and z to leading order in α_s through medium-modified fragmentation functions, expressed as a convolution between vacuum fragmentation functions and the energy loss probability distribution which I recently computed. Using the transport coefficient $\hat{q}$ previously determined from Drell-Yan production, the predictions are found to be in good agreement with EMC and HERMES preliminary data. Calculations on Xe targets are also discussed. More recently, I explored and suggested two observables which may clarify the origin of the observed attenuation, disentangling between parton energy loss on the one hand and nuclear absorption on the other hand.

Photon correlations in nuclear collisions at the LHC

in collaboration with P. Aurenche, Z. Belghobsi, J.-P. Guillet (LAPTH, Annecy) and M. Werlen (Tokyo University)

Energy loss of hard partons propagating through a dense QCD medium (say a pion gas or quark-gluon plasma) is expected to be large. Consequently, this mechanism may serve to signal deconfinement in high energy nuclear reactions. In order to probe how this produced medium affects the fragmentation process, we suggest to study the correlations of two photons, experimentally accessible and calculable in QCD perturbation theory. Tagging on the photon directly produced in the hard collision allows us to map out the medium-modified fragmentation function of the less energetic photon. Furthermore, such correlations are experimentally accessible and calculable in QCD perturbation theory. First results indicate that this observable proves a promising tool to characterize dense media produced at the LHC.

Non-universality of transverse momentum broadening

in collaboration with J. Aichelin, P.-B. Gossiaux, T. Gousset, M. Thomas (SUBATECH) and S. Peigné (LAPTH, Annecy)

Within the scalar QED model of Brodsky, Hoyer, Marchal, Peigné and Sannino, we compare the leading-twist $K_\perp$-dependent quark distributions $f_{\rm q}(x, K_\perp)$ probed in deep inelastic scattering and Drell-Yan production. We extend the Drell-Yan production model to the case of a neutral composite projectile and study the role of spectator Coulomb rescatterings. The model is consistent with $K_\perp$-factorization and the universality of $f_{\rm q}(x, K_\perp)$. We then show that at higher-twist, Coulomb rescatterings are responsible for non-universal transverse momentum exchange. In Drell-Yan production the typical transfer is of the order of an infrared cut-off, possibly explaining the surprising smallness of nuclear transverse momentum broadening in Drell-Yan production.

• Tommaso Calarco

We showed that fermionic atoms have several advantages over bosonic atoms in terms of loading in optical lattices for use as a possible quantum computation device. The most important feature is the possibility of reaching virtually unit occupancy of each lattice site, via a simple and robust procedure, with much higher fidelity and on shorter time scales, even at finite temperature, than in the bosonic case.

We examine the performance of a quantum phase gate implemented with cold neutral atoms in microtraps, when anharmonic traps are employed and the effects of finite temperature are also taken into account. Both the anharmonicity and the temperature are found to pose limitations to the performance of the quantum gate. We present a quantitative analysis of the problem and show that the phase gate has a high quality performance for the experimental values that are presently or in the near future achievable in the laboratory.

We develop a new scheme for one- and two-qubit gates based on molecular interactions between neutral atoms and on adiabatic transport of atoms in state-independent periodic external traps. This allows for relaxing a number of experimental constraints for quantum computation with neutral atoms in microscopic potential, including single-atom laser addressability. We discuss the advantages of this approach in a concrete physical scenario.

We proposed a scheme where quantum memory is represented by the spin of an excess electron stored in each dot, and two-qubit gates are realized by switching on trion-trion interactions between different dots. State selectivity is achieved via conditional laser excitation exploiting Pauli Exclusion Principle: utilizing the Pauli blocking effect, we are able to have ultra-fast control and read out of the electronic spin degrees of freedom by conditionally coupling them with charged excitations of the quantum dot. Our scheme benefits from the vast time-scale separation between excitonic and spin dephasing processes: whereas our proposed qubit is given by the spin of a conduction electron and thus decoheres on a micro-second time scale, our conditional two-qubit phase gate is driven/controlled by Coulomb interaction on a picosecond time-scale. However, to claim that a certain implementation scheme for quantum information processing is viable, one has to carefully understand the fundamental sources of decoherence acting in that specific physical system, and to show that they can actually be controlled. To this aim, we analyzed in detail the different decoherence mechanisms affecting our scheme. In particular, we took into account the effect of hole mixing, leading to a violation of the Pauli-blocking selection rule, and of coupling to phonons at a finite temperature, estimating their impact on each of the building blocks of a quantum computer: single- and two-qubit gates, and state read-out. We developed a strategy to circumvent such unwanted effects via an adiabatic laser excitation scheme, simulated its performance under realistic conditions and evaluated the corresponding fidelity. Our scheme turns out to be able to suppress the effect of both of these decoherence sources on the proposed gate, and therefore constitutes a viable proposal for all-optical quantum information processing in semiconductor quantum dots. For the detection part, we started from the fact that shining circular polarized light on a singly charged quantum dot induces spin dependent fluorescence. Employing a quantum-jump approach we theoretically demonstrated that, by utilizing the resonance-luminescence technique, which has been proven to be very effective in the field of quantum optics, it is possible to measure the spin of an excess electron confined to a QD. The complications arising from the underlying crystal have been critically examined, showing that even in the presence of heavy and light hole mixing and imperfect detection efficiency one is still able to measure the electron spin to a very high degree of accuracy.

• Pietro Faccioli

Chiral dynamics and topological interactions in QCD

in collaboration with T. DeGrand (Univ. Colorado)

We have proposed a new framework to investigate the non-perturbative dynamics of the light-quark sector of QCD, based on some recent results of lattice simulations with chiral fermions. We have analyzed some correlators that are designed to probe the Dirac structure of the quark-quark interaction at different scales. We have found that, in the non-perturbative regime, such an interaction contains very large scalar and pseudo-scalar components and observed quantitative agreement between lattice QCD results and the predictions of the Instanton Liquid Model (ILM).

Instantons and nucleon electro-magnetic form factors

The electro-magnetic form factors of the nucleon, from small to large momentum transfer, were studied in the context of the ILM. As a first step, we have analyzed the role of single-instanton effects, which dominate the form factors at large momentum transfer. We then performed a numerical calculation to all order in the 't Hooft interaction. We have found that the ILM is in good agreement with the available experimental data. Based on these results, we concluded that instantons provide a microscopic mechanism that explains the delay of the onset of the asymptotic perturbative regime, in the electro-magnetic form factors.

