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astronomy
computer science
mathematics
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Scientific Report 2004

Foreword by the Director

It is a pleasure for me to introduce to you the annual report of the Lorentz Center for 2004 and to highlight some aspects of the program and of recent developments at the center.

The core of this report consists of personal impressions and reports that organizers have written about their workshops. In comparison with most other workshop centers in the sciences, a special feature of the Lorentz Center is the fact that we are not rooted in one single scientific discipline, but in at least four: astronomy, computer science, mathematics and physics. All these fields have slight differences in their way of working and their style – when you leaf through the report you will see that this is reflected in our workshops, which range from open-ended workshops aimed mostly at exchange of ideas and discussions to more project-oriented meetings, centered around e.g. a particular telescope.

Being based in various disciplines gives the Lorentz Center a very good position from which to promote interdisciplinary workshops, not only workshops between our core disciplines but also activities which branch out beyond these. Let me simply illustrate these remarks by drawing your attention to some noteworthy examples of the program of 2004:

- The Lorentz Center hosted a graduate course on "History of Mathematics".
- The workshop on "Continuous and Discrete Random Spatial Processes" in April was a very good example of a successful workshop bringing together mathematicians and theoretical physicists.
- The workshop "Equation-of-State and Phase-Transition Issues in Models of Ordinary Astrophysical Matter" attracted both astronomers and physicists working on high density matter; various new collaborations and interactions were initiated at the workshop, and the meeting even lead to a book. Another noteworthy feature of this workshop is that this is the first astronomy workshop proposed and organized by groups from outside the Netherlands.
- Two of our three workshops in computer science during the year, "Quantum Computing" and "Molecular Computing", were on inherently interdisciplinary subjects.
- At a workshop on "Statistical Physics of Disorder and Pattern Formation in Fracture" researchers from various disciplines met, including people who measured the formation of cracks in the ice at the North Pole.
- Progress in a field like astronomy strongly depends on the availability of state of the art facilities, so planning for the future with large international collaborations is crucial in astronomy; we had one short meeting of the Herschel Group and one meeting which partly aimed at advising ESA about future prospects for coronographic methods.
- At the workshop "Volatility of Financial Markets: Theoretical Models, Forecasting and Trading", physicists, financial mathematicians and economists met to exchange views on methods recently developed, mostly by physicists.

Our program boards are increasingly active in soliciting new topics and ideas and in judging proposals that have been submitted to the center. Most of these exchanges are done by email, so as to keep the response time for proposals to a minimum. In 2004 the boards also met for the first time to advise the center and discuss its program. These meetings do stimulate further cross-fertilization between the fields - e.g. the suitability of a workshop modeled after the national study group "Mathematics with Industry" is presently being discussed by our physics board.

The Lorentz Center is only a few kilometers away from the NIAS (Netherlands Institute of Advanced Study), an advanced study center in social sciences and humanities. Together with their management, we have started to explore the possibilities of having joint workshops with the NIAS in the future, on topics like data mining in social sciences, history and philosophy of science, physical methods for archeology, etcetera.

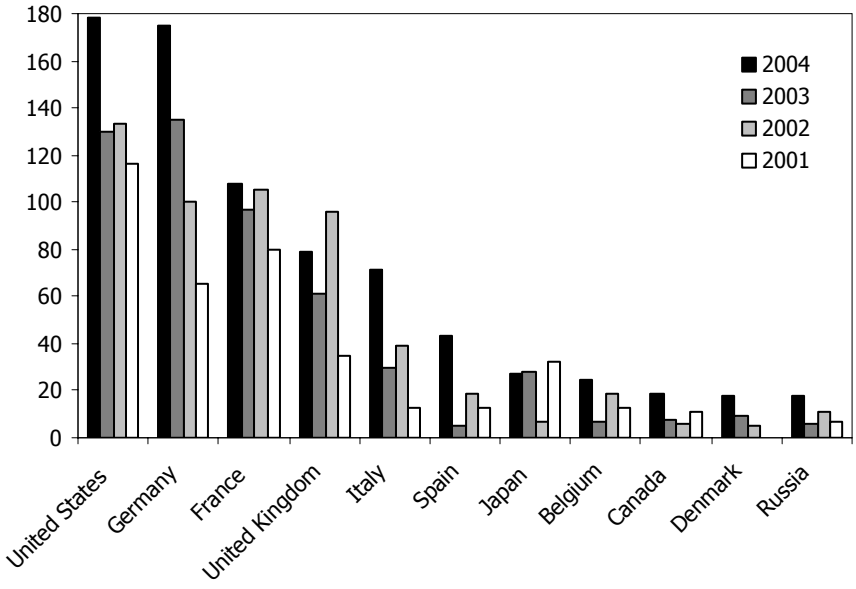
We are very happy that the Lorentz Center is nowadays able to support the increased role and importance of the program boards more actively and systematically: in the spring of 2004, dr. Eppo Bruins has joined the staff of the Lorentz Center in the position of *science manager*. The science manager assists the boards, both, in the evaluation of workshops proposals that have been submitted to the center, and in soliciting new topics and proposals.

The increased activity at the Lorentz Center is reflected in the number of visitors and workshop participants again being somewhat larger than the year before, as the table below shows. Another noteworthy fact about our workshops is that we have a much higher participation rate of young researchers than most other comparable centers: 36% of our registered participants are PhD students or postdocs.

YEAR	2000	2001	2002	2003	2004
Number of Meetings	23	31	34	31	38
Number of Workshops	**15**	**21**	**23**	**22**	**31**
Number of Visitors	880	1002	1421	1436	1640
Reg. workshop participants	**640**	**735**	**1005**	**1007**	**1133**

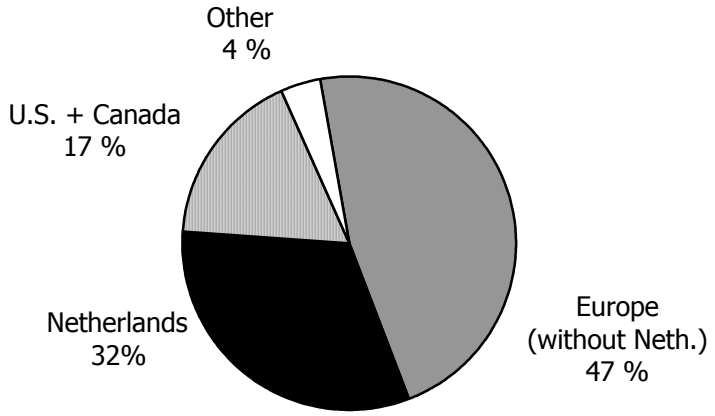
Our international status is illustrated by the diagrams below which show that we continue to draw workshop participants from a large number of countries.

Main countries of origin in 2004 – 2001



Although the numbers for individual countries fluctuate year by year, the distribution over the various continents of origin, shown in the pie graph below, is remarkably constant over the years.

Continent of origin of workshop participants in 2004



Finally, I am happy to be able to report two improvements in the facilities we offer the participants of our workshops. At the Lorentz Center itself, we have equipped all offices with new desks which provide better work space. Secondly, the Bastion Hotel, where most of our guests are staying, now has a special "Lorentz Lounge" for our workshop participants - here they can relax, meet their colleagues or check their email.

Wim van Saarloos
Director, Lorentz Center

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Scientific Report

The structure and composition of Active Galactic Nuclei: Optical Interferometry and Adaptive Optics of NGC 1068

January 12 – 14, 2004

Active galactic nuclei (AGNs) are among the most spectacular objects in the sky. They display many energetic phenomena – relativistic jets, broad emission lines, X-rays, radio lobes – originating from accretion on to a supermassive black hole. The varying importance of these phenomena results in a complex classification of AGNs into quasars, radio galaxies, Seyfert galaxies etc. Much of this diversity seems caused by orientation effects: from certain viewpoints, circumnuclear dust clouds block the view of the central accretion disk and jets. The dust re-radiates the absorbed energy at infrared wavelengths. The universality of this model, and the dust geometry are still controversial; even the largest telescopes have not resolved the dust structures. Recently the first mid-infrared *interferometric* spectral observations of the nearby AGN, NGC 1068, at a resolution of ~30 milli-arcsec were carried out. These spectra prove the existence of a compact dust structure only a few parsec across, around an unresolved hot core, possibly the accretion disk; models invoking much larger dust distributions are excluded. The spectra indicate dust of distinctly different composition from that common in our Galaxy.
The sketched observations have been conducted by a team of astronomers from Leiden, Heidelberg, Paris and ESO. At the beginning of November 2003 a new and more extended data set has been obtained. Also at the 10m Keck telescope interferometric observations have been obtained. In addition, a number of other techniques have come to bear interesting results. These include adaptive optics measurements and X-ray and radio measurements.
This workshop brought together the team that is carrying out the interferometric observations. Furthermore, the workshop was attended by (i) astronomers that are in the process of detailed modelling the observed phenomenon and (ii) astronomers that are carrying out observations of AGN with other techniques. The final programme contained a number of elements, including:

- an overview of the recent results of multi-wavelength observations of nearby AGN.
- a detailed discussion of the VLTI data obtained together with a comparison of the various reduction methods
- a first confrontation of the various models with the data obtained last year.

As a measure of success, we would like to point out that the discussions greatly improved our draft of the Nature paper, which was subsequently accepted (Jaffe, Meisenheimer, Röttgering et al. 2004, Nature, 429, 47). In the same issue of Nature, one of the theorists that we invited, wrote a very nice article in the news and views section of this issue of Nature (Krolik, page 29), emphasizing the importance of the results discussed at this Lorentz Center workshop.

Huub Röttgering (Leiden University, The Netherlands)
Walter Jaffe (Leiden University, The Netherlands)
Klaus Meisenheimer (Max Planck, Heidelberg)
Helen Sol (Meudon, Paris)

Coronographic Methods for the Detection of Terrestrial Planets

February 02 – 06, 2004

We are privileged to live in an age when we can realistically expect to search for Earth-like planets around nearby stars, and to look for evidence of life on those planets. For thousands of years mankind has wondered about these questions. We need no longer wonder. For the first time, we now possess the technical ability to carry out the dream of really finding out.

To detect and characterize Earth-sized planets, and to search for evidence of life, we must directly detect the information-carrying photons from the planet itself. Future extremely large ground-based telescopes will play a role in detecting planets, but it is at present unclear whether ground-based techniques can be pushed into the realm of Earth-like planets. It is therefore generally assumed that space missions will provide the most direct path towards these goals. Two main types of instruments have been proposed to do this: an interferometer operating at thermal infrared wavelengths, and a coronograph operating at visible wavelengths.

The Leiden meeting was held as a workshop devoted specifically to the coronograph technique. We realized that researchers in the US and Europe both had already made very strong contributions to the optical theory of coronographs. We also recognized that the technical aspects of coronographs had been pursued more strongly in the US, owing to funding considerations. Therefore we decided to focus this joint meeting on taking an inventory of current efforts in this area, and on fostering a stronger European level of contribution to the technical side of coronographs, in the universities, in industry, and at national levels. The recent announcement by NASA of an intended launch of a coronographic option for TPF (TPF-C) in 2014 reinforces the pertinence of our effort.

Attendance of the workshop was limited in number to match the facilities available. Approximately 50 people attended, in about equal numbers from the US and Europe. We were very fortunate to be offered the full use of the wonderful facilities and generous hospitality of the Lorentz Center at the University of Leiden.

The workshop itself was opened by a few introductory talks, followed by a round of self-introductions by the participants. Most of the week was spent in focus groups, developing the material for a detailed report to the space agencies on both sides of the Atlantic (printed by ESTEC, also available electronically from Andreas Quirrenbach). By the end of the last day of the workshop, every participant had contributed to the report, and the first drafts were all in hand. Polishing and editing required another few months.

Our goal was to quickly produce a comprehensive snapshot of the state of the art in coronography, complete with clear suggestions as to areas where more research and technical development are required. It is our hope that many of these areas will grow and flourish in Europe and in the US.

The workshop organizers and participants would like to express their sincere thanks to the Lorentz Center at Leiden University and its staff, in particular Dr. Martje Kruk-de Bruin and Yolande van der Deijl, for their hospitality and the flawless organization of the meeting. The US participants were supported by NASA JPL, and ESTEC generously hosted a detailed tour of their facilities during the workshop.

Andreas Quirrenbach (Leiden University, The Netherlands)
Claude Aime (Nice University, France)
Bob Brown (Space Telescope Science Institute, Baltimore, USA)
Christophe Dumas (Jet Propulsion Laboratory, Pasadena, USA)
Malcolm Fridlund (European Space Research and Technology Center, Noordwijk, The Netherlands)
Alan Greenaway (Heriott-Watt University, Edinburgh, UK)
Daniel Rouan (Observatoire de Paris, Meudon, France)
Wes Traub (Harvard-Smithsonian Center for Astrophysics, Cambridge, USA)

Radiative Transfer Modelling of Water

March 22 – 24, 2004

Water is one of the most important molecules in star-forming interstellar clouds. Only present in trace amounts in cold molecular clouds, it becomes the third most abundant species (after molecular hydrogen and helium) in regions heated by newly formed stars. With this more than 10,000-fold abundance variation, the water emission- and absorption-line spectrum offers a unique probe of the physical structure of star-forming clouds and of the fundamental interaction between gas and grains in such regions. Furthermore, study of the water spectrum may prove essential to understand the energy balance in these clouds.

Largely inaccessible from the ground, the water spectrum of astrophysical sources will be prime targets of the Herschel Space Observatory and its Heterodyne Instrument for the Far-Infrared (HIFI), to be launched by the European Space Agency in 2007. A HIFI key project is currently being defined focussing specifically on water in star-forming regions (led by van Dishoeck, Leiden, NL), and many open-time proposals involving water-line observations are foreseen.

This workshop brought together 28 experts in the field of radiative transfer modelling and astrophysical spectroscopy of water, essential techniques to interpret the upcoming HIFI data. The workshop addressed two themes: testing and benchmarking of computer codes used to simulate the line formation of water in astrophysical environments, and exploration of the diagnostic capabilities of the water spectrum.

