ECT*

Annual Report 2002

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 2002 has seen a further substantial expansion of ECT*'s activities. Apart from its regular workshop projects and collaboration meetings, the ECT* Advanced Doctoral Training Programme started, emphasising the Centre's broadening profile as a Marie Curie Training Site. The first training programme, held in the period June-October 2002, focused on "Hot and Dense QCD". The second one in 2003 will be devoted to "Nuclear Structure". The future of research in nuclear physics and its related areas depends crucially on the active transfer of knowledge, experience and challenges to the younger generations. ECT* has taken its role in this important task. The expansion of the Centre's activities, with workshop projects and training programmes occasionally running in parallel, is made possible by the opening of a new lecture hall with high-tech audiovisual facilities.

In June 2002, ECT* as one of the European Commission's Large Scale Infrastructures went through an evaluation procedure within the EC's Transnational Access Programme. The outcome was quite positive. The panel of experts described ECT* as "... very rare in Europe and the research is of very high quality". The review pointed out that an "... additional benefit is the interdisciplinary character" of the ECT* activities, and highlighted "... very good achievements in a broad range of nuclear physics and related research".

ECT* is playing an increasingly visible role in research co-ordination at various levels. In August 2002, the Centre provided proper conditions for a QCD Working Group to prepare a chapter of the new NuPECC Long Range Plan in Nuclear Physics. ECT* also hosted the FINUPHY ("Frontiers in Nuclear Physics") meeting in October 2002. Important interactions have been established with medical and computing sectors at the regional level. The Centre's Scientific Secretary, Renzo Leonardi, acts as a co-ordinator of the proton therapy project of the Trentino Province. He has also initiated active links with Neuricam-Eurotech in Trento, the company that builds the APE computer systems. As a result, ECT* has been able to add an APEmille machine to its computing facilities.

In 2002 the European nuclear physics community entered into extensive preparations for coherent actions within the EU's upcoming Sixth Programme. Two major initiatives for integrated infrastructures have been formed: EURONS which focuses on nuclear structure physics and applications, and the Hadron Physics initiative which represents experiments and theory directed towards the exploration of hadron structure and hadronic matter. ECT* decided to be formally anchored in EURONS but emphasises at the same time its bridge-building role, in accordance with the Centre's primary mission, unifying the physics of hadrons, nuclei and matter under extreme conditions.

While ECT*'s financial situation in 2002 can be characterized as "stable", the expanding activities of the Centre in response to increasing demands by its user community will require a modest increase of the running budget in coming years.

ECT*'s achievements of the past year would have been unthinkable without the continuous and dedicated teamwork of its entire staff and its Scientific Secretary, and the devotion to research of its postdocs. Special thanks go to Rachel Weatherhead, François Arleo and Dolores Sousa for their assistance in preparing this Annual Report.

Wolfram Weise
Director, ECT*

Contents

1 ECT* Board of Directors, Staff and Researchers

1.1 ECT* Board of Directors (BoD)

Professor Juha Äystö	NuPECC and CERN, Geneva, Switzerland
Professor Marcello Baldo	INFN, Catania, Italy
Professor Gordon Baym	Univ. Illinois, Urbana-Champaign, USA
Professor Peter Braun-Munzinger	GSI, Darmstadt, Germany
Professor Philippe Chomaz	GANIL, Caen, France
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Honorary Member of the Board:

Professor Ben Mottelson	NORDITA, Copenhagen, Denmark

ECT* Director
Professor Wolfram Weise
(left in the photo)

ECT* Scientific Secretary
Professor Renzo Leonardi
(right in the photo)

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
Mauro Mion	Web Manager
Luana Slomp	Technical Programme Assistant
Rachel Weatherhead	Technical Programme Manager Assistant to the Directors

1.3 Resident Postdoctoral Researchers

François Arleo (France)

Tommaso Calarco (Italy) (until Aug. 2002)

Pietro Faccioli (Italy) (from Sept. 2002)

Marina Gibilisco (Italy) (until June 2002)

Luca Girlanda (Italy) (from Sept. 2002)

Evgeni Kolomeitsev (Russia) (until Aug. 2002)

Barbara Pasquini (Italy)

Francesco Pederiva (Italy)

Akaki Rusetsky (Georgia) (from Sept. 2002)

Dolores Sousa (Spain)

Timothy Walhout (USA) (until May 2002)

1.4 Marie Curie Fellows

Marek Góźdź (Poland)

Sami Räsänen (Finland)

Thorsten Renk (Germany)

Roland Schneider (Germany)

Karolis Tamosiunas (Norway)

1.5 Visitors in 2002

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.

Nir Barnea, Hebrew University, Jerusalem, Israel (VS)

Gordon Baym, University of Illinois at Urbana-Champaign, USA (TP)

Hans Bijnens, University of Lund, Sweden

Jean-Paul Blaizot, CEA, Saclay, France (TP)

Nicolas Borghini, Université Libre de Bruxelles, Belgium (TP)

Peter Braun-Munzinger, GSI Darmstadt, Germany (TP)

Franco Bradamante, University of Trieste, Italy

Lex Dieperink, KVI, Groningen, The Netherlands (VS)

Viktor Efros, Kurchatov Institute, Moscow, Russia (VS)

Pietro Faccioli, State University of New York, Stony Brook, USA (TP)

Paolo Finelli, University of Bologna, Italy

Aida Galoyan, JINR, Dubna, Russia (TP)

Michel Garçon, CEA, Saclay, France

Vincenzo Greco, University of Catania, Italy (TP)

Harald Griesshammer, TU Munich, Germany (RA)

Thomas Hemmert, TU Munich, Germany (RA)

Melvin H. Kalos, Lawrence Livermore Laboratory, USA (VS)

Edwin Laermann, University of Bielefeld, Germany (TP)

Matthias Lutz, GSI, Darmstadt, Germany

Gennadi Lykasov, JINR, Dubna, Russia

Nils Marchal, University of Savoie, France and NORDITA, Copenhagen, Denmark (TP)

Stefano Mattiello, University of Rostock, Germany (TP)

Larry McLerran, Brookhaven National Laboratory, USA (TP)

Giuseppe Pagliara, University of Ferrara, Italy (TP)

Alberto Polleri, TU Munich, Germany (VS)

Massimiliano Procura, TU Munich, Germany and ECT* (RA)

Georges Ripka, CEA, Saclay, France (VS)

Rainer Santo, University of Münster, Germany (VS)

Helmut Satz, University of Bielefeld, Germany (TP)

Norberto Scoccola, Comisión Nacional de Energía Atómica, Argentina (VS)

Johanna Stachel, University of Heidelberg, Germany (TP)

Giuliana Tonini, University of Florence, Italy (TP)

Gerard van der Steenhoven, NIKHEF, Amsterdam, The Netherlands

Marc Vanderhaeghen, University of Mainz, Germany (VS)

Dario Vretenar, University of Zagreb, Croatia

Aldo Zenoni, University of Brescia, Italy

2 Projects in 2002

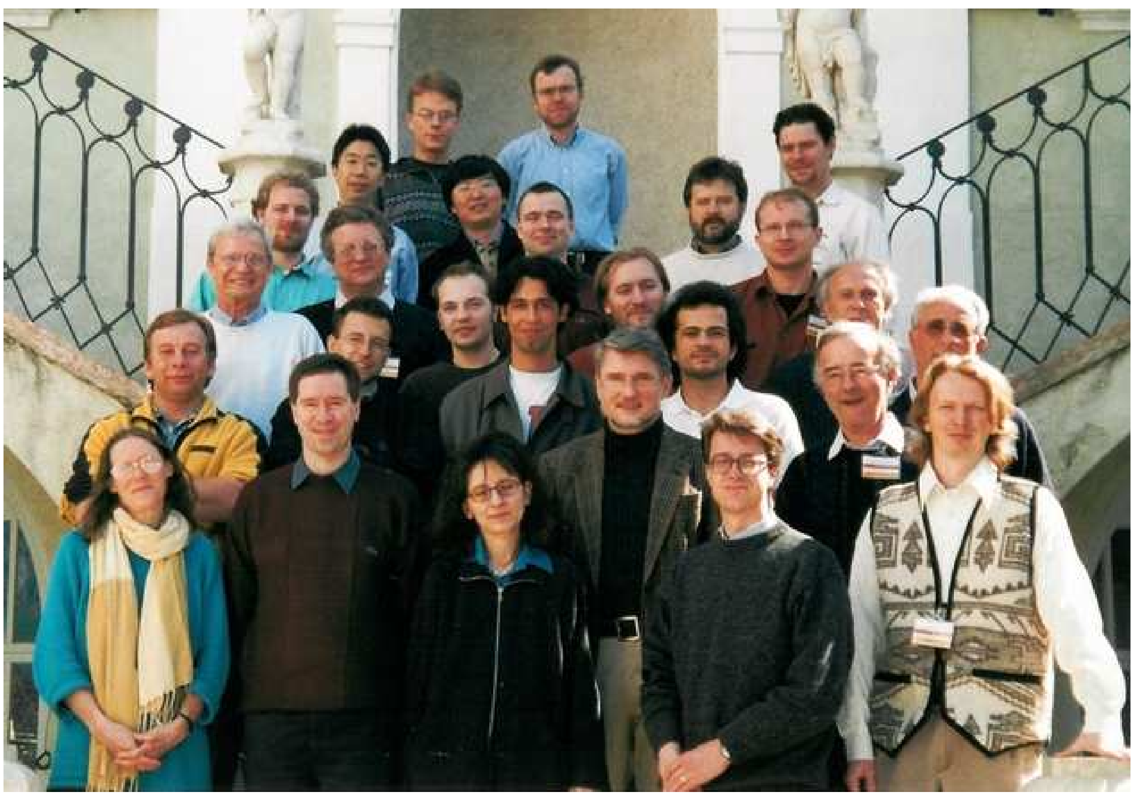
8–9 Mar.	**BCPL User Group Meeting on Computational Physics** Organisers: L. Csernai (Co-ordinator) (*Univ. Bergen*) [p. 9]
18–28 Mar.	**Nuclear Collective Dynamics at Extreme Conditions** Organizers: H. Wolter (Co-ordinator) (*Univ. Munich*), M. Di Toro (*LNS, INFN Catania*), V. M. Kolomietz (*INRM, Kiev*) S. Shlomo (*Texas A&M Univ.*) [p. 11]
10–12 Apr.	**The Physics of the Roper Resonance** Organizers: M. Soyeur (Co-ordinator) (*CEA, Saclay*) [p. 15]
15–19 Apr.	**Baryon Structure Probed with Quasistatic Electromagnetic Fields** Organisers: L. Van Hoorebeke (Co-ordinator) (*Univ. Gent*), B. Pasquini (*ECT**), M. Vanderhaeghen (*Inst. für Kernphysik, Mainz*) [p. 17]
22–26 Apr.	**Fission at Finite Thermal Excitations** Organisers: H. Hofmann (Co-ordinator) (*TU Munich*), K. Pomorski (*UMCS, Lublin*), K-H. Schmidt (*GSI, Darmstadt*) [p. 18]
3–7 Jun.	**Continuum Aspects of the Nuclear Shell Model** Organisers: M. Ploszajczak (Co-ordinator) (*GANIL, Caen*), W. Nazarewicz (*Univ. Tennessee*), H. Sagawa (*Univ. Aizu*) [p. 21]
17–22 Jun.	**Charm Production: from SPS to RHIC and LHC** Organisers: A. Polleri (Co-ordinator) (*TU Munich*), J. Hüfner (*Univ. Heidelberg*), B. Kopeliovich (*MPI, Heidelberg*), M. Leitch (*LANL, Los Alamos*), J-C. Peng (*LANL, Los Alamos*) [p. 22]
1 Jul.–10 Aug.	**Bose-Einstein Condensation Summer Programme 2002** Organisers: S. Stringari (Co-ordinator) (*Univ. Trento*), F. Laloë (*ENS, Paris*), C. Clark (*Nist, Gaithersburg*) [p. 25]
8–19 Jul.	**Non-Perturbative Aspects of QCD** Organisers: P. Damgaard (Co-ordinator) (*NBI, Copenhagen*), U-M. Heller (*Florida State Univ.*), J. J. M. Verbaarschot (*SUNY, Stony Brook*) [p. 27]
2–11 Sept.	**Structure of the Nucleon** Organisers: M. Birse (Co-ordinator) (*Univ. Manchester*), E. Henley (*Univ. Washington*), A. W. Thomas (*Univ. Adelaide*), W. Weise (*ECT**) [p. 29]

16–21 Sept. **The Physics of Quantum Fluid Clusters**
Organisers: M. Barranco (Co-ordinator) (*Univ. Barcelona*),
F. Dalfovo (*Univ. Cattolica, Brescia*), J. Navarro (*CSIC and Univ. Valencia*)
[p. 31]

14–25 Oct. **Coherent Effects at RHIC and LHC: Initial Conditions and Hard Probes**
Organizers: B. Kopeliovich (Co-ordinator) (*MPI, Heidelberg*),
Y. Kovchegov (*Univ. Washington*), L. McLerran (*BNL, Brookhaven*),
G. Miller (*Univ. Washington*) [p. 33]

29–31 Oct. **Physics of Stellar Collapse and Neutron Stars**
Organisers: C. Pethick (Co-ordinator) (*NORDITA, Copenhagen*),
W. Weise (*ECT**) [p. 36]

5–6 Nov. **Vacuum Pair Creation**
Organisers: S. Schmidt (Co-ordinator) (*Helmholtz Association, Bonn*),
A. Ringwald (*DESY, Hamburg*) [p. 37]



Participants of the workshop on "Baryon Structure Probed with Quasistatic Electromagnetic Fields"

3 Report on Scientific Activities

3.1 Summary

The ECT* projects in 2002 emphasized, as in the previous years, the strong links between nuclear physics and its neighbouring fields of research. Among the summer highlights were the extended programmes on "Bose-Einstein Condensation" and "Hot and Dense QCD". The former gave an exciting state-of-the-art view of this rapidly developing field, while the latter focused on advanced training towards frontier research exploring matter under extreme conditions.

Altogether 14 projects were accepted. Active exchange between theory and experiment was a central feature of the majority of these programmes. The projects were performed by selected international groups of experts from Europe and around the world. Efforts were made to give priority support to researchers of the younger generations.

Present developments and future perspectives, all at the frontiers of nuclear physics (nuclear structure, hadron physics, QCD and matter under extreme conditions) and related areas (astrophysics, many-body problems, field theory) were explored and discussed in the following fields:

- **Nuclear Structure and Reactions**

The project on "Nuclear Collective Dynamics at Extreme Conditions" gave a broad and lively account of the variety of collective modes encountered in nuclear many-body dynamics at different energy scales. Similarly, "Fission at Finite Thermal Excitations" reviewed and updated this important topic. "Continuum Aspects of the Nuclear Shell Model" brought together the experts in this very active sector of nuclear structure investigations and pointed to future developments, intensifying contacts between theory and experiment.

- **QCD and Hadron Physics**

Several projects explored the structure of the nucleon, an exciting and challenging many-body problem all by itself. The workshop on "Physics of the Roper Resonance" summarized the state-of-the-art in the understanding of this very special mode of excitation of the nucleon and pointed towards new experimental developments as well as new results from lattice QCD computations. "Baryon Structure probed with Quasi-static Electromagnetic Fields" focused on real and virtual Compton scattering with the purpose of extracting nucleon polarisabilities, and related topics, in very active exchange between theorists and experimentalists. The extended project on "Structure of the Nucleon" covered recent progress and future perspectives, from structure functions and parton distributions to chiral dynamics and QCD on the lattice. Last but not least, the project on "Non-Perturbative Aspects of QCD" explored concepts and strategies concerning key phenomena of low-energy QCD, such as confinement and chiral symmetry breaking.

- **Matter under Extreme Conditions**

Two projects concentrated on important aspects of present and future research directed towards producing matter under extreme conditions in heavy ion collisions at the highest available energies. “Charm Production: from SPS to RHIC and LHC” brought together theorists and experimentalists in lively discussions about the evolution of systems of charmed quarks in matter. The workshop project on “Coherent Effects at RHIC and LHC: Initial Conditions and Hard Probes” focused on the conditions for creating a quark-gluon plasma in heavy-ion collisions and probing the properties of the produced matter. This was a timely and very active event related to future activities at LHC. The extended training programme “Hot and Dense QCD” with its series of lectures (see Section 3.3) gave an excellent introductory overview of the foundations and challenges of this field.

