ANNUAL REPORT 2006

HELSINKI UNIVERSITY OF TECHNOLOGY
Low Temperature Laboratory
Brain Research Unit and
Low Temperature Physics Research
http://ltl.tkk.fi

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PREFACE

The LTL is the home of two national Centers of Excellence (CoE), one in *Low Temperature Quantum Phenomena and Devices* and another one in *Systems Neuroscience and Neuroimaging*. Both CoEs started their six-year funding period in 2006. The international Scientific Advisory Board of the CoE in Low Temperature Quantum Phenomena and Devices held its first evaluation meeting on November 9th, 2006. The board has two members, Professor Mats Jonson from University of Gothenburg and Professor John Saunders from Royal Holloway, University of London, elected by the Academy of Finland. The evaluation report is enclosed in Appendix 1.

In 2006 the members of the LTL organized two medium-size scientific meetings. The traditional ULTI User Meeting took place on April 21–26, 2006, in Lammi. The previous five ULTI meetings were organized in 1994, 1998, 2001 and 2004. For the first time the meeting attracted over 100 scientists from 22 countries. The Proceedings of the meeting were published in a special issue of Journal of Low Temperature Physics in January 2007. Matti Krusius organized on November 10, 2006, on Otaniemi campus a symposium "Fundamental Physics as Profession". The symposium honored the long scientific carreers of Nikolai Kopnin and Grigory Volovik who both celebrated their 60th birthday in 2006. Six prominent speakers, among them Alexei Abrikosov, the 2004 Nobel Laureate in Physics, attracted an audience of about 70 people.

In 2006 five scientists of the LTL received either national or international recognition. Riitta Hari received the 2nd Kivalo Prize of the Neurology Foundation for her achievements in the research, education, clinical applications and administration in the area of neurosciences. Erika Kirveskari was awarded the W.A. Cobb Young Investigator Prize in the XXVIII International Congress of Neurophysiology in Edinburgh, Scotland, for the best contributed paper. Veikko Jousmäki and Simo Vanni were appointed to docentships in University of Kuopio and Helsinki, respectively. Finally, The Royal Society of Arts and Sciences in Göteborg elected Mikko Paalanen to be a foreign member of its physics group. The Royal Society in Gothenburg, founded already in 1778, is one of the oldest scientific societies in the world.

Mikko Paalanen

Director of the LTL

SCIENTIFIC ADVISORY BOARD

LTL has a Scientific Advisory Board (SAB), appointed by the rector of TKK for the years 2006 – 2011. The members also serve in the SABs of the Centers of Excellence of the Academy of Finland, coordinated by LTL. Our current SAB has the following 5 members:

For the Center of Excellence on *Low Temperature Quantum Phenomena and Devices*

- Prof. Mats Jonson, Gothenburg University, Gothenburg, Sweden
- Prof. John Saunders, Royal Holloway, University of London, UK

For the Center of Excellence on *Systems Neuroscience and Neuroimaging*

- Prof. Chris Frith, Functional Imaging Laboratory, University College London, UK
- Prof. Denis Le Bihan, CEA Saclay, France
- Prof. Nikos K. Logothetis, MPI for Biological Cybernetics, Tübingen. Germany

PERSONNEL

The number of persons working in the LTL fluctuates constantly since scientists are employed for relatively short periods only and students often work on part-time basis.

SENIOR RESEARCHERS

Mikko Paalanen, D.Sc. (Tech.), Professor, Director of the LTL
Riitta Hari, M.D., PhD, Professor, Head of the Brain Research Unit
Peter Berglund, D.Sc. (Tech.). Docent, Technical Manager
Harry Alles, D.Sc. (Tech.)
Rob Blaauwgeers, PhD
Romain Danneau, PhD, from 20.11.
Vladimir Eltsov, PhD
Nina Forss, M.D., PhD, Docent, part-time
David Gunnarsson, PhD
Pertti Hakonen, D.Sc. (Tech.), Professor
Marja-Liisa Halko, PhD, part-time, from 11.9.2006
Tero Heikkilä, D.Sc. (Tech.), Docent
Päivi Helenius, PhD, part-time
Meri Helle, D.Sc. (Tech.), from 1.7.2006
Risto Hänninen, D.Sc. (Tech.), from 8.5.2006
Veikko Jousmäki, PhD, Docent
Erika Kirveskari, M.D., PhD., part-time, on leave from 1.1.2006
Nikolai Kopnin, PhD, Professor
Juha Kopu, D.Sc. (Tech.), until 1.8.2006
Matti Krusius, D.Sc. (Tech.), Professor
René, Lindell, D.Sc. (Tech.), until 28.2.2006
Seppo Mattila, PhD, civil alternative service
Matthias Meschke, PhD
Mikko Möttönen, D.Sc. (Tech.)
Jukka Pekola, D.Sc. (Tech.), Professor