Testing of codes
Before the start of the workshop participants received two test problems that captured some essential stumbling blocks for the modelling of water lines: opacity to the line photons and excitation that is far from thermal equilibrium. Comparison of the returned results at the workshop did not show perfect agreement, but the fact that all codes were capable to produce results is very encouraging. After fixing a number of obvious mistakes (a useful outcome in itself!), two important lessons were learnt from the remaining discrepancies. One lesson is that a functional rather than discretized description of the velocity field is essential. The other lesson is an important reminder that reliable convergence criteria are indispensable in the presence of the large opacities common in water lines. The short duration of the workshop did not allow implementation of these lessons in the participating codes, but a follow-up program will ensure that this will be done by mid 2004.

Diagnostic tools
One afternoon session presented previous observations of water with ground- and space-based instruments, and served as a starting point for the discussion of the diagnostics of water. The participants split up into 8 subgroups, each focussing on a particular type of object (pre-stellar cloud cores; embedded high- and low-mass young stars; shocks; giant molecular clouds; protoplanetary disks; and shells around evolved stars). Each subgroup formulated a follow-up program that will define a template structure for the object in question, simulate the emergent water spectrum (using the benchmarked codes), and derive the *minimum* set of water lines to be observed with HIFI that can yield reliable estimates of the abundance of water. The results will be collected in October 2004.

Special Sessions
Two special sessions addressed water masers and the availability of (and need for) basic molecular data.

This workshop was generously supported by Stichting Ruimte-Onderzoek Nederland, the Lorentz Center, and de Nederlandse Onderzoeksschool Voor Astronomie. The organizers are grateful for the excellent assistance by Ms Martje Kruk and Ms Yolande van der Deijl.

Michiel Hogerheijde (Leiden University, NL)
Edwin Bergin (University of Michigan, USA)
José Cernicharo (Instituto de Estructura de la Materia, Spain)
Frank Helmich (Stichting Ruimte-Onderzoek Nederland, NL)
David Neufeld (Johns Hopkins University, USA)
Floris van der Tak (Max-Planck-Institut für Radioastronomie, Germany)
Jeremy Yates (University College London, UK)

Scientific Report

Benchmarking of PDR models

April 5 – 8, 2004

Introduction

The aim of this workshop was to test and benchmark models of Photo-Dominated Regions (PDR). Photon-Dominated Regions are molecular clouds exposed to intense radiation where UV photons dominate much of the chemistry and heating. Since a large fraction of the interstellar medium consists of PDRs, a good understanding of their physical and chemical structure is essential. In the last twenty years, considerable effort has gone into constructing PDR models. Unlike models of the chemical evolution of shielded dense clouds, PDR models require a spatial treatment of the chemistry and the heating and cooling of the gas. The ultraviolet radiative transfer needs to be solved with depth into the cloud, in particular to model the transition from H to H^2, and C+ to CO, including dust attenuation and self-shielding. In view of the near-future space and ground telescopes such as Herschel and ALMA the need for preparatory working groups led a group of astronomers to invest some time in the benchmarking of various chemistry codes against each other. At least 10 different groups have developed independent codes of PDR. While there is a general agreement among modellers about the qualitative trends, there are large quantitative differences in the results for key species and their lines.

The Workshop

About 30 people from Europe and USA attended the workshop: most of the participants were representing a PDR code but observers were also invited to participate. The number of participants was small enough that a well coordinated pre-workshop preparation was possible: several months before the workshop we started testing our codes with few simple benchmarking tests and by the time we started the workshop we were already in the position to address specific questions regarding our codes, more specifically the workshop highlighted six major questions that were chosen in advance of the meeting by the organizing committee:

1) Geometry in PDR codes: uni-directional vs isotropic illumination and plane-parallel vs spherical line emission.
2) Chemical reactions and rate coefficients: identification of crucial rates and PAH chemistry.
3) UV transfer and shielding: treatment of H^2 and CO; clumpiness vs homogeneous treatment etc.
4) H^2 formation rate
5) Heating and cooling balance: heating rates, cooling rates and temperature structures
6) Theory meets Observations: key observational issues in light of future missions such as HIFI and ALMA.

We had a full program with few lectures and 6 discussion sessions each covering one of the questions above. Discussion leaders were assigned for each of these sessions. Their main job was to introduce the topic and start the discussion. Everyone then was free to contribute, either by discussion or by showing a few slides. Large part of the afternoons was spent actually performing benchmarking tests in our offices: this is one example of how the unique facilities of the Lorentz Center were central to the success of such a workshop.

Outcome of the Workshop
By the end of the workshop summaries of each discussion were drawn up by each leader, and the coordinator of the benchmarking tests gave a great short presentation showing the 'before' and 'after' comparisons of the codes: the differences were outstanding and this showed how one week of benchmarking tests performed by people placed in the same location achieves so much more than several months of long distance benchmarking! Again, this could only be achieved thanks to the generosity, infrastructure and outstanding organization of the Lorentz Center and of the people working there.

Finally, the results of this benchmarking effort will shortly be published in a refereed journal. We hope that all present and future PDR codes will take into consideration the outcome of this extremely successful workshop.

S. Viti (University College London, United Kingdom)
J. Stutzki (University Koeln, Germany)
E.F. van Dishoeck (Leiden University, The Netherlands)

Continuous and Discrete Random Spatial Processes

April 20 – 29, 2004

The subject and purpose of the workshop
One of the leading topics was the recent deveopments in what is called the Stochastic Loewner Evolutions to which Beffara gave an excellent introduction. A two-sentence summary of this subject is that a path penetrating a two-dimensional domain can be studied by means of the conformal maps that expel the growing initial segment of the path from the domain. Thus a measure on such paths can be studied by means of a measure on such maps.
Very similar techniques have been used in the field of Laplacian growth, studying clusters growing as the result of diffusion of particles driven in a field determined by the cluster. Also this subject was discussed extensively in several of the seminars. These research fields and more generally the field of spatial stochastic processes is typically studied by mathematicians and by physicists. These two communities tend to use a different language and ask different questions. Therefore this workshop was intended to bridge the gap between the two and thus have a fruitful exchange of ideas.

The population of the workshop
The participants of this workshop were about equally divided over the mathematics and theoretical physics. The fact that people from different disciplines working on the same or related questions came together, resulted in a lively exchange. The seminar programme had three to four talks every day, so there was ample time to discuss and collaborate. The organizers encouraged and initiated the organization of informal meetings on subjects that clearly attracted the attention of a significant fraction of the participants. However, though a few of such meetings were held, it turned out that there was no great need for this level of formality between that of plenary talk and private discussion. Discussions in the comfortable common room often attracted a handfull of participants.

The workshop definitely helped to exchange ideas between the mathematians and physicists among the participants. It was useful that neither of the two groups dominated in number. The sign of the success of the workshop was that in several discussions the initiative of similar workshops was contemplated.

J. van den Berg (CWI, Amsterdam)
B. Nienhuis (University of Amsterdam)

Near- and mid-IR studies of galaxies in or near the Local Group

May 3 – 7, 2004

The workshop was set up because in recent years new, much more sensitive and much larger detector arrays and, especially, large new telescopes (4m to 8m diameter) have come on line and that has strongly enlarged the observational possibilities. One may now detect and study in detail very young and very old stars in all galaxies belonging to the Local Group, i.e. the group of galaxies held together by the gravitational attraction of two large galaxies, the Andromeda galaxy and our Milky Way galaxy. Many comparable programmes are under way and it appeared to be a good time to bring active researchers together for their mutual benefit. 33 participants arrived from Japan, South Africa, Chile, the USA and from several European countries. We followed the program of presentations suggested initially almost without change.

The LC workshops aim at stimulating informal contacts between the participants expecting that some of these informal contacts will lead to new and fruitful studies. Much research in astronomy (and probably also in other fields) is done by consortia; some consortia have a very well defined focus and may disappear once that goal is reached, other consortia concentrate on larger topics and then have a much longer life. During the workshop of this report many informal gatherings took place between people from very different locations. We even heard the complaint: "why are there presentations anyway, they keep us away from our joint discussions!"

We have asked several of the participants their opinion about the workshop. We got positive replies from everyone. The topic was well-chosen as it is a lively field with many programmes underway. Most participants arrived with questions and (sometimes) answers of great value to the other participants.

The assistance of the staff of the Lorentz Center was once again excellent and professional and left a very positive impression in all those who visited the Lorentz Center for the first time.

Harm Habing (Leiden University, The Netherlands)
Maria-Rosa Cioni (ESO, Germany)

High-Field Electron Paramagnetic Resonance Spectroscopy: Technology and Applications

May 10 – 12, 2004

This workshop was held from May 10 till May 12 2004 in the Lorentz Center and assembled 46 scientists active in Electron Paramagnetic Resonance (EPR) spectroscopy. EPR spectroscopy is already 60 years old but the last decade has seen a remarkable revival of interest owing to the development towards higher and higher microwave frequencies and accompanying magnetic fields. In 1990 the majority of EPR experiments were carried out at the conventional frequencies of 9-35 GHz but now 95 GHz has become a common frequency for many scientists. Presently a small number of EPR spectroscopists is pioneering to develop EPR to the range of 250-360 GHz, i.e., the highest frequency possible with the present-day superconductor-magnet technology.
The center of activity in the development of high-frequency EPR is in Europe and the European Community is supporting a Network SENTINEL that aimes at coordinating the efforts of 5 European research groups in the field of high-frequency EPR. One of the activities of SENTINEL is a yearly meeting and for 2004 it was decided that it was going to be held in Leiden. Since the start of SENTINEL considerable progress has been made and for the first time the meeting was opened for all European scientists interested in this field of research and not directly connected to the SENTINEL Network. The aims of the meeting were threefold. First to discuss technological problems and progress. Secondly to transfer the knowledge acquired in SENTINEL to the European EPR science community at large. Third to develop common projects between members of SENTINEL and interested scientists who do not have access to high-frequency EPR equipment. The hope was that the technical progress in EPR would stimulate scientists to think about new experiments in various domains and that reciprocally the demands from the users would stimulate the high-frequency EPR experts to develop new experimental possibilities.
The scientific program consisted of several scientific and technological presentations by 6 invited speakers, 8 speakers from the groups participating in the SENTINEL Network and 3 speakers from interested groups. In addition 13 posters were presented. The meeting was characterized by extensive discussions after the presentations. One of the high-lights was a lively round-table discussion about three themes that look particularly promising for future applications of the newly developed high-frequency EPR and ENDOR (Electron Nuclear Doble Resonance) techniques in various fields of science.
In addition to the scientific part of the meeting a special session was held about the future of the science program of the EC in particular for setting up new networks. To this end Mrs. Sambain of the EC Commission in Brussels gave a special presentation of the opportunities for financial support by the EC for the coming years.
The participants were all enthousiastic about the meeting and its scientific level. In particular they were extremely pleased with the smooth, efficient and flexible organization by the management of the Lorentz Center. It was decided that this kind of meeting should be continued to maintain the contact with the EPR community. The next meeting will be held from May 4-8, 2005 in Budapest in Hungary.

E.J.J. Groenen (Leiden University, The Netherlands)
M.I. Huber (Leiden University, The Netherlands)
J. Schmidt (Leiden University, The Netherlands)

Quantum Information Processing

May 24 – 28, 2004

This workshop was held at the Lorentz Center from May 24 to May 28. It was organized by Harry Buhrman (CWI and University of Amsterdam) and Ronald de Wolf (CWI). There were 30 registered participants, among which 10 from Dutch universities, 4 from other European countries, 12 from North-America, 2 from Israel, 1 from Australia, and 1 from Japan.

The topic was quantum information processing, a.k.a. quantum computing. This young research area studies the power of computers based on quantum mechanical principles such as superposition, interference, and entanglement. The workshop brought together some of the leading researchers in the field. Despite being organized by computer scientists, it had a clear interdisciplinary character, with computer scientists, theoretical physicists, and mathematicians all contributing. As such, it accorded very well with the aims of the Lorentz Center.

The five days of the workshop each had two talks in the morning and one in the afternoon, with a big slot of free time in between for informal scientific discussions. The 15 talks (for which see the program website) covered the following areas:

* Algorithms and complexity (6 talks)
The power and limitations of quantum algorithms was probably the main focus of the workshop. Several talks discussed the power of so-called "quantum proofs", extending the notion of classical nondeterministic or non-uniform computation. Such research has clear links with quantum cryptography, as well as with quantum and classical complexity theory. Another talk analyzed the power of quantum entanglement to produce correlations between distant parties that classically one can only produce using much communication. Finally, two more talks studied various tradeoffs (time vs space, and classical vs quantum gates) for quantum complexity, delineating for instance to what extent adding quantum workspace can decrease the amount of time needed for sorting an array.

* Models (4 talks)
The quantum circuit model, which decomposes an algorithm into a sequence of elementary gates, has been and still is the dominant model for describing quantum algorithms. However, in the past few years a number of alternative approaches have come to the fore. These include quantum random walks, adiabatic computation, and quantum computation via single-qubit measurements on a given "cluster state". The workshop included a talk on each of these. In addition, one talk analyzed the possibilities of dealing with non-Markovian (non independent) random noise and showed that under certain assumptions, errorless quantum computation is possible even in the presence of such noise.

* Quantum cryptography (3 talks)
Some parts of quantum cryptography are already fairly close to commercial implementation. On the other hand, there are also some notorious impossibility results, for instance the impossibility of perfect quantum "bit commitment" and "coin tossing". A number of talks identified to what extent and under what circumstances imperfect versions of such useful cryptographic primitives are possible in the quantum world.

* State estimation (2 talks)
Finally, two talks from the Utrecht group analyzed statistically how well quantum states can be identified and manipulated given certain classical outcomes of measurements on those states.

Despite the fact that one of the organizers fell ill for part of the week, the workshop went very smoothly, due in large measure to the organizational support of Martje Kruk and Yolande van der Deijl. According to the feeling of the organizers, as well as the responses from participants, the workshop was very well received and quite stimulating.