Instantons and chiral extrapolation

in collaboration with J.W. Negele and D.Renner (MIT)

We have progressed in our study of the behaviour of hadronic observables as a function of the quark masses. The idea is to use the ILM to generate the gauge configurations in boxes which are larger than those of currently feasible lattice simulations. We have finished writing the code for the evaluation of the first moments of structure functions.

Lattice QCD and the electro-magnetic properties of the nucleon

in collaboration with SPQR lattice collaboration

We have continued our study of nucleon electro-magnetic observables in QCD, at zero and finite θ-angle, using lattice simulations. We have performed the $o(a^2)$ improvement of the relevant correlation functions and analyzed the results for the electro-magnetic form factors. We have also started the first run of an exploratory calculation of the neutron electric dipole moment.

• Paolo Finelli

We developed a novel description of nuclear many-body systems, both for nuclear matter and finite nuclei, emphasizing the connection with the condensate structure of the QCD ground state and spontaneous chiral symmetry breaking. We derived a microscopic relativistic point-coupling model of nuclear many-body dynamics, constrained by in-medium QCD sum rules and chiral symmetry, in which the nucleus is described as a system of interacting nucleons moving in mean fields generated by contact interactions. The effective Lagrangian is characterized by density dependent coupling parameters that are determined by pionic fluctuations (long-range interactions "explicitly" included), short-distance dynamics encoded in contact terms, and background fields representing in-medium changes of quark condensates. The basic assumptions at the origin of our approach are:

- The nuclear ground state is characterized by large scalar and vector fields of approximately equal magnitude and opposite sign. These fields have their origin in the in-medium changes of the scalar quark condensate (the chiral condensate) and of the quark density. An efficient way to include these effects is by using in-medium QCD sum rules.
- Nuclear binding and saturation arise in part from chiral pionic fluctuations (one- and two-pion exchange processes in combination with Pauli blocking effects), superimposed on the condensate background fields and calculated according to the rules of in-medium chiral perturbation theory.

This approach was tested in the analysis of the equations of state for nuclear matter, and of bulk and single-nucleon properties of finite nuclei. Iterated 1-π exchange and 2-π exchange processes have been included, for the first time, in finite nuclei calculations. In comparison with purely phenomenological mean-field approaches, the built-in QCD constraints and the explicit treatment of pion exchange processes reduce the freedom in adjusting parameters and, in particular, functional forms of density dependent couplings.

We have only considered spherical even-even light and medium-heavy $N \approx Z$ nuclei. Satisfactory agreement, around few parts per thousand, was found in comparison with experimental values for bulk properties (binding energies, charge radii,...) and for neutron-proton single particle spectra.

The important result of our analysis is a "microscopic" description of the underlying dynamics of the so-called relativistic mean field models.

This work has been done in collaboration with N. Kaiser (TUM, Technical University of München), D. Vretenar (University of Zagreb) and W. Weise (TUM and ECT*).

• Luca Girlanda

Chiral Perturbation Theory in a nuclear background

The observation of deeply bound pionic states sets tight constraints on the fundamental pion-nucleus interaction. The existing theoretical framework to address the problem from first principles was the In-medium Chiral Perturbation Theory, where the nucleus is treated as a uniform background of protons and neutrons. Such framework had clearly to be improved, in order to properly describe bound states where the effects of the nuclear boundary are expected to be important. We succeded in constructing a suitable, mathematically consistent framework which we have called "Chiral Perturbation Theory for Heavy Nuclei". All the information from nuclear structure is encoded in a set of functions representing nuclear matrix elements of local combinations of free-nucleon field operators. The criteria of the chiral expansion applied to these matrix elements help to reduce considerably their number. As an application we have calculated the pion-nucleus optical potential up to next-to-leading order of the chiral expansion, $O(p^5)$. As a result, we have identified new terms, already at the leading level (linear in density), which are not present in the case of a uniform background, among which those corresponding to the D-wave part of the pion-nucleon scattering amplitude. The paper "Chiral perturbation theory in a nuclear background", written in collaboration with A. Rusetsky and W. Weise, has been published in Annals of Physics.

The effect of vacuum fluctuations of $\bar{q}q$ pairs in Chiral Perturbation Theory

Recent $\pi\pi$ scattering data from the E865 experiment at Brookhaven have confirmed the standard scenario of large condensate in the limit of two massless flavours. The theoretical interest has therefore focused on the SU(3) chiral dynamics. Actually one realizes that the order parameters appearing in the SU(3) ChPT are very special experimentally observable quantities: they are the most directly related to chiral symmetry breakdown. The same is not true for the two-flavour order parameters, defined with the strange quark kept at its physical mass: the latter is not large enough to decouple from the theory. In this case massive $\bar{s}s$ pairs, which are abundant in the vacuum, induce e.g. an SU(2)×SU(2) breaking condensate, through OZI rule violating correlations, which adds up to the genuine condensate. The determination of the two main three-flavour order parameters, $\Sigma(3)$ and $F^2(3)$, respectively the quark condensate and the pion decay constant in the $N_f = 3$ chiral limit, is a delicate issue because the fluctuations of massive $\bar{s}s$ pairs induce instabilities in the SU(3) chiral series. We have proposed, in collaboration with S. Descotes, N. Fuchs and J. Stern, a possible cure for such instabilities, which amounts to a non-perturbative resummation of vacuum fluctuations encoded in the low-energy constants L_4 and L_6. A suitable class of observables is expressed in terms of $\Sigma(3)$, $F^2(3)$ and the quark mass ratio $r = 2m_s/(m_u + m_d)$. Uncertainties due to higher chiral orders and theoretical constraints coming from first principles (vacuum stability and paramagnetic inequalities) can be suitably accounted for in the framework of Bayesian statistical inference when fitting to data. We show that, while present $\pi\pi$ data are not accurate enough to constrain the three-flavour order parameters, they yield a lower bound on the quark mass ratio, $r \geq 14$ at 95% confidence level.

• Daisuke Jido

Electromagnetic form factor of nucleon and role of pion cloud

The electromagnetic form factors of the nucleon are key subjects in the understanding of the structure of the nucleon as a composite object. Recently it has been suggested by an extensive analysis on data available now that all four form factors have a common structure at small momentum transfer $Q^2 \approx 0.3\text{GeV}^2$ showing a bump on the top of a smooth broad distribution, which is interpreted as a signal of the pion cloud surrounding the nucleon. We have confirmed that this bump structure is dominantly seen in the isovector form factors. In this project, we take a spectral function approach, in which we consider the imaginary parts of the form factors in the time-like region, and describe the form factors using dispersion relation techniques. The advantages of this approach is that the spectral function has a direct relation to the physical processes in e^+e^--to-hadrons reactions, which provides us with experimental constraints on the form factors. This work is still in progress.