Tuukka Raij, M.D., PhD, part-time, until 31.3.2006
Riitta Salmelin, D.Sc. (Tech.), Academy Professor
Alexander Savin, PhD
Alexander Sebedash, PhD
Päivi Sivonen, PhD, from 1.5.2006
Oguz Tanzer, D.Sc. (Tech.), until 31.12.2006
Reeta Tarkiainen, D.Sc. (Tech.), until 31.1.2006
Igor Todoschenko, PhD
Taku Tsuneta, PhD, until 31.10.2006
Juha Tuoriniemi, D.Sc. (Tech.), Docent
Simo Vanni, M.D., PhD, Docent
Juha Vartiainen, D.Sc. (Tech.)
Minna Vihla, M.D., PhD, part-time, on leave from 9.6.2006
Grigori Volovik, PhD, Professor

ADMINISTRATION AND TECHNICAL PERSONNEL

Henri Autti, civil alternative service, until 5.7.2006
Teija Halme, secretary
Antti Huvila, technician
Mia Illman, nurse, laboratory technician on leave 15.8.2005 -
Arvi Isomäki, technician
Juhani Kaasinen, technician
Antti-Iivari Kainulainen, research assistant, from 31.5.2006
Helge Kainulainen, technician
Jari Kainulainen, nurse, laboratory technician, from 18.9.2006
Tuire Koivisto, secretary
Markku Korhonen, technician
Leena Meilahti, secretary, from 10.4.2006
Pirjo Muukkonen, financial secretary
Satu-Anniina Pakarinen, project secretary, until 14.3.2006
Liisi Pasanen, secretary
Veli-Matti Saarinen, M.Sc. (Tech.) project engineer, from 1.9.2006
Ronny Schreiber, research engineer, from 1.12.2006

GRADUATE STUDENTS - (SUPERVISORS)

Gina Caetano, M.Sc. (Tech.) - (Veikko Jousmäki, Riitta Hari)
Robert de Graaf, M.Sc. - (Matti Krusius)
Linda Henriksson, M.Sc. (Tech.) - (Simo Vanni)
Jaana Hiltunen, Phil. Lic. - (Riitta Hari)
Yevhen Hlushchuk, M.D. - (Riitta Hari)
Tommy Holmqvist, M.Sc. (Tech.) - (Jukka Pekola)
Annika, Hultén, M.Sc. (Psych.) - (Riitta Salmelin, Matti Laine)
Heikki Junes, M.Sc. (Tech.) - (Harry Alles)
Antti Kemppinen, M.Sc. (Tech.) - (Jukka Pekola)
Jan Kujala, M.Sc. (Tech.) - (Riitta Salmelin)
Hannu Laaksonen, M.Sc. (Tech.) - (Riitta Salmelin)
Satu Lamminmäki, M.D. - (Riitta Hari)
Lorenz Lechner, M.Sc. - (Pertti Hakonen)
Teijo Lehtinen, M.Sc. (Tech.), until 28.2.2006 - (Pertti Hakonen)