Harry Buhrman (CWI and University of Amsterdam)
Ronald de Wolf (CWI)

Equation-of-State and Phase-Transition Issues in Models of Ordinary Astrophysical Matter

June 2 – 11, 2004

The need for a precise knowledge of the equation of state for hot dense matter, together with an indication of the location of phase transitions, arises frequently in physics and astrophysics. Good examples in terrestrial physics are the various laboratory experiments carried out under static and dynamical high pressure. Such experiments will be supplemented in the next few years by the planned large-laser-fusion experiments of NIF (Livermore, USA) and Megajoule (Bordeaux, France). All these experiments also serve as sources for plasma diagnostics. Good examples for equation-of-state needs in astrophysics range from studies of the early universe to present-day astrophysical objects such as the Sun, stars, brown and white dwarfs, and planets.

The aim of the workshop was to bring together physicists and astronomers with an interest in this interdisciplinary field. The highest promise lies in the possibility not only to model astrophysical objects, but to use these models to improve our knowledge of basic physics. Thus, astrophysical objects become a novel, alternative method of plasma diagnostics.

The topics of the workshop could be classified in three groups.
I. Astrophysics of hot dense plasmas and applications of laboratory diagnostics
II. Astrophysics of solid-state objects and links to high-pressure experiments
III. Fundamental theory of the equation of state and phase transitions.

The key-note talks of the first group were:
-Werner Däppen: "Equations of State for Stellar Interiors"
-Douglas Gough: "The power of helioseismology to address issues of fundamental physics"
-Sergei Vorontsov: "Helioseismic inversions and the equation of state"
-Jørgen Christensen-Dalsgaard: "An introduction to solar oscillations and seismology"
-Sylvaine Turck-Chièze: "From helioseismology to asteroseismology"
-Victor Gryaznov: "Equation of state and thermodynamic functions of Solar plasma"
-Vladimir Baturin: "Thermodynamics of the solar convection zone through adiabatic compressibility"
-Sergey Ayukov: "Heavy element settling in the Sun and equation of state"
-Sergey Ayukov: "Solar models with SAHA-S equation of state"
-Günter Houdek: "Asteroseismic helium abundance determination"
-Chia-Hsien Lin: "Isolating Heavy-Element Effects in the Equation of State"
-Maria Pia Di Mauro: "Seismic inferences of EOS effects in solar and stellar modelling"
-Regner Trampedach: "Improved phenomenological equations of state in the chemical picture"
-Aihua Liang: "Emulating Physical-Picture Effects in the Chemical Picture" (presented by W. Däppen)
-Boris Vasiliev: "The equilibrium state of a dense electron-nuclear plasma in self-gravitationing fields"

The key-note talks of the second group were:
-Vladimir Filinov: "Phase Transition in Dense Hydrogen and Hydrogen-Helium Plasmas"

-Igor Iosilevskiy: "Unexpected Features of Phase Transitions in Astrophysical Objects"
-Vladan Celebonovic: "Selected results and open problems in a semiclassical theory of dense matter"
-Hugh Dewitt: "Report on Flying plate results vs. the Nova laser shock results obtained at Livermore"
-Vladan Celebonovic: "Basic notions of static high pressure experiments"

The keynote talks of the third group were:
-Hugh Dewitt: "Thermodynamics of strongly coupled plasmas in dense stellar interiors, and the screening enhancement of thermonuclear reaction rates"
-Giora Shaviv: "Numerical Experiments in Screening Theory"
-Giora Shaviv: "Kohn-Sham Calculations for the Ionization of Beryllium in the Solar Center"
-Hugh Dewitt: "On regroupings and energy-level shifts in activity expansions"
-Andrey Starostin: "Corrected EOS of weakly nonideal hydrogen plasmas without mysteries"

During the last day of the workshop, a plenary session was held to discuss what had emerged. Unanimously, Hugh Dewitt's report of the end of a 7-year controversy about high-pressure experiments with hydrogen and deuterium was considered to be the most novel announcement made during the workshop.

Besides this timely event, the principal outcome of the workshop was that it allowed two different research communities to meet. On the one hand, physicists could obtain a first-hand glance that their work (good models of equations of state) is in high demand by astronomers, on the other hand, astronomers could observe that there is (still) a bustling production of elaborate equation-of-state formalisms.

Further highlights, among other, were (i) Shaviv's clear demonstration of the need to take dynamical effects in screening enhancements of nuclear reactions seriously, (ii) Vorontsov's insistence on a critical assessment of observational data, in particular, of systematic errors, which are often glossed over, and (iii), the realization, after numerous presentations by various authors, that there is an impressive number of independent advanced formalisms for astrophysically useful equations of state.

However, on the important topic of the plasma phase transition (PPT), unfortunately not much progress could be reported, not to the least because two potential participants (Gilles Chabrier, Lyon, and Didider Saumon, Los Alamos) were unable to come to the workshop.

There were 28 registered participants from a broad range of countries and continents. The largest contingent came from Russia (8). Then followed the United Kingdom (4); France (3), Serbia and Montenegro (3); Bulgaria (2) and the United States (2). Australia, Belgium, Denmark, Germany, Israel and Italy were each represented with one participant. Finally, one participant (Aihua Liang) could not attend the workshop, because she was unable to obtain the necessary Dutch visa in time. For her, a citizen of the Peoples Republic of China, especially long processing times would have been required.

The workshop was exciting and highly successful. The interactions during the lectures, as well as the additional personal contacts established outside the formal program, were extremely useful for all participants. All agreed that a follow up meeting in about 2-3 years would be most welcome to consolidate and communicate the new work that will have undoubtedly been stimulated by this workshop. All participants praised the facilities and

accommodations. Most of them had never before experienced such a type of venue that provides an informal working space so efficiently. Everybody truly enjoyed the professional support and hospitality by the local program assistant Gerda Filippo and the executive manager Dr. Martje Kruk-de Bruin. However, had not Prof. Wim van Saarloos approached Vladan Celebonovic three years ago, to suggest such a kind of a workshop, the event would not have taken place. His continuous encouragement and support were crucial at several stages of the preparation of the workshop, and we all feel deeply indebted to him.

The American Institute of Physics agreed to publish the results of this workshop in their series of Conference Proceedings.

V. Celebonovic (Institute of Physics, Belgrade, Serbia and Montenegro)
W. Däppen (University of Southern California, U.S.A.)
D.O. Gough (Institute of Astronomy, Cambridge, U.K.)

Collective Aspects of Stochastic Non-Equilibrium Phenomena at Surfaces and Interfaces

June 14 – 25, 2004

The purpose of this meeting was to bring together experts in experiment, theory, and computer simulation, working on collective stochastic phenomena in condensed matter physics, in particular in surface and interface physics, to intensify interactions between these communities and facilitate new joint projects.

Stochastic, non-equilibrium processes form a popular theme in modern research in condensed matter and statistical physics. The two-dimensional playground constituted by the surfaces and interfaces of condensed matter systems provides a multitude of exciting and highly relevant experimental and practical realizations of a variety of models considered in analytical theory and computer simulations. Examples of processes addressed during the workshop were: surface diffusion, crystal growth or erosion, surface phase transitions, reaction front dynamics, and friction.

Where the experimental focus in this area has long been on the atomic-scale detail of these processes, the more sophisticated experimental tools and improved analysis techniques available today are enabling new types of investigations, covering the full hierarchy of length scales from that of a single atom to that of the resulting collective response of the two-dimensional system. A similar development can be observed in ab initio theory (e.g. DFT) and computer simulations, which nowadays can handle sufficiently large systems over sufficiently long time scales, by virtue of the available computer power and of newly developed, smart computational strategies, that they both incorporate the essential microscopic aspects and capture the emerging collective behavior on larger length and time scales. At the statistical mechanics side, progress in the fundamental understanding of collective phenomena in non-equilibrium statistical processes has been rapid, due to the application of scaling theory, generalized from its roots in equilibrium phase transitions during the last quarter of the 20th century, numerical simulations, and exact solutions (e.g., the Bethe Ansatz method in specific one-plus-one dimensional processes, like KPZ growth and asymmetric exclusion transport processes).

The workshop was unusual in the sense that, instead of bringing together a group of specialists to make progress in one narrow focussed issue, we aimed at bridging the three above mentioned communities. All presentations were therefore overview like. Making sure that, e.g., computer experts on ab initio type calculations of interface structures and single particle diffusion learn more about current theoretical work on collective stochastic phenomena like KPZ type interface growth, and that the latter group learns more about the goals and possibilities of the latest microscopic friction experiments.

In the program we deliberately minimized grouping talks according to topics. Trying to maximize cross fertilization. Each day ended with a open one-hour discussion about the presentations of the day, and was lead by one of the invited participants. These sessions typically started with one or two 5 minute long introductions to posters displayed in the hallway of the Lorentz Center, mostly by participating post-docs and graduate students.

Many participants expressed the wish to present an additional short talk. We agreed to this, and it worked out very well, except that having more than 4 talks a day during the first week was a bit too much. During the second week, when the group was smaller, the number of open time slots was sufficient to accommodate these extra ad-hoc presentations. We advise future organizers to leave more open slots in the program than we did.

The meeting worked out very well from a different perspective as well. About 1/3 of the presentations was by Dutch physicists, many at the assistant professor level. Having the ear of international senior experts (about 2/3 of the total participants) raised not only their own visibility but also promoted Dutch physics in general.

Marcel den Nijs (University of Washington, Seattle)
Tapio Ala-Nissila (Helsinki University of Technology)
Joost Frenken (Leiden University)

Magnetic Fields in Galaxies

July 5 – 8, 2004

From July 5-8, 2004, a 4-day workshop was held in the Lorentz Center on the subject of "Magnetic Fields in Galaxies". This workshop brought together 36 people from Europe (incl. Russia), China, Australia, India, USA, Canada and Mexico, working either on the theory of the generation of galactic magnetic fields, or on the observational aspects of galactic magnetic fields. This workshop represented a rare, intense, and very successful confrontation between both communities.

The main driver for this workshop was indeed to bring together the theorists and observers working on galactic magnetic fields, to discuss the outstanding questions, to sort out apparent contradictions and to define new approaches to, sometimes old, problems. Therefore, all sessions of the programme included extended plenary discussions. For the latter, some participants had been asked to prepare a brief statement of successes and problems in the particular subject area, to start off these discussions which were otherwise wide-ranging.

One session dealt with the large-scale (or mean) magnetic field in galaxies, for the generation of which the alpha-omega dynamo was proposed already quite some time ago. Yet, this (analytic) theory still has some problems, mainly related to the escape of magnetic flux. Some of these are now also being addressed through numerical simulations. An important point in the discussion was how the predictions of the models may be best compared with the data. The influence of the environment on galactic magnetic fields was discussed from new data for galaxies in clusters and galaxy pairs.

The observations of the large-scale field of our own Galaxy have long yielded results that were seemningly at odds with results obtained for external galaxies. The main problem, viz. that our Galaxy seemed to show field reversals when going from one spiral arm to the next, which were not observed in other galaxies, has essentially been resolved. This is due to the increased number of observations of pulsars (in our Galaxy), an improved model of the distribution of thermal electrons in the Galaxy, and a large increase in the data on extragalactic radio sources with which the global Galactic magnetic field can be mapped. The evidence for field reversals in our Galaxy has become much weaker.

Another central theme was the relation between the large-scale and small-scale fields. The latter is influenced by the processes that shape the Interstellar Medium. Results of advanced numerical magnetohydrodynamic modelling were compared with recent observational results on the strength and structure of the small-scale field, as derived from radio polarimetry. The newly developed method of Rotation-Measure synthesis was considered particularly promising.

In the last session, future observational facilities and the next generation of models were discussed, with an attempt to define some crucial observational tests for the applicability of the models.

The workshop provided a very good opportunity to discuss all these matters, as there was a good balance between the numbers of those with theoretical and experimental backgrounds. In particular, the excellent facilities and atmosphere provided by the Lorentz Center were

greatly appreciated by the participants, and these conditions provoked an unusually large amount of very stimulating interaction; actually several participants remarked that "It was an excellent, if not (one of) the best workshop(s) I ever attended".

P. Katgert (Leiden University, The Netherlands)

Electronic Structure beyond Density Functional Theory

July 12 – 16, 2004

The focus of the workshop was on electronic structure beyond density functional theory, in particular, quantum Monte Carlo methods. The primary objective of the workshop was to spur and facilitate rapid growth of the field by bringing together scientists from different communities with a common interest in ab-initio many-body calculations, and by reaching out to junior researchers and researchers doing quantum Monte Carlo in smaller or isolated groups. A total of 53 participants from 9 countries attended the workshop, with research focus on quantum Monte Carlo, quantum chemistry, lattice models, computational diagrammatic approaches such as the GW, dynamical mean-field theory, etc. The participation was substantially larger than anticipated, and essentially at peak capacity of the Lorentz Center venue.

The format of the workshop was chosen to allow ample time for interactions. The number of talks per day was typically three or four, and a total of six focused discussions on outstanding issues were also scheduled. Each discussion had a leader who gave introductory presentations on the topic and was in charge of organizing the session. This formula was very successful in creating lively sessions and a relaxed atmosphere where participants felt comfortable to openly discuss problems encountered in calculations, partial solutions or preliminary results, and new avenues for further investigation.

Within quantum Monte Carlo for electronic structure, the workshop covered recent methodological developments and efforts to push the frontier of applications to ever more complex systems. The main topics, each followed by a partial list of speakers/discussion-leaders, were: Geometry optimisation and incorporation of molecular dynamics in quantum Monte Carlo (Ceperley, Grossman, Rappe), general and robust ways to obtain variational many-body wave functions (Fahy, Filippi, Sorella), new algorithms and insight for the fermionic problem in quantum Monte Carlo (Bressanini, Kalos, Sorella, Zhang), pseudopotential in many-body calculations (Bachelet, Dolg), computation of observables (Ceperley, Reynolds), and applications to large realistic systems (Williamson, Mitas, Moroni, Needs, Wood).