Magnetic moment of $N(1535)$ in the chiral unitary approach

We calculate the magnetic moment of $N(1535)$ in the chiral unitary approach (ChUA), where the resonance is dynamically generated in the meson-baryon scattering. First of all, it is important that "magnetic moments" of short-living states can be represented as complex numbers due to the uncertainty principle. In ChUA, one can calculate scattering amplitudes analytically. The resonance shows up as a pole of the amplitude in the complex plane on the second Riemann sheet, and one can evaluate the magnetic moment exactly on the position of the pole as its residue. Therefore the value obtained in ChUA is free from continuum backgrounds. As an additional aspect, we consider the magnetic moment of the nucleon in the linear realization of chiral symmetry. Since the term in the Lagrangian that gives the anomalous magnetic moment is not invariant under the linear transformation of the nucleon, in order to generate the anomalous magnetic moment, one needs a similar mechanism as for the generation of the nucleon mass, such as the condensate of a scalar field and/or the introduction of the chiral partner.

• Olivier Leitner

The asymmetry between matter and antimatter remains an enigma for our understanding of the universe through the Standard Model of particle physics. Even though the Cabibbo-Kobayashi-Maskawa matrix (which represents the charged current couplings between quark transitions) is expected to be responsible for this asymmetry, so far we do not have a satisfactory explanation to describe this phenomena.

One way to extend our research in this field is the analysis of B decays which, according to theoretical predictions, allows for a large direct CP violation. Moreover, by including the effects of the $\rho - \omega$ mixing (coming from the quark mass difference between the u and d quarks) and its implications for B decays, it is possible to take into account the first order in isospin violation for the calculations of asymmetry and branching ratio. In order to deeply investigate this possibility, theoretical predictions have to be able to deal with a lot of uncertainties currently included in the calculations. These are mainly the transition form factors, the Cabibbo-Kobayashi-Maskawa parameters (ρ, η) and the factorization approach (the most important uncertainty) applied to the evaluation of the hadronic matrix elements.

My main areas of interest lie in QCD factorization where an analysis of Final State Interactions through the calculations of the Wilson coefficients involved in a perturbative approach is utilized and the explicitly Covariant formulation of Light Front Dynamics. In CLFD, the investigation of wave functions and form factors is done through a relativistic framework where the analysis is derived on an arbitrary light-front plane in four dimensional space. In comparing theoretical predictions and experimental results for the branching ratios in B decays into pions or/and kaons, we expect to understand or at least confirm (or not) the Standard Model description of direct CP violation. B physics is a very exciting field of investigation and offers new insight into particle physics and all its mechanisms.

• Barbara Pasquini

My research activity at ECT* has focused on the theoretical investigation of the hadron structure with electromagnetically induced reactions. In particular, I have investigated the Compton scattering process in different kinematical regimes, where it is possible to gain complementary information on the internal structure of the nucleon.

Real and Virtual Compton scattering at low energy

The nucleon structure effects probed in real Compton scattering (RCS) at low energies can be parametrized in terms of fundamental structure constants like the polarizabilities. However, in order to obtain a better filter to identify the active degrees of freedom which are responsible for the internal nucleon structure, the two concepts of Compton multipoles and nucleon polarizabilities can be combined introducing so-called "dynamical polarizabilities" of the nucleon. These dynamical polarizabilities are functions of the excitation energy and encode the dispersive effects of πN, N^* and other higher intermediate states. We investigated the dynamical polarizabilities both within dispersion theory and leading-one-loop chiral effective field theory with explicit $\Delta(1232)$ degrees of freedom, trying to disentangle the role of chiral dynamics and resonance excitations in shaping the energy dependence of these observables.

On the other hand, the virtual Compton scattering (VCS) reaction at low photon energy generalizes the RCS and maps out the spatial distribution of the polarization densities of the proton, through generalized polarizabilities (GPs). In order to extract GPs from VCS data over a larger range of energies, including the Δ resonance, we extended the analysis of dispersion relations to virtual photons and we started an active collaboration with the various experimental groups. In particular, recent VCS data from JLab in the energy domain up to the Δ resonance region were analyzed within the dispersion relation approach. The new JLab data with the previous analysis at MAMI at different virtuality Q^2 allowed us to gain first information about the Q^2 dependence of the scalar GPs, showing a behaviour that does not resemble a simple dipole form.

Deeply virtual Compton scattering

Over the years hard scattering processes in the deep inelastic scattering regime have provided us with considerable insight into the internal nucleon structure. A significant step further in the investigation of such a dynamics is offered by the recently proposed generalized parton distributions (GPDs).

Extending our previous investigations on the unpolarized GPDs, we derived helicity-dependent GPDs from the overlap representation of GPDs using light-cone wave functions obtained in constituent quark models. In this framework, we were able to establish a link between the constituent quark structure of the nucleon at the hadronic scale and the partonic description of GPDs which emerges in the deep inelastic kinematics. From the knowledge of both polarized and unpolarized GPDs, we investigated the role of the quark-valence degrees of freedom in the angular momentum sum rule, and, in the limit of forward kinematics, we analyzed the spin asymmetry in polarized electron scattering. For these observables, we emphasized the crucial role of both a proper relativistic approach within light-front dynamics and a correct treatment of Pauli principle in building up the constituent quark wave functions.

These projects received a large benefit from stimulating discussions and active collaborations promoted during the workshop "Compton scattering from low to high momentum transfer", organized at ECT* by Ch. Weiss, M. Vanderhaeghen and myself.

• Francesco Pederiva

During the course of 2003 the research activity was focussed on the following subjects:

Study of the ground state properties of semiconductor nanostructures

The properties of quantum dots and rings under the influence of a transverse magnetic field were studied, In particular two problems have been addressed: the study of the fractional Aharonov-Bohm effect, i.e. the appearance of oscillations in the ground state energy of quantum rings as function of the flux through the ring of an applied transverse magnetic field, that are connected to the effects of electron–electron correlations; the study of the effects of the effective Dresselhaus spin–orbit term in the determination of the chemical potential of quantum dots as function of the strength of the magnetic field.

Ground state properties of neutron matter and neuron drops

The ground state energy and spin orbit contributions in ^{8}n and ^{7}n confined with an external field of variable strength in order to change the density of the drop have been analyzed in great detail by means of AFDMC calculations. Results have been compared with HF calculations with the use of Skyrme forces. The study of the energy and structure of neutron rich oxygen isotopes has started. In this case we use the results of a mean field calculation to generate the potential well and the single particle wavefunctions to be used in the Monte Carlo evaluation of the energy of the off–shell neutrons.