- **Related areas: Many-Body Problems, Astrophysics, Field Theory**

The interdisciplinary character and style of ECT* was emphasized through several projects of different sizes and durations, the most prominent one being the extended summer programme on “Bose-Einstein Condensation” which brought together many of the world’s leading experts in this rapidly developing area. “The Physics of Quantum Fluid Clusters” addressed a variety of problems with primary emphasis on helium clusters, a key issue being the understanding of superfluidity at nanoscopic scales. The interplay of new developments in nuclear many-body theory and dense matter problems in astrophysics was explored and discussed in the joint ECT*–NORDITA workshop “Physics of Stellar Collapse and Neutron Stars”. And “Vacuum Pair Creation” in strong electro-magnetic background fields was reviewed in a lively atmosphere joining the expertise of field theorists and plasma physicists addressing questions relevant for X-ray free electron lasers.

Larry McLerran (Brookhaven), one of the lecturers of the Marie Curie Training Programme on “Hot and Dense QCD”

3.2 Projects and Collaboration Meetings

1. BCPL USER GROUP MEETING ON COMPUTATIONAL PHYSICS

(Collaboration Meeting)

DATE: 8–9 March

ORGANISERS:
L. Csernai (*Univ. Bergen*)

NUMBER OF PARTICIPANTS: 13

MAIN TOPICS:

- nuclear, particle, atomic and molecular reaction modelling
- fluid- and continuum-dynamics
- quantum mechanical and quantum field theoretical dynamical modelling.

SPEAKERS:
C. Anderlik (*Univ. Bergen*),
L. Csernai (*Univ. Bergen*),
M. Gorenstein (*Univ. Frankfurt*),
C. Höhne (*Univ. Marburg*),
V. Magas (*IST, Lisbon*),
J. Manninen (*Univ. Oulu*),
J. F. McCann (*Queen's Univ., Belfast*)
L. Nagy (*Babes-Bolyai Univ., Cluj,*),
J. Pipek (*Univ. Tech. and Econ., Budapest*),
D. Ridikas (*CEA, Saclay*),
A. Ster (*MTA, Budapest*),
Z. Stuchlik (*Silesian Univ., Opava*)
M. Voit (*Univ. Bergen*)

SCIENTIFIC REPORT:

The objective of the workshop was to discuss the computational aspects of the participants' work, introduce the research carried out in the various projects, present results achieved by working with the supercomputer, share experiences, and exchange ideas on using supercomputing facilities.

Each participant held a presentation on the scientific project he/she was working on. In addition, a representative from Parallab, the organisation operating the supercomputer at the University of Bergen, talked about the newly installed machine.

Some scientific highlights from the workshop

Nuclear Waste Management

Danas Ridikas from Project no. 30 addressed topics related to nuclear waste, entitled "Optimization of the Th-U Fuel Cycle for Molten-Salt Reactor" worked also on optimization of reactor core and fuel configurations. The aim of the project was to check the advantages of parallel processing in these Monte-Carlo codes. The project was successful, most codes could be converted by using local help, and most test runs were completed successfully.

Subatomic Reactions

Project no. 20 “Event Generator for A+A Collisions at RHIC” from Ins. für Theoretische Physik, Universität Frankfurt, Germany led by Mark Gorenstein had the ambitious goal to unify or match parton cascade, hydrodynamic and hadron cascade models for the description of A+A reactions. At the present stage physical assumptions on how to match different models were tested on the computer, to see what are the consequences of different assumptions and which can be realized in a computational model at all. Most assumptions lead to an excessive computational task, and it is not trivial to find an accurate but computationally well realizable model.

Project no. 29 “Hadronization and Freeze Out in Fluid Dynamics” from Instituto Superior Tecnico, Lisbon, Portugal, led by Volodymyr Magas, had similar aim of coupling different modules of reaction models. The model was successful in working out the initial stage and its coupling to the CFD module. The publication reporting this work has already been submitted to Phys. Rev. D for publication already. The final module and the problem of Entropy production at this stage is still under intensive study.

Project no. 16 “Strangeness production in heavy ion collisions” from University of Oulu, Finland represented by Jaakko Manninen, works exactly on the same part of the problem. A highly parallelized hadronization code was worked out, which can be used in connection with a preceding CFD module. Several publications are expected soon based on these results, and this will lead to the evaluation of measurable hadron data in a detailed and accurate reaction model.

A specific problem related to the same topic is studied in project no. 15 “Lambda (1520) production in NN collisions” from University of Marburg, Germany, represented by Claudia Höhne. This particle has the same energetic properties as most other hadrons but its formation cross section is much smaller. Consequently it can make a difference between coalescence type of reaction models and thermal equilibrium models. The project works intensively on evaluating the consequences of the different model assumptions in different reaction models and compares the model results to the experimental data. This project illustrates the advantages of a very close collaboration between theory and experiment.

Subatomic Reactions and Astrophysics

Project no. 6 “Internal structure of neutron stars”, from Opava, Czech Republic, led by Zdenek Stuchlik, studied the consequences of QGP formation, as these influence the properties of neutron stars. Going beyond usual simplified studies, the group numerically evaluated the properties of rotating compact stars and their dependence on the QGP equation of state. In this way the astrophysical and accelerator studies can mutually complement each other for better understanding the high energy properties of matter.

Project no. 33: "Dynamics of Atomic Bose Condensates", from Belfast, UK, led by James F. McCann, aims at developing efficient high performance codes for modeling ultra-cold weakly interacting gases in a time dependent Hartree equation approach. The group developed a new method for studying complex deformation dynamics in irregular trap shapes such as asymmetric ellipsoids. The findings of this work are prepared for publication in Phys. Rev. In addition the group has identified gyroscopic precession of vortex lines in ellipsoidal traps. This finding is now under further study.

Project no. 27: "Cusp Conditions on Wavelet Density Operators", from the Budapest University of Technology and Economics, Hungary, led by Janos Pipek, has found superstructures in electron density distributions in some mesoscopic systems. These superstructures are detected by calculating the structural entropy of distributions. These calculations have required massive computing power.

Conclusion

The workshop objectives have been achieved and the workshop was a success. The participants could learn about one another's research activities and it can also be the foundation of future cooperation. It was also important to introduce the features of the new supercomputer to the users, as this is the basis that provides the common background to all these research projects on computational physics.

2. NUCLEAR COLLECTIVE DYNAMICS AT EXTREME CONDITIONS

DATE: 18–28 March

ORGANISERS:
H. Wolter (Co-ordinator) (*Univ. Munich*), M. Di Toro (*LNS, INFN Catania*), V. M. Kolomietz (*INRM, Kiev*), S. Shlomo (*Texas A&M Univ.*)

NUMBER OF PARTICIPANTS: 46

MAIN TOPICS:

- Giant resonances in nuclei at and far from stability
  - Isoscalar compression modes and the compressibility anomaly
  - Structure and excitation mechanism of giant resonances at the drip line
  - Isospin dependence of compressibility
  - Giant resonances in hot nuclei

- Relations to Nuclear Astrophysics
- Collective excitations in fusion and fission dynamics
- Chemical and mechanical instabilities in asymmetric nuclear matter
- Energy, matter and momentum flow in heavy-ion collisions

SPEAKERS:

N. Auerbach (*Univ. Tel Aviv*),
B. Borderie (*IPN Orsay*),
F. Bortignon (*Univ. Milan*),
A. Botvina (*GSI*),
M. Centelles (*Univ. Barcelona*),
G. Colo (*Univ. Milan*),
M. Colonna (*LNS Catania*),
N. Dang (*Riken*),
P. Danielewicz (*MSU*),
J. De (*VECC Calcutta*),
A. Dellafiore (*Univ. Florence*),
M. Di Toro (*LNS Catania*),
A. Drago (*Univ. Ferrara*),
L. Fortunato (*Univ. Padova*),
Ch. Fuchs (*Univ. Tuebingen*),
M. Fujiwara (*Univ. Osaka*),
U. Garg (*Univ. Notre Dame*),
N. v.Giai (*IPN Orsay*),
M. Gorelik (*Tech. U. Moscow*),
I. Hamamoto (*Univ. Lund*),
H. Hofmann (*TU Munich*),
R. Ionescu (*LMU Munich*),
V. Kolomietz (*INR Kiev*),
A. Larianov (*Univ. Giessen*),
Y. Leifels (*GSI*),
J. Lukasic (*GSI*),
W. Lynch (*MSU*),
F. Matera (*Univ. Florence*),
J. Piekarewicz (*FSU*),
T. Rauscher (*Univ. Basel*),
P. Ring (*TU Munich*),
V. Rodin (*Univ. Tuebingen*),
H. Sagawa (*Univ. Aizu*),
H. Sakai (*Univ. Tokyo*),
S. Samaddar (*Saha Inst. Calcutta*),
M. Serra (*Univ. Tokyo*),
L. Shi (*MSU*),
S. Shlomo (*Texas A&M*),
C. Simenel (*GANIL*),
M. Urin (*Tech. Univ. Moscow*),
X. Vinyes (*Univ. Barcelona*),
A. Vitturi (*Univ. Padova*),
V. Voronov (*JINR Dubna*),
G. Westfall (*MSU*),
H. Wolter (*LMU Munich*),
D. Youngblood (*Texas A&M*),
V. Zelevinsky (*MSU*)

SCIENTIFIC REPORT:

Collective phenomena are an ideal window for studying the properties of nuclear matter because they provide information about its coherent features arising from the Fermi-liquid nature and the effective interactions. One expects to obtain new insight into nuclear systems by studying these at extreme conditions, such as in regions of extreme isospin, low or high density, high temperature or extreme shapes. These conditions are realized in nuclear systems in a variety of ways, as e.g. giant resonances, large amplitude collective motion in fusion fission dynamics and heavy ion collisions at intermediate energies. The project consisted in discussing the various theoretical approaches to these phenomena and encouraging interaction between these methods. It was also an objective to confront the results with the rapidly growing body of experiental data from reactions with unstable beams, heavy ion collisions, and also from astrophysical observations.

Compressional collective modes have been the classical way to learn about the nuclear incompressibility. Besides the monopole mode the new isoscalar giant dipole mode (ISGDR) is a second window to the incompressibility but has been a puzzle, because the information seems to be contradictory. The present state was reviewed in detail by Shlomo, different theoretical approaches (relativistic, scaling, semi-microscopic) were reported by Garg, Colo, Piekarewicz, Urin and Hamamoto, and the present experimental situation was reviewed by Youngblood. It became clear that the ISGDR consists of two components, of which only the higher one is sensitive to the compressibility and yields consistent information to the monopole if all the strength is taken into account. The lower component seems to be a surface mode not connected to the compressibility.

Collective motion in weakly bound nuclei is of special interest to radioactive beam physics and to astrophysical questions. It was demonstrated by v. Giai that coordinate space time-dependent methods are well suited to treat these cases. Vitturi showed that the special features of the strength destributions are connected to matching effects of the weakly bound orbitals and lead to the low lying strength in the continuum (pygmy resonances). Sagawa discussed the difficulty to extract GR strength for drip line nuclei but also demonstrated big progress in this field. Vinas, Centelles and Samaddar discussed surface properties and incompressibilities for nuclei, also in the presence of a neutron gas.

Relativistic formulations of nuclear structure and reactions are of increasing importance and are also applied for collective motion as discussed at the workshop. Ring, Piekarewicz and others discussed relativistic RPA. DiToro discussed in particular the effect of the scalar-isovector δ-meson and of Fock terms with respect to asymmetric systems, which constituted a recurrent theme in the workshop. Serra showed how pairing can be treated consistently in the RMF approach. A special seminar by Weise introduced a new appraoch to nuclear matter based on QCD symmetries and chiral perturbation theory, which is also being applied to finite systems.

Several speakers discussed modifications and extensions of the RPA in the investigation of new modes and new regions of the nuclear chart, such as anharmonicities (Simenel), renormalized RPA and ground state correlations (Dang), temperature dependence (Hofmann), separable approximations (Voronow), and the treatment of giant pairing vibrations (Fortunato). Fission and large amplitude motion was treated in a talk by Kolomietz on non-markovian Fermi sphere deformation effects.

A very exciting part of the workshop was the question of the impact of collective motion on astrophysics. In a very nice review talk Rauscher discussed the needs of astrophysicists from the nuclear physics community, such as nuclear reaction rates, strength functions for instable nuclei, level densities, fission barriers and the nuclear equation-of-state for a large density and asymmetry range. In other talks special attention was given to connections to β-decay, weak interactions and neutrino-nucleus scattering. Of special interest is the spin-dipole resonance, which allows us to learn more about these processes. Theoretical aspects were presented by Auerbach and the experimental state of affairs by Fujiwara and Sakai. The astrophysical connections were also discussed extensively in various talks in the second week with respect to the equation of state and the high density behaviour.

In the second week the workshop discussed collective phenomena as they occur in intermediate energy heavy ion collisions at high density in the compression phase and at low density in the expansion and fragmentation phase. As demonstrated by Borderie, the spinodal instability has been seen in special multifragmentation events which can be selected experimentally by charge correlations. This phase transition gains particular interest from the fact that nuclear systems are binary systems of protons and neutrons and that this degree of freedom can be varied with the selection of various collision systems, and increasingly so in the future with radioactive beams. Fragmentation of asymmetric systems should contain information on the isovector-EOS at low density.

The experimental evidence was presented by Lynch for isotope yields from collisions of asymmetric systems. He showed that isoscaling coefficients parametrize the yield distributions in a compact manner and contain information about the nature of the processes. Theoretical interpretations of these results have been done in various approaches which were presented at the workshop: Statistical Multifragmentation (Lynch, Botvina), stochastic dynamical transport models (Colonna) and semiclassical methods (Kolomietz, Samaddar). It was discussed controversially whether a statistical interpretation is sufficient or whether dynamical effects influence the isospin fractionation and diffusion. Conclusions are difficult to draw because secondary evaporation effects partly wash out the signals. Matera showed how fluctuations occur in static and dynamical situations and how they affect fragment distibutions.

The other important window on the EOS is the discussion of collective flow and of stopping in heavy ion collisions at intermediate energies. The experimental situation was reviewed in several contributions. (Westfall, Kukasic, Leifels).

From the theory side Danielewicz elaborated in two lectures various aspects of stopping and mixing, and ways to determine the viscosity and isospin diffusion transport coefficients. He and Larionov showed how a systematic investigation of differential flow – with respect to impact parameter, longitudinal and transverse momentum – can put strong constraints on the momentum dependence of the interactions, the EOS of symmetric matter, and less certain limits on the isovector contributions. Wolter discussed the use of interactions derived from microscopic many body approaches in such investigations including the importance of non-equilibrium effects. Ionescu showed the results of differential elliptic flow in such calculations. Fuchs demonstrated that kaon production is a strong probe to determine the EOS.

The workshop demonstrated that collective phenomena in stable and unstable regions are a unifying aspect with which to investigate nuclear systems at extreme conditions, as was repeatedly emphasized in the talks. In this spirit the workshop served to bring together the different parts of the community working in this field and strengthened the exchange between them.

3. THE PHYSICS OF THE ROPER RESONANCE

(Collaboration Meeting)

DATE: 10–12 April

ORGANISERS:
M. Soyeur (Co-ordinator) (*CEA, Saclay*)

NUMBER OF PARTICIPANTS: 15

MAIN TOPICS:

- The Roper resonance in quenched lattice QCD
- Quark model descriptions of the Roper resonance
- The role of the N*(1440) in single pion production processes
- The role of the N*(1440) in double pion production processes
- Photoproduction of the Roper resonance
- Excitation of the Roper resonance in proton, deuteron and α-particle induced reactions off proton targets
- Chiral approaches to the pionic decays of the N*(1440)

SPEAKERS:

R. Beck (*Univ. Mainz*)
F. Cano (*CEA, Saclay*)
T. Hennino (*IPN, Orsay*)
E. Hernández (*Univ. Salamanca*)
B. Höistad (*Univ. Uppsala*)
B. Juliá Díaz (*Univ. Salamanca*)
D. Merten (*Univ. Bonn*)
F. X. Lee (*George Washington Univ.*)
V. Metag (*Univ. Giessen*)
B. Metsch (*Univ. Bonn*)
E. Oset (*Univ. Valencia*)
T. Peña (*CFIF, Lisbon*)
D. O. Riska (*Univ. Helsinki*)
S. Sasaki (*Tokyo Univ.*)
M. Soyeur (*CEA, Saclay*)

SCIENTIFIC REPORT:

The Roper resonance, the N*(1440), has been a long-standing puzzle for both theorists and experimentalists. It is the first excited state of the nucleon. It has the same quantum numbers as the nucleon, spin 1/2, isospin 1/2 and positive parity. It is a very broad state, with an estimated width of (350 ± 100) MeV. This width results mainly from strong decays into the pion-nucleon and the two-pion nucleon channels.