Topics and the respective key participants in related fields included: Coupled cluster calculations (Dolg, Schütz), quantum Monte Carlo for lattice models of strongly correlated systems (Sorella, Troyer, Zhang), GW calculations (Godby), dynamical mean-field theory calculations (Lichtenstein).

The meeting reached the intended goal to create an opportunity to discuss recent progress as well as current limitations of quantum Monte Carlo approaches. The presence of researchers from a broader many-body community had a significant impact on the workshop. Practitioners were able to compare and discuss in some detail different techniques for treating electron correlations in materials, and found the experience mutually stimulating. The participants clearly enjoyed the workshop both for its scientific content as well as for the logistical aspects, which were very smoothly taken care of by the management of the Lorentz Center. The workshop was funded by the Lorentz Center and the Psi-k ESF Programme, with additional support for US junior participants from the US NSF.

Claudia Filippi (Leiden University, The Netherlands)
Matthew Foulkes (Imperial College, Condensed Matter Theory Group, London, UK)
Shiwei Zhang (College of William and Mary, Department of Physics, Williamsburg, USA)

Emerging Issues in Heavy-Fermion Materials Physics

July 19 – 23, 2004

Within the past two to three years, several new materials systems have been discovered with properties that question old beliefs as well as raise entirely new issues about the way strongly interacting electrons organize themselves at low temperatures. Because the pace of new developments has been so rapid, it seemed timely to organize a workshop where these issues could be summarized and discussed intensively by leading participants in their creation. The Workshop gave special, but not exclusive, attention to strongly correlated f-electron systems in which several new states have been found.
These compounds included the Pr-based skutterudites, $CeCu_2Si_{2-x}Ge_x$, $CeMIn_5$ and $PuMGa_5$. During the first four days of the Workshop, there were two oral presentations in the morning and afternoon briefly reviewing issues that have emerged most recently from the study of these materials as well as topically-related materials, such as MnSi, $Sr_2Ru_3O_7$, $U/NpMGa_5$ and the cuprate superconductors. These short presentations were followed by extended discussion periods, which comprised the core of the Workshop, with each being guided by one of the more senior participants. The fifth morning and part of that afternoon were devoted to a roundtable discussion of the outstanding issues raised during the previous four days. This discussion, as well as that earlier in the week, produced several well-posed questions that contain the essence of a week's work and point the direction for future research. A subset of those questions, somewhat editorialized, is as follows:

(1) In the absence of the equivalent of an isotope-effect experiment, how do we identify unequivocally the superconducting pairing mechanism in unconventional superconductors? (Is it quadrupolar fluctuations in the skutterudites, spin/quantum-critical fluctuations in $CeMIn_5$ and $PuMGa_5$, valence/charge fluctuations in the high-pressure phase of $CeCu_2Si_2$? What is the superconducting gap symmetry in these systems—s, p, $d_{x^2-y^2}/d_{xy}$?)
(2) What happens to antiferromagnetic order once it is tuned, e.g., by pressure, below the superconducting transition temperature? (Does superconductivity 'eat up' the magnetism with which it coexisted at lower pressures when Néel order was established before the onset of superconductivity? Is this what happens to the f-electron moments in $PuMGa_5$ and the skutterudites?)
(3) What is an appropriate description of the non-Fermi-liquid behaviors found in these materials? (How do we understand the extended NFL regime beyond the quantum-critical point in MnSi and the quantum-critical phase that appears to emanate from $H_{c2}(0)$ in $CeCoIn_5$? How valid are fits of NFL data to the Moriya model? How confident experimentally are we that a line of second order phase transitions persists to T=0 and does not become a line of first order transitions that terminates at a critical end point?)
(4) How should 5f electrons be treated and what determines their configuration? (Are they all itinerant, all localized, some of both, and why? Is J-J coupling the most appropriate scheme? Are crystal fields relevant at all? What is the appropriate microscopic model? In most, but not all, cases, bandstructure calculations and deHaas-vanAlphen/magnetic experiments agree remarkably well, but what are the 'anomalous' cases telling us?)
(5) How generally valid, from experiments, is the argument for a universal dissipation rate $\tau=\hbar/k_BT$ and what are the implications of this universal rate for the emergence of unconventional superconductivity and quantum-criticality and their apparent association?

Scientific Report

The Workshop was dynamic in several respects - the range of scientific issues considered, the enthusiasm of participants, and even the constitution of participants, with some leaving to give and others coming from giving invited talks at simultaneous conferences in Prague and Trieste. The latter, though potentially disruptive, actually was a net positive for the Workshop in that discussions/issues at these other conferences also were brought into our Workshop and vice versa, effectively making a more comprehensive virtual workshop. Time-averaged, the Workshop had about 33 participants per day, with half of these from European countries and the others equally divided between Japan and North America. Nearly half of the participants were early career - either students, postdocs, or recently past postdoc.

This Workshop would not have been possible without financial support of the Lorentz Center or its remarkably efficient and cooperative organizational staff. We especially want to thank Dr. Martje Kruk and Yolande van der Deijl for making our stay so enjoyable. The substantial scientific success of the Workshop was due solely to the numerous thoughtful contributions of each participant to whom we are most grateful.

G. Zheng (Osaka University)
J. Zaanen (Leiden University)
J.D. Thompson (Los Alamos National Laboratory)
G.R. Stewart (University of Florida)
J.L. Sarrao (Los Alamos National Laboratory)

Scientific Report

The Nuclei of Galaxies

July 26 – 30, 2004

The meeting was focused on understanding and comparing data on nuclei of galaxies obtained recently by the two large groups working on this problem: The Nuker Group (using high spatial resolution Hubble Space Telescope data) and the Sauron Group (using lower resolution but full area coverage data obtained with an Integral Field Spectrometer). Many members of both groups, and a few additional investigators attended. The meeting roughly followed the plan of joint sessions in the morning, with the two groups meeting separately in the afternoon.

The joint sessions concentrated mostly on a comparison of dynamical modelling methods used by the two groups and by a third collaboration also represented at the meeting. All three groups presented models of specific galaxies, and all three groups discussed their methods. The basic procedure is the representation of a real galaxy by a collection of orbits run in a specified gravitational field. This problem is ill-conditioned since a presumably smooth distribution function is represented by a sum of delta-functions in the space of orbital integrals of motion- whereas most observers believe that the solution is smooth. In addition, solutions are, in general, thought to be highly degenerate in the orbit weights, even though they may (or may not) be quite well-defined in terms of bulk parameters of the galaxy, like the total mass or the mass of a black-hole. Considerable progress occurred in reaching a common view of the character of this problem, which led to a strong impression that the groups were finding valid solutions to the problem. The groups agreed on two specific test problems which would be done by each team and compared in the future. This key part of the meeting included three plenary discussions in the common room, involving all participants. The picture gallery on the Lorentz Center website provides a photographic record of one of these discussions.

The joint sessions also included talks on, and considerable discussion of the core-scouring paradigm, in which cores of large galaxies are proposed to be 'scoured out' by inspiraling black holes, and theories and evidence for disk evolution and the formation of 'pseudobulges', which appear to have (at fixed mass or binding energy) the same black hole mass as normal bulges thought to be formed by collapse or mergers and violent relaxation.

During private meetings, the Nuker team worked on a paper describing their method, papers on NGC 4258, NGC 1399 and several galaxies with observed gas kinematics. The SAURON team worked on papers presenting the gas kinematics and linestrength maps for their survey galaxies, and on dynamical modelling of the entire sample of early-type galaxies, and planned the next set of observing proposals.

The meeting barbeque in Katwijk was very well attended, and enjoyed by all (photograph available). It included a bike ride, and provided many of the participants from abroad their first look at the Dutch Alps.

Douglas Richstone (University of Michigan)
Tim de Zeeuw (Leiden University, The Netherlands)
Michele Cappellari (Leiden University, The Netherlands)

Recent Progress and Prospects in Density-Matrix Renormalization

August 2 – 13, 2004

Density Matrix Renormalization forms the basis of a powerful set of techniques for handling an increasingly diverse range of physical problems with many degrees of freedom. The Density Matrix Renormalization Group (DMRG) originally evolved as a numerical technique to treat quasi-one-dimensional strongly correlated systems at low temperature, but has since been extended to treat quantum systems in two dimensions and at finite temperature, dynamical excitations, and classical systems in two and three dimensions. Recently, a strong connection to fundamental aspects of quantum information theory has been discovered. This has lead to new prospects both for improving the fundamental understanding of many-body quantum systems and for developing new algorithms. Examples include the simulation of the exact time evolution of quantum systems and the efficient treatment of translationally invariant and higher dimensional systems.

This workshop brought together experts in fields as varied as strongly correlated electronic systems, nuclear physics, quantum information theory, quantum chemistry, classical statistical physics, and soft condensed matter physics. The fifty participants came from a variety of countries including China, Japan, India, Argentina, Brazil, and Turkey as well as European countries and the United States.

The timing of the workshop was particularly fortuitous because a number of new ideas involving quantum information and time evolution were proposed in the months leading up to the workshop. This has made the workshop an stimulating forum for the presentation of these new ideas as well as a catalyst for new developments and collaborations. There was a general feeling of excitement about new developments in DMRG techniques and new prospects for applications. In particular, the study of out-of-equilibrium time evolution opens up new possibilities in improving the fundamental understanding of quantum systems and determining experimentally important properties such as transport in nanostructures and the dynamics of atoms in optical lattices.

The format of the workshop, consisting of three talks per day and including plentiful time for discussion and collaboration, was very conducive to the goals of scientific interchange and collaboration. The Lorentz Center environment, providing ample office, seminar and computer facilities (especially the wireless network), was particularly suited for a workshop with a strong computational emphasis.

The organizers and participants appreciate the financial support, provided by the Lorentz Center, the Lorentz Fonds, and the Stichting voor Fundamenteel Onderzoek der Materie (FOM). This support made possible the participation of leading experts in the field as well as researchers from countries with limited funding resources.

We thank the Lorentz Center staff for the efficient and friendly organization, particularly the program assistant Gerda Filippo, the executive manager Dr. Martje Kruk-de Bruin, and especially the program assistant during the workshop, Klaske Kruk. The excursions provided

a nice opportunity for social interaction and relaxation and the pleasant summer weather added to the congenial atmosphere.

Ian McCulloch (Aachen, Germany)
Eric Jeckelmann (University Mainz, Germany)
Reinhard M. Noack (University Marburg, Germany)

Automorphisms of Curves

August 16 – 24, 2004

The focus of this Workshop was on automorphisms groups of algebraic curves in positive characteristic, and the (im)possibility of lifting a given group of automorphisms of an algebraic curve from positive to zero characteristic. This field has witnessed several exciting developments during the last few years. These have lifted the topic to a new level of sophistication. Not only the latest developments are exciting, but also several intriguing questions and open problems stimulate further scientific research.

In this Workshop we had several lectures of 2 x 60' describing the main new methods in the field (some still in a seminal stage). Topics included indigenous bundles, patching method, liftability obstructions/results, Oort groups, bounding automorphisms, deformation theory and ramification theory. There were a few 60' talks about related topics (modular representation theory, rigid analytic uniformisation). The 2 hour talks were very much appreciated by most of the participants, as they allowed for a more thorough treatment of the (technical) material which is normally left out in shorter presentations, but vital for a good understanding of the matter.

Next to that we organized Problems Sessions, in which 9 speakers discussed an open problem in a 15' talk.
In this way, on the one hand, the latest developments were highlighted, and, on the other hand, new openings were created for further research.
One afternoon was devoted to a survey of the topic. This was advertised as being understandable for a wider mathematical audience. The room was packed with quite a diversity of people who witnessed an inspiring talk.

The meeting had 33 registered participants, occasionally enhanced by visiting mathematicians (graduate students to faculty) from the Netherlands. All ages and career stages were present, and quite a few of the speaker were junior faculty, but all were experts in the field. This relatively small group created a good atmosphere for discussions, and we indeed witnessed several intense discussions among participants.
As we had foreseen, some mathematicians saw that yet unpublished (and unknown to them prior to the workshop) results complemented their own research, which led to extra interactions of a very special kind (example: using deformation theory to "geometrise" proofs of bounds on automorphism groups). A few times, the same results could be obtained by entirely different methods, and again, people felt the need to discuss and combine them (example: dimension of deformation spaces by patching method, or by a cohomological method, or by a functorial comparison; impossibility of lifting by ramification data, or by deformation theory).

No doubt, the excellent working conditions at the Lorentz Center together with the no-nonsense attitude of the very collaborative staff contributed to the success of the meeting.

G.L.M. Cornelissen (University Utrecht, The Netherlands)
F. Oort (University Utrecht, The Netherlands)

Harmonic Analysis and Homogeneous Spaces

August 23 – 26, 2004

The workshop Harmonic Analysis and Homogeneous Spaces was held in the Lorentz Center at Leiden University, in the period 23-26 August 2004. The opening words of the conference were spoken by mr. A.W. Kist, the president of the board of Leiden University in the presence of prof.dr. F.W. Saris, dean of the faculty of Mathematics and Natural Sciences.
The workshop aimed at the presentation and exchange of new ideas in the area of 'harmonic analysis and homogeneous spaces', and intended to give the possibility to start collaborations amongst the participants, especially with younger mathematicians such as post-docs. The research area is a broad field in mathematics, with applications in, and related to, a variety of other fields, like mathematical physics (e.g., quantization, symmetry, integrability), geometry and number theory. By organising the workshop it was expected to stimulate the international communication between researchers in the field.
The facilities offered by the Lorentz Center greatly contibuted to achieving these goals. The 48 participants all enjoyed the friendly atmosphere, the well-equipped offices and lecture facilities, which all allowed for ample discussions. The informal dinner and boat trip were also a success in this respect.
With regard to the scientific content, each of the four days had a theme in order to highlight a particular aspect of the broad topic of harmonic analysis and homogeneous spaces. This allowed at the same time for cross-theme discussions.
The following themes had been defined:

- Analysis on symmetric spaces; invited speakers: Oshima, Van den Ban, Schlichtkrull, Wakayama and Thomas.
- Causal structures, conformal geometry, and harmonic analysis; invited speakers: Orsted, Faraut, Olafsson, Zhang and Pasquale.
- Integrable systems, quantization, and special functions; invited speakers: Ochiai, Vershik, Koornwinder and Molchanov.
- Geometry and representation theory; invited speakers: Howe, Kobayashi, Heckman and Helgason.