Mia Liljeström, M.Sc. (Tech.), on leave until 25.9.2006 - (Riitta Salmelin)
Sanna Malinen, M.Sc. (Tech.) - (Riitta Hari)
Teemu Ojanen, M.Sc. (Tech.) - (Tero Heikkilä)
Lauri Parkkonen, M.Sc. (Tech.) - (Riitta Hari)
Tiina Parviainen, M.Sc. (Psych.), on leave from 4.9.2006 - (Riitta Salmelin)
Elias Pentti, M.Sc. (Tech.) - (Juha Tuoriniemi)
Ville Renvall, M.Sc. (Tech.) - (Riitta Hari)
Miiamaaria Saarela, M.Sc. (CognSci.) - (Riitta Hari)
Anssi Salmela, M.Sc. (Tech.) - (Juha Tuoriniemi)
Jayanta Sarkar, M.Sc., from 21.9. - (Pertti Hakonen)
Mika Seppä, M.Sc. (Tech.) - (Matti Hämäläinen, Riitta Hari)
Jaana Simola, M.Sc. (Psych.), 18.1.-31.8.2006 – (Simo Vanni)
Roman Solntsev, M.Sc. - (Matti Krusius)
Linda Stenbacka, M.D. - (Simo Vanni)
Topi Tanskanen, M.Sc. (Psych.) - (Riitta Hari)
Andrey Timofeev, M.Sc. - (Jukka Pekola)
Johanna Uusvuori, M. Sc. (Tech.) - (Riitta Salmelin)
Nuutti Vartiainen, M.D. - (Nina Forss, Riitta Hari)
Pauli Virtanen, M.Sc.Tech. - (Tero Heikkilä)
Fan Wu, M.Sc. - (Pertti Hakonen)

UNDERGRADUATE STUDENTS

Maarit Aro
Henri Autti, 6.7. – 31.12.
Kurt Baarman
Linda Ehnholm, until 28.2.
Petri Heikkinen
Liisa Helle, until 20.8.
Jaakko Hosio
Antti Jalava
Marika Kaksonen, from 22.5.
Laura Korhonen
Matti Laakso, from 29.5.
Laura MacDonald
Matti Manninen
Antti Mäkelä, until 30.4.
Lauri Nurminen, from 15.5.
Antti Paila
Joonas Peltonen
Miika Pihlaja
Antti Puska, from 22.5.
Pavan Ramkumar, from 28.8.
Tomi Ruokola
Juho Rysti, from 22.5.
Timo Saarinen
Olli-Pentti Saira, from 1.6.
Sini-Maaria Sipponen, from 19.5.
Matti Tomi, from 22.5.
Juha Voutilainen

VISITORS

ULTI VISITORS (LOW TEMPERATURE AND NANO PHYSICS)

Ankerhold, Joachim, PhD, 10. - 17.8., Universität Freiburg, Physikalisches Institut, Germany
Bueno, Juan, M.Sc., 2.5. - 21.7., Leiden University, Kammerlingh Onnes Laboratory, The Netherlands
Bunkov, Yury, Prof., 2. - 28.2. and 20.4 - 5.5, CRTBT-CNRS, Grenoble, France
Chagovets, Timofiy, M.Sc., 3.4. - 24.6., Academy of Sciences of the Czech Republic, Institute of Physics, Prague, Czech Republic
Eschrig, Matthias, PhD, 23. - 27.1., Universität Karlsruhe, Institut für Theoretische Festkörperphysik, Germany
Giazotto, Francesco, PhD, 3. - 7.7., Scuola Normale Superiore, NEST-INFM, Pisa, Italy
Golov, Andrei, PhD, 1.10. - 1.12., University of Manchester, School of Physics and Astronomy, UK
Guichard, Wiebke, PhD, 8. - 14.1., Joseph Fourier University, LCMI-CNRS, Grenoble, France
Haley, Richard, PhD, 18. - 26.7., Lancaster University, Lancaster, UK
Hekking, Frank, Prof., 3. - 8.10., Joseph Fourier University, LPMMC-CNRS, Grenoble, France
Khmelnitskii, David, Prof., 13. - 20.7., University of Cambridge, Cavendish Laboratory, UK
Laperashvili, Larisa, Prof., 25.10. - 5.11., University of Copenhagen, Niels Bohr Institute, Denmark
Lvov, Viktor, Prof., 27. - 30.4. and 3. - 24.8., Weizmann Instutute of Science, Rekhovot, Israel
Schomerus, Henning, PhD, 27.11. - 2.12., Lancaster University, UK
Sonin, Edouard, Prof., 1.2. - 2.3., Hebrew University of Jerusalem, Racah Institute of Physics, Israel
Sosnin, Igor, PhD, 6. - 29.4., Royal Holloway, University of London, Surrey, UK
Tsepelin, Viktor, PhD, 29.5. - 10.6. and 13. - 25.11., Lancaster University, Lancaster, UK
Zou, Jing, PhD, 24.4. - 24.5., Royal Holloway, University of London, Surrey, UK