Ground state properties of condensed p–H_2

The calculation of the vacancy formation energy in solid fcc and hcp p–H_2 by means of Variational Monte Carlo Shadow Wave Function calculations has been completed. We started now the investigation of the different model intermolecular potentials present in the literature, in order to determine which form is the most suitable for the study of the condensed phases. In this case we compute the equation of state by means of Diffusion Monte Carlo, which guarantees an exact estimate of the ground state energy for a given interaction.

• Uffe Poulsen

I came to the ECT on the 2nd of October 2003 and have since then been working in collaboration with T. Calarco on problems in Quantum Information Processing. In particular, we have been investigating which model Hamiltonians that can be more efficiently simulated on a Quantum Computer than on a classical computer, the goal being to come up with a concrete proposal for experimental effort. Recent work in this area includes an algorithm by G. Vidal that shows how all 1D lattice systems can be efficiently simulated on classical computers provided that their content of correlations is suitably bound. For this reason, we have now started to focus on 2D systems and especially on the error-propagation properties of stroboscopic simulation schemes, i.e., schemes where some given interaction between particles combined with fast, global transformations to simulate another interaction.

• Georges Ripka

In 2003 I continued to model color confinement, in an attempt to obtain a relativistic description of a meson and a baryon, including both spontaneous chiral symmetry breaking and confinement.

• Akaki Rusetsky

In 2003, I have been working at ECT* Trento (01.01.2003 – 31.03.2003), and in Helmholtz-Institut für Strahlen und Kernphysik (Theorie) der Universität Bonn (01.04.2003 – 31.12.2003). During this period, my research was concentrated on the following topics:

- We have investigated the general procedure of including the electromagnetic interactions in the low-energy effective Lagrangian of QCD. The prescription for splitting strong and electromagnetic contributions in the physical observables was studied, as well as the scale- and gauge- dependence of the couplings of the effective Lagrangian.

- The generalization of the Chiral Perturbation Theory in the background of the finite nuclei has been formulated. Using this approach, we have performed the systematic calculation of the pion-nucleus optical potential at $O(p^5)$ in ChPT, which can be used to describe energy levels of the the deeply bound pion-nucleus bound states, experimentally observed at GSI.

- By using the non-relativistic effective Lagrangian approach to bound states, a complete expression for the isospin-breaking corrections to the energy levels and the decay widths of kaonic hydrogen is obtained up-to-and-including $O(\alpha, m_d - m_u)$ in QCD. It is demonstrated that, although the leading-order corrections at $O(\alpha^{1/2}, (m_d - m_u)^{1/2})$ emerging due to the unitarity cusp, are huge, they can be expressed solely in terms of the KN S-wave scattering lengths. Consequently, at leading order, it is possible to derive parameter-free modified Deser-type relations, which can be used to extract the scattering lengths from the hadronic atom data. We foresee the publication of the above results in the beginning of 2004.

• Dolores Sousa

My general interests during this year have been focusing on heavy ion collisions and search of QGP. The goal is to include all major features of the fundamental theories into a model which can describe ultrarelativistic heavy ion reactions from low to high energies. Such a model can also guide experimentalists to design their detectors for RHIC and LHC colliders in order to have the best chance of observing new physics in that energy regime.

Strange particle production at RHIC in the Dual Parton Model

in collaboration with A. Capella (LPT, Université de Paris XI, France) and C.A. Salgado (CERN–TH Division)

The enhancement of yields of strange baryons and antibaryons per participant nucleon, observed at CERN-SPS, is one of the main results of the Heavy Ion CERN program. These data can be described in the framework of the Dual Parton Model, supplemented with final state interaction (including strangeness exchange reactions as well as the inverse reactions required by detailed balance). The net baryon yield is computed taking into account the mechanism of baryon stopping, associated with baryon junction transfer in rapidity.

We use this implementation to analyze the strange baryon and antibaryon production in $Au\ Au$ collisions at RHIC energies ($\sqrt{s} = 130$ GeV). We have computed the mid-rapidity densities of pions, kaons, baryons and antibaryons and we have found that the ratios B/n_{part} ($\overline{B}/n_{part}$) increase between peripheral ($n_{part} = 18$) and central ($n_{part} = 350$) collisions by a factor 2.4 (2.0) for Λ's, 4.8 (4.1) for Ξ's and 16.5 (13.5) for Ω's. The ratio K^-/π^- increases by a factor 1.3 in the same centrality range. It is important to point out that, before final state interactions, all ratios K/h^-, B/h^- and $\overline{B}/h^-$ decrease slightly with increasing centrality. This effect is rather marginal at RHIC energies and mid-rapidities. The final state interactions lead to a gain of strange particle yields. We compare our results with available experimental data and we found a good agreement.

New J/ψ suppression data and the comovers interaction model

in collaboration with A. Capella (LPT, Université de Paris XI, France)

Before the Quark Matter conference of 2002, the NA50 interpretation of the data on J/ψ suppression was as follows. The pA, SU and peripheral $Pb\ Pb$ data (up to $E_T \sim 35 \div 40$ GeV) can be described with nuclear absorption alone, with an absorptive cross-section $\sigma_{abs} = 6.4 \pm 0.8$ mb. At $E_T \sim 40$ GeV there is a sudden onset of anomalous suppression, followed by a steady fall off at larger E_T. However, at variance with this view, the most peripheral points in $Pb\ Pb$ collisions lied above the NA50 nuclear absorption curve – which extrapolates pA and SU data.

Two important sets of new data have been presented recently. The new NA50 data on pA reactions at 450 GeV/c indicate a smaller value of σ_{abs} than the one given above. However, within errors, pA and SU data can still be described with a single value of the absorptive cross-section $\sigma_{abs} = 4.4 \pm 0.5$ mb – substantially lower than the previous one. The new, preliminary, $Pb\ Pb$ data, taken in 2000 with a target under vacuum, are consistent with previous ones except for the most peripheral ones – which are now lower and consistent with the nuclear absorption curve.

We show that these new data, together with the final ones on SU interactions, can be described in the framework of the comovers interaction model with a unique set of three parameters : the nuclear absorption cross-section, the comovers interaction cross-section and a single (rescaled) absolute normalization.

• Wolfram Weise

Our research activities in 2003 focused on several projects in the theory of hadrons, nuclei and strongly interacting matter under extreme conditions:

Quasiparticle approach to dense and hot QCD

in collaboration with Michael Thaler (TU Munich)

The quasiparticle model description of lattice QCD thermodynamics has been extended to finite quark chemical potential.