A number of speakers (at the time of writing: 14) have agreed to write a scientific paper to appear in a special issue of the journal Indagationes Mathematicae devoted to the subject of this workshop. Some of these papers are joint work among invited speakers and/or workshop participants.
In conclusion, we may state that the workshop was a great success, both in the appreciation of the participants as in its various consequences: new contacts have been established and existing ones have been renewed. We also feel pleased by the amount of participants willing to contribute a scientific paper on topics discussed in the workshop. We – and we expect the other researchers in the field too – are looking forward to the special issue of Indagationes Mathematicae.

Eric Opdam (University of Amsterdam; chair)
Marcel de Jeu (Leiden University)
Sander Hille (Leiden University)
Erik Koelink (Technical University Delft)
Walter Kosters (Leiden University)
Misha Pevzner (University Reims – France)
Fred Bakker (Leiden University)

Workshop Algebraic Cycles and Motives
Annual EAGER Conference 2004

August 30 – September 3, 2004

The theory of algebraic cycles deals with the study of subvarieties of a given projective algebraic variety. To this end, one considers the (very large) abelian group generated by the irreducible subvarieties and takes the quotient by a suitable equivalence relation ("rational equivalence") to obtain a more manageable group. Intersection product makes this quotient into a ring, the Chow ring. This still mysterious ring can be studied through its relation to cohomology, the first example of which is the cycle class map: every algebraic cycle defines a class in singular, de Rham, or l-adic cohomology. Ultimately this cohomological approach leads to the theory of motives and motivic cohomology developed by Grothendieck and Voevodsky.
There were about 60 participants for the workshop, coming from Europe, US, India and Japan. On Friday, September 3 there were three special lectures devoted to the scientific work of Murre.
During the workshop there were 22 one hour lectures; two in the morning and two or three in the afternoon. Wednesday afternoon was free. The lectures covered a wide range of topics, such as the study of algebraic cycles using Abel--Jacobi/regulator maps and normal functions, motives (Voevodsky's triangulated category of mixed motives, finite--dimensional motives in the sense of Kimura), the conjectures of Bloch--Beilinson and Murre on filtrations on Chow groups and Bloch's conjecture, and results of a more arithmetic flavour for varieties defined over number fields or local fields.
On Tuesday night Peters presided a panel discussion addressing the lack of support for the fundamental sciences in Europe, exemplified by the failure of the Lorentz Center to secure EC-funds. Conte (network coordinator) pointed out that in the new European framework program 50% less mathematics networks will be supported. This is in sharp contrast with what happens in the USA, as explained to us by Griffiths (former president of the Institute for Advanced Study in Princeton). Beauville (Institut Universitaire de France) spoke about the successful protest of researchers against cuts in the research budget in France.
We feel that the meeting was very successful. The workshop was attended by many of the leading experts in the field, but also by a number of young researchers; several of those gave a lecture. The level of the lectures was high, and there were many discussions between participants during and after the lectures. The atmosphere during the meeting was pleasant and informal; we received many positive reactions from the participants.
The workshop was financed by the Lorentz Center, EAGER (European Algebraic Geometry Research Training Network), the KNAW (Royal Netherlands Academy of Arts and Sciences), and the Thomas Stieltjes Instituut.

The excellent facilities of the Lorentz Center and the efficient help of Martje Kruk and Gerda Filippo greatly contributed to the success of the workshop.

C. Peters (Inst. Fourier Grenoble, France)
S.J. Edixhoven (Leiden University, The Netherlands)
J. Nagel (Univ. Lille 1, France)

FIRES: The Study of Near-IR selected High Redshift Galaxies

September 13 – 17, 2004

This workshop was organized to bring together investigators studying the high redshift universe through deep Near-IR imaging, and related techniques. The workshop was a great success as it brought together astronomers from various specialities, and allowed for extensive exchange of information and ideas. The workshop focussed on the evolution of galaxies, as measured in several ways: from detailed analysis of photometry, through emission line kinematics, through analysis of (very recent) imaging taken with the Spitzer telescope. The program was left open for ample discussion in small groups, with general discussion sessions at the end. The success of the workshop can be measured by the large number of new projects spawned by this meeting. We used the white-boards in the common room to write down our new projects and collaborations: and the notes barely fitted on the white-boards.

The setup of the Lorentz Center is critical for the success of this workshop: the meeting rooms have the right size of easy interaction, the offices are necessary for true "work" sessions and small group discussions. About half the time during the workshop was spent in the offices, either at work behind the computer, or in discussion. The support of the staff was magnificent: all the local arrangements were done very efficiently and very well, and hence the coordinators did not have to worry in any way about this significant task.

The financial support of the Lorentz Center is greatly appreciated.

M. Franx (Leiden University, The Netherlands)
P. van Dokkum (Yale University, United States)
H.W. Rix (MPI Heidelberg, Germany)

Nonlinear Dynamics, Ergodic Theory and Renormalization

September 20 – 24, 2004

The workshop took place at the overlap of mathematics and physics, where the subjects of nonlinear dynamics, ergodic theory and renormalization meet. This is an area of science with a great development, where participants can learn a lot from each other. A major theme is the mathematical characterization of chaotic dynamics, which up to now only is succesful in the lower dimensional setting, but where currently methods are being developed for generalization to higher dimensions. In this program ergodic theory and renormalization theory are important tools, which partially have to be developed from start, but also often are adapted from other area's in mathematical physics. During the workshop there was a lot of cross fertilization between various groups of mathematicians and physicists in related area's. Also links were made with research in life sciences.

Intendly, the speakers were partly mathematicians and partly physicists. Quite a few mathematical speakers (Avila, Benedicks, Bruin, Liverani, Lyubich, de Melo) addressed problems regarding ergodic theory and renormalization theory in low dimensional dynamics. The lectures on KAM theory (Eliasson, Gentile, Krikorian, Puig), partly also involved renormalization. From the more physical point of view lectures (Van Beijeren, Van den Berg, Bricmont, Dorlas, Den Hollander, Kager, Lamb, Posch, Verbitsky) were given involving renormalization theory in fluid dynamics and statistical mechanics. More general, but related, talks on dynamics and physics (Avron, Dumortier, Roussarie) completed the total picture.

The workshop demonstrated the value of bringing together mathematicians and physicists working on these area's of research, that are so strongly related regarding the contents. It was fortunate that there was an intensive communication between the various groups. This communication was further enhanced by quite a number of poster sessions.

H.W. Broer (University of Groningen)
A.C.D. van Enter (University of Groningen)
M. Martens (University of Groningen)
F. Takens (University of Groningen)

Probabilistic Graphical Models 2004 (PGM'04)

October 4 – 8, 2004

This was the second of two PGM workshops (the first one having been held at Cuenca, Spain in 2002). The aim of the workshop was to offer European researchers in the field of graphic statistic models (a.o. Bayesian networks and Markow networks) an international scientific forum for presenting their own researches in such a way that dominance by American researchers, as was the case in the Uncertainty in AI (UAI) Conference, could be avoided. As the Lorentz Center can accommodate 50-60 participants at the most, and in order to maintain the workshop small scale, participation occurred strictly on invitation by the Lorentz Center. All significant European researchers as well as numerous PhD-students in the field were invited. Eventually, our target was achieved with the presence of, in most cases, more than one member of all important European groups in the field of probabilistic graphic models.

The workshop was considered a great success by all participants. Almost everyone was present at every presentation, lively discussions took place and the evening program was beyond expectations. Steps were undertaken during the workshop towards an application for EU funding for the research on probabilistic graphic models.

Peter Lucas (Radboud University, The Netherlands)
N.A. el Moustakim (Radboud University, The Netherlands)

The VLTI/MIDI School for Data Reduction, Analysis and Science

October 11 – 15, 2004

The School was organized by the NEVEC project group at Leiden University with major contributions from the University of Amsterdam, from the Max Planck Institute for Astronomy, Heidelberg, and from the European Southern Observatory, Garching bei Munchen.

39 participants attended, mostly astronomy graduate students and post-docs, and a few senior scientists. The participants were chiefly from Germany, Netherlands, and Belgium, but there were also representatives from Italy, Poland, the Czech Republic, Chile, Poland and the UK.

The intent of the school was to create a group of astronomers who felt capable of proposing observations on the new MIDI interferometric instrument at ESO's Paranal Observatory, carrying out the observations, and reducing and interpreting the data.

In the mornings the participants heard lectures on the basic principles of optical interferometry, on the specific characteristics of the MIDI instrument and the Paranal Observatory, on the various reduction techniques available, and on the types of astronomical problems best suited to MIDI observations. Examples of successful observational projects were given.

In the afternoons, the participants attempted the reduction of sample MIDI data sets on the computers provided by the Lorentz Center, under supervision of software experts from Leiden and Heidelberg.

Besides the goal of transfering expertise on MIDI from the organizers to the participants (which succeeded), the school also transferred information in the other direction of which observation and reduction tools still need to be developed in order to make MIDI observations accessible to a larger community.

E.J. Bakker (Leiden University, The Netherlands)
W. Jaffe (Leiden University, The Netherlands)
A. Quirrenbach (Leiden University, The Netherlands)
B. Tubbs (Leiden University, The Netherlands)
C. Leinert (MPIA Heidelberg, Germany)
U. Graser (MPIA Heidelberg, Germany)
F. Paresce (ESO Garching, Germany)

Volatility of Financial Markets: Theoretical Models, Forecasting and Trading

October 18 – 29, 2004

The aim of the workshop was to gather together different scientific communities (from economics, financial mathematics and physics), both from academia and the financial industry. The focus was the volatility of financial markets, and more precisely the understanding of why this volatility is (i) much too high compared to that of the underlying fundamental economic values, (ii) exhibits enormous spikes (crashes) and (iii) reveals long term persistence in time. These features are of crucial importance for investment, risk control and derivative markets. It is also a challenging theoretical puzzle; devising plausible agent-based or mathematical models that grasp the full complexity of financial markets will require ideas and techniques from different communities. In particular, the strong and intriguing analogy between financial markets, turbulent flows and critical phenomena lead physicists to believe that their input may be valuable.
Several topics related to volatility modelling were discussed in great details during the workshop: data analysis (fat tails, volatility clustering), microstructure (tick by tick price changes, order book data), mathematical models (stochastic volatility, multifractal/cascade models, statistical feedbacks), applications to option pricing, agent based models of various type (minority games, semi-realistic trading rules), feedback of derivative markets on stock markets, models of income, wealth and company growths, new techniques to detect correlations, etc. Some of the outstanding questions, that could be debated at depth thanks to the format of the workshop, were: What causes large price changes on the markets? Is the statistics of financial time series time reversal invariant? (This puts strong contraints on the mathematical modelling). What empirical facts should mathematical/agent based models reproduce? Are financial markets close to a critical point, and in what precise sense? What can regulators do to control the volatility of financial markets?
Participants of the workshop seemed enthousiastic and interested, and felt that presentations and discussions did contribute to the understanding of the various issues. The most notable outcome is the creation of a website where a battery of standard statistical tests for financial markets will be available, and will serve as a benchmark for theoretical model. This will undoubtedly be a huge service to the community.
Although this workshop was by many accounts successful, the organizers felt disappointed and frustrated by (a) the little interest of the economics community to come to the workshop, (b) the large number of cancellations, just before or even during the workshop, mostly from the financial mathematics community and (c) the small number of local students/post-docs that would have been welcome to attend the tutorials organized at the beginning of the workshop.
The resulting composition of the participants was therefore strongly biased in favor of physicists, which was not what we anticipated. Comments from the other communities were that things "would take time". On a brighter side, the workshop sparkled projects of special issues in economics journals devoted to the work of physicists, to filling the gap between communities. This in itself would be a notable success of a workshop like this one.