Because of its positive parity, the three-quark state describing the N*(1440) should involve two quanta of excitation in quark models based on harmonic confining forces. This leads to baryon masses of the order of 1700 MeV, much above the observed mass of the Roper resonance. Many suggestions were made to accommodate the low mass of the N*(1440): anharmonic interactions, collectivity, three-quark forces. Recently, it has been shown that a particular scheme implementing chiral symmetry in quark models led to the correct ordering of positive and negative parity states in the baryon spectrum and to the right mass for the N*(1440). This suggests that the structure of the Roper resonance could be linked to the chiral symmetry of quantum chromodynamics.

Experimentally, about a third of the width of the Roper resonance is due to its decay into the two-pion channel. There are many components in this decay channel, all involving an intermediate state of large width: $\pi\Delta$, ρN and $(\pi\pi)^{I=0}_{s-wave}$ N (often parametrized by a σN channel). Consequently, those components are very hard to disentangle. The couplings of the Roper resonance to vector-meson nucleon and scalar-meson nucleon channels play however an important role in determining the role of the N*(1440) in the nuclear many-body problem. Significant experimental progress was achieved in the last few years through studies of the Roper resonance in the $\pi^0\pi^0$N channel, which has no overlap with the ρN final state.

Quenched lattice QCD calculations have recently tackled the problem of computing the masses of baryonic excitations of spin 1/2 and 3/2. A particularly interesting issue is the structure of the spectrum of positive and negative parity spin 1/2 baryons as a function of the quark mass.

In view of the recent developments mentioned above, it seemed timely to devote a meeting to the Roper resonance and to the issues closely related to this particular baryonic state. The format of a Collaboration Meeting at Trento appeared ideal. The participants consisted of 11 theorists and 4 experimentalists. All promising new theoretical approaches could be presented: lattice studies of excited baryons with improved actions, quark models with interactions related to chiral symmetry, chiral Lagrangian descriptions of the pionic decays of the Roper resonance. The recent data relevant to the understanding of the Roper resonance were shown: two-pion production in photon-induced reactions, in proton-proton inelastic scattering and in αp reactions. Future plans for experimental studies of the N*(1440) were discussed. Phenomenological approaches relevant to the description of these data were reviewed. It was very fortunate that the regular seminar of the ECT* given during the meeting by Matthias Lutz dealt with the closely related issue of a coupled-channel effective theory for meson-nucleon scattering.

The overall conclusions of this meeting can be summarized as follows.

The Roper resonance is clearly one piece of a larger problem because the spectrum of every baryonic state (for given quantum numbers) exhibits a resonance with similar properties. The importance of new data on the Σ, Ξ, Λ_c and Σ_c spectra was particularly emphasized.

The discussion of the very nature of baryon resonances appeared to be in a very interesting stage. Two, possibly complementary, descriptions have been considered for a long time, the dynamic generation of resonances through meson-nucleon scattering and three-quark states in quark models. Very recently, lattice QCD calculations of low-lying baryons became possible. These three approaches may converge to a more accurate picture of baryon resonances. This is due to the availability of new relativistic coupled-channel calculations of meson-nucleon scattering (strongly constrained by data), to more reliable spectra for $q^4\bar{q}$ configurations (with flavour-spin interactions producing the proper level ordering for q^3 states) and to the future possibility of projecting lattice QCD baryonic states on q^3 and $q^4\bar{q}$ components.

Important directions for future work involve the relation of the spin 1/2 baryon spectrum to chiral symmetry (on the lattice and in quark models), consistent calculations of baryon masses and decay widths and proper descriptions of the σ degree of freedom. Regge trajectories and high spin states emerged also as relevant issues.

There are very interesting new data in need of detailed theoretical understanding. Of particular relevance are the CELSIUS data on two-pion production in proton-proton collisions ($pp \to pp\pi^+\pi^-$, $pp \to pp\pi^0\pi^0$, $pp \to pn\pi^+\pi^0$, $pp \to nn\pi^+\pi^+$) and exclusive SATURNE data recently analyzed on the single and double pion channels in $\alpha\, p$ collisions. An experiment planned at MAMI: the photoproduction of π^0's with linearly polarized photons scattered off longitudinally polarized proton targets, should bring new detailed information on the coupling of the Roper resonance to the photon field.

4. BARYON STRUCTURE PROBED WITH QUASISTATIC ELECTROMAGNETIC FIELDS

(Collaboration Meeting)

DATE: 15–19 April

ORGANISERS:
L. Van Hoorebeke (Co-ordinator) (*Univ. Gent*), B. Pasquini (*ECT**), M. Vanderhaeghen (*Inst. für Kernphysik, Mainz*)

NUMBER OF PARTICIPANTS: 27

MAIN TOPICS:

- Experimental overview of virtual Compton scattering (VCS)
- Theoretical overview of VCS
- Dispersion relations in real and virtual Compton scattering
- Sum rules for real and virtual photons
- Magnetic moment of the Δ resonance
- Experimental plans to measure the Δ^+ magnetic moment

SPEAKERS:

R. Beck (*Univ. Mainz*)
W. T. Chiang (*Nat. Taiwan Univ.*)
N. D'Hose (*CEA, Saclay*)
D. Drechsel (*Univ. Mainz*)
P. Faccioli (*SUNY, Stony Brook*)
H. Fonvielle (*Univ. Blaise Pascal Clermont*)
M. Gorchtein (*Univ. Mainz*)
H. Griesshammer (*TU Munich*)
P. Guichon (*CEA, Saclay*)
T. R. Hemmert (*TU Munich*)
R. Hildebrandt (*TU Munich*)
C.W. Kao (*Univ. Manchester*)
M. Kotulla (*Univ. Giessen*)
G. Laveissiere (*Univ. Blaise Pascal Clermont*)
A.I. L'vov (*Lebedev Phys. Inst., Moscow*)
A. E. Mariano (*Univ. Nacional de la Plata*)
H. Merkel (*Univ. Mainz*)
A. Metz (*Vrije Univ., Amsterdam*)
A. Özpineci (*ICTP, Trieste*)
B. Pasquini (*ECT**)
E. Santopinto (*Univ. Genova*)
L. Van Hoorebeke (*Univ. Gent*)
M. Vanderhaeghen (*Univ. Mainz*)
S. Wells (*Louisiana Tech. Univ.*)

SCIENTIFIC REPORT:

Aim and Purpose

The aim of this collaboration meeting was to bring together the people (both theoreticians and experimentalists) who are very actively involved in the recent developments in the fields of baryon structure as probed with quasi-static electromagnetic fields. Items to be covered were real and virtual Compton scattering with the aim to extract nucleon polarizabilities, sum rules in electron scattering and the "quasi-static" properties of resonances, in particular their magnetic moments. Recent progress and prospects in these fields were discussed. For the duration of the collaboration meeting oral presentations about the status of experimental analysis of recent Compton scattering data and the developments in their theoretical interpretation were alternated with open discussions to plan the next steps in these fields.

This meeting was very successful. It has brought together specialists in the fields mentioned above. Very new results, both from the theoretical and from the experimental side were presented and were thoroughly discussed. The informal atmosphere allowed for very open and profound discussions, giving rise to new ideas to tackle existing problems. Bringing together both theoreticians and experimentalists in this meeting allowed for a productive interaction which steered both groups into certain directions to continue their work in the future. In this meeting the roots for future collaborations were planted.

5. FISSION AT FINITE THERMAL EXCITATIONS

(Collaboration Meeting)

DATE: 22–26 April

ORGANISERS:
H. Hofmann (Co-ordinator) (*TU Munich*), K. Pomorski (*UMCS, Lublin*), K-H. Schmidt (*GSI, Darmstadt*)

NUMBER OF PARTICIPANTS: 16

MAIN TOPICS:

- Survey of experimental methods, results and limitations
- Review of the transition state theory (Bohr-Wheeler formula)
- Nuclear thermodynamics
- Level densities and determination of temperatures
- Transport equations (Fokker-Planck vs Langevin)
- Evaporation of light particles and emission of γ's
- Potential landscapes, fission paths and role of rotational degrees of freedom
- Transport coefficients and time scales
- Importance of transient and saddle-scission times

- Kramers' rate formula and possible extensions
- Applications in statistical codes

SPEAKERS:

A. Yasuhisa (*Univ. Kyoto*)
J. Bartel (*IReS, Strasbourg*)
J. Benlliure (*Univ. Santiago*)
J-F. Berger (*CEA/DIF, Bruyères*)
H. Hofmann (*TUM Munich*)
A. Ignatyuk (*IPPE, Obninsk*)
F. A. Ivanyuk (*GSI, Darmstadt*)
B. Jurado (*GSI, Darmstadt*)
S. Karamyan (*LMU, Munich*)
A. Kelic (*GSI, Darmstadt*)
L. Phair (*LBL, Berkeley*)
K. Pomorski (*Univ. Marie Curie-Sklodowska*)
K. H. Schmidt (*GSI, Darmstadt*)
A. Sierk (*LANL, Los Alamos*)

SCIENTIFIC REPORT:

Aim and Purpose

The process of nuclear fission is one of the oldest examples of nuclear collective dynamics. Nevertheless, to date there is no definite understanding of how this process may be described quantitatively, despite the vast amount of experimental information one has gained in the past, in particular for fission at finite thermal excitation. The latter process allows one to study fundamental questions not only of nuclear collective dynamics, but of transport processes of small and isolated systems in a more general context also. On the one hand, the measurement of emitted light particles or gammas supplies important information on the time scale of the process. On the other hand, the latter takes place within a small and isolated system. This requires the consideration of self-consistency as well as of that of quantum effects. Self-consistency between collective and nucleonic degrees of freedom rules out applications of Hamiltonians which are widely used in general transport theory, for instance to describe the decay of meta-stable systems. Furthermore, in the nuclear case quantum effects will at least show up in the dynamics of the nucleons in their mean field, which nevertheless feel the residual interactions. Fortunately, fission is expected not to be influenced by strong non-Markovian effects, simply because it may safely be assumed to be a slow process, very different from the entrance phase of heavy ion collisions, for instance.

At present there is perhaps a good chance to reach a better and deeper understanding of fission, as there already exist various efforts to explore this field. Unfortunately, these approaches have often relied on too diverse and to large extent "decoupled" methods. There are, first of all, the experimental groups who have obtained beautiful data which are being interpreted with statistical codes which often lack relevant physical input. On the other hand, there exist theoretical descriptions of the fission process through Langevin or Fokker Planck equations, for which often no direct connection has been established to microscopic input. The numerical effort may easily become unfeasible if it cannot be restricted by some physical motivation – which can only come through advice from the groups mentioned previously. One of the main goals of the meeting was to promote and facilitate such an exchange of information between these individual groups.

Main Results

With respect to this essential issue the meeting can be said to have been completely successful. There was a very fruitful exchange of information on existing results and on the different concepts used. Considering the truly complex and complicated physical situation at stake, it may well be claimed that in parts astonishingly good descriptions of experimental data has been obtained. Nevertheless, at the end of the meeting there was a general agreement that presently no model or theory explains all existing experimental data, in particular if one aims at cross sections for both fission events and evaporation residues. It has thus become apparent that some of the conclusions previously reached by the application of existing statistical codes have to be taken with some caution. Amongst others, this concerns the dependence of transport coefficients on temperature and shape. Possible reasons for such a failure were mentioned and discussed extensively. It can be said, that, whereas the linear response approach supports experimental findings that dissipations grows with temperature, no microscopic justification of a strong increase of friction on the way from saddle to scission was reported.

It was agreed that the Bohr-Wheeler formula for the decay must be supplemented by dynamical effects, be it simply through the so called "Kramers factor" or by the additional influence of the transient saddle to scission time. Otherwise the enhanced emission of light particles and gammas can be explained. It was demonstrated that experimental evidence suggests the emission of such particles prior to the stationary situation of fission. No agreement could be reached to the extent such events are due to a truly non-equilibrium initial stage, which would indicate a failure of Bohr's compound hypothesis. Related to this question is the one of an eventual initial hindrance of the nuclear decay through fission (transient effect), and whether or not this delay may be described within Kramers' picture of the fission mode.

Quite some time was spent on the temperature dependence of the level density in connection to the disappearance of shell effects in the free energy. Likewise, the calculation and the importance of the smooth part of the static energy have been discussed and various models have been compared with each other, in particular the new liquid drop (LSD) and the Yukawa-folded model with respect to the evaluation of fission barriers. It has been stressed that for a full understanding of the dynamics of fission as a transport process it does not suffice to study only the effects of dissipation. Besides the potential landscape, one must also not discard the subtle question of calculating properly the inertia, a feature which reflects the importance of self-consistency mentioned previously. Last but not least, emphasis has been put on the need for choosing more optimal degrees of freedom along which the fission dynamics would be describable in more realistic fashion than done so far.

In summary it can be said that many fundamental questions have been clarified, but it remains open as to how such answers might directly be incorporated into practical applications. The meeting was extremely fruitful in paving the way for necessary future work.

6. CONTINUUM ASPECTS OF THE NUCLEAR SHELL MODEL

DATE: 3–7 June

ORGANISERS:
M. Ploszajczak (Co-ordinator) (*GANIL, Caen*), W. Nazarewicz (*Univ. Tennessee*), H. Sagawa (*Univ. Aizu*)

NUMBER OF PARTICIPANTS: 39

MAIN TOPICS:

- The description of coupling between discrete and continuum states is an urgent and important problem in nuclear physics, mainly in connection with the description of both the structure of weakly bound exotic nuclei and the reactions which could exhibit their structure and are often important astrophysically. Important experimental projects in Europe, in the USA, and in Japan are devoted principally to the study of nuclei at the edge of the particle stability. It is therefore urgent to discuss and to stimulate the theoretical developments which could accompany these exciting and vigorous experimental projects.
- New qualitative effects of coupling through continuum
- Pairing effects in weakly bound nuclei
- Continuum quasiparticle random phase approximations - new developments
- Few-body decays and two-proton radioactivity

SPEAKERS:

K. Bennaceur (*IPNL, Lyon*)
S. Cotanch (*N. Carolina State Univ.*)
D. Dean (*Oak Ridge Nat. Lab.*)
J. Dobaczewski (*Warsaw Univ.*)
J. Engel (*Univ. N. Carolina*)
L. Grigorenko (*GSI, Darmstadt*)
S. A. Gurvitz (*Weizmann Inst. Science*)
K. Hagino (*Yukawa Inst. Theo. Physics*)
M. Hjorth-Jensen (*Univ. Oslo*)
M. Horoi (*Michigan State Univ.*)
E. Khan (*IPN, Orsay*)
A. Kruppa (*Inst. Nuc. Res., Debrecen*)
M. Matsuo (*Niigata Univ.*)
N. Michel (*GANIL, Caen*)
T. Nakatsukasa (*Tohoku Univ.*)
W. Nazarewicz (*Univ. Tennessee*)
F. Nunes (*Univ. Fernando Pessoa*)
M. Ploszajczak (*GANIL, Caen*)
I. Rotter (*MPI, Dresden*)
S. Shlomo (*Texas A&M Univ.*)
M. Stoitsov (*Univ. Tennessee*)
N. Tajima (*Fukui Univ.*)
J. Terasaki (*Oak Ridge Nat. Lab.*)
I. Thompson (*Univ. Surrey*)
J. Vaagen (*Univ. Bergen*)
N. Van Giai (*Univ. Paris Sud*)
T. Vertse (*Hung. Acad. of Sciences*)
D. Vretenar (*Univ. Zagreb*)
M. Yamagami (*IPN, Orsay*)
S. Yoshida (*Hosei Univ.*)
V. Zelevinsky (*Michigan State Univ.*)

SCIENTIFIC REPORT:

Aim and Purpose

The aim of the workshop was to get together theorists from different communities, i.e. nuclear structure, nuclear reactions and atomic physics, to discuss the best strategies of attacking the problem of weakly bound nuclei and the nature of unbound nuclear states. The workshop had necessarily an interdisciplinary aspect because various theoretical approaches to the problem of the particle continuum are being developed in other fields of physics, especially in atomic physics. Intense experimental efforts to study properties of atomic nuclei at the edge of the particle stability were guiding our approach in preparing the detailed program of the workshop. One of the objectives of the meeting was precisely an identification of the experimental input crucial to the future developments of the continuum shell model. Hopefully, this may lead in future to more synchronized efforts of experimentalists and theoreticians in the fast developing field of weakly bound (particle unstable) nuclei.

Main Achievements

First, significant progress has been made in the area of the quasiparticle random phase approximations. A number of novel techniques have been proposed to study the nuclear response to multiple fields, taking into account pairing effects and particle continuum. All these different developments have been presented and thoroughly discussed during the workshop. Second, a clear strategy of how to treat multiparticle correlations in continuum has been developed. The method, so-called Gamow Shell Model, is based on Berggren completeness relations employing the bound-states, resonances, and non-resonant continuum. An alternative approach, so-called Shell Model Embedded in the Continuum, which presently takes into account coupling to only one-nucleon decaying channels, was analysed. The advantage of this approach is that structure and reaction data are discussed in a unified framework. The description of pairing effects in weakly bound nuclei was discussed, and various methods and approximations were critically analyzed.