Thermodynamics of two-colour QCD

in collaboration with Claudia Ratti (TU Munich and ECT)*

An investigation using a Nambu and Jona-Lasinio model with two colours and two flavours has been started in order to explore the capability of such models to reproduce $N_c = 2$ lattice QCD results at finite temperature and chemical potential.

Chiral extrapolations of nucleon properties from lattice QCD

in collaboration with Massimiliano Procura (TU Munich and ECT)*
and Thomas Hemmert (TU Munich)

Lattice QCD on one side and chiral effective field theory on the other are progressively developing as important tools to deal with the non-perturbative nature of low-energy QCD and the structure of hadrons. We have continued and extended investigations of the quark mass dependence of two fundamental properties of the nucleon: its mass and the axial vector coupling constant, in comparison with lattice QCD results.

Nucleon electromagnetic form factors: pion cloud effects and dispersion relation approach

in collaboration with Daisuke Jido (ECT)*

This project has been started in view of new experimental data for electromagnetic form factors of the proton. An improved dispersion relation analysis of these form factors is developed, with special emphasis on the spectrum of multi-pion continuum excitations coupled to the nucleon, and on constraints from the timelike region of nucleon form factors.

The nuclear many-body problem in the context of low-energy QCD

in collaboration with Paolo Finelli (ECT), Norbert Kaiser (TU Munich)*
and Dario Vretenar (Univ. of Zagreb)

A microscopic relativistic point-coupling model for nuclear dynamics has been derived, constrained by chiral symmetry and in-medium QCD sum rules. Chiral two-pion exchange is shown to play a prominent role for nuclear binding and saturation, whereas the strong Lorentz scalar and vector fields of about equal magnitude and opposite sign, induced by changes of QCD vacuum condensates in the presence of baryonic matter, generate the large spin-orbit coupling in finite nuclei.

Chiral perturbation theory of finite nuclear systems

in collaboration with Luca Girlanda (ECT)*
and Akaki Rusetsky (ECT and Univ. of Bonn)*

A systematic approach to low-energy pion interactions with finite nuclei has been developed, based on chiral perturbation theory and taking into account the specific features of finite nuclear mass distributions. This approach represents a novel effective field theory framework for further studies of pion-nuclear bound states (such as deeply bound pionic atoms) and low-energy pion-nucleus scattering.

3.5 Publications of ECT* Researchers

A. Accardi et al.
Hard Probes in Heavy Ion Collisions at the LHC: Jet Physics
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Z.J. Ajaltouni, O. Leitner, P. Perret, C. Rimbault and A.W. Thomas
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Preprint ECT-03-30

F. Arleo
Quenching of hadron spectra in DIS on nuclear targets
Eur. Phys. J C30 (2003) 213 [*Preprint ECT-03-13*]

F. Arleo
Tomography of nuclear matter: comparing Drell-Yan with Deep Inelastic Scattering data
Nucl. Phys. A715 (2003) 899

F. Arleo
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To be published in the ALICE Physics Performance Report [*Preprint ECT-03-16*]

F. Arleo
Parton energy loss or nuclear absorption: What quenches hadron spectra at HERA ?
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Photon Physics in Heavy Ion Collisions at the LHC
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S. Descotes, N.H. Fuchs, L. Girlanda and J. Stern
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Proceedings of the "International Symposium on Color Confinement (Confinement 2003)", Tokyo, July 2003 [Preprint ECT-03-10]

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Prog. Theor. Phys. Suppl. 149 (2003) 1 [Preprint ECT-03-18]

W. Weise
Baryons 2002: Outlook
Proceedings of the 9th International Conference on the Structure of Baryons, C.E. Carlson and B.A. Mecking, eds. [World Scientific, Singapore (2003), p. 290]

3.6 Presentations at International Conferences and Symposia

- **François Arleo**

  Tomography of hot QCD matter: tools and diagnosis
  CERN Heavy Ion Forum
  11 February 2003, CERN, Geneve, Switzerland

  Parton energy loss in cold and hot QCD media
  ALICE TRD Meeting
  3-4 March 2003, ECT, Trento, Italy*

  Quenching of hadron spectra in DIS on nuclear targets
  XI International Workshop on Deep Inelastic Scattering (DIS03)
  23-27 April 2003, Saint-Petersburg, Russia

  Energy loss of hard partons in dense media
  Workshop on the First Three Years of Heavy Ion Physics at RHIC
  2-21 June 2003, INT, Seattle, USA

  Quenching of hadron spectra in DIS on nuclear targets
  Electromagnetic Interactions with Nucleons and Nuclei
  7-12 October 2003, Santorini, Greece

- **Tommaso Calarco**

  Quantum Computing with neutral atoms and artificial ions
  Simons Conference Quantum and Reversible Computation
  29-31 May 2003, SUNY, Stony Brook, USA

  All-optical spin quantum computation in quantum dots
  4th European QIPC Workshop, "Hot Topics" session
  13-17 July 2003, Oxford, UK

  Quantum computing via molecular interactions
  Focus Meeting Few-qubits applications of QIP
  11-14 December 2003, Budmerice, Slovakia

- **Pietro Faccioli**

  Linking Chiral and Topological Aspects of the Quark-Quark Interaction, in QCD
  International Symposium on Color Confinement (Confinement 2003)
  October 2003, Univ. Roma, Italy

  Studying the Role of the t 'Hooft Interaction in QCD, by Means of Lattice Simulations
  XXI International Symposium on Lattice Gauge Theories (Lattice 2003)
  July 2003, Tsukuba, Japan

  Instanton Contribution to the Pion and Proton Electro-Magnetic Form Factors at $Q^2 \geq 1\,\mathrm{GeV}^2$
  2nd International Conference on Nuclear and Particle Physics at Jefferson Laboratory
  May 2003, Dubrovnik, Croatia

- **Paolo Finelli**

  Nuclear many-body dynamics constrained by QCD and chiral symmetry
  WE-Heraeus-Seminar Relativistic Structure Models for the Physics of Radioactive Nuclear Beams
  12 - 16 May 2003, Bad Honnef, Germany

  Nuclear many-body dynamics (a QCD constrained model)
  International Workshop in Pions and Deltas in Nuclear Many-Body Dynamics
  10 - 15 November 2003, ECT, Trento, Italy*

- **Luca Girlanda**

  Resumming vacuum fluctuations in the three-flavor ChPT
  Second Euridice Collaboration Meeting
  6-8 February 2003, Orsay, France