J.P. Bouchaud (Science & Finance/CFM, France)
X. Gabaix (MIT, Dept. of Economics, United States)
M. Avellaneda (Courant Inst. of Math. Sciences, United States)

Third international symposium on Formal Methods for Components and Objects (FMCO 2004)

November 1 – 5, 2004

From the 2nd to the 5th of November 2004, 28 international scientists, leading experts in the fields of Theoretical Computer Science and Software Engineering, gathered together at the Lorenz Center in Leiden to offer their view of the use of formal methods for object-oriented and component based systems. They all were invited to the third international symposium on Formal Methods for Components and Objects (FMCO), organized by Marcello Bonsangue (LIACS) and Frank de Boer (CWI, Amsterdam), Susanne Graf (Verimag, France) and Willem-Paul de Roever (University of Kiel, Germany). FMCO symposia traditionally build on invited talks only, and this year it received the attention of 78 participants from 15 countries (including USA, Macao, and China). In order to provide an atmosphere that fosters collaborative work, discussions and interaction, this year, the symposium included, a welcome and farewell drink for all participants, a visit to the national museum of antiquities in Leiden and a dinner at the faculty club of Leiden University.
The opening keynote speech was by Robin Milner (Cambridge University, UK), who presented a new mathematical and visual model for mobile and ubiquitous computing. On the same day, the other keynote speaker Kim Bruce (Williams College, USA) discussed a rigorous model for object-oriented languages. Other invited talks of the morning of first day included that of Rocco de Nicola (University of Firenze, IT) on models for coordination languages and that of Eugenio Moggi (Genova University, IT) on program generation, an important issue in component based software development. The afternoon session was dedicated to fully abstract models for component and object oriented languages, with presentation by Julian Rathke (Sussex University, UK), Martin Steffen (Kiel University, DE), and Marcello Bonsangue (LIACS, NL). The day concluded with a welcome drink at the Lorentz Center, that gave the occasion to the participants to meet the speakers in an informal environment.
On the second day, Tom Henzinger (University of California, Berkeley, USA) gave a keynote lecture on a novel use of game theory for describing component behavior, paying particular attention to new notions of equilibria in order to take into account security issues. On the more applicative side, Wolfgang Weck (Software Architect, CH) told three stories showing the complexity of component based design, whereas Wang Yi (Uppsala University, SE) talked about the generation of real-time software with predictable timing behavior. The afternoon was opened by Thomas Ball (Microsoft Research at Redmond, USA) presenting a theory of static analysis of programs. In the early afternoon there were two talks, one by Frits Vaandrager (Nijmegen University, NL) on probabilistic I/O automata and another by Susanne Graf (Verimag, FR) on the specification and verification of systems with UML. The day concluded with the social event in the center of Leiden.
On November 4, Kim Larsen (Aalborg University, DK) illustrated in his keynote lecture the state of the art in model checking real time systems by using priced timed automata. Immediately afterward, Ed Brinksma (University of Twente, NL) gave a comprehensive lecture on hybrid systems modeled using a process algebraic approach. The morning closed with a lecture of Andreas Podelski (Max Plank Institute for Informatics, DE) on transition invariants and transition predicate abstraction, that gave rise to many interesting discussions. After lunch Chris Hankin (Imperial College, UK) gave a keynote lecture on

probabilistic coordination languages. The 1 remaining of the afternoon was dedicated to object-oriented program verification and specification, with a lectures by David Naumann (Stevens Institute of Technology, USA), Tobias Nipkow (Munchen University, DE), and Liu Zhiming (UNU-IIST, Macao).
The last day was opened by a keynote lecture of Samson Abramsky (Oxford University, UK) on game semantics for open systems and components. The other tutorial of the day was by Reinhard Wilhelm (Saarland University, DE) on timing analysis of hard real-time systems. The morning of was dedicated behavioral types and categorical semantics of component based systems with lectures by Luca de Alfaro (UC Santa Cruz, USA) and Luis Barbosa (Minho University, PT). The afternoon session featured a lecture on aspect oriented programming by Pierre Cointe (Ecole des Mines de Nantes, FR), and a lecture on formal language for open, distributed and object-oriented systems by Olaf Owe (University of Oslo, NO).

It was an exciting and successful symposium. The interactions during the lectures as well as the contact established in smaller meetings at the Lorentz Center were very useful to many of the participants. The participants and the speakers unanimously agreed that this kind of symposia are of great value for Computer Science, because of the wide range of topics touched by the speakers, each with an in-depth character. Indeed, the presented works have been considered by the participants as an exceptional representation of the state of the art in the field of Formal Methods for Component and Object-based systems. All the speakers were unanimous in their praise for the facilities and accommodations. Positive comments were made on the Lorentz Center as the perfect venue for this type of symposium contributing to the informal and yet efficient working atmosphere created by the organizers.

As for the previous years, the results of this symposium will be published in a forthcoming volume of "Lecture Notes in Computer Science". The organizers are also considering the publication of selected papers in a special issue of the journal Theoretical Computer Science.

Marcello Bonsangue (Leiden University, The Netherlands)
Frank de Boer (CWI, Amsterdam, The Netherlands)

Nonlinear Partial Differential Equations describing Front Propagation and other Singular Phenomena

November 8 – 2, 2004

Nonlinear partial differential equations (PDEs) are the language in which the laws of nature are written. The workshop was the midterm meeting of the RTN network Fronts-Singularities which focusses on the theory and applications of parabolic and elliptic nonlinear PDEs. Since this was the perfect opportunity for the group in this European network to gather, there were no less than 55 participants who came from Austria, Crete, France, Germany, Greece, Israel, Italy, the Netherlands, Slovakia, Spain, Turkey and the United Kingdom. Additionally, several PhD students from universities in the Netherlands attended the workshop.

One of the main positive aspects of the workshop was the large number of talks by young mathematicians on their current research: 29 in total. This led to a very dynamic atmosphere with many talks provoking a lot of discussion. Furthermore, nine established experts in the field were invited to give an overview lecture aimed at the audience of PhD students and Postdocs.

Some of the scientific highlights of the conference were

- new methods to obtain global asymptotic bounds for a variety of parabolic problems (thin film equation, Kuramoto-Shivashinsky, Cahn-Hilliard)
- progress in the desription and mathematical understanding of moving and annihilating vortices in the Ginzburg-Landau system.
- several new insights in blow-up phenomena (e.g. symmetry breaking instabilities in thin viscous films, general numerical strategies, harmonic maps).
- understanding the relation between braids and scalar parabolic equations.
- analysis of several biological systems, such as the degradation of tissue by bacteria.

One day of the meeting was set aside for the midterm review of the RTN project. In a relaxed atmosphere the previous two years of the project were discussed by a selection of the participants and a representative from Bruxelles. We can conclude that the review was successful, since the second half of the project has now received funding.

The main purpose of the workshop was to provide an opportunity for the young scientists in the network to present their research, to exchange ideas and to learn new and complementary techniques. From the very positive response we received during and after the workshop we may conclude that many participants think this was a good approach. The collaborations started and extended at the workshop will no doubt lead to more fruitful interaction of the different mathematical schools in Europe.

J. Hulshof (VU Amsterdam, The Netherlands),
J.B. van den Berg (VU Amsterdam, The Netherlands),
M. Bertsch (Istituto per le Applicazioni del Calcolo, Italy)

Statistical Physics of Disorder and Pattern Formation in Fracture

November 15 – 19, 2004

Aim of the workshop

The aim of the workshop has been to bring together scientists from different application areas, interested in the physics of pattern formation during fracture of disordered media. In the various engineering fracture mechanics worlds there is a growing interest for fundamental understanding, while especially for brittle fracture, the subject has over the past decade been approached from a general pattern-formation and pattern-morphology perspective by the physics community. Important challenges set for the workshop were:

(i) to bring together scientists from the different fracture communities and to explore common physical phenomena that are becoming recognised;
(ii) to further narrow the gap between experiments that can be done with ever increasing resolution and multiscale modelling of fracture/pattern formation;
(iii) to assess, in the light of the above, the value and practical relevance of fundamental physics approaches to fracture and disorder, notably on fracture growth processes and surface morphology;
(iv) to see what communalities remain, which fundamental differences appear, and what new generic science emerges when studies on patterns in fracture are extended to tough and soft materials.

Participants

The workshop was attended by 30 participants, of which 15 invited by the organizers. The composition of the group was very international: from The Netherlands 13, France 5, USA 5, Norway 2, and from Canada, Germany, India, Japan and Switzerland each 1 participant.
A broad range of material classes was represented (see the programme below). In addition it is worth mentioning that via the Dutch participants there were connections with all three materials-oriented Leading Technology Institutes, the NIMR, DPI and WCFS.

Programme

The workshop was structured via 15 invited lectures, addressing four main topics: the geometrical and scaling aspects of fracture patterns, the fracture in quasi-brittle materials, the kinetics of fracture growth, and soft materials:

E. Bouchaud (CEA, Saclay, France) - *Stress corrosion fracture and damage of glass*
B.K. Chakrabarti (Saha Institute, Calcutta, India) - *Dynamics of fracture in random fiber bundle models*
S. Ciliberto (ENS, Lyon, France) - *Life time prediction of sample under stress*
A. Hansen (NTNU, Trondheim, Norway) - *Anomalous scaling in brittle fracture*
A. Jagota (Lehigh University, PA, USA) - *Cohesive and adhesive strength of soft solids*
R.K. Kalia (University of Southern California, USA) - *Hierarchical atomistic simulations of fracture in nanostructured materials*
D.M. McClung (University of British Columbia, Canada) - *Shear fracture properties for dry snow slabs from field estimates*
J.J. Mecholsky (University of Florida, USA) - *On the fractal nature of fracture*

J. van Mier (ETH Zuerich, Switserland) - *Experimental and numerical analysis of pre-critical crack growth in concrete: implications for scaling*
J.J. Rottler (Princeton University, NJ, USA) - *Molecular mechanisms of deformation and failure in glassy materials*
S. Schmauder (University of Stuttgart, Germany) - *Role of interfaces on damage in metal matrix composites*
C.H. Scholz (Columbia University, New York, USA) - *Populations of geological faults*
M. Tanaka (Akita University, Japan) - *Geometrical analysis of fracture surfaces and its application to materials science and fractography*
J. Weiss (CNRS St. Martin Dheres, France) - *Pattern formation, scaling and intermittency in the deformation and fracture of the arctic sea ice cover*

In addition, 6 shorter contributions were made, also as an introduction to discussions:

A. Hansen (NTNU, Trondheim, Norway) - *Fracture scaling exponents*
H. Luyten (WCFS, Wageningen, NL) - *Fracture and sound. Research on crispy foods*
E. Schlangen (Delft University, NL) - *Why are lattice models better than FE/continuum models?*
L. Vanel (ENS, Lyon, France) - *Slow crack growth in a paper sheet. Pinning and crack jumps*
W.P. Vellinga (Groningen University, NL) - *Cracks, crack propagation and thin films: an experimental perspective*
T. van Vliet (WCFS, Wageningen, NL) - *Soft foods*

Outcome
By many participants the workshop was experienced as a very timely occasion that resulted in lively and informative discussions among researchers from different directions. In this respect the facilities, staff support and atmosphere provided by the Lorentz Center were referred to frequently as excellent.

The scientific product of the workshop, in the form of abstracts, copies of all presentations and posters, and a short review of aims and conclusions, will be available on CD via the organizers. Some general observations can be made here.

Very clarifying discussions proved relevant on how to look at fractality, self-affineness, multifractality and intermittent patterns in fracture morphology, how to perform fractal analyses, and which numerical fractal exponents to expect where. The relation with theoretical concepts of fractals, percolation and nonlinear dynamics has been heavily discussed as well, and certainly still leaves important open theoretical questions.

There is clear experimental evidence that the fractal roughness in bulk fracture, with roughness exponents similar among different materials but different in different length-scale regimes, holds for wider and wider classes of materials. At the workshop such evidence could be given e.g. for glass fracture on the nanoscale, which can now be probed with AFM. Intriguing data were also presented on semi-crystalline polymers, suggesting that under the right conditions even in these systems with local viscous effects the observation may hold, but more research on polymers clearly is necessary to confirm this.

Mechanistic pictures of fracture growth reappeared in many of the presentations, with common elements of crack growth via nucleation of more distributed damage zones ahead of a single crack tip, and coalescence of such zones with the tip or with each other.

Important length scales to distinguish, also in terms of roughness exponents, are then those relating to a single damage zone and to the distribution of damage nuclei. This may call for a more generic study of crack population dynamics in model systems. In one detailed study on thermally activated crack growth the kinetics could be mechanistically understood well in terms of a scaling of events with time, in approach of a critical divergence; the understanding allowed to construct a model for life-time prediction.

In several presentations impressive examples were shown of how large-scale molecular or mesoscopic computer simulations already allow realistic studies of fracture in complex micro- or nanostructured materials such as metals, concrete, ceramics and polymers. The further growth of computer power will only enhance the potential of these approaches.

Interesting analogies could sometimes be drawn between totally different material systems, e.g. on the pattern formation in geological faults of the brittle top layer of the Earth or Venus, and the patterns showing up in brittle coatings strained on top of a ductile substrate. Such complex systems can already be understood in considerable physical detail through lattice simulations and fracture-population analyses.

Via a number of workshop presentations it was shown that in materials that practically all could be termed soft, widely different behaviour may happen. Under appropriate conditions semicrystalline polymers, dry snow and crispy foods may all show brittle fracture, for which analogies may be drawn with well-studied inorganic quasi-brittle materials. Fracture in low-modulus rubbery or gel-like materials however is dominated by crack blunting, while in amorphous polymers stretched beyond the regime of constant modulus craze formation is the dominant damage mechanism. The study of fracture in soft materials is still a relatively unexplored but promising research subject, both from an application and from a fundamental physics perspective.

As a general conclusion it can be stated that the subject of the workshop is one that should attract more and more fundamentally oriented physicists, while the potential for application is still broadening.

M.A.J. Michels (University Eindhoven, The Netherlands)
E. van der Giessen (University of Groningen, The Netherlands)

Molecular Computing

November 22 – 26, 2004

The Workshop on Molecular Computing took place from 22-26 November 2004 in the Lorentz Center, and was organized by Joost Kok (Leiden University) and Giancarlo Mauri (University of Milano-Bicocca, Italy) in cooperation with Grzegorz Rozenberg (Leiden University), Marloes van der Nat (Leiden University) and Gerda Filippo of the Lorentz Center. The workshop was attended by 31 participants from 11 different countries.

The topic of the workshop is a novel, exciting and a genuinely interdisciplinary research area which lies at the boundary of Computer Science and Molecular Sciences, especially Molecular Biology, and Chemistry. Therefore, not only Computer Science aspects, but also Biological aspects - both theoretical and experimental issues - were presented and discussed during this workshop.

The organizers aimed to have an informal atmosphere during the meeting, so that the participants had a chance to have discussions leading to more cooperation between the several research groups and to have time to start future (short and long term) research based on combining the existing European expertise.

The workshop started on Monday afternoon with the following presentation/discussion sessions: P. Frisco (University of Exeter, UK) on *Unique-sum sets and DNA computing*, C. Zandron (University of Milan-Bicocca, Italy) on *Reversible computing in P-systems*, M. Gheorghe (University of Sheffield, UK) on *Population P systems: Results and future developments*, and S. Verlan (University of Metz, France) on *Optimal results on tissue P systems with minimal support/antiport.* After the scientific program there was a drink that took place in the Snellius building of Leiden University.