OTHER VISITORS

Abrikosov, Alexei, Prof., 8. - 12.11., Argonne National Laboratory, Illinois, USA
Aggujaro, Silvia, M.Sc., 8.3. - 30.9., Università degli studi di Milano-Bicocca, Italy
Andreev, Alexander, Academician, 21.8. - 4.9., Kapitza Institute for Physical Problems, Moscow, Russia
Andresen, Soren, PhD, 15. - 18.8., University of Copenhagen, Niels Bohr Institute, Denmark
Boldarev, Sergei, PhD, 30.10. - 29.12., Kapitza Institute for Physical Problems, Moscow, Russia
Danneau, Romain, PhD, 27. - 30.7., University of New South Wales, Sydney, Australia
Goh, Xin-Lin, M.Sc., 5. - 21.9., Australian National University, Canberra, Australia
Gracco, Vincent, Prof., 29.1. - 4.2., McGill University, School of Communication Sciences and Disorders, Montreal, Canada

Gutierrez, Ricardo, Mr., 1.1 - 31.3., Universidad Politecnica de Madrid (E.T.S.I.T.), Spain
He, Biyu, B.Sc., 5. - 19.9., Washington University School of Medicine. St.Louis, Missouri, USA
James, Andrew, PhD, 5. - 21.9., Australian National University, RSBS, Canberra, Australia
Jonson, Mats, Prof., 8. - 11.11., University of Gothenburg, Sweden
Jordan, Jeanine, Ms., 26. - 28.10., Springer, New York, USA
Lebedev, Vladimir, Prof., 2. - 5.5. and 9. - 15.11. Landau Institute for Theoretical Physics, Chernogolovka, Russia
Leonhardt, Ulf, Prof., 9. - 11.11., University of St. Andrews, UK
Longcamp, Marieke, PhD, 21.8. - 15.9., Universite Paul Sabatier, LAPMA, Toulouse Cedex , France
Makhlin, Yurij, PhD, 6. - 26.4. and 31.10. - 11.11., Landau Institute for Theoretical Physics, Chernogolovka, Russia
Mel'nikov, Alexander, PhD, 20.3. - 20.4., Institute for Physics of Microstructures, RAS Nizhny Novgorod, Russia
Mineev, Vladimir, Prof., 8. - 11.11., CEA, Grenoble, France
Nakahara, Mikio, Prof., 20.2 - 5.4., Kinki University, Osaka, Japan
Ohki, Thomas A, PhD, 17. - 31.7., University of Rochester, New York , USA
Parshin, Alexander, Prof., 6. - 21.4., 29.6. - 19.7. and 6. - 25.11. Kapitza Institute for Physical Problems, Moscow, Russia
Pryadko, Leonid, PhD, 19. - 22.8., University of California, Riverside, USA
Sarkar, Jayanta, M.Sc., 29.5 - 4.6., Indian Institute of Science, Bangalore, India
Saunders, John, Prof., 8. - 11.11., Royal Holloway University of London, Engham, UK
Schürmann, Martin, PhD, 14.8 - 6.9., University of Nottingham, UK
Schützhold, Ralf, PhD, 26. - 29.4., Institute für Theoretische Physik, Dresden, Germany
Song, Woon, PhD, 10.1. - 8.2., Korea Research Institute of Standards and Sciences, Daejeon, Korea
Tremblay, Pascale, PhD, 28.1. - 10.2., McGill University, School of Communication Sciences and Disorders, Montreal, Canada
Velichkovsky, Boris, Prof., 25.8., TU Dresden, Germany
Vorselman, Pieter, M.Sc., 27.9. - 01.10., Leiden Cryogenic BV, The Netherlands
Yano, Hideo, Prof., 13.11. - 25.11., Osaka City University, Graduate School of Sciences, Japan
Yurke, Bernard, PhD, 27.2. - 17.3., Bell Laboratories, Murray Hill, USA
Zmeev, Dmitry, M.Sc., 6.1. - 5.4., Kapitza Institute for Physical Problems, Moscow, Russia

GROUP VISITS

Staff from **Science Center Heureka**, 20.1.