7. CHARM PRODUCTION: FROM THRESHOLD VIA SPS TO RHIC AND LHC

DATE: 17–22 June

ORGANISERS:
A. Polleri (Co-ordinator) (*TU Munich*), J. Hüfner (*Univ. Heidelberg*), B. Kopeliovich (*MPI, Heidelberg*), M. Leitch (*LANL, Los Alamos*), J-C. Peng (*LANL, Los Alamos*)

NUMBER OF PARTICIPANTS: 40

MAIN TOPICS:

- Charm production mechanisms
- Charmonium evolution in the Quark Gluon Plasma
- Final state interactions
- Future perspectives

SPEAKERS:

F. Arleo (*ECT**)
T. S. Bauer (*NIKHEF, Amsterdam*)
D. Blaschke (*Univ. Rostock*)
G. Burau (*Univ. Rostock*)
A. Capella (*Univ. Paris XI*)
V. Cianciolo (*Oak Ridge Nat. Lab.*)
E. Ferreiro (*Univ. Santiago*)
M. Gorenstein (*Bogolyubov Inst., Kiev*)
P-B. Gossiaux (*SUBATECH, Nantes*)
K. Griffioen (*College of William and Mary*)
Y. Ivanov (*Univ. Heidelberg*)
S. H. Kahana (*BNL, Brookhaven*)
C-M. Ko (*Texas A&M Univ.*)
B. Kopeliovich (*MPI, Heidelberg*)
D. Koudela (*Univ. Heidelberg*)
M. J. Leitch (*LANL, Los Alamos*)
G. Lykasov (*JINR, Dubna*)
M. Medinnis (*DESY, Hamburg*)
S. Peigné (*LAPTH, Annecy*)
J-C. Peng (*Univ. Illinois*)
K. Peters (*Univ. Bochum*)
A. Polleri (*TU Munich*)
R. Rapp (*SUNY, Stony Brook*)
J. Raufeisen (*LANL, Los Alamos*)
H. Satz (*Univ. Bielefeld*)
E. Scomparin (*INFN, Turin*)
C-Y. Wong (*Oak Ridge Nat. Lab.*)
P. Zhuang (*Univ. Heidelberg*)
A. Zieminksi (*Indiana Univ.*)
B. Zou (*IHEP, Beijing*)

SCIENTIFIC REPORT:

Aim and Realization of the Workshop

The intent of the organizers was to have a meeting in which both theorists and experimentalists could be confronted with each other. This resulted in very interesting and lively discussions, both on present and future issues. Out of 40 participants more than 25% were young researchers under 35 years of age. These provided plenty of fresh ideas and established useful contacts with the senior participants. Each day started with a review lecture on a general problem, setting the ground for the following talks, which addressed more specific issues related to the lecture. About one third of the time allocated for each speaker was dedicated to discussion, allowing the audience to ask detailed questions and receive thorough answers. The last day, dedicated entirely to discussion, served to summarize the results presented, and to establish connections among different approaches. Future research directions were also outlined.

Focus of the Workshop

As it is for most of the studies within heavy ion physics, the two main areas of interest concern initial state effects and final state interactions with the medium. The first aspect of the problem concerns the understanding of the so-called nuclear effects which appear already in proton-nucleus (pA) collisions but can be studied also with the photon-nucleus (γA) system. These are parton energy loss, transverse momentum broadening, absorption, coherence, shadowing, etc. The second aspect is directly related to the issue of quark gluon plasma production in nucleus-nucleus (AB) collisions, since it concerns the effects of a medium with high energy density on the probe under consideration, in the present context charmed particles. A summary of what was presented and discussed at the workshop follows:

Charm production mechanisms

The production mechanism of charmed hadrons, even at the proton-proton level is only partially understood. Available data, mainly from the FERMILAB-TEVATRON, were reviewed. Theoretically, what one knows is based on the parton model which is not very suitable for nuclear interactions. Some discussions were dedicated to the analogy between that parton model description and a fairly new, alternative formulation in terms of the dipole-proton cross section in the target rest frame, both for Drell-Yan and for charm production. The latter formulation can be extended to collisions involving nuclei in a straightforward manner. This was done and presented extensively, both for pA and γA reactions. Good agreement with the pA data of the FERMILAB-E866 experiment revealed the interplay of formation time effects at Feynman's $x_F < 0$, absorption and energy loss at $x_F \sim 0$, energy loss, coherence and shadowing at $x_F > 0$. Dramatic predictions for the x_F-dependence of J/ψ production at RHIC energies were shown, soon to be tested experimentally. Furthermore, the program of experiments SLAC-E160 (γA) and DESY HERA-B (pA) was presented. They will produce high quality data in a wide enough acceptance window such that predictions based on the above mentioned ideas can be tested further.

Alternative theoretical points of view were also put forward in great detail, and the final discussion on the last day of the workshop seemed to provide enough hints that various approaches lead to quite similar conclusions. It appeared clear that more clarifying studies in this direction would be welcome, in order to establish a common language. Additional discussion concerning the importance of understanding nuclear effects as benchmark for AB collision studies was prompted by the presentation, first of new pA data from the CERN-NA50 experiment and then of the planned deuteron-nucleus experiments at the BNL-RHIC machine.

Charm final state interactions with the produced medium

Concerning the evolution of systems of charmed quarks in the medium produced in AB collisions, most of the discussion regarded the possibility of statistical charmonium production in the event that the medium is a Quark-Gluon Plasma (QGP). Various theoretical approaches were presented, ranging from pure thermodynamics to kinetic theory. The main concern was about the possible *enhancement* of charmonium production, as compared to the expectation from pp collisions. Some predictions for the running BNL-PHENIX experiment were given. The experiment itself was presented in great detail and a lively discussion about the capabilities, in particular regarding acceptance, clarified that a study of the x_F dependence of charmonium spectra will be feasible. This important point will clarify several unsolved theoretical issues, still left open by the great efforts of the CERN-NA50 experiment.

Its successor, NA60, was also presented and its potential in gaining further insight to the problem was discussed.

Still in the context of charmonium evolution in a QGP, the question whether suppression is caused by static screening or by collisions with the plasma constituents was raised and debated. It appeared that only a comprehensive, dynamical study of the issue can suggest the best point of view and indicate the subsequent theoretical approach. The problem was partially addressed within transport simulations, showing that both aspects of the dissociation mechanism can be important.

Aside from charmonium, the issue of possible open charm enhancement below the J/ψ mass was considered. Finally the plan of the future GSI antiproton-nucleus facility was presented and the flexibility of the various experiments in addressing various aspects of charm physics was discussed.

Summary

All in all it was a very exciting and fruitful meeting, in which participants discussed openly different physics ideas with the intent to find a common ground. It also was evident that a high degree of sophistication is beginning to be employed to address various problems. This is an important and necessary step for further advances in this field.

8. BOSE-EINSTEIN CONDENSATION SUMMER PROGRAMME 2002

DATE: 1 July–10 August

ORGANISERS:
S. Stringari (Co-ordinator) (*Univ. Trento*), F. Laloë (*ENS, Paris*), C. Clark (*NIST, Gaithersburg*)

NUMBER OF PARTICIPANTS: 102

MAIN TOPICS:
- coherence properties
- low dimensionality
- optical lattices
- quantized vortices
- rotating systems
- new quantum phases
- degenerate Fermi gases
- stochastic and numerical methods
- large scattering length

SPEAKERS:

G. Astrakharchic (*Univ. Trento*)
G. Baym (*Univ. Illinois*)
D. Blume (*Univ. Colorado*)
L. Carr (*Lab. Kastler Brossel, Paris*)
J. Brand (*MPI, Dresden*)
I. Carusotto (*ENS, Paris*)
M-L. Chiofalo (*Scuola Normale Sup., Pisa*)
E. A. Cornell (*Univ. Colorado*)
A. Csordas (*Eötvös Univ., Budapest*)
F. Dalfovo (*Univ. Trento*)
P. D. Drummond (*Univ. Queensland*)
R. Duine (*Univ.Utrecht*)
M. Edwards (*Georgia Southern Univ.*)
T. Esslinger (*ETH, Zurich*)
P. Fedichev (*Univ. Innsbruck*)
A. L. Fetter (*Stanford Univ.*)
D. M. Gangardt (*ENS, Paris*)
C. Gardiner (*Victoria Univ. Wellington*)
S. Giovanazzi (*Univ. Stuttgart*)
K. Goral (*Univ. Warsaw*)
A. Griffin (*Univ. Toronto*)
J. Ho (*Ohio State Univ.*)
M. Kraemer (*Univ. Trento*)
W. V. Liu (*MIT, Cambridge*)
C. Menotti (*Univ. Trento*)
M. Modugno (*Univ. Florence*)
E. Mueller (*Ohio State Univ.*)
D. O'Dell (*Univ. Sussex*)
M. Olshanii (*Univ. Southern California*)
D. Petrov (*AMOLF, Amsterdam*)
L. Pitaevskii (*Univ. Trento*)
N. P. Proukakis (*Univ. Durham*)
J. Ruostekoski (*Univ. Hertfordshire*)
K. Rzazewski (*Univ. Warsaw*)
G. Shlyapnikov (*AMOLF, Amsterdam*)
H. T. C. Stoof (*Univ. Utrecht*)
S. Stringari (*Univ. Trento*)
J. Tempere (*Univ. Antwerp*)
M. Ueda (*Univ. Tokyo*)
J. Williams (*NIST, Gaitherburg*)
S. Yukalov (*JINR, Dubna*)
E. Zaremba (*Univ. Ontario*)

SCIENTIFIC REPORT:

Aim and Purpose

The Bose-Einstein Condensation (BEC) Summer Programme held in Trento in 2002 was the third of a series of long programmes devoted to Bose-Einstein condensation. The first one was organized in Santa Barbara (USA) in 1998, the second one in Leiden (Netherlands) in 2000. The aim of this programme was to bring together scientists working in this rapidly evolving field of physics, promoting new scientific exchanges involving both senior and junior physicists.

The field of ultracold atoms and in particular Bose-Einstein condensation is extremely active nowadays, both from the experimental and theoretical points of view. Long term activities, like the BEC Summer Programme, are expected to favour the interdisciplinary interchange of researchers. The Trento BEC Summer Programme was particularly successful, providing a concrete answer to the need of contacts and interactions which is particularly urgent in this field of physics.

The programme consisted of:

- An activity held at the European Centre for Theoretical Studies in Nuclear Physics and Related Areas (ECT*). About 25-30 scientists were simultaneously participating in this activity for a typical period of 2-3 weeks per person within the duration of the Programme. The participants were mainly theorists and the activity was organized in the form of daily seminars and round tables on different topics related to BEC.

- A formal workshop on "Recent developments in the physics of cold atomic gases" which was held at the Physics Department of the University of Trento during the third week of the Summer Programme and were the most recent and important experimental and theoretical results were presented by outstanding speakers coming from the most prestigious laboratories in the world, including Eric Cornell and Wolfgang Ketterle, two of the three winners of the Nobel Prize in Physics 2001.

The Trento BEC Summer Programme has stimulated many useful interactions, providing unique opportunities especially to young people, present in large numbers at the BEC Summer Programme. The hottest themes of research, involving the physics of degenerate Fermi gases, optical lattices, new quantum phases, low dimensionality, quantized vortices, etc., were discussed in depth, providing new insights in the future programmes of research.

The friendly atmosphere characterizing both the activity at ECT* and the workshop at the Physics Department is expected to favour new future international links and new collaborations at European and non-European levels.

9. NON-PERTURBATIVE ASPECTS OF QCD

DATE: 8–19 July

ORGANISERS:
P. Damgaard (Co-ordinator) (*NBI, Copenhagen*), U.-M. Heller (*Florida State Univ.*), J. J. M. Verbaarschot (*SUNY, Stony Brook*)

NUMBER OF PARTICIPANTS: 25

MAIN TOPICS:
- Light quarks in Lattice QCD: physics from new algorithms
- The instanton vacuum
- Random Matrix Theory and Dirac spectra
- Lattice QCD at finite baryon and isospin chemical potential
- QCD near the confinement phase transition
- Chiral Lagrangians at nonzero chemical potential

SPEAKERS:

G. Akemann (*CEA, Saclay*)
J. A. Bowers (*MIT, Cambridge*)
S. Chandrasekharan (*Duke Univ.*)
P. Faccioli (*Stony Brook/ECT**)
M. Goltermann (*San Francisco State Univ.*)
T. Guhr (*Univ. Lund*)
S. Hands (*Univ. Swansea*)
U. M. Heller (*Florida State Univ.*)
A. Kalloniatis (*Univ. Adelaide*)
F. Karsch (*Univ. Bielefeld*)
M. P. Lombardo (*INFN, Padova*)
B. Lucini (*Univ. Oxford*)
H. Neuberger (*Rutgers Univ.*)
K. Rummukainen (*NORDITA, Copenhagen*)
F. Sannino (*NORDITA, Copenhagen*)
B. Schlittgen (*Yale Univ.*)
M. Stephanov (*Univ. Chicago*)
B. Svetitsky (*Tel Aviv Univ.*)
M. Teper (*Univ. Oxford*)
D. Toublan (*Univ. Illinois*)
P. Van Baal (*Univ. Leiden*)
J. Verbaarschot (*State Univ. New York*)
T. Wettig (*Yale Univ.*)

SCIENTIFIC REPORT:

Aim and Purpose

Nonperturbative effects are responsible for chiral symmetry breaking, confinement and complex phenomena such as the existence of nuclei. They have been analyzed from different perspectives and by different methods. Best known is lattice QCD which is in principle an exact method but is in practice greatly restricted by the limited power of todays computers. Other methods can provide us with exact results for the low-energy limit of QCD. For example, Chiral Perturbation Theory, Chiral Random Matrix Theory, Small Volume expansions. Other approaches that have had a great deal of impact are semi-classical methods with Instanton Liquid Models as best known example. One of the major breakthroughs in lattice QCD during the past few years has been the development of algorithms allowing us to simulate full QCD with light or zero quark mass. The main goal of this workshop was to confront lattice results for full QCD with light quarks with exact results for the low-energy limit of the QCD partition function, and to discuss the effective theory of low-energy QCD from different angles. Bringing together some of the most active researchers in these areas allowed us to seek and address questions about chiral symmetry in QCD with light quarks. One part of our workshop was the analysis of results obtained by means of recent algorithms for simulating chiral fermions such as Ginsparg-Wilson fermions and Domain wall fermions. A second part was the discussion of recent progress for exact results for the low-energy limit of QCD. Among others we mention the description of the Dirac spectrum by means of partially quenched chiral perturbation theory and chiral Random Matrix Theory. A third part was the discussion of exact non-perturbative results for QCD at finite density. In recent years a large number of scenarios have been sketched for QCD with three colors. Because of the failure of Monte-Carlo simulations, these speculations could not be tested. However, a Bose-Einstein condensation phase transition predicted for QCD with two colors has been observed in recent lattice QCD simulations.

The workshop was much enjoyed by the participants, who, outside the scheduled program, were given ample time for informal discussions. A few informal talks outside the main program were also organized on the spot. This workshop took place simultaneously with the longer-term Bose-Einstein condensate workshop/conference, and the ECT* Doctoral Training Program "Hot and Dense QCD". Several participants of the workshop attended the lectures of this program, which was close in topic to our workshop. Also students from the Doctoral Training Program attended some of our seminars.

10. STRUCTURE OF THE NUCLEON

DATE: 2–11 September

ORGANISERS:
M. Birse (Co-ordinator) (*Univ. of Manchester*), E. Henley (*Univ. of Washington, Seattle*), A. W. Thomas (*Univ. of Adelaide*), W. Weise (*ECT*/TU Munich*)

NUMBER OF PARTICIPANTS: 35

MAIN TOPICS:
- Chiral dynamics
- Lattice QCD
- Electromagnetic interactions
- Nucleon resonances
- Quark models and hadron spectroscopy
- Structure functions and parton distributions

SPEAKERS:

M. Alberg (*Seattle Univ.*)
R. Alkofer (*Univ. Tübingen*)
W. Bentz (*Tokai Univ.*)
T. Cohen (*Maryland Univ.*)
A. D'Angelo (*Univ. Roma*)
R. Ent (*JLab, Newport News*)
P. Faccioli (*ECT**)
H. Gao (*MIT, Cambridge*)
H. Griesshammer (*TU Munich*)
T. Hemmert (*TU Munich*)
B. Holstein (*Massachusetts Univ.*)
R. Holt (*ANL, Argonne*)
N. Kaiser (*TU Munich*)
S. Krewald (*Forschungszentrum, Jülich*)
T. Londergan (*Indiana Univ.*)
J. McGovern (*Univ. Manchester*)
W. Melnitchouk (*JLab, Newport News*)
G. Miller (*Washington Univ.*)
S. Paul (*TU Munich*)
W. Plessas (*Univ. Graz*)
D. Richards (*JLab, Newport News*)
C. Roberts (*ANL, Argonne*)
A. Schäfer (*Univ. Regensburg*)
G. Schierholz (*DESY, Hamburg*)
N. Scoccola (*Buenos Aires and ECT**)
A. Szczepaniak (*Indiana Univ.*)
P. Tandy (*Kent State Univ.*)
A. Thomas (*Adelaide Univ.*)
M. Vanderhaegen (*Univ. Mainz and ECT**)
M. Vetterli (*TRIUMF, Vancouver*)
T. Walcher (*Univ. Mainz*)
H. Weigel (*Univ. Tübingen*)
A. Williams (*Adelaide Univ.*)

SCIENTIFIC REPORT:

The nucleon is of fundamental importance for our understanding of the strong interaction. As the only stable strongly interacting particle, its structure can be probed with high precision. This means that it can be used to probe all of the phenomena associated with Quantum Chromodynamics (QCD), notably confinement, chiral symmetry breaking and asymptotic freedom.