The scientific program on the second day started with an invited talk by N. Krasnogor (University of Nottingham, UK) on *An appealing computational mechanism drawn from bacterial quorum sensing,* and was followed by the following scientific presentations: G. Mauri (University of Milan-Bicocca, Italy) on *Regular splicing languages and below*, G. Paun (Romanian Academy of Sciences, Bucharest, Romania) on *Membrane computing after exactly six years* (with news from the last six weeks), D. Besozzi (University of Milan, Italy) on *P-systems for modelling cellular processes* and T. Harju (University of Turku, Finland) on *Folding and unfolding in graphs and DNA*.

The third day began again with an invited talk by Ch. Henkel (Institute of Molecular Cell Biology, Leiden University) on *Experimental DNA Computing* and was continued by talks/discussions on other subjects: E. Csuhaj-Varjú (Hungarian Academy of Sciences) on *Grammar systems versus membrane computing: the case of CD grammar systems*, G. Vaszil (Hungarian Academy of Sciences) on *Grammar systems versus membrane computing: the case of PC grammar systems*, and P. Wasiewicz (Warsaw University of Technology, Poland) on *Neural networks approximation*. In the evening the conference dinner took place, and most of the attendees were present there.

On Thursday the invited talk was given by M. Holcombe (University of Sheffield) on *An agent-based framework for modelling insect societies, tissue and cellular processing*,

followed by two talks on P-systems: R. Freund (Technical University of Vienna) on *P systems working in the asynchronous and the sequential mode* and M. Oswald (Technical University of Vienna) on *Tissue P systems simulating grammar systems.* After this last talk the participants took advantage of attending the lecture by A. Turberfield (Dept. of Physics, Oxford University) on *DNA self-assembly and molecular machinery*, organized by Bioscience initiative of Leiden University.

On the last day of the workshop there were only two talks: M. Amos (University of Exeter, UK) on *Cellular computing research in Exeter* and M. Margenstern (University of Metz, France) *on Research activities of the Metz group*. The last point on the scientific program was the EMCC Assembly, which is the general meeting of the members European Molecular Computing Consortium that takes place twice a year. Research centers are spread throughout Europe, and most of them belong to the European Molecular Computing Consortium, the scientific organization encompassing currently groups from 14 countries. A lot of current research is supported by MolCoNet, a thematic network on Molecular Computing which is financed by the European Commission. The travel and lodging expenses of all attendees was financed by the MolCoNet project.

The workshop was very successful both from the scientific and the social point of view. All participants were very satisfied with the facilities the Lorentz Center offers and the nice and efficient atmosphere there.

J.N. Kok (Leiden University, The Netherlands)
G. Mauri (University of Milano-Bicocca, Italy)

Scientific Report

Herschel Space Observatory Calibration Workshop: Models and observations of astronomical calibration sources

December 1 – 3, 2004

The "Herschel Space Observatory Calibration Workshop: Models and observations of astronomical calibration sources", organized by the Herschel Calibration Steering Group, took place in the Lorentz Center from 1 to 3 December 2004. The Herschel Space Observatory, an ESA cornerstone mission, is the first space facility dedicated to the submillimetre and far-infrared wavelength range, and will be operated as a multi-user astronomical observatory that will provide observation opportunities to the entire astronomical community. The launch is scheduled for the third quarter of 2007. It will carry a 3.5 metre passively cooled telescope, and will perform imaging photometry and spectrometry in the far-infrared and submillimetre part of the spectrum, covering approximately the 60-670 micrometres range. The science payload consists of three instruments which will be provided by consortia led by Principal Investigators: The Heterodyne Instrument for the Far-Infrared, HIFI, whose PI is Th. de Graauw, SRON, Groningen, The Netherlands; the Photodetector Array Camera and Spectrometer, PACS, whose PI is A. Poglitsch, MPE, Garching, Germany; and the Spectral and Photometric Imaging REceiver, SPIRE, whose PI is M. Griffin, Cardiff University, UK. The wavelength coverage and unprecedented sensitivity of the Herschel Space Observatory, together with our limited knowledge of the astronomical calibration sources in the far-infrared and submillimetre, make the calibration of the instruments particularly challenging.

The main purpose of the workshop was to provide an overview of the state of the art of models, observations and laboratory spectroscopic studies associated with Herschel calibration sources, and to facilitate the discussion between experts. The workshop brought together calibration scientists from the three Herschel instruments, members of the Herschel Science Centre and the NASA Herschel Science Centre, planetary and stellar modellers and observers, and calibration scientists from ground and space observatories that cover similar wavelength regions, in particular from ALMA, ASTRO-F, ISO, JCMT, SOFIA, Spitzer Space Telescope, and SWAS.

Over 45 scientists from Europe, USA and Japan attended the meeting. The workshop program was organized in plenary and splinter sessions. The four splinter sessions focussed on the following topics: 1) Mars and giant planets; 2) Asteroids and satellites; 3) Stars and secondary calibrators; and 4) Calibration and cross-calibration strategies. The talks in the plenary sessions covered subjects common across the splinters. They started with presentations of the Herschel mission and of the Herschel instruments calibration strategies. Other talks provided overviews on the usage of solar system objects as calibrators, of the current knowledge of solid state features in the far-infrared and of the work in progress to study and model the far-infrared background. In addition, summaries of the splinter sessions were presented by the respective chairpersons. The high involvement of the participants was reflected in the extensive and lively discussions that followed the great majority of the talks. From the calibration scientists presentations, the commonality among far-infrared and submillimetre observatories became evident, both in terms of astronomical calibration sources and calibration strategies. A future collaboration will be extremely beneficial, not only to Herschel, but also to other observatory facilities in the far-infrared and submillimetre.

The workshop achieved its objectives and definitely helped in determining the future path for the calibration preparatory work. In fact, the workshop was a starting point for the implementation of a future working scheme. The splinter chairpersons will become coordinators of the calibration area covered in their respective splinters, will contact the experts to complete the identified actions, will monitor progress and pursue new initiatives. The majority of the external invited experts expressed their willingness to continue their collaboration in this scheme. The overall coordination, monitoring and information distribution will be the responsibility of the Herschel Calibration Steering Group.

The output of the workshop will be collected in a Web page, which will include the viewgraphs of the presentations and a consolidated list of the actions identified during the meeting. The outcome of the activities initiated in the workshop will be fundamental in the preparation of the calibration plans and will have a definitive impact in the mission's accuracy and scientific validity. The models and observations of astronomical calibration sources that will be gathered as a result of these collaborations, will be consolidated, documented and made available to the calibration scientists through a common database.

The organizers of the workshop greatly appreciate the financial support of the following sponsors: The Lorentz Center, the European Space Agency, the Max-Planck-Institut für extraterrestrische Physik (Germany), the Instituut voor Sterrenkunde, KU Leuven (Belgium), and the Space Research Organization of the Netherlands, SRON.

We would like to thank the Lorentz Center staff, Dr. Martje Kruk-de Bruin and Gerda Filippo for their professional and efficient support, and very specially for their hospitality and readiness to discuss any aspect of the local organization. The excellent facilities and good atmosphere of the Lorentz Center clearly contributed to the success of the workshop.

Ana Heras (ESA/RSSD, The Netherlands)
Thijs de Graauw (SRON, The Netherlands)
Dieter Lutz (MPE, Germany)
Joris Blommaert (KUL, Belgium)
Peter Hargrave (Cardiff University, United Kingdom)
Martin Harwit (Cornell University, USA)
Sarah Leeks (ESA/RSSD, The Netherlands)

Scientific Report

Molecular Universe

December 13 – 14, 2004

The Molecular Universe is a highly interdisciplinary network of European researchers in 21 institutes in 9 countries studying the physics and chemistry of molecules in space. The network combines experts in the areas of laboratory spectroscopy. laboratory astrochemistry, molecular quantum mechanical studies, and astronomical modelling of species of astrophysical relevance. This consortium has been selected under the European Community's Sixth Framework Program as a Marie Curie Research Training Network. The network contract was concluded between the European Commission and the consortium on October 1st, 2004 with a duration of 48 months.

The kick off meeting of this Marie Curie Training and Research Network was organized at the Lorentz Center on December 13 and 14, 2004. Teams were represented by their team leaders. In addition, the network coordinator, deputy coordinator, training coordinator, and administrative coordinator as well as the science task managers attended this meeting. The goals of the kick off meeting were to get organized, divide tasks, coordinate the science objectives and the timeline of the deliverables, and establish the schedule of meetings. In addition, training aspects of the Early Stage Researchers and the Experienced Researchers to be appointed by the network were discussed. The recruitment strategies for these appointees of the network were also reviewed. An important goal of this network is to develop data bases and web interfaces for the quick dissemination of results to the general science community. The strategies for these endeavors were also discussed. The meeting consisted of plenary meetings supplemented by splinter meetings, where details on the joint science projects and appointments were discussed.

The meeting was highly successful from the point of view of organizing the network, establishing good communication channels, and of starting up the science projects, which are at the core of the network. We particularly appreciated the facilities at the Lorentz Center which are very conducive to a highly interactive workshop such as this one. Last but not least, we are grateful to the staff of the Lorentz Center for the highly professional way in which this workshop was organized.

Frank Helmich (SRON, The Netherlands)
Xander Tielens (University Groningen, The Netherlands)

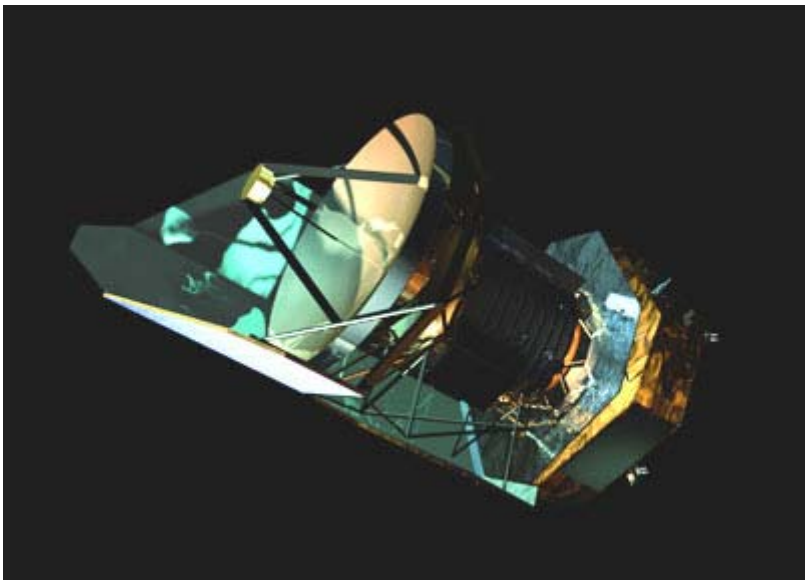
Herschel Preparatory Science

December 15 – 17, 2004

This workshop was held at the Lorentz Center from December 15th to December 17th. It was organized by J. Cernicharo (CSIC, Spain). More than 60 researchers from different fields and specialities participated in the meeting. Astronomers, Chemists and Physicists from Holland, Spain, Switzerland, Sweden, CFH, France, Germany, UK, Poland, Italy, and U.S.A. discussed during these three days on several topics related to the future interpretation of the data that the Herschel Satellite will provide. This satellite is a cornerstone of the European Space Agency. It will be the largest space telescope of its kind when launched. Its 3.5-metre diameter mirror will collect long-wavelength infrared radiation from some of the coolest and most distant objects in the Universe. It will be the only space observatory to cover the range from far-infrared to submillimetre wavelengths. Exploring formation of stars and galaxies, ESA's Herschel space observatory will solve the mystery of how stars and galaxies were born.

Three instruments, HIFI (A Heterodyne receiver covering the 500-1900 GHz domain), PACS (a Photodetector Array Camera & Spectrometer covering the 60-200 microns) and SPIRE (a Spectral and Photometric Imaging Receiver covering the 200-600 microns domain) will be on board the satellite.

The PACS instrument will be built by a consortium led by MPE, Garching, Germany. SPIRE will be built by a consortium led by University of Cardiff, United Kingdom. HIFI will be built by a consortium led by SRON, Groningen, The Netherlands.



Artist's impression of the Herschel Satellite of the European Space Agency (ESA)

Among the very positive aspects of the meeting is the fact that people from laboratory and theoretical chemistry and physics, and astronomers come together to discuss and interact over a number of problems related to the multidisciplinary world of Molecular Astrophysics.

The three instruments on board Herschel will provide spectroscopic capacities to observe the molecular emission/absorption in molecular clouds, star forming regions, evolved stars, nearby galaxies and very distant and cold objects (quasars, high redshift galaxies,...). The interpretation of these data require a huge amount of data from laboratories and theoretical calculations. During the workshop four different topics were discussed:

1) **Collisional rates** (D. Flower, M.L. Dubernet, J. Noga, P. Valiron, A. Faure, M.L. Senent, A. Spieldfeld, T. Stoecklin, S. Montero)

2) **Chemistry** (E. Herbst, T. Millar, M. Roellig, C. Joblin, B. Kerkeni, E. Roueff, M. Costes, P. Cassavecchia, I. Sims, S. Viti, E. Dartois)

3) **Spectroscopy** (J. Pearson, H. Muller, G. Wlodarczak, J.P. Maier, J. Cernicharo, P. Encrenaz).

4) **Astrophysical Modelling** (A. Hjalmarson, E. van Dishoeck, J. Alcolea, J. Goicoechea, M. Gerin, M. Hogerheijde, J. Black)

The workshop demonstrated the value of bringing together astronomers, both observers and modellers, chemists and physicists studying basic processes in the interstellar medium with important implications in laboratories and theoretical groups. The preparation of the Science that Herschel could perform will benefit from the discussions and collaborations emerging from this workshop.