A group of librarians from **TKK**, 26.1.

Mr. **Mariano Gago**, Minister of Science and Technology from Portugal and Delegation, 6.3.

The **Millenium Prize** Selection Committee, 29.3.

- Prof. **Pekka Tarjannne**, Chairman of the Committee, Finland

- Prof. **Jean-Claude Charpentier**, France
- Prof. **Juhani Kuusi**, Finland
- Prof. **Bengt Nordén**, Sweden
- Prof. **Bengt Stenlund**, Finland
- Prof. **Charles M. Vest**, United States
- Dr. **Tapio Alvesalo**, Secretary

Mr **Aleksander Rumjantsev,** Russian ambassador and deputy with scientific adviser. 29.8.,

Alexander von Humboldt Foundation, 21.9.

- Dr. **Ursula Hamenstaedt**, University of Bonn
- Dr. **Jürgen Kaube**, Journalist, Frankfurter Allgemeine Zeitung
- Dr. **Barbara Sheldon**, ABt. Strategie und Aussenbeziehungen, Alexander von Humboldt Foundation
- Dr. **Sven Baszio**, Head of Division Europe 1, Alexander von Humboldt Foundation

Groups from various high schools in Finland.

INTERNATIONAL COLLABORATIONS

COSLAB (COSMOLOGY IN THE LABORATORY)

Coordinators: **Grigory Volovik** (LTL) and **Tom Kibble** (Imperial College, London, UK)

Funding: ESF, Physical and Engineering Sciences

Duration: 1.7. 2001 - 31.12.2006

Participants: 14 groups from European universities and research institutes in 12 countries.

Condensed matter systems at low temperatures and the universe, evolving after the "Big Bang", have many analogies. The aim of this programme is to exploit these analogies through studies of ultra-low-temperature superfluid helium and of other condensed-matter systems, such as atomic Bose condensates, superconductors, Josephson junction arrays and liquid crystals, together with theoretical work to establish the validity of the analogy. The required sensitivity demands the most sophisticated apparatus, in particular state-of-the-art cryogenic equipment.

COSLAB WORKSHOPS IN 2006:

Condensates in Physics: From Atoms to Cosmology

University of Nottingham, UK, April 19-21, 2006

The workshop attracted over 40 participants including 17 speakers. The expertise of the speakers varied from early universe cosmology, experimental particle physics through to the theory behind and experimental status of Bose-Einstein condensates in condensed matter as well as atomic physics. The new physics that is emerging at an astonishing rate from studying nonlinear effects in atomic Bose-Einstein condensates could also influence matter at the extreme opposite of the length scale. For example,

there is great current interest in the idea that non-baryonic dark matter in the universe might consist of a Bose-Einstein condensate formed from ultra-light bosons whose coherence length is of astronomical size. Scalar fields play a crucial role in particle physics. For example the Higgs field is responsible for giving all particles in nature their mass. It is not surprising therefore that the possible formation of condensates in the early universe has been of interest to cosmologists. There are a number of proposals demonstrating how they could form either out of phase transitions, at the end of a period of inflation or from collisions of particles. They are used to explain phenomena as diverse as the current acceleration of the universe, the distribution of non-baryonic dark matter in the universe and the formation of non-topological solitons. However, no experimental evidence of their existence currently exists. In fact there is currently no evidence of the Higgs field. A goal of our workshop was to determine what specific aspects of the condensate could be looked for in order to ascertain their existence in cosmology.

Laboratory Cosmology - COSLAB 2006

Lorentz Center, Leiden, The Netherlands, September 4 – 9, 2006

This workshop was the last in a series of six annual conferences sponsored by the ESF through its COSLAB programme. It continued to explore condensed matter analogues of cosmological phenomena that have been discussed in previous workshops in the series, and it also introduced some new topics and analogue systems detailed below.