In the past our understanding of nucleon structure has developed miserainly through the use of a wide range of models. Recently, however, improved algorithms and increased computing power have led to significant progress in numerical simulations of QCD on a lattice. In addition there are two limits where we can extract model-independent information on the structure of the nucleon. At very high momenta, perturbative QCD can be used to analyse deep-inelastic scattering on the nucleon in terms of parton distributions, while at very low momenta the appropriate framework is an effective field theory based on chiral symmetry. In parallel with these theoretical advances, a wealth of information is coming from experiments using electromagnetic and weak interactions to probe the nucleon. At high energies, the applicability of perturbative QCD has been established, and more subtle aspects of nucleon structure are now being studied. The very rich physics associated with nonperturbative QCD is now being explored with high precision experiments at lower energies.

Traditionally these different aspects of nucleon structure have been studied by different communities of physicists, often with rather little contact between them. The aim of this workshop was to bring together leaders from these various areas, in order to review recent progress, both theoretical and experimental, and to determine the open questions which can be addressed most profitably in the next 5–10 years.

Presentations of the significant progress which has been achieved recently led to a wide range of fruitful discussions. The following particular themes emerged.

- Developments in lattice QCD are starting to make possible realistic calculations of more than just hadron masses. Of particular interest are studies of nucleon form factors, structure functions and excitations.
- Progress is being made with the chiral extrapolation of results from lattice QCD. This is expected to lead to significant further improvements as calculations with lower quark masses become possible.
- The importance of low-energy Compton scattering was stressed as a probe of aspects of nucleon structure dominated by spontaneously broken chiral symmetry and of the role of the Δ resonance.
- Better models are needed to allow us to interpret recent data on nucleon form factors at intermediate momenta. Recent progress with covariant quark models may be important here.
- Generalised parton distributions, measurable in deeply-virtual Compton scattering, will open a new window on nucleon structure, uniting partonic and coherent descriptions.
- Recent experimental progress has been in measuring the strange-quark content of the nucleon, which is essential for understanding its spin structure. This highlighted the need for better measurements of the polarised gluon content of the nucleon.

11. THE PHYSICS OF QUANTUM FLUID CLUSTERS

DATE: 16–21 September

ORGANISERS:
M. Barranco (Co-ordinator) (*Univ. Barcelona*), F. Dalfovo (*Univ. Cattolica, Brescia*), J. Navarro (*CSIC and Univ. Valencia*)

NUMBER OF PARTICIPANTS: 42

MAIN TOPICS:
- Structure and elementary excitations of quantum fluid clusters
- Spectroscopy of embedded atoms and molecules
- Scattering from and within quantum fluid clusters
- Quasi-1D quantum fluids

SPEAKERS:

F. Ancilotto (*Univ. Padova*)
V. Apkarian (*Univ. California*)
J. Boronat (*Univ. Poli. de Catalunya*)
F. Dalfovo (*Univ. Trento*)
E. Draeger (*LLNL, Livermore*)
W. E. Ernst (*Tech. Univ. Graz*)
D. E. Galli (*Univ. Milan*)
F. Garcias (*Univ. Balearic Islands*)
F. A. Gianturco (*Univ. La Sapienza*)
M. C. Gordillo (*Univ. Pablo de Olavide*)
R. Guardiola (*Univ. Valencia*)
S. Hernandez (*Univ. Buenos Aires*)
E. Krotscheck (*J. Kepler. Univ. Linz*)
Y. Kwon (*Konkuk Univ.*)
A. Leadbeater (*Univ. Durham*)
K. K. Lehmann (*Princeton Univ.*)
M. Lewerenz (*Univ. Paris VI*)
H. Maris (*Brown Univ.*)
R. Miller (*Univ. North Carolina*)
M. Pi Pericay (*Univ. Barcelona*)
A. Poves (*Univ. Aut. Madrid*)
L. Reatto (*INFN/Univ. Milan*)
A. Sarsa (*SISSA, Trieste*)
R. Schmied (*Princeton Univ.*)
C. P. Schulz (*Max-Born-Institut, Berlin*)
F. Stienkemeier (*Univ. Bielefeld*)
S. Stringari (*Univ. Trento*)
J. Tiggesbäumker (*Univ. Rostock*)
J. P. Toennies (*MPI, Göttingen*)
A. F. Vilesov (*Univ. Southern California*)
K. von Haeften (*Ruhr-Univ. Bochum*)
A. Wyatt (*Univ. Exeter*)
R. E. Zillich (*Univ. California, Berkeley*)

SCIENTIFIC REPORT:

The aim of the workshop was to address the structure and excitations of quantum fluid clusters, with major emphasis on ^{3}He and ^{4}He drops, as well as the spectroscopy of molecules embedded in ^{4}He clusters. Key issues are to understand superfluidity at a nanoscopic scale; the determination of the rotational parameters of linear molecules such as OCS and HCN embedded in ^{4}He drops (as simple examples) using fully microscopic [Diffusion and Variational Monte Carlo (DMC and VMC), Path Integral Monte Carlo (PIMC)] and more phenomenological approaches based on Density Functional (DF) theory; the stability of vortex lines in ^{4}He and ^{3}He-^{4}He drops as well as in Bose-Einstein condensates; the structure of small mixed ^{3}He-^{4}He droplets and the determination of the minimum number of ^{3}He atoms to produce a selfbound cluster; the description of elastic and inelastic processes in the diffusion of helium atoms by ^{4}He drops; the properties of electron bubbles in liquid helium, etc.

There has been an enormous progress in the understanding of the structure and stability of small mixed ^{3}He-^{4}He droplets using VMC techniques, whereas there is still some uncertainty in the minimum number of ^{3}He atoms needed to build a selfbound droplet. More microscopic calculations (DMC) are called for to shed light on both issues. From the experimental side, new experiments aiming at detecting small mixed clusters of larger (but still small) masses will be useful to test the results of current theories. DF and VMC calculations have yielded similar results for the structure of open shell ^{3}He clusters, pointing to a sizeable spin alignment. In this respect, it would be very interesting to address the shell structure of the fermionic component of mixed droplets.

PIMC and DF calculations indicate that if vortex lines are generated in doped ^{4}He clusters, the cluster+dopant+vortex complex would be rather robust even if fairly large amounts of ^{3}He atoms in the normal phase are added to the drop. The open, key issue is how to detect the presence of vortices in doped ^{4}He drops. It seems that at present the only possibility might be offered by the changes that the presence of vortices could produce in the roto-vibrational spectrum of the dopant molecule.

Closely related to this problem, and a far more fundamental issue because of its practical importance, is to determine the rotational parameters of the embedded molecules. An added difficulty is to have accurate interaction potentials describing the helium-molecule interaction (a classical problem in Quantum Chemistry). For simple but very interesting cases such as linear molecules (OCS, HCN and others), PIMC and DMC calculations have been able to determine their moments of inertia, which compare well with experiment. In this context, it is worth pointing out that the structure of the first solvation layer has been determined within PIMC, finding a decreased superfluid response. It seems well established that the PIMC method is well suited to address superfluidity at the nanoscopic scale. From the experimental side, a key issue is that molecular structures produced in the bulk of ^{4}He nanodroplets, even if the helium-molecule interaction is weak, are under some circumstances different from the structures in the gas phase, providing us with access to new regions of the intermolecular potential energy surface. This advantage compensates by far the disadvantage of the linebroadening of the molecular roto-vibrational spectrum as compared with that in the gas phase.

The crucial contribution of inelastic processes in the diffusion of helium atoms impinging on ^{4}He clusters has been elucidated in a VMC/EL approach, yielding results in good agreement with experiment. Finally, the first real-time 1D (dynamics of the expansion of spherically symmetric electron bubbles) and 3D (dynamics of superfluid helium droplets on Cs flat surfaces) within DF theory have been reported, together with robust indications that a new class of ^{3}He states may appear at the edge of a ^{4}He droplet splashed on a Cs surface. These last topics indicate that DF theory is still a useful tool to address complex problems that cannot be tackled by more microscopic approaches.

12. COHERENT EFFECTS AT RHIC AND LHC: INITIAL CONDITIONS AND HARD PROBES

DATE: 14–25 October

ORGANISERS:
B. Kopeliovich (Co-ordinator) (*MPI, Heidelberg*), Y. Kovchegov (*Univ. Washington, Seattle*), L. McLerran (*BNL, Brookhaven*), G. Miller (*Univ. Washington, Seattle*)

NUMBER OF PARTICIPANTS: 56

MAIN TOPICS:
Initial Conditions for Heavy Ion Collisions:

- Saturation of Gluon Distributions and Coherence
- The Color Glass Condensate
- Gluon Shadowing and the Consequences of Diffraction

Hard QCD Probes and Coherence

- Energy Loss of Jets
- Landau-Pomeranchuk-Migdal Effects in Jet Production
- The Drell-Yan process at RHIC
- Heavy Quark and Quarkonium Production

Coherent Coulomb Interaction of Heavy Ions
- Coulomb Photoproduction as a Probe of Initial Conditions and Parton Distributions
- Coulomb Photoproduction and Diffraction

SPEAKERS:

A. Accardi (*Columbia Univ.*)
R. Baier (*Univ. Bielefeld*)
I. Balitsky (*Old Dominion Univ.*)
A. Baltz (*BNL, Brookhaven*)
J. Bartels (*DESY, Hamburg*)
G. Baur (*Forschungszentrum Jülich*)
J.P. Blaizot (*CEA, Saclay*)
M. Braun (*Univ. St. Petersburg*)
G. Carter (*Univ. Washington*)
B. Cole (*Columbia Univ.*)
L. Csernai (*Bergen Univ.*)
A. Dumitru (*BNL, Brookhaven*)
F. Gelis (*LPT, Orsay*)
S. Gevorkyan (*JINR, Dubna*)
E. Iancu (*CEA, Saclay*)
K. Itakura (*BNL, Brookhaven*)
D. Ivanov (*Univ. Regensburg*)
Y. Ivanov (*Univ. Heidelberg*)
A. Kovner (*Univ. Plymouth*)
M. Johnson (*LANL, Los Alamos*)
S. Klein (*LBNL, Berkeley*)
B. Kopeliovich (*Regensburg/Heidelberg*)
Y. Kovchegov (*Univ. Washington*)
A. Krasnitz (*Algarve Univ.*)
E. Kuraev (*JINR, Dubna*)
T. Lappi (*Univ. Helsinki*)
P. Levai (*RKMI, Budapest*)
E. Levin (*Tel Aviv Univ.*)
M. Lublinsky (*DESY, Hamburg*)
G. Lykasov (*JINR, Dubna*)
L. McLerran (*BNL, Brookhaven*)
J. Moss (*LANL, Los Alamos*)
V. Muccifora (*INFN, Frascati*)
A. Mueller (*Columbia Univ.*)
J. Nemchik (*IEF, Kosice*)
H.J. Pirner (*Univ. Heidelberg*)
A. Polleri (*TU Munich*)
S. Räsänen (*Trento/Jyväskylä*)
J. Raufeisen (*LANL, Los Alamos*)
C. Salgado (*CERN, Geneva*)
I. Sarcevic (*Arizona Univ.*)
E. Shuryak (*SUNY, Stony Brook*)
P. Stankus (*ORNL, Oak Ridge*)
M. Strikman (*Penn State Univ.*)
L. Szymanowski (*Inst. Nucl. Stud., Warsaw*)
D. Treleani (*Univ. Trieste*)
D. Triantafyllopoulos (*Columbia Univ.*)
K. Tuchin (*Univ. Washington*)
U. Uggerhoj (*Univ. Aarhus*)
H. Van Hees (*Univ. Bielefeld*)
R. Venugopalan (*BNL, Brookhaven*)
H. Weigert (*Univ. Regensburg*)
I. Zahed (*SUNY, Stony Brook*)

SCIENTIFIC REPORT:

Much of our workshop was related to initial conditions for creation of quark-gluon plasma in heavy ion collisions. The medium created at the early stage of heavy ion collisions is expected to be overwhelmed by gluon radiation. Although the high transverse momenta gluons are produced by incoherent gluon interactions, the total multiplicity is dominated by a cutoff at lower transverse momenta. This cutoff most likely is determined by the onset of coherence in the sources which produce the radiation. This is the famous "intrinsic transverse momentum scale". The coherence here is probably due to the simple fact that one has to treat the sources of gluon radiation as fields, and fields can be added together coherently, and unlike the case at higher transverse momenta do not add as the sum of squares of sources. The onset of these coherent effects is sometimes referred to as "parton saturation".

The same phenomenon looks quite different when it is interpreted in the infinite momentum frame of the nucleus. The Weizsäcker-Williams gluons overlap and interact at small Bjorken x. As a result very strong gluonic fields are created in heavy ion collisions modifying the gluon density at small transverse momenta (saturation) and creating the so called Color Glass Condensate.

A major problem in hunting for the quark-gluon plasma is to probe the properties of the produced matter. The phenomenon of coherence is important for this key issue. On one hand, the interference effects essentially modify our expectations for gluon radiation at mid rapidities in heavy ion collisions, i.e. the initial conditions for production of a dense matter. On the other hand, the hard QCD processes probing the properties of the produced matter are also significantly affected by coherence phenomena.

High-p_T hard particle production is a probe of the early time behavior of matter produced in heavy ion collisions. It is expected to be influenced by the effect of "jet quenching". This is related to the early stage of heavy ion collisions when the high-p_T partons are propagating through the created matter and losing energy for induced gluon radiation. The process is known to be strongly suppressed by interference of gluons radiated off different sources (Landau-Pomeranchuk-Migdal effect) and is sensitive to the density of the matter. High-p_T jets can therefore serve as a probe for the properties of the created matter, and properly computing their production and propagation involves understanding coherence. In spite of the significant progress which has been made over the last decade, results for high p_T particle production are not practically implemented.

There is currently much work trying to understand and compute the properties of coherence effects for both gluon radiation and hard scattering processes. We brought those experts interested in such phenomena to develop more effective theoretical tools for calculation of initial conditions and provide more reliable predictions for application of hard QCD probes to the search of QGP. The currently used Monte-Carlo codes also needed to be corrected to include coherence effects, therefore experts in event generating algorithms and experimentalists also took part in the workshop.

The large coherent electromagnetic field of a heavy nucleus ($\propto Z$) is important for peripheral nucleus-nucleus scattering. Observing such events opens new possibilities to study large rapidity gap events in heavy ion collisions. More generally one can consider reactions mediated by either photons or colorless gluonic systems (in different combinations of these two). (Colorless gluon exchange is oftentimes called a "diffractive process".) Such experiments are already running at RHIC, and our goals were to discuss and interpret any available data as well as to exploit the new opportunities.

Of particular importance for the understanding of initial conditions are the parton distribution functions themselves. These distributions include effects of shadowing corrections due to the iteration of lower order diffractive processes (colorless exchange), and one would like to understand quantitatively the relationship between diffraction and shadowing.