  Chiral Perturbation Theory in a nuclear background
  Workshop on Chiral Dynamics of Hadrons and Hadrons in a Medium
  26-28 June 2003, Valencia, Spain

  Deeply bound pionic atoms: optical potential at $O(p^5)$ in ChPT
  Chiral Dynamics 2003: Theory and Experiment
  8-13 September 2003, Bonn, Germany

  The impact of $\pi\pi$ scattering data on SU(3) chiral dynamics
  HadAtom03, Workshop on Hadronic Atoms
  13-17 October 2003, ECT, Trento, Italy*

- **Daisuke Jido**

  Chiral dynamics of the two Lambda(1405) states
  Workshop on Hadronic Atoms (HadAtom03)
  13-17 October 2003, ECT, Trento, Italy*

  Chiral symmetry for baryons
  Symposium on Hadron Spectroscopy, Chiral Symmetry and Relativistic Description of Bound Systems
  24-26 February 2003, Nihon Daigaku Kaikan, Ichigaya, Tokyo

  Chiral symmetry for baryons
  U.S. Japan Joint Workshop on Nuclear Chiral Dynamics
  19-22 February 2003, University of Hawaii, Honolulu

- **Barbara Pasquini**

  Linking Generalized Parton Distributions to Constituent Quark Models
  Workshop on Generalized Parton Distributions and Hard Exclusive Processes
  29 June-20 July, INT, Seattle, USA

  Sum rules and polarizabilities of the nucleon
  EuroConference on Hadron Structure Viewed with Electromagnetic Probes
  7-12 October, Santorini, Greece

- **Francesco Pederiva**

  Application of Fermion Monte Carlo to Continuous Systems
  CECAM Workshop on Sign Problem
  July 2003, Lyon, France

  Study of Vacancies and surface properties of solid pH_2 with Shadow wave functions
  XVII workshop on Condensed Matter Theories
  September 2003, Toulouse, France

- **Georges Ripka**

  Effective theories of Low-Energy QCD
  Second International Workshop on Hadron Physics
  25-29 Sep 2002, Coimbra, Portugal

- **Akaki Rusetsky**

  Theory of hadronic atoms
  LNF Spring School in Nuclear, Subnuclear and Astroparticle Physics
  19-23 May 2003, Frascati, Italy

  Introduction to ChPT for heavy nuclei
  HadAtom03
  13-17 October 2003, ECT, Trento, Italy*

- **Wolfram Weise**

  Topics in Low-Energy QCD
  Workshop on Subnuclear Physics with Electromagnetic Probes
  14-15 April 2003, Bad Honnef, Germany

  Exploring the nucleus in the context of Low-Energy QCD
  International Workshop "Relativistic Models for the Physics of Radioactive Nuclear Beams"
  12-16 May 2003, Bad Honnef, Germany

  QCD constraints on the nuclear many-body problem
  International Workshop on Density Functional Theory in Nuclear Structure
  21-25 July 2003, ECT, Trento, Italy*

  Constraints on the nuclear many-body problem from QCD and chiral symmetry
  XXVIII Mazurian Lakes Conference on Physics
  1-6 September 2003, Krzyze, Poland

  Nucleon structure: lattice QCD and effective field theory
  International Symposium on Quarks in Hadrons and Nuclei
  15-20 September 2003, Oberwölz, Austria

  Chiral extrapolations from lattice QCD
  International Workshop on Hadronic Atoms (HadAtom03)
  13-17 October 2003, ECT, Trento, Italy*

  Chiral dynamics of nuclear many-body systems
  International Workshop on Pions and Deltas in Nuclear Many-Body Dynamics
  10-14 November 2003, ECT, Trento, Italy*

3.7 Lectures and Seminars

3.7.1 Lectures

- Dual Superconductors and their applications to Color Confinement in QCD
  (February)
  Lecturer: Georges Ripka (CEA Saclay and ECT*)
- Chiral Dynamics and the Hadronic Phase of QCD
  (May, University of Padova)
  Lecturer: Wolfram Weise (ECT* and TU Munich)
- Neutrino Nuclear Astrophysics
  (June 9-13)
  Lecturer: Wick Haxton (INT Seattle)
- Effective Theory Applications
  (June 9-13)
  Lecturer: Wick Haxton (INT Seattle)
- The Shell Model as Unified View of Nuclear Structure
  (June 23-27)
  Lecturer: Frederic Nowacki (IRES Strasbourg)
- Many Body Theory of Nuclei, Nuclear and Neutron Star Matter
  (June 23-27)
  Lecturer: Vijay Pandharipande (Urbana)
- Structure of Heavy Nuclei
  (July 14-18)
  Lecturer: Witek Nazarewicz (ORNL/Warsaw)
- Studies of Spectral Properties of Stable and Unstable Nuclei
  (July 28-August 1)
  Lecturer: Achim Richter (TU Darmstadt)
- Few-Body Models of Direct Nuclear Reactions
  (August 25-29)
  Lecturer: Jim Al-Khalili (Surrey)
- How do Nuclei Rotate?
  (September 8-12)
  Lecturer: Stefan Frauendorf (Notre Dame)
- Topics in Laboratory Nuclear Astrophysics
  (September 22-26)
  Lecturer: Michael Wiescher (Notre Dame)
- Nuclear Reactions, Nuclear Structure, Nuclei far from Stability
  and their Role in Astrophysics
  (September 29-October 3)
  Lecturer: Friederich Thielemann (Basel)
- The Origin of Independent Particle Motion
  (October 6-10)
  Lecturer: Ben Mottelson (Nordita)

3.7.2 Seminars

17.01
Anisotropic Colored Superfluids
J. Hosek (*Rez/Prague*)

23.01
Resumming Vacuum Fluctuations in Three-flavour ChPT
L. Girlanda (*ECT**)

12.02
The Gross-Neveu Model at Finite Temperature
N. Wschebor (*SphT, Saclay*)

20.02
Excited Baryons in the 1/Nc Expansion
N. Scoccola (*Buenos Aires*)

25.02
Instantons and Hadron structure
P Faccioli (*ECT**)

13.03
Axial Coupling of the Quark
G. Carter (*Univ. of Washington, Seattle*)

20.03
Chiral Effective Field Theory and Nucleon Properties from Lattice QCD
W. Weise (*ECT**)

25.03
Equation of State and Magnetic Susceptibility of Spin Polarized Isospin Asymmetric Nuclear Matter
I. Vidana (*Pisa*)