There were 53 participants from ESF countries, Canada, Israel, India, New Zealand and the US. The programme consisted of about 30 talks and 3 long discussion sessions, as well as 4 question and answer sessions for informal discussion.

The last day, September 9th, was dedicated to a special event to commemorate the publication in 1976 of T.W.B. Kibble's paper on his famous defect formation mechanism. This paper started the research field of cosmic defects and, would lead, much later, to the birth of Laboratory Cosmology. The event was entitled “30 years of cosmic strings” and gave an opportunity to reflect on the successes of the COSLAB programme and what lies ahead.

ULTI - ULTRA LOW TEMPERATURE INSTALLATION

Coordinator: **Mikko Paalanen**

Funding: EU's 6th framework program, Transnational Access to Major Research Infrastructures. (EU contract # RITA-CT-2003-505313)

Duration: 1.4. 2004 - 31.3. 2008

Participating groups of the LTL: INTERFACE, NANO, PICO, ROTA, THEORY and YKI

The ULTI Large-Scale Facility continues the services of ULTI III for European scientists. It will provide them with 72 visitor months in the LTL and full access to its research facilities.

During 2006 altogether 37 European visitors from 11 different countries used the facility for 23 months.

ULTI web page: http://ltl.tkk.fi/eu.html

WORKSHOPS

Quantum Phenomena at Low Temperatures

Lammi, Finland April 21-26, 2006 (ULTI User Meeting)

The Workshop attracted 101 scientists from 22 countries. It belongs to a series of meetings sponsored by the European Union visitors' programme ULTI. The previous ULTI meetings were organized in 1994, 1998, 2001 and 2004.

The object of the workshop was to review the progress of the ongoing ULTI projects and explore the possibilities for future experiments. The scientific programme of the symposium consisted of 48 oral contributions and 27 posters in four main areas:

- Quantum fluids and solids
- Turbulence
- Mesoscopic conductors
- Quantum engineering

The Proceedings of the Workshop contained 16 contributions and were published in JLTP 146, 1-2, January 2007.

Web page: http://ltl.tkk.fi/ULTI2006/

Fundamental Physics as Profession

Otaniemi November 10, 2006, (60th birthday symposium of **Nikolai Kopnin** and **Grigory Volovik**)

Matti Krusius organized in Otaniemi on November 10, 2006, a symposium to celebrate the 60th birthday of **Nikolai Kopnin** and **Grigory Volovik**. Both scientists have made great contributions in the theory of superfluidity, superconductivity, nanoelectronics and quantum field theory. They started their carreer in the Landau Institute of Russian Academy of Sciences in Moscow. They have collaborated over 25 years with the experimental groups of the Low Temperature Laboratory, during last 15 years as staff members.

The symposium attracted an audience of about 70 people. The programme contained six invited talks by **Alexei Abrikosov** (Argonne National Laboratory, USA), **Vladimir Lebedev** (Landau Institute, Moscow), **Yuriy Makhlin** (Landau Institute, Moscow), **Mats Jonson** (University of Gothenburg, Sweden), **John Saunders** (Royal Holloway, University of London) and **Ulf Leonhardt** (University of St. Andrews). Professor Alexei Abrikosov, the 2004 Nobel Laureate, worked also at the beginning of his carreer in the Landau Institute.

LOW TEMPERATURE PHYSICS RESEARCH

NANO group

R. Danneau, D. Gunnarsson, **P. Hakonen**, L. Korhonen, L. Lechner, A. Paila, A. Puska, J. Sarkar, M. Tomi, and F. Wu

Visitors: J.C. Cuevas, Yu. Makhlin, and E. Sonin

The research work of the NANO group is focused on three areas: 1) Mesoscopic quantum amplifiers and qubits, 2) Current fluctuations and fast electron dynamics in

phase coherent systems, and 3) Quantum transport in carbon nanotubes. In all of these categories, our measurements are more and more centered at microwave frequencies which supplement the information obtained using regular (audio frequency) AC conductance measurements. We have two setups for low-noise microwave studies around 1 GHz: one down to 20 mK and another one for 4.2 K. During the past year our experimental efforts have become progressively collaborative in character within the domain of the European Union ruled research funding. Two new projects have been started: one of them, coordinated by P. Hakonen, is an IST-STREP dealing with carbon nanotubes and the second one is an INTAS-project, coordinated by Y. Makhlin, which deals with quantum information.