13. PHYSICS OF STELLAR COLLAPSE AND NEUTRON STARS

(Collaboration Meeting)

DATE: 29–31 October

ORGANISERS:
C. Pethick (Co-ordinator) (*NORDITA, Copenhagen*), W. Weise (*ECT**)

NUMBER OF PARTICIPANTS: 17

MAIN TOPICS:

- Present status of stellar collapse calculations
- Role of neutrinos in stellar collapse and nucleosynthesis
- Rates of weak interactions in presupernovae
- Cooling of neutron stars and other compact objects
- Rates of neutrino processes in dense matter
- Equation of state of dense matter

SPEAKERS:
B. Balantekin (*Univ. Wisconsin*)
D. Bandyopadhyay (*Saha Inst. Nuc. Phys.*)
S. T. Cowell (*Univ. Illinois*)
H-T. Janka (*MPI, Garching*)
N. Kaiser (*TU Munich*)
E. Kolomeitsev (*NBI, Copenhagen*)
L. Langanke (*Univ. Aarhus*)
G. Lykasov (*JINR, Dubna*)
M. Prakash (*SUNY, Stony Brook*)
E. Olsson (*NORDITA, Copenhagen*)
A. Schwenk (*Ohio State Univ.*)

SCIENTIFIC REPORT:

Aim and Purpose

The purpose of the project was to promote collaboration between physicists and astrophysicists working on stellar collapse, supernovae, and neutron stars. To make realistic calculations of these astrophysical objects and processes, state-of-the-art calculations of the microscopic properties of hot, dense matter are a prerequisite. The meeting was aimed to bring together nuclear physicists doing microscopic theory with astrophysicists engaged in astrophysical modelling. Topics of particular interest are the rates of weak interaction processes in dense matter, and the nuclear equation of state.

Programme

The programme was designed to make possible presentations and discussion in a relaxed atmosphere. The schedule was flexible, so that extended discussion was possible when participants desired.

The meeting was very successful in bringing together a number of the prominent workers in the field. There was a good mixture of experienced scientists, postdocs, and graduate students. The small size of the workshop made for a great sense of unity among the participants.

Scientifically, many new results were reported, Among these one may mention the work of Achim Schwenk and collaborators on effects of the tensor force, the work of Shannon Cowell and Vijay Pandharipande on the effect of the nuclear medium on weak-interaction matrix elements, and the calculations of Karl-Heinz Langanke on weak interactions in presupernova stars.

14. VACUUM PAIR CREATION

(Collaboration Meeting)

DATE: 4–6 November

ORGANISERS:
S. Schmidt (Co-ordinator) (*Helmholtz Association, Bonn*), A. Ringwald (*DESY, Hamburg*)

NUMBER OF PARTICIPANTS: 12

SPEAKERS:
J. Baacke (*Univ. Dortmund*)
D. Blaschke (*Univ. Rostock*)
H. de Vega (*Univ. Paris VI*)
A. Dolgov (*INFN Ferrara/ITEP, Moscow*)
G. Dunne (*Univ. Connecticut*)
H. M. Fried (*Brown Univ.*)
A. Hoell (*Univ. Rostock*)
E. Saldin (*DESY, Hamburg*)
S. Schmidt (*Helmholtz Association, Bonn*)
C. Schubert (*Univ. Michoacana*)
D. Vinnik (*Univ. Tübingen*)

SCIENTIFIC REPORT:

Spontaneous vacuum pair creation is one of the most challenging problems in modern field theory although the ideas have been worked out already decades ago. The idea is the following: The QED vacuum is unstable in the presence of a strong electro-magnetic background field. Such a deformed vacuum state decays by emitting pairs of particles. This theoretical prediction of spontaneous particle creation was made long ago and is often referred to as the Schwinger Mechanism. Since then a variety of interesting aspects has been explored ranging from black hole quantum evaporation, to particle production in ultra-relativistic heavy ion collisions and in early universe physics.

Unfortunately, it seems inconceivable to produce macroscopic electric fields with optical lasers that are strong enough to melt directly the QED vacuum. Therefore the most striking application was in heavy ion collisions where a chromoelectric field is formed between two disc-like nuclei. According to the flux tube model such a field could be strong enough to produce a quark-gluon plasma.

There are definite plans for the construction of X-ray free electron lasers both at DESY where the so-called XFEL is part of the design of the e^+e^- linear collider TESLA as well as at SLAC where the so-called Linac Coherent Light Source (LCLS) has been proposed. Such an X-ray laser promises to provide a means to explore high-field science.

The theoretical investigation is important since the experimental verification of the Schwinger mechanism would validate an important prediction of QED in the region of very strong fields. However its proper treatment is challenging since perturbation theory fails and non-perturbative techniques must be developed to describe vacuum pair creation within a sophisticated field theoretical approach. A complete understanding requires the study of the production mechanism as a dynamical time dependent process and the description of the time evolution of a created strongly coupled plasma exposed to a strong external laser field.

This collaboration meeting has brought together experts in the field of spontaneous pair creation to focus on theoretical and experimental challenges opened by the new X-ray free electron lasers. Three immediate goals were discussed (i) the description of vacuum pair creation in strong fields within non-perturbative methods; (ii) dynamical aspects of the evolution of an e^+e^- plasma exposed to an alternating laser field; (iii) experimental realization and its observation. Additionally striking applications to cosmology and heavy-ion collisions have been discussed.

The small number of participants but with well regarded expertise has allowed for very lively discussions and a constructive atmosphere. Personal contacts have been renewed or established. Participants from DESY, the University of Dortmund and Rostock plan to apply for a Virtual Helmholtz Institute in Germany addressing plasma physics relevant for X-ray free electron lasers.

3.3 ECT* Doctoral Training Programme

The first Doctoral Training Programme, opening ECT*'s role as a Marie Curie Training Site, was held in the period June-October 2002 under the title:

Hot and Dense QCD

(Co-ordinator: Wolfram Weise)

It offered a unique combination of lecture series and workshops, summarising theoretical and experimental research focused on matter under extreme conditions, to a group of altogether 18 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):

- **Hard Probes of Hot and Dense Matter**
  Lecturer: Helmut Satz (University of Bielefeld, Germany)

- **Physics of High Parton Densities**
  Lecturer: Larry McLerran (Brookhaven National Laboratory, USA)

- **QCD Thermodynamics on the Lattice**
  Lecturer: Edwin Laermann (University of Bielefeld, Germany)

- **The Quark-Gluon Plasma**
  Lecturer: Jean-Paul Blaizot (CEA, Saclay, France)

- **Matter under Extreme Conditions**
  Lecturer: Gordon Baym (University of Illinois, Urbana Champaign, USA)

- **Ultra-Relativisitic Heavy Ion Experiments**
  Lecturers: Johanna Stachel (University of Heidelberg, Germany),
  Peter Braun-Munzinger (GSI, Darmstadt, Germany)

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

- **Charm Production: from SPS to RHIC and LHC**
- **Non-Perturbative Aspects of QCD**
- **Structure of the Nucleon**
- **Coherent Effects at RHIC and LHC**

3.3.2 Participants

On the basis of their academic and scientific profiles and achievements, 14 advanced doctoral students were selected as participants of the Training Programme. Five 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 optimal working conditions at the Centre, including full access to the ECT* computing facilities.

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

- Nicolas Borghini (French, Université Libre de Bruxelles)
- Pietro Faccioli (Italian, State University of New York, Stony Brook)
- Aida Galoyan (Armenian, JINR, Dubna)
- Marek Góźdź* (Polish, University of Lublin)
- Vincenzo Greco (Italian, University of Catania)
- Nils Marchal (French, University of Savoie and NORDITA, Copenhagen)
- Stefano Matiello (Italian, University of Rostock)
- Giuseppe Pagliara (Italian, University of Ferrara)
- Massimiliano Procura (Italian, Technical University of Munich and ECT*)
- Sami Räsänen* (Finnish, University of Jyväskylä)
- Thorsten Renk* (German, Technical University of Munich)
- Roland Schneider* (German, Technical University of Munich)
- Karolis Tamosiunas (Lithuanian, University of Bergen)
- Giuliana Tonini (Italian, University of Florence)

The following postdoctoral fellows resident at ECT* also participated actively in the Training Programme: François Arleo (French), Luca Girlanda (Italian), Evgeni Kolomeitsev (Russian), and Dolores Sousa (Spanish).

[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

Parton energy loss in QCD media

The energy loss experienced by a fast parton may serve as a measure of the density of color charges of the QCD medium it travels through. It may be huge in a dense medium such as the quark-gluon plasma, expected to be formed in the early stage of ultrarelativistic heavy ion collisions. Although the understanding of medium-induced parton energy loss has been extensively developed over the last few years, less is known about how to relate this mechanism to observable quantities. A step in that direction has however been taken recently by Baier, Dokshitzer, Mueller, and Schiff, who connect the quenching weight $D(\epsilon)$ to the induced gluon spectrum $dI/d\omega$ radiated by the leading parton. Recently, I presented a complete calculation of the quenching weight from the perturbative medium-induced gluon spectrum for both incoming and outgoing partons traveling through a QCD medium. It is shown to follow an empirical log-normal behavior which allowed me to give a simple analytic parameterization. The sensitivity of the results under the infrared and ultraviolet behavior of the induced gluon spectrum is carefully studied. This calculation may be useful for future phenomenological investigations.

Phenomenology of hard QCD processes in high energy nuclear reactions

As previously emphasized, the large energy loss expected in a dense medium may be a clear signal for deconfinement in high energy nuclear reactions. Therefore, it is of first importance to evaluate the energy loss experienced by hard partons in cold QCD media. Stringent constraints on the transport coefficient of nuclear matter were set from a leading-order analysis of Drell-Yan production data on nuclear targets. Based on this estimate, the quenching of semi-inclusive hadron spectra in DIS on nuclei has been computed and compares well with EMC and HERMES preliminary data. Finally, I investigated the effects of parton energy loss in quark-gluon plasma on the quenching of high $p_\perp$ inclusive pion spectra reported in heavy ion collisions by the PHENIX, PHOBOS, and STAR collaborations at RHIC.

• Tommaso Calarco

Holonomic quantum computation: trapped atoms in cavities

I proposed an experimentally feasible scheme to achieve quantum computation based solely on geometric manipulations of a quantum system. The desired geometric operations are obtained by driving the quantum system to undergo appropriate adiabatic cyclic evolutions. Focusing onto the case of neutral atoms in cavity QED, I showed how to perform generic single- and two-qubit gates, the latter by encoding a two-atom state onto a single, many-level atom. To overcome limitations due to cavity imperfections, I developed different strategies, whose relevance goes beyond QIPC, to the broader field of cavity QED with (micro-)trapped atoms.

Molecular interactions: adiabatic coupling via Feshbach resonances

This most recent work concerns the possibility of exploiting Feshbach resonances in order to perform Rabi rotations via a virtual molecular state, thereby acquiring the required logical phase with a high fidelity in a time much shorter than via the simple collisional approach outlined above. Based on the above entangling schemes, I also developed a theory of parallel QIP, showing that the inherent parallelism in a micro-trap quantum computer can be used for efficient quantum error correction and, ultimately, fault-tolerant implementations.

Pauli blocking and dipole-dipole interactions in semiconductor quantum dots

I also developed a solid-state implementation of an all-optical spin-based quantum computer using semiconductor quantum dots. Quantum memory is represented by the spin of an excess electron stored in each dot. 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. Read-out is performed via a quantum-jump technique. I analyzed the effect on the scheme's performance of the main imperfections present in real quantum dots: exciton decay, hole mixing and phonon decoherence. I introduced an adiabatic gate procedure that allows one to circumvent these effects, and evaluated quantitatively its fidelity.

• Pietro Faccioli

The research performed in these first four months of activity at ECT* has focused on non-perturbative aspects of QCD, in particularly with relation to the hadron structure. In the following, the progress made in each specific project are briefly outlined.

Lattice QCD and the structure of the nucleon

In collaboration with Rome La Sapienza, and Roma Tre Physics Departments, we have set-up the theoretical framework and written the computer codes required for the calculation of the proton and nucleon electro-magnetic form factors in lattice QCD. We have run preliminary test calculations and implemented the improvements required to avoid leading corrections in the lattice spacing. The main run will be started in 2003 and should lead to the first lattice calculation of the proton electric-over-magnetic form factor ratio, $G_E(Q^2)/G_M(Q^2)$, in the region of interest for current Jlab experiments ($2\ \mathrm{GeV}^2 < Q^2 < 5\ \mathrm{GeV}^2$)

Instanton contribution to the proton electro-magnetic form factors

We have started a project to investigate if the behavior of the proton $G_E(Q^2)/G_M(Q^2)$ ratio at large Q^2 can be at least in part explained by the non-perturbative chirality-mixing interaction induced by instantons. The calculation of the relevant Green function has been performed and the results are currently being analyzed.

Systematic study of the chirality mixing interaction in QCD

We have developed a new framework to investigate from first-principles the dynamics which mixes the chirality of quarks in QCD. This method is based on the analysis of an appropriate combination of Euclidean Green functions, which has a simple probabilistic interpretation in terms of quark helicity flips. We have shown that the dominant chirality flipping interaction is mediated by topological fields. We have derived a model-independent semi-classical prediction. Such a relationship allows to study on the lattice the contribution of instantons in light quark dynamics.

Instantons and chiral extrapolations in lattice QCD

In collaboration with Prof. J. Negele (MIT), we have started an analysis of the non-linear dependence of the moments of DIS structure functions on the bare quark masses, in lattice QCD. We have written a code that generates gauge links from the Instanton Liquid Model. This way, we aim to model the result of unquenched lattice simulations performed in very large volumes and therefore with small quark masses.

• Marina Gibilisco

During the year 2002, Marina Gibilisco had a collaboration with ECT*, from January to June:

Study of the thermal structure of Titan's atmosphere

Marina Gibilisco performed a detailed study of the physical and chemical characteristics of the atmosphere of Titan, the largest satellite of Saturn. Titan is a celestial body particularly interesting, because it presents an atmosphere very rich in molecular nitrogen (N_2) and methane (CH_4); the chemical conditions on this satellite are similar, for some features, to the ones characterizing the primordial Earth. Therefore, Titan might really represent an important laboratory to understand the first evolution of our planet's atmosphere. The mission Cassini-Huygens will explore the Saturn system from July 2004 to 2008, thus providing new important information on this planet, its magnetosphere, its rings and its satellites; from these new data, we will expect a definitive confirmation or a rejection of many theoretical models, up to now based on too many unknown parameters.

In the light of these future experimental measurements, Marina Gibilisco proposed some models for the Titan's upper atmosphere: the thermal profiles presently obtained are however influenced by some uncertainties on the molecular parameters involved in the calculation, thus the future results of the mission Cassini-Huygens will really represent a big improvement in your knowledge of the Saturn satellite system.

• Luca Girlanda

Effective theory of the pions inside heavy nuclei

Since my arrival at ECT* as a post-doc, in September 2002, I have enormously profited from the presence of Akaki Rusetsky and Wolfram Weise, with whom I started a collaboration aimed at the construction of an effective theory of pions inside the nucleus. The canonical approach of the In-medium Chiral Perturbation Theory is based on the description of the nucleus as an infinite and uniform Fermi sea of nucleons. Some ad-hoc prescription (local density approximation) is then applied e.g. for the study of the deeply bound pionic atoms. We have developed an approach in which the criteria of the chiral expansion allow to unambiguously identify the dependence on the shape of the nuclear density profile, in the framework of a derivative expansion. We have explicitly shown the consistency of our approach at the next-to-leading order by computing the pion self-energy at $O(p^5)$.

Vacuum fluctuations of $\bar{q}q$ pairs in QCD

Our understanding of the mechanism of chiral symmetry breaking in QCD continues to evolve, both on the experimental and on the theoretical side. While a new high statistics experiment on K_{e4} decays seems to have selected the so-called "standard option" of a large condensation of quark-antiquark pairs, we have recently realized that the chiral structure of the vacuum could be much richer: the alternative possibility that chiral symmetry breaking occurs without formation of quark antiquark condensate cannot be excluded by measurements of low-energy $\pi\pi$ phaseshifts. The reason is that this observable is only sensitive to the two-flavour quark condensate, i.e. the quark condensate in the limit of two massless flavours, with all other flavours taken at their physical masses. It turns out that the strange quark mass m_s is comparable with Λ_{QCD}, certainly not heavy enough to decouple from the low-energy theory: virtual $s\bar{s}$ pairs will be abundant in the vacuum. Correlations between the light u, d, and massive s quark-antiquark pairs break the SU(2)×SU(2) chiral symmetry and induce, via OZI-rule violating diagrams, an SU(2) chiral condensate. It is not possible experimentally to disentangle this induced SU(2) quark condensate from the genuine one, defined in a theory with two massless flavours and nothing else. In particular, close to a chiral phase transition point, one expects the genuine quark condensate to decrease and correspondingly its fluctuations (related to the above mentioned correlations) to increase. In such a situation the presence of massive strange quark-antiquark pairs would mimic a large quark condensate. In order to test this picture one should instead consider the SU(3) chiral condensate, which is defined in the limit of three massless flavours with all other flavours taken at their physical mass. It is clear that such a quantity is much closer to the genuine condensate, since the c, b, t quarks are heavy enough to decouple at low energy. A reorganization of the Chiral Perturbation Theory is necessary in order to account for the possibly large fluctuations. This is the subject of a collaboration with S. Descotes (Orsay), N.H. Fuchs (Purdue) and J. Stern (Orsay). I have reported about this work in the HadAtom02 meeting, held at CERN, on October 14-15, 2002.