J. Cernicharo (CSIC, Spain)

Eerste waarnemingen van kern-actieve sterrenstelsels

Astronomen uit binnen- en buitenland komen van 12 tot en met 14 januari 2004 bijeen in het Lorentz Center (Leiden) in een workshop over actieve sterrenstelsels, één van de meest spectaculaire en energetische objecten in het heelal. Een aantal deelnemende astronomen heeft onlangs voor het eerst gedetailleerde waarnemingen aan deze sterrenstelsels gedaan. De workshop is het uur der waarheid voor eerdere hypotheses over de opbouw van deze objecten.
Actieve sterrenstelsels zorgen voor vuurwerk in het heelal. Sommige laten in hun centrum bijzonder explosieve verschijnselen zien. Andere werpen langs smalle straalstromen materie naar buiten. Weer andere hebben een superheldere kern, die het hele sterrenstelsel overstraalt. Vaak is er sterke röntgenstraling waar te nemen.
Astronomen zijn het er over eens dat een massief zwart gat de oorzaak van al deze verschijnselen is. Maar er zijn nog veel open vragen. Hoe ontstaan zulke explosieve verschijnselen? Wat is precies de structuur van zo'n actief sterrenstelsel? Daarover verschillen de opvattingen, en computerberekeningen geven geen uitsluitsel. Tot voor kort gaven telescopen geen scherp genoeg beeld om de actieve kernen van deze stelsels te onderscheiden.
Het Mid IR Interferometrie Instrument (MIDI), een nieuw Nederlands-Duits-Frans instrument, bracht daar in juni 2003 verandering in. De MIDI kan het infrarode licht dat wordt opgevangen door twee acht-meter telescopen combineren tot één enkel beeld. Door die combinatie worden uiterst kleine details in de stofring rond het zwarte gat in het hart van het sterrenstelsel NGC 1068 voor het eerst zichtbaar. Er is een compacte opeenhoping van warm stof zichtbaar, uiterst dicht bij het zwarte gat. Waarschijnlijk is het een massieve schijf van gas en stof die om het gat wervelt, en waaruit voortdurend materiaal het zwarte gat wordt ingezogen.
In het najaar van 2003 zijn de astronomen bezig geweest met het verwerken van hun waarneemgegevens. Tijdens de workshop zullen ze de eerste resultaten laten zien. Deze eerste resultaten zijn spannend, voor de aanwezige vakgenoten. Deelnemende sterrenkundigen hebben eerder theorieën opgesteld over de opbouw van actieve sterrenstelsels. De waarde van hun ideeën zal nu blijken. De nieuwe waarnemingen geven een impuls aan de theorievorming op dit gebied.
Meer informatie over de waarnemingen en het instrument op:
http://www.eso.org/outreach/press-rel/pr-2003/pr-17-03.html
In de workshops van het Lorentz Center komen vooraanstaande wetenschappers uit binnen- en buitenland samen om in gezamenlijke afzondering te werken aan een actueel wetenschappelijk probleem. Discussie en interactie staan centraal in de workshops. De samenballing van uiteenlopende kennis levert vaak in korte tijd een grote vooruitgang op.
De workshop 'The structure and composition of Active Galactic Nuclei: Optical interferometry and adaptive optics of NGC 1068' wordt van 12 tot en met 14 januari 2004 gehouden. Wetenschappers kunnen de lezingen kosteloos bijwonen. Inlichtingen en inschrijving: Gerda Filippo, tel. (071) 5275401, email: filippo@lc.leidenuniv.nl. Zie ook http://www.lc.leidenuniv.nl.

De ontdekking van planeten buiten het zonnestelsel

Astronomen uit binnen- en buitenland komen komen van 2 tot 6 februari 2004 bijeen in het Lorentz Center (Leiden) in een workshop over planeten buiten ons zonnestelsel. Zowel Europa als de VS plannen nieuwe ruimtetelescopen om aardse planeten te kunnen ontdekken. In de workshop komen experts uit de VS en Europa bijeen om de verschillende technieken daarvoor te bespreken.
Is de aarde uniek in het heelal? De meeste astronomen denken van niet, maar er is nog nooit een 'aardse planeet' waargenomen buiten ons zonnestelsel. Ze zijn gewoon te klein voor de huidige telescopen. De Hubble ruimtetelescoop kon een enkele reuzenplaneet onderscheiden, maar voor kleinere planeten zijn scherpere kijkers nodig.
De Amerikaanse en Europese ruimtevaarorganisaties (NASA en ESA) plannen ieder afzonderlijk de lancering van een speciale telescoop voor de ontdekking van aardse planeten, waarschijnlijk rond 2015. De Europeanen gebruiken echter een principieel andere telescooptechniek dan de Amerikanen. Experts van beide zijden van de Atlantische Oceaan komen nu in de Leidse workshop bij elkaar om te discussiëren over de beste manier om planeten te ontdekken.
De ESA zette tot nu toe de kaarten op een satelliet voor infrarood-waarnemingen (een 'infrarood interferometer'). Daarmee kun je bijvoorbeeld kooldioxide en water aantonen in de atmosfeer van verre planeten. Ook Nasa bestudeert deze techniek, maar onderzoekt daarnaast nog een alternatief: Een telescoop die zichtbaar licht waarneemt. Daarbij willen ze 'coronografie' gebruiken, een techniek die ook wordt gebruikt voor het waarnemen van de corona van de zon. Een deel van het beeld wordt daarbij afgedekt, zodat het niet wordt overstraald door de heldere zon of ster.
Een ander discussiepunt: Hoeveel sterren moet je waarnemen om een redelijke kans te hebben aardse planeten waar te nemen? En kun je volstaan met lichtsterke, nabije sterren, of moet de telescoop ook zwakkere sterren kunnen waarnemen? De antwoorden zijn bepalend voor de kosten van zo'n telescoop.
De workshop moet de Europese sterrenkundige meer inzicht geven in de mogelijkheden van coronografie. Zo raken zij intensiever betrokken bij het Amerikaanse onderzoeksprogramma.
In de workshops van het Lorentz Center komen vooraanstaande wetenschappers uit binnen- en buitenland samen om in gezamenlijke afzondering te werken aan een actueel wetenschappelijk probleem. Discussie en interactie staan centraal in de workshops. De samenballing van uiteenlopende kennis levert vaak in korte tijd een grote vooruitgang op.
De workshop 'Coronographic Methods for the Detection of Terrestrial Planets' wordt van 2 tot 6 februari 2004 gehouden in het Lorentz Center in Leiden. Wetenschappers kunnen de lezingen kosteloos bijwonen. Inlichtingen en inschrijving: Yolande van der Deijl, email: deijl@lc.leidenuniv.nl, tel (071) 5275400, Zie ook http://www.lc.leidenuniv.nl.

Nieuwe manieren van rekenen voor quantumcomputer

Fysici en computerwetenschappers uit binnen- en buitenland komen van 24 tot 28 mei bijeen in het Lorentz Center (Leiden) in een workshop over quantuminformatieverwerking. Zij zullen nieuwe computer-algoritmen bestuderen, die mogelijk worden dankzij een nieuw type computer.
De huidige computers werken met enen en nullen, die in een lange reeks van handelingen worden opgeteld, vermenigvuldigd of op een andere manier bewerkt. Dat is niet de enige manier om een computer te laten werken. Bij het verder verkleinen van computeronderdelen, kan slim gebruik gemaakt worden van de bijzondere eigenschappen van individuele elektronen en fotonen. Men spreekt dan van quantuminformatieverwerking. Die bijzondere eigenschappen maken het mogelijk maken om 'qubits' te construeren. Een qubit kan net als een klassiek bit een '1' of een '0' bevatten, maar ook een combinatie van 1 en 0. Fysici spreken dan van een superpositie van verschillende quantumtoestanden. Bovendien zijn de eigenschappen van optellen en aftrekken anders. Verschillende toestanden kunnen elkaar beïnvloeden – een eigenschap die 'interferentie' wordt genoemd. Die superpositie en interferentie maken een quantumcomputer fundamenteel verschillend. Die eigenschappen maken het mogelijk om informatie collectief te bewerken. Dat kan een aantal berekeningen aanzienlijk versnellen.
Omdat deze eigenschappen ingebakken zitten in een quantumcomputer, kan een grotere winst worden behaald. In theorie althans, want er zijn voor zo'n quantumcomputer nog veel problemen op te lossen. Maar computerwetenschappers lopen zich alvast warm, en ontwerpen nieuwe rekentechnieken voor zo'n computer.
Het blijkt dat een quantum-computer razendsnel een groot getal kan ontbinden in priemgetallen (factoriseren). Op een klassieke computer gaat dat tergend langzaam. Het factoriseren van een getal van 300 cijfers duurt letterlijk eeuwen. Vaak is cryptografische beveiliging erop gebaseerd dat factoriseren van grote getallen praktisch onmogelijk is. Met een quantumcomputer wordt dat wél mogelijk. Dat kan met een algoritme dat slim gebruik maakt van de superpositie van quantumtoestanden en interferentie. Factoriseren wordt daardoor minutenwerk. Daarmee kan beveiligde computercommunicatie van bijvoorbeeld banken gekraakt worden. Theoretisch, want een echte quantumcomputer laat nog vele jaren op zich wachten.
Ook sommige andere rekentaken kunnen spectaculair sneller worden uitgevoerd. Zo kunnen quantumcomputers ook beter zoeken in een database. Vooral het zoeken in ongeordende informatie gaat sneller. Een klassieke computer moet alles van begin tot eind doorzoeken, en vindt de gezochte gegevens gemiddeld ergens halverwege. Een quantumcomputer gebruikt superpositie en inteferentie om alle informatie tegelijk te bekijken. Als je dat slim programmeert, gaat dat veel sneller.
Daarnaast kunnen quantumcomputers onderling efficiënter communiceren, en daardoor makkelijker werken aan één gezamenlijke rekentaak.
Fysici en computerwetenschappers zullen op de workshop in Leiden dit soort nieuwe algoritmes met elkaar bespreken. Er is veel tijd ingeruimd om nieuwe ideeën uit te testen en nieuwe onderzoekslijnen te bedenken. De deelnemers hopen zo meer nieuwe algoritmes op het spoor te komen.
In de workshops van het Lorentz Center komen vooraanstaande wetenschappers uit binnen- en buitenland samen om in gezamenlijke afzondering te werken aan een actueel wetenschappelijk probleem. Discussie en interactie staan centraal in de workshops. De samenballing van uiteenlopende kennis levert vaak in korte tijd een grote vooruitgang op.
De workshop 'Quantum Information Processing' wordt van 24 tot en met 28 mei 2004 gehouden. Wetenschappers kunnen de lezingen kosteloos bijwonen.

De natuurwetten van de financiële markten

Wiskundigen, fysici en economen komen van 18 tot 29 oktober bijeen in het Lorentz Center (Leiden) in een workshop over het voorspellen van marktbewegingen op de financiële markten.
Wie de bewegingen op de financiële markten kan voorspellen, kan geld verdienen. Financiële instellingen doen daarom veel onderzoek naar de mechanismen op de financiële markten. De laatste jaren zijn belangrijke nieuwe inzichten verkregen, die betere voorspellingen mogelijk maken. De computerisering van de handel is een belangrijke hulp bij het onderzoek naar financiële wetmatigheden. Vraag en aanbod worden veel gedetailleerder vastgelegd dan bij het loven en bieden van handelaars op een beursvloer. De microstructuur van de handel leert veel over het ontstaan van dynamiek in de markt. Processen van prijsvorming en prijsbewegingen kunnen daardoor beter bestudeerd worden.
Economen, wiskundigen en natuurkundigen bestuderen dit soort gegevens, ieder op hun eigen manier. Economen met hun marktkennis, wiskundigen met hun statistisch inzicht, natuurkundigen met hun vaardigheid om wetmatigheden op te sporen. De parallellen met andere wetenschapsgebieden blijken daarbij leerzaam. Kennis over turbulenties en schokgolven blijkt bruikbaar op de financiële markten. Temperatuursafhankelijke 'brownse' bewegingen zijn ook te zien in de koersvorming. Fractale structuren komen voor in de tijdreeksen van beursnoteringen. Die parallellen verdiepen het inzicht, en helpen om de natuurwetten van de financiële markten op te sporen. Dat heeft geleid tot nieuwe statistische modellen, nieuwe hulpmiddelen om opties te waarden en het risico van grote portfolio's te berekeningen.
Tot nu toe werden deze inzichten vooral in de praktijk bij financiële instellingen ontwikkeld. De workshop wil deze modelvorming ook bij het wetenschappelijk onderzoek betrekken. Gedetailleerd inzicht in de financiële markten is van fundamenteel belang, omdat zich daar onder gecontroleerde omstandigheden mechanismen voordoen, die ook elders in de maatschappij economische processen bepalen.
Economen, wiskundigen en natuurkundigen zullen op de workshop in Leiden hun kennis uitwisselen en nieuwe onderzoekslijnen uitzetten. Er zijn inleidingen over bijvoorbeeld zelforganiserende systemen, thermische processen, en chaostheorie. Er is in de workshop veel tijd ingeruimd voor discussies.
In de workshops van het Lorentz Center komen vooraanstaande wetenschappers uit binnen- en buitenland samen om in gezamenlijke afzondering te werken aan een actueel wetenschappelijk probleem. Discussie en interactie staan centraal in de workshops. De samenballing van uiteenlopende kennis levert vaak in korte tijd een grote vooruitgang op.
De workshop 'Volatility of financial markets: theoretical models, forecasting and trading' wordt van 18 tot 29 oktober 2004 gehouden. Wetenschappers kunnen de lezingen kosteloos bijwonen. Inlichtingen en inschrijving: Gerda Filippo, email: filippo@lc.leidenuniv.nl , tel. (071) 5275401. Zie ook http://www.lc.leidenuniv.nl.
J.P. Bouchaud is directeur van Capital Fund Management, een van de grootste systematische hedge funds in Europa. Als fysicus draagt hij bij aan financiële modellen. Daarnaast onderzoekt hij de fysica van spin-glazen.
X. Gabaix is assistant-professor op de afdeling economie van MIT, USA. Als econoom onderzoekt hij de wetmatigheden in grote fluctuties op financiële markten.
M. Avellaneda hoogleraar in de toegepaste wiskunde en waarschijnlijkheidstheorie op het wiskundig instituut van New York University, onderzoekt de wiskundige modellering van financiële markten.