8.05
Chiral Symmetry for Baryons
D. Jido (*ECT**)

22.05
Extending the Pinch Technique to All Orders
D. Binosi (*Valencia*)

19.06
Topological Aspects of the Quark-Quark Interaction
P. Faccioli (*ECT**)

24.06
Chiral Transition and Scalar and Vector Correlations in Hot and/or Dense Medium
T. Kunihiro (*Kyoto*)

2.07
Softness to Deformation in Transitional Nuclear Structure
M. Caprio (*Yale University*)

3.07
Structure of the Nucleon from Electromagnetic Form Factors
F. Iachello (*Yale University*)

28.07
Beyond the mean field approach: angular momentum projection in constrained Hartree-Fock-Bogoliubov calculations
T.R. Rodriguez (*Madrid*)

28.07
Fine structure of the isoscalar giant quadrupole resonance in closed-shell nuclei from high-resolution proton scattering
A. Shevchenko (*Darmstadt*)

28.07
Theoretical justification of the equal filling approximation (EFA)
S. Perez (*Madrid*)

28.07
Nuclear many-body dynamics constrained by QCD and chiral symmetry
P. Finelli (*ECT**)

29.07
Fine Structure of the Gamow-Teller resonance in the $^{90}Zr(^{3}He,t)^{90}Nb$ reaction
Y. Kalmykov (*Darmstadt*)

29.07
Investigating ^{11}N using pionic double charge exchange
E. Roche (*Edinburgh*)

29.07
Weak interaction processes in nuclei for core collapse supernovae
J. Sampaio (*Aarhus*)

30.07
The $^4He(\gamma, n)^3He$ reaction with full final state interaction
S. Quaglioni (*Trento*)

30.07
2D Hartree-Fock-Bogoliubov calculations of neutron rich nuclei
A. Blazkiewicz (*Nashville*)

30.07
Chiral dynamics of nuclear matter
S. Fritsch (*Munich*)

31.07
Light nuclei and related astrophysical problems
N. Ryezayeva (*Darmstadt*)

31.07
Canonical r-process calculation
U. Heinzmann (*Mainz*)

31.07
Angular momentum population in the projectile fragmentation of ^{238}U at 750MeV/nucleon
K. Gladnishki (*Sofia*)

11.09
Nucleon Form Factors and the Shape of the Proton
G. Miller (*Seattle*)

23.10
Quenching of Hadron Spectra in DIS on Nuclear Targets
F. Arleo (*ECT**)

30.10
A Model for Pure Gauge $SU(3)_c$ Phase Transition
C. Ratti (*ECT**)

5.11
Chiral order parameters from ChPT: a Bayesian approach
L. Girlanda (*ECT**)

20.11
Chiral Dynamics of the two $\Lambda(1405)$ States
D. Jido (*ECT**)

27.11
QCD Instanton Effects in the Color Singlet Form Factor of a Quark
I. Cherednikov (*Trieste*)

4.12
New J/ψ Suppression Data and the Comovers Interaction Model
D. Sousa (*ECT**)

10.12
Searching for an Effective Low-momentum Chromodynamics
J. Hosek (*Rez/Prague*)

11.12
B Meson Decays into Vector-Vector and/or Pseudoscalar-Vector
O. Leitner (*ECT**)

18.12
The Triton at Very Low Energies
H. Grießhammer (*TU Munich*)

4 Ten Years of ECT*: Achievement and Vision

A scientific symposium was held on October 10-11 to celebrate ECT*'s tenth anniversary. The programme of this symposium reflects the rich spectrum of research areas represented by the Centre.

TEN YEARS OF ECT*: ACHIEVEMENT AND VISION

ECT*, Trento

10 - 11 October 2003

Programme

Friday (October 10):

14.00-14.10:	*Welcome: Local Authorities*
14.10-14.30:	*Introduction: W. Weise (ECT*, TU Munich)*
14.30-15.15:	*Origin of Indipendent Particle Motion: B. Mottelson (NORDITA)*
15.15-16.00:	*Nuclear Structure: A. Richter (Darmstadt)*
16.30-17.15	*Astrophysics: Thermonuclear Supernovae and the Accelerating Universe: W. Hillebrandt (MPI Garching)*
17.15-18.00	*Particles and Fields on the Lattice: A. Di Giacomo (Pisa)*

Saturday (October 11):

09.30-10.15:	*Neutrino Physics: W. Haxton (Seattle)*
10.15-11.00:	*Matter under Extreme Conditions: J-P. Blaizot (Saclay)*
11.30-12.15:	*QCD and Hadrons: A. W. Thomas (Adelaide)*
14.15-15.00:	*Neutron Stars: C. Pethick (NORDITA)*
15.00-15.45:	*Bose-Einstein Condensation: S. Stringari (Trento)*
16.15-17.00:	*Nuclear Physics and Painting: R. Leonardi (Trento)*
17.00-17.45	*Future Experiments in Nuclear Physics: W. Henning (GSI)*

ECT* entering its second decade: mission and perspectives

An address to the Istituto Trentino di Cultura (ITC), local sponsor of the Centre
by Wolfram Weise, Director

The tenth anniversary of ECT*, the European Centre of Theoretical Studies in Nuclear Physics and Related Areas, has been a welcome occasion to review its achievements and to look forward into its future. ECT* was founded early in 1993 by the Istituto Trentino di Cultura on behalf of the European Nuclear Physics Community, following an earlier initiative by physicists from Copenhagen in 1990 and a decisive community meeting at Orsay in 1992. The scientific activities of the Centre started under its first director, Prof. Ben Mottelson (Nordita, Copenhagen), and its Vice Director, Prof. David Brink (Oxford and Trento). They evolved further under the directorships of Prof. Aage Winther (Copenhagen) and Prof. Rudi Malfliet (Groningen). The Scientific Secretary of ECT* from its foundation to the present, Prof. Renzo Leonardi (Trento), has been playing a crucial role ever since in shaping, guiding and guarding the Centre. An international Board of Directors, composed of eminent physicists from Europe and the United States, defined and developed the scientific profile of ECT* into what is now unanimously considered a unique research institution, not only in Europe but also on a worldwide scale.

On its way, the Centre received the blessings as an institutional member of the European Science Foundation in 1997, as a Major Research Infrastructure of the European Commission's 5th Framework Programme in 1999 and as a Marie Curie Training Site in 2001. In its first decade, ECT* hosted more than 6000 visitors from all over the world who came together in about 130 projects (workshops, collaboration meetings) in order to advance the science in their fields: from elementary particles to nuclei and stars, from the fundamental interactions of quarks to the physics of Bose-Einstein condensates. The uniqueness of the Centre derives from its unifying interdisciplinary concept, creating connections between subfields of basic research that are all in rapid processes of increasing specialization.