• Evgeni Kolomeitsev

Chiral dynamics of deeply bound pionic states

in collaboration with N. Kaiser (TU Munich) and W. Weise (TU Munich and ECT)*

Recent accurate data on $1s$ states of π^- bound to Pb and Sn isotopes have set new standards and constraints for the detailed analysis of s-wave pion-nucleon interactions. This topic has a long history culminating in various attempts to understand the notorious "missing repulsion" in the π-nucleus interaction: the standard ansatz for the (energy independent) s-wave pion-nucleus optical potential, given in terms of the empirical threshold πN amplitudes times nucleon densities, ρ and supplemented by sizeable double-scattering corrections, still misses the observed repulsive interaction by a large amount. This problem has traditionally been circumvented on purely phenomenological grounds by introducing an extraordinarily large repulsive real part ($\mathrm{Re}B_0$) in the ρ^2 terms of the π-nucleus potential. The arbitrariness of this procedure is of course unsatisfactory.

We have reinvestigated this issue from the point of view of the distinct explicit energy dependence of the pion-nuclear polarization operator in a calculation based on systematic in-medium chiral perturbation theory. we have also clarified the relationship of our approach to a hypothesis launched previously that the extra repulsion needed in the s-wave pion-nucleus optical potential at least partially reflects the tendency toward chiral symmetry restoration in a dense medium.

Resonance states below pion-nucleon threshold in nuclear systems

in collaboration with D.N. Voskresensky (GSI Darmstadt and MEPhI, Moscow)

Regular sequences of narrow peaks have been observed in the missing mass spectra in the reactions $pp \to p\pi^+X$ and $pd \to ppX_1$ below pion-production threshold. They are interpreted in the literature as manifestations of supernarrow light dibaryons, or nucleon resonances, or light pions forming resonance states with the nucleon in its ground state. Being motivated by these experimental studies and their interpretations, we have investigated how the existence of exotic light dibaryons, nucleon resonances and pions, would manifest itself in nuclear systems. We have shown that dibaryons and N' resonances below the πN threshold would be absent in atomic nuclei, if their interactions with nucleons are sufficiently small, as it is demanded by their production rates. Also light pions cannot be accumulated in atomic nuclei.

In the neutron star matter the new exotic states could manifest themselves in a remarkable way: they would drastically change the composition of a neutron star and make the equation of state much softer. The equation of state with dibaryons and nucleon resonances becomes so soft that it would not be able to support neutron stars with the observed masses. Thus the dibaryon and nucleon-resonance interpretations of the above mentioned experiments should be questioned.

The existence of light pions would not lead to a contradiction with observed neutron star masses. The presence of light pions would allow the existence of abnormal nuclei ($A > 10^3$) and "nuclei-stars" of arbitrary size, bound by strong and electromagnetic interactions.

Thus, the importance of astrophysical consequences of the low-mass resonance states should strongly motivate further experimental investigations, as well as a search for new theoretical interpretations.

• Barbara Pasquini

My research activity has been addressed to the study of hadronic systems with electromagnetically induced reactions, focusing the attention on those reaction mechanisms where a fruitful interpretation in terms of nucleon structure observables is possible. In particular, I worked on the following topics:

Real and virtual Compton scattering off the nucleon at low energy within a dispersion relation formalism

The first topic concerns a summary of the research activity which I developed during the last years in collaboration with the theory group in Mainz and motivated the publication of a review article in Physics Reports. In this work, we reviewed the way in which dispersion relations for Compton scattering amplitudes establish connections between low energy nucleon structure quantities, such as polarizabilities or anomalous magnetic moments, and the nucleon excitation spectrum. In particular, we addressed the study of various sum rules for forward real and virtual Compton scattering, such as the Gerasimov-Drell-Hearn sum rule and its generalizations, the Burkhardt-Cottingham sum rule, as well as sum rules for forward nucleon polarizabilities. Then, by extending the dispersion relation formalism for forward scattering to real Compton scattering (RCS) on the nucleon for all angles, we developed an analysis based on various types of dispersion relations with the aim to extract nucleon polarizabilities from RCS data. The dispersion relation formalism was also extended to virtual Compton scattering, which allows us to study generalized polarizabilities as function of four-momentum transfer squared and, therefore, to explore the spatial distribution of the polarization effects.
This work also benefitted from a very stimulating meeting organized at ECT*, where new collaborations between different groups actively involved in the recent developments in these fields were established.

Virtual Compton scattering with deeply virtual photon at high energy

The second topic of my research was addressed to the study of generalized parton distributions (GPDs) which can be accessed experimentally through the deeply virtual Compton scattering process. The GPDs interpolate between the inclusive physics of parton distributions and the exclusive limit of electromagnetic form factors, and therefore contain new information on parton correlations and the internal spin structure of the nucleon. In my work, I focused the attention on the region where quark GPDs describe emission and reabsorption of a single active quark by the target nucleon, establishing a link between the constituent quark structure of the nucleon at the hadronic scale and the partonic description of GPDs which emerge at large virtuality.

• Francesco Pederiva

During the course of 2002 the research activity was focused on four subjects:

Study of the ground state properties of semiconduuctor nanostructures

We carried on Diffusion Monte Carlo and mean field calculations for understanding the ground state and spin properties of quantum dots and rings. In particular we were able to compute low–energy excitation spectra of open-shell quantum dots; ground state properties and localization effects in narrow quantum rings; multipair effects in the two-dimensional electron gas.

Ground state properties of solid pH_2

We applied the Shadow Wave function formalism to the study of the equation of state of solid molecular para-hydrogen. The application of this formalism is important in order to proceed to the study of inhomogeneous systems of pH_2 (in particular the computation of the surface tension, and small clusters embedded in ^{4}He matrices). First results were obtained for the vacancy excitation energy in the fcc and hcp crystals.

Ground state properties of neutron matter and neuron drops

Auxiliary-Field Monte Carlo methods are employed to study the ground state energy of homogeneous neutron matter with a v_6' and v_8' interaction plus the three-body UIX interaction. Results have been obtained for the equation of state for densities up to $2.5\rho_0$, and with up to 114 neutrons. The ground state energy and spin orbit contribution 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 computed. The aim was to study the strength of the spin orbit contribution to the total energy avoiding possible finite size effects.

New quantum Monte Carlo methods for many fermion systems

We proceeded with the application of FMC techniques to relatively large ^{3}He systems (54 particles), and begun to apply them to the case of two-dimensional electron gas. New versions of second-stage importance sampling have been introduced and studied. In the context of a collaboration in this research line ECT* hosted in August prof. Malvin H. Kalos from Lawrence Livermore National Laboratories.

• Georges Ripka

A study and a survey of the dual superconductor models applied to the confinement of quarks in hadrons has been completed. It gave rise to a series of 10 lectures given at ECT* and to a publication commissioned by Springer Verlag lecture series.

A talk entitled "Models of color confinement based on dual superconductors" as well as the summary talk has been published in the proceedings of the "Second international workshop on Hadron Physics", in Coimbra, Portugal (September 2002).

A talk given at the 18th European Conference on Few-Body Problems in Physics, Bled, Slovenia, 8-14 Sep 2002, has been published in Few Body Syst. Suppl. 14 (2003) 1 (hep-ph/0212077) under the title "Baryons as solitons in chiral quark models", with B. Golli (Univ. Ljubljana & Stefan Inst., Ljubljana), W. Broniowski (INP, Cracow) as co-authors.

• Akaki Rusetsky

In 2002, I have been working at ITP, University of Bern (January - August 2002), and ECT* Trento (from September 2002). During this period, my research was concentrated on the following topics:

We have evaluated electromagnetic corrections to the threshold $\pi^- p$ elastic scattering amplitude, and in the strong shift of the ground state energy of the pionic hydrogen, at $O(p^3)$ in ChPT. These results, which have been published in Eur. Phys. J. C, are important for the analysis of the experimental data provided by the Pionic Hydrogen collaboration at PSI.

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. In 2002, the results of these studies have been reported at QNP 2002 Conference, and at the seminar in Vienna University. The published version first appeared on the web in 2003 [J. Gasser, A. Rusetsky and I. Scimemi, arXiv:hep-ph/0305260].

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, which are experimentally observed at GSI. It is foreseen, that the results will be published on web in 2003.

• 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.

Analysis of the first RHIC results in the String Fusion Model

in collaboration with N. Armesto (CERN, Geneva) and C. Pajares (Univ. Santiago)

We have recently developed a Monte Carlo code to simulate nuclear collisions in the energy range going from SPS to LHC energies. The model is based on the ideas of the Dual Parton Model (DPM) or Quark Gluon String Model (QGSM), considering both soft and semihard components on a partonic level. These elementary partonic collisions lead to the formation of color strings. Collectivity is taken into account considering the possibility of strings in color reprensentations higher than triplet or antitriplet, by means of string fusion. Strings breaking leads to the production of secondaries. At this point the model can be used as an initial condition for the further evolution by a transport model. Rescattering between secondaries is considered on the basis $2 \rightarrow 2$ collisions, using a very simple model which allows us just to estimate the effects of such a process.

In this framework we analized the first results from RHIC on charged multiplicities, evolution of multiplicities with centrality, particle ratios and transverse momentum distributions in central and minimum bias collision. Multiplicities and their evolution with centrality are successfully reproduced. Recently is has been proposed that the evolution of multiplicities with centrality can be used as a tool to discriminate among several models for multiparticle production in high energy nuclear collisions. Transverse momentum distributions in the model show a larger p_T tail than experimental data, disagreement which grows with increasing centrality. A possible explanation is jet quenching, i.e., the energy loss of high energy partons in hot medium containing free color charges. Results on particle ratios show , when compared to experimental data, similar problems of antibaryon excess previously found at SPS, and are probably related to the oversimplification of the model of rescattering and to problems with data at SPS.

Strange particle production at RHIC in the Dual Parton Model

in collaboration with A. Capella (LPT, Orsay) and C.A. Salgado (CERN, Geneva)

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. 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.

I presented these results at the XXXVII Rencontres de Moriond, Les Arcs (France), March 2002.

• Wolfram Weise

Our research activities in 2002 have focused on several projects in the theory of hadrons, nuclei and matter under extreme conditions:

Quasiparticle model description of lattice QCD thermodynamics

The quasiparticle description of lattice QCD thermodynamics has been further developed and applied to lepton and hadron production in ultra-relativistic nucleus-nucleus collisions. A consistent space-time evolution picture emerges, starting from a fireball which reflects initial conditions above the critical temperature for the transition into the quark-gluon phase, and which subsequently cools down and expands into the hadronic phase. The results compare well with data from nucleus-nucleus collisions taken at CERN-SPS, and predictions are made for observables measured at RHIC.

Connections between low-energy QCD and the nuclear many-body problem

We are exploring connections between basic features of low-energy QCD (the role of chiral symmetry, the condensate structure of the QCD vacuum) and the nuclear many-body problem. Pions as Goldstone bosons of spontaneously broken chiral symmetry are important degrees of freedom that must be taken into account explicitly. Pionic fluctuations primarily from two-pion exchange in combination with Pauli blocking effects play an essential role in the binding and saturation of nuclear matter. The isospin dependence of these forces accounts for the empirical assymmetry energy. Applications to finite nuclei, combining methods of in-medium chiral perturbation theory with constraints on vector and scalar fields from in-medium QCD sum rules, have yielded promising results. Using such QCD-constrained input in a relativistic mean-field approach with density-dependent contact interactions, a description of various properties of finite nuclei is achieved with a minimal number of adjustable parameters, at the same level of accuracy as the best phenomenological relativistic mean-field calculations.

Chiral dynamics of deeply bound pionic atoms

The theory of low-energy (s-wave) pion-nucleus interactions based on chiral dynamics has been further developed and applied to deeply bound pionic atom states recently measured at GSI. A successful description of such states (both their energy shifts and widths) is achieved taking the explicit energy dependence of the pion-nucleus optical potential fully into account. This energy dependence is characteristic of the low-energy expansion implied by spontaneously broken chiral symmetry. The relationship between the resulting wavefunction renormalisation and the tendency towards "chiral restoration" in matter, expressed through a density-dependent effective pion decay constant, has been clarified. Further developments are now directed towards a deeper foundation of chiral perturbation theory in finite nuclear systems.

Chiral extrapolations from lattice QCD

Systematic extrapolations of lattice QCD results for nucleon properties, down to realistically small quark masses, have been performed using methods of chiral effective field theory. The results obtained for proton and neutron magnetic moments, as well as for the axial vector coupling constant of the nucleon, have demonstrated the feasibility of such extrapolations. Present work focuses on the nucleon mass for which full (unquenched) lattice QCD data are now available. Such studies become increasingly important as further advances in computational power will promote lattice computations in a range of quark masses which are still significantly larger than the physically realistic ones, but closer to the range which permits accurate chiral extrapolations down to actual observables.

Work on these projects has been performed in collaborations with ECT* researchers (Luca Girlanda, Evgeni Kolomeitsev, Massimiliano Procura, Akaki Rusetsky), ECT* visitors (Paolo Finelli (Bologna), Dario Vretenar (Zagreb)), and members of the theory group of the Technical University of Munich, Germany.

3.5 Publications of ECT* Researchers

E. Andersson, T. Calarco, R. Folman, M. Andersson, B. Hessmo, J. Schmiedmayer
Multimode interferometer for guided matter waves
Phys. Rev. Lett. 88 (2002) 100401

F. Arleo
Constraints on quark energy loss from Drell-Yan data
Phys. Lett. B532 (2002) 231 [*Preprint ECT-02-03*]

F. Arleo
Drell-Yan tomography of cold QCD matter
Preprint ECT-02-11* [*Proceedings 37th Rencontres de Moriond on QCD, Les Arcs, France, March 2002*]

F. Arleo
Tomography of nuclear matter: Comparing Drell-Yan with Deep Inelastic Scattering data
Preprint ECT-02-23* [*Nucl. Phys. A715 (2003) 899*]

F. Arleo
Tomography of cold and hot QCD matter: tools and diagnosis
JHEP 11 (2002) 044 [*Preprint ECT-02-24*]

F. Arleo, J. Aichelin. P.B. Gossiaux and T. Gousset
Heavy-quarkonium hadron interaction from a leading twist QCD analysis
J. Phys. G28 (2002) 1943 [*Preprint ECT*-02-02*]

N. Armesto, C. Pajares and D. Sousa
Analysis of the first RHIC results in the String Fusion Model
Phys. Lett. B527 (2002) 92

S. Bettelli, T. Calarco, and L. Serafini
Towards an architecture for quantum programming
European Physical Journal D, in print [*IRST technical report 0103-010*]

S. Boffi, B. Pasquini, M. Traini
Linking generalized parton distributions to constituent quark models
Preprint ECT-02-20* [*Nucl. Phys. B649 (2003) 243*]

T. Calarco, D. Jaksch, J. I. Cirac, P. Zoller
Controlling dynamical phases in quantum optics
J. Opt. B: Quantum Semiclass. Opt. 4 (2002) S430

A. Capella, C.A. Salgado, D. Sousa
Strange particle production at RHIC in the Dual Parton Model
Preprint ECT-02-10 [Eur. Phys. J. C (2003), in print]*

A. Capella, C.A. Salgado, D. Sousa
Baryon and Antibaryon production at RHIC energies in the Dual Parton Model
Preprint ECT-02-13 [Proceedings of the 37th Rencontres de Moriond on QCD, Les Arcs, France, March 2002]*

L. Colletti, F. Pederiva, E. Lipparini, C.J. Umrigar
Investigation of excitation energies and Hund's rule in open shell quantum dots by diffusion Monte Carlo
Eur. Phys. J. B27 (2002) 385

A. Drago and M. Gibilisco
Evaporation of the gluon condensate: a model for pure gauge SU(3)c phase transition
Preprint ECT-02-01 [Submitted to Nucl. Phys. A]*

D. Drechsel, B. Pasquini and M. Vanderhaeghen
Dispersion relations in real and virtual Compton scattering
Preprint ECT-02-19 [Phys. Rep. 378 (2003) 99]*

P. Faccioli
A systematic study of the chirality - mixing interactions in QCD
Preprint ECT-02-29 [Submitted to Eur. Phys. J. C]*

P. Finelli, N. Kaiser, D. Vretenar and W. Weise
Nuclear Many-Body Dynamics constrained by QCD and Chiral Symmetry
Preprint ECT-02-09 [Eur. Phys. J. A (2003), in print]*

S. Fritsch, N. Kaiser and W. Weise
Chiral dynamics of nuclear matter at finite temperature
Phys. Lett. B545 (2002) 73 [Preprint ECT-02-05]

J. Gasser, M.A. Ivanov, E. Lipartia, M. Mojzis, and A. Rusetsky
Ground-state energy of pionic hydrogen to one loop
Eur. Phys. J. C26 (2002) 13

M. Gibilisco
Thermal Structure of the Titan's Atmosphere
Preprint ECT-02-14 [Submitted to Review of Planetary Science]*

J. Golak, R. Skibinski, W. Glöckle, H. Kamada, A. Nogga, H. Witala, V.D. Efros, W. Leidemann, G. Orlandini and E.L. Tomusiak
Benchmark calculation of the three-nucleon photodisintegration
Nucl. Phys. A707 (2002) 365 [*Preprint ECT-02-07*]

T.R. Hemmert, M. Procura, W. Weise
Chiral extrapolations of nucleon properties from Lattice QCD
Preprint ECT-02-31* [*Proceedings PANIC 02, Osaka, Japan, September 2002, Nucl. Phys. A (2003), in print*]

T.R. Hemmert, M. Procura, W. Weise
Quark mass dependence of nucleon properties and extrapolations from Lattice QCD
Preprint ECT-02-34* [*Prog. Part. Nucl. Phys. 50 (2003) 419*]

T.R. Hemmert and W. Weise
Chiral Magnetism of the Nucleon
Eur. Phys. J. A15 (2002) 487 [*Preprint ECT-02-08*]

T.R. Hemmert and W. Weise
Nucleon Magnetic moments, their quark mass dependence and lattice QCD extrapolations
Preprint ECT-02-15* [*Proceedings BARYONS 2002, Jefferson Lab., Newport News (Virginia), USA, March 2002*]

N. Kaiser, S. Fritsch and W. Weise
Chiral Dynamics and Nuclear Matter
Nucl. Phys. A697 (2002) 255

N. Kaiser, S. Fritsch and W. Weise
Nuclear Mean Field from Chiral Pion Nucleon Dynamics
Nucl. Phys. A700 (2002) 354

E.E. Kolomeitsev, N. Kaiser and W. Weise
Chiral dynamics of deeply bound pionic atoms
Preprint ECT-02-16* [*Phys. Rev. Lett. 90 (2003) 092501*]

E.E. Kolomeitsev, N. Kaiser and W. Weise
Chiral dynamics and pionic 1s states of Pb and Sn isotopes
Preprint ECT-02-30* [*Proceedings PANIC 02, Osaka, Japan, September 2002, Nucl. Phys. A (2003), in print*]

E. E. Kolomeitsev and M. F. M. Lutz
A Unified Chiral Approach to Meson-Nucleon Interaction
Preprint ECT-02-15* [*Proceedings BARYONS 2002, Jefferson Lab., Newport News (Vir-*

ginia), USA, March 2002]

E.E. Kolomeitsev and D.N. Voskresensky
Resonance state below pion-nucleon threshold and their consequences for nuclear systems
Preprint ECT-02-18* [*Phys. Rev. C67 (2003) 015805*]

E. Kolomeitsev and D.N. Voskresensky
Negative kaons in dense baryonic matter
Preprint ECT-02-28* [*Phys. Rev. C, in print*]

E. Lipartia, V.E. Lyubovitskij, and A. Rusetsky
Hadronic potentials from effective field theories
Phys. Lett. B533 (2002) 285

E. Marco, R. Hofmann and W. Weise
Note on finite temperature sum rules for vector and axial-vector correlation functions
Phys. Lett. B530 (2002) 88

B. Pasquini, D. Drechsel, M. Gorchtein, A. Metz and M. Vanderhaeghen
Dispersion relations in virtual Compton scattering
Preprint ECT-02-33* [*Proceedings SPIN 2002, Brookhaven (New York), USA, Sept. 2002*]

B. Pasquini, D. Drechsel, A. Metz, M. Gorchtein, M. Vanderhaeghen
Dispersion relation formalism for virtual compton scattering off the proton
Preprint ECT-02-21* [*Proceedings BARYONS 2002, Jefferson Lab., Newport News (Virginia), USA, March 2002*]

B. Pasquini, D. Drechsel, M. Vanderhaeghen
Fixed-t And Hyperbolic Dispersion Relations For Real Compton Scattering
Preprint ECT-02-22* [*Proceedings GDH 2002, Genova, Italy, July 2002*]

B. Pasquini, D. Drechsel and M. Vanderhaeghen
Dispersion relations in real Compton scattering
Preprint ECT-02-32* [*Proceedings Cortona 2002, Cortona, Italy, October 2002*]

E. Pazy, E. Biolatti, T. Calarco, I. D'Amico, P. Zanardi, F. Rossi, and P. Zoller
Spin-based optical quantum gates via Pauli blocking in semiconductor quantum dots
Europhysics Letters 62 (2003) 175

E. Pazy, T. Calarco, I. D'Amico, P. Zanardi, F. Rossi, P. Zoller
All-optical spin-based quantum information processing
J. Supercond. 16 (2003) 383

E. Pazy, T. Calarco, I. D'Amico, P. Zanardi, F. Rossi, and P. Zoller
Implementation of an all-optical spin-based quantum computer
Physica Status Solidi, in print

F. Pederiva, A. Emperador, E. Lipparini
Electron localization in low density quantum rings
Phys. Rev. B66 (2002) 165314

F. Pederiva, A. Emperador, E. Lipparini
Multipair excitations in the two-dimensional electron gas
Phys. Rev. B66 (2002) 153320

A. Recati, T. Calarco, P. Zanardi, J.I. Cirac, P. Zoller
Holonomic quantum computation with neutral atoms
Phys. Rev. A 66 (2002) 032309

T. Renk
Statistical hadronization and the Equation of State of the quark gluon plasma
Preprint ECT-02-25* [*Submitted to Phys. Rev. C*]

T. Renk, R.A. Schneider and W. Weise
Hadronic and quark-gluon excitations in dense and hot matter
Nucl. Phys. A699 (2002) 1

T. Renk, R.A. Schneider and W. Weise
Phases of QCD, Thermal Quasiparticles and Dilepton Radiation from a Fireball
Phys. Rev. C66 (2002) 014902

T. Renk, R.A. Schneider and W. Weise
QCD thermodynamics and fireball evolution in URHICs
Preprint ECT-02-06* [*Proceedings Hirschegg 2002, Hirschegg, Austria, January 2002*]

A. Rusetsky
Including virtual photons in strong interactions
arXiv:hep-ph/0209182 [*Proceedings of Conference on Quarks and Nuclear Physics (QNP 2002), Jülich, Germany, Jun 2002*]

J. Schmiedmayer, R. Folman, T. Calarco
Quantum information processing with neutral atoms on an atom chip
Journal of Modern Optics 49 (2002) 1375

R.A. Schneider
Debye Screening at Finite Temperature, Revisited
Phys. Rev. D66 (2002) 036003

R.A. Schneider
A note on asymptotic freedom at high temperatures
Preprint ECT-02-26* [*Phys. Rev. D67 (2003) 057901*]

R.A. Schneider, T. Renk, M. Thaler, A. Polleri and W. Weise
Probing the QCD Equation of State
Preprint ECT-02-27* [*Proceedings PANIC 02, Osaka, Japan, September 2002, Nucl. Phys. A (2003), in print*]

R.A. Schneider, T. Renk and W. Weise
Model for dilepton rates from a fireball
Nucl. Phys. A698 (2002) 428

R.A. Schneider, T. Renk and W. Weise
Quasiparticles in QCD thermodynamics and applications
Preprint ECT-02-04* [*Proceedings Hirschegg 2002, Hirschegg, Austria, January 2002*]

W. Weise
BARYONS 2002: Outlook
Preprint ECT-02-12* [*Proceedings BARYONS 2002, Jefferson Lab., Newport News (Virginia), USA, March 2002*]

3.6 Presentations at International Conferences and Symposia

- **François Arleo**

  Quark energy loss in cold matter : Constraints from Drell-Yan data
  Workshop on Hard Probes in Heavy Ion Collisions at the LHC
  11-15 March 2002, CERN, Geneva, Switzerland

  Drell-Yan tomography of cold QCD matter
  37th Rencontres de Moriond on QCD
  16-23 March 2002, Les Arcs, France

  Heavy quarkonium hadron interaction in QCD
  Workshop on Charm Production: from Threshold via SPS to RHIC and LHC
  17-22 June 2002, ECT, Trento, Italy*

  Tomography of nuclear matter: comparing Drell-Yan with deep inelastic scattering data
  Quark Matter 2002
  18-24 July 2002, Nantes, France

- **Tommaso Calarco**

  Quantum information processing with atom chips
  Quantum Electronics and Laser Science Conference
  19-24 May 2002, Long Beach, CA, USA

  Paving the road for an all-optical spin-based quantum computer
  6th International Conference on Quantum Communication, Measurement, and Computing
  19-22 July 2002, Cambridge, MA, USA

- **Pietro Faccioli**

  Instantons and hadronic form factors
  Workshop on The Structure of the Nucleon
  2-11 September 2002, ECT, Trento, Italy*

- **Luca Girlanda**

  Need for new low-energy $\pi\pi$ data
  Workshop on Hadronic Atoms (HadAtom02)
  14-15 October 2002, CERN, Geneva, Switzerland

- **Evgeni Kolomeitsev**

  χ-BS(3): a unified chiral approach to meson-nucleon interaction
  International Conference on the Structure of Baryons (Baryons 2002)
  3-8 March 2002, JLab, Newport News (Virginia), USA

- **Barbara Pasquini**

  Dispersion relation formalism for virtual Compton scattering off the proton
  International Conference on the Structure of Baryons (Baryons 2002)
  3-8 March 2002, JLab, Newport News (Virginia), USA

  Dispersion relations in real Compton scattering
  2nd International Symposium on the Gerasimov-Drell-Hearn Sum Rule and the Spin Structure of the Nucleon (GDH2002)
  3-6 July 2002, Genova, Italy

  Dispersion relations in virtual Compton scattering
  15th International Spin Physics Symposium (SPIN2002)
  9-14 September 2002, Brookhaven (NY), USA

  Dispersion relations in real Compton scattering
  9th Conference on Problems in Theoretical Nuclear Physics (Cortona2002)
  9-12 October 2002, Cortona, Italy

- **Georges Ripka**

  Baryons as solitons in chiral quark models
  18th European Conference on Few-Body Problems in Physics
  8-14 September 2002, Bled, Slovenia

  Phenomenological models of color confinement based on dual superconductors
  II International Workshop on Hadron Physics
  25-29 September 2002, Coimbra, Portugal

- **Akaki Rusetsky**

  Including virtual photons in strong interactions
  Conference on Quarks and Nuclear Physics (QNP 2002)
  9-14 Jun 2002, Jülich, Germany

- **Dolores Sousa**

  Baryon and antibaryon production at RHIC energies in the Dual Parton Model
  37th Rencontres de Moriond on QCD
  16-23 March 2002, Les Arcs, France

- **Wolfram Weise**

  Nucleon magnetic moments, their quark mass dependence and lattice QCD extrapolations
  International Conference on the Structure of Baryons (Baryons 2002)
  3-8 March 2002, JLab, Newport News (Virginia), USA

  Baryons 2002: Outlook
  International Conference on the Structure of Baryons (Baryons 2002)
  3-8 March 2002, JLab, Newport News (Virginia), USA

  Chiral dynamics and the hadronic phase of QCD
  International Enrico Fermi School of Physics
  "From Nuclei and their Constituents to Stars"
  6-16 August 2002, Varenna, Italy

  The Chiral Structure of the Nucleon
  Gordon Conference on Photonuclear Reactions
  18-23 August 2002, Tilton, New Hampshire, USA

  Quark mass dependence of nucleon properties and extrapolations from lattice QCD
  International School "Quarks in Hadrons and Nuclei"
  16-24 September 2002, Erice, Italy

  Chiral dynamics of deeply bound pionic atoms
  XVI International Conference on Particles and Nuclei (PANIC 02)
  30 September- 4 October 2002, Osaka, Japan

  Chiral extrapolations of nucleon properties from lattice QCD
  XVI International Conference on Particles and Nuclei (PANIC 02)
  30 September- 4 October 2002, Osaka, Japan

  Chiral dynamics in nuclear systems
  International Workshop on Chiral Dynamics (CHIRAL 02)
  7-11 October 2002, Kyoto, Japan

  Chiral dynamics of hadronic atoms
  International Workshop on Exotic Atoms (EXA 2002)
  28-30 November 2002, Vienna, Austria

3.7 Lectures and Seminars

3.7.1 Lectures

- **Dual Superconductors and their applications to Color Confinement in QCD**
  (January-February)
  Lecturer: Georges Ripka (CEA, Saclay, France, and ECT*)
- **Hard Probes of Hot and Dense Matter**
  (June 11-13)
  Lecturer: Helmut Satz (University of Bielefeld, Germany)
- **Physics of High Parton Densities**
  (June 7-20)
  Lecturer: Larry McLerran (Brookhaven National Laboratory, USA)
- **Experimental High-Energy Heavy-Ion Physics**
  (June 24-26)
  Lecturer: Rainer Santo (University of Münster, Germany)
- **QCD Thermodynamics on the Lattice**
  (July 3-5)
  Lecturer: Edwin Laermann (University of Bielefeld, Germany)
- **The Quark-Gluon Plasma**
  (July 9-11)
  Lecturer: Jean-Paul Blaizot (CEA, Saclay, France)
- **Matter under Extreme Conditions**
  (July 8-16)
  Lecturer: Gordon Baym (University of Illinois, Urbana Champaign, USA)
- **Ultra-Relativisitic Heavy Ion Experiments: Soft Probes**
  (July 29-August 1)
  Lecturer: Johanna Stachel (University of Heidelberg, Germany)
- **Ultra-Relativisitic Heavy Ion Experiments: Hard Probes**
  (July 29-August 1)
  Lecturer: Peter Braun-Munzinger (GSI, Darmstadt, Germany)

3.7.2 Seminars

14.02
Neutron Stars and Kaon Condensation
E. Kolomeitsev (*ECT**)

21.03
Chiral Symmetry and the Nuclear Many-Body Problem
W. Weise (*ECT**)

11.04
Scattering of Vector Mesons off Nucleon
M.F.M. Lutz (*GSI and TU Darmstadt*)

23.04
Charge Multiplicities and Baryon Production in the Dual Parton Model
D. Sousa (*ECT**)

07.05
Color Screening in QCD: Concepts and Problems
Roland Schneider (*TU Munich*)

07.05
J/ψ Suppression in the Dual Parton Model
Dolores Sousa (*ECT**)

07.05
Phases of QCD and Hadro-Chemistry
Thorsten Renk (*TU Munich*)

08.05
Azymuthal Asymmetry of $D\overline{D}$ Mesons in Hadron-Nucleon and Heavy Ion Collisions
Gennadi Lykasov (*JINR, Dubna*)

08.05
Charmonium Production in Heavy-Ion Collisions
Alberto Polleri (*TU Munich*)

08.05
Energy Loss Effects in Drell-Yan and Charmonium Production
François Arleo (*ECT**)

16.05
Hadronic Atoms in QCD : An Overview
A. Rusetsky (*Univ. Bern*)

27.06
Renormalization Group Methods in Elementary Particle Physics
M. Góźdź (*Univ. Lublin*)

18.07
Neutrino Interactions In Neutron Stars
L. Dieperink (*KVI, Groningen*)

26.09
On Hydrodynamical Modeling of Relativistic Heavy Ion Collisions
S. Räsänen (*Jyväskylä / ECT**)

17.10
A Study of the Dynamical Origin of Chiral Symmetry Breaking and of the Axial Anomaly in QCD
P. Faccioli (*ECT**)

22.10
Physics of Hadronic Atoms
A. Rusetsky (*ECT**)

24.10
Influence of Strange Quark Pairs on Spontaneous Chiral Symmetry Breaking
L. Girlanda (*ECT**)

19.11
Tomography of QCD Matter : Tools and Diagnosis
F. Arleo (*ECT**)

21.11
Results of the String Fusion Model at SPS and RHIC
D. Sousa (*ECT**)

04.12
Linking Generalized Parton Distributions to Constituent Quark Models
B. Pasquini (*ECT**)

05.12
Stability of Strange Quark Matter: Model Dependence
C. Ratti (*Torino*)

4 ECT* Computing Facilities

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

3 license servers:	1 Sparc Ultral (Numerical Recipes) 1 Sparc10 (Mathematica) 1 PC Linux (Mathematica)
3 computation servers (SCSI):	1 Alpha bi-processor 533 MHz (NAG libraries) 1 Pentium III bi-processor 500 MHz 1 Pentium IV 1.6 GHz
12 PC for local research (SCSI):	7 Pentium III up to 800 MHz 5 Pentium IV 1.6 GHz
28 PC for users (IDE):	23 Pentium III up to 600 MHz 5 Pentium IV 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)

5 Link Members

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6 Statistics

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