In the last decade, 37 postdoctoral fellows from all over the world came to ECT* for periods of typically two years, pursuing research projects and broadening their experience. Most of them now hold responsible positions at universities, at research centres, or in industry and economy. Throughout the years, the Centre has also greatly benefited from its ties with the University of Trento, especially through programmes on Bose-Einstein condensation held at ECT* and initiated by Prof. Sandro Stringari at the Physics Department of the University.

Starting from 2001, advanced training of young researchers has become the second major component of ECT*'s activities. Recent and forthcoming developments at international research facilities worldwide in the frontier areas of nuclear physics and related fields require major efforts in training young researchers with top qualifications. The future of basic and applied research depends crucially on the active transfer of knowledge, expertise and challenges to the younger generations. ECT* is playing an increasingly important role in this task.

Looking into the near future, ECT*'s third cornerstone will be a cluster-based supercomputing facility in the Teraflop range, to be installed at its headquarters, Villa Tambosi, following the initiative of the Centre's Scientific Secretary. This is a prime example of a fruitful enterprise in which the Province of Trento and ITC act together with INFN, ECT* and the Exadron branch of Eurotech, in a joint venture connecting basic science and high-tech industry.

While basic research in the areas of nuclear and subnuclear physics has been and continues to be the primary mission of ECT*, it is at the same time playing an increasingly visible role in European scientific co-ordination at various levels. The Centre provided the proper conditions for exchanging expertise in the process of preparing the new Long Range Plan of NuPECC, the Nuclear Physics Experts Committee of the European Science Foundation. Important connections have been established also at the regional level: ECT*'s Scientific Secretary acts as co-ordinator of the proton therapy project of the Trentino Province.

Last but not least, ECT* owes its uniqueness to its location in the center of Europe and to the generous sponsorship provided by the Province of Trento and the Istituto Trentino di Cultura, together with national funding agencies and European programmes. Physicists from all over the world who have visited the Centre are deeply impressed and gratefully acknowledge the outstanding continuous efforts that the Province and ITC are making to promote science at its frontiers. ECT* is looking forward with confidence into its second decade.

5 ECT* Computing Facilities

System manager:	Barbara Currò Dossi
Co-ordinator:	Francesco Pederiva

2 license servers:	1 PC Linux (Mathematica and MATLAB) 1 PC Linux (Mathematica)
1 computation servers:	1 Alpha Bi-Processor 533 MHz (NAG libraries)
14 PC for local research:	Pentium III up to 800 MHz Pentium IV up to 1.6 GHz
29 PC for users:	Pentium III up to 600 MHz Pentium IV up to 1.6 GHz
1 cluster:	Front/End and 36 CPU Communication Band width Gbit/second
1 APEmille:	128 CPU managed by 4 PC for the Input/Output and 1 Front End (64 GFlops)

6 Link Members

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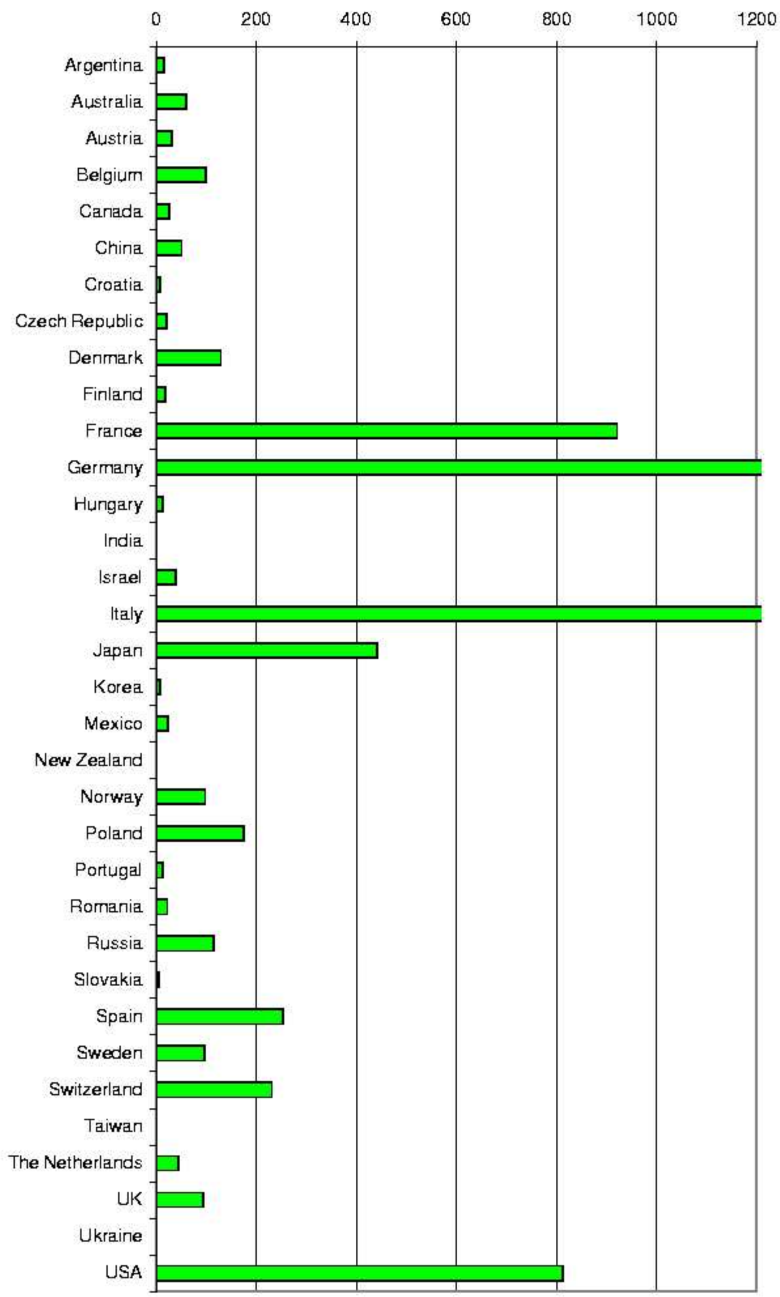
7 Statistics

Visitor Days Spent at ECT*

(total number of visitors in 2003: 872)



Includes: Workshop Participants, Postdocs, Visiting Scientists, Marie Curie Fellows and Lecturers

Projects and Training Weeks at ECT*