LANDAU-ZENER INTERFEROMETRY IN A COOPER PAIR BOX (C-SET)

D. Gunnarsson, **P. Hakonen**, Yu. Makhlin, A. Paila, and M. Sillanpää

Landau-Zener (LZ) tunneling is a celebrated quantum-mechanical phenomenon, taking place at the intersection of two energy levels that repel each other due to a weak interaction. In our Cooper pair box (CPB), modulated periodically by the gate voltage, a beam is split at the charge degeneracy point into two partial waves, which interfere during subsequent passes through the degeneracy point, either destructively or constructively depending on the geometrical phase acquired by the waves between the passes. Thus, we may interpret our experiment in terms of a multi-pass analog to the well-known optical Mach-Zehnder interferometer: The beam splitting occurs by Landau-Zener tunneling at the charge degeneracy, while the arms of the Mach-Zehnder interferometer in energy space are represented by the ground and excited state

We have performed extensive modelling of a CPB using Bloch equations in order to calculate the effective capacitance during the LZ-interference. One has to go beyond a determination of the steady state populations of the two levels: the relaxation during $1/f_m$ (f_m is the measurement frequency) has to be taken into account, *i.e.*, linear response theory based on doubly modulated magnetic field $B(t)$ (both rf-drive and measurement frequency) in Bloch equations has to be employed in the simulations. The calculated capacitance is found to agree rather well with the measured results.

INDUCTIVELY READ SUPERCONDUCTING QUBIT (L-SET)

D. Gunnarsson, **P. Hakonen**, A. Paila, and J. Sarkar

In essence, both the L-SET and C-SET are integrated qubit-detector systems in which reactive measurements of the qubit state can be performed. Recently, we have been working with a LSET qubit in which the shunting inductance is superconducting, *i.e.*, we have now a fully superconducting L-SET circuit. The main advantage of this circuit is that the coherence times are expected to be longer than in the old non-superconducting design. In addition, the superconducting design allows for investigations as a function of the phase bias point of the L-SET, which previously were not possible. The gate capacitance was rather weak in this sample due to a near-by Nb ground plane that is employed in order to reduce cross talk of the measurement lines.

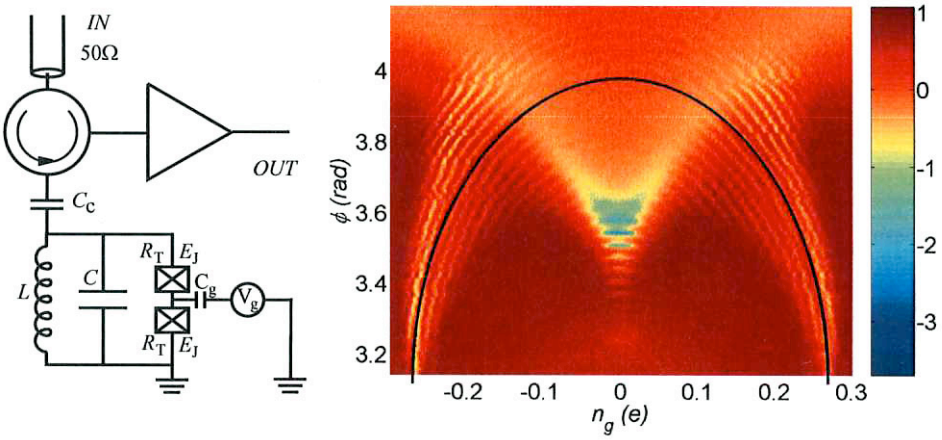

Fig. 1. Logarithmic reflection magnitude from a fully superconducting L-SET sample (illustrated on the left) measured as a function of flux bias ϕ and charge n_g (in units of electron charge e). The black half ellipsoid illustrates the band separation corresponding to the external rf-irradiation of 22 GHz. Multiphoton resonances with emission and absorption of resonator quanta are visible as parallel curves to the ellipsoid (T = 30 mK).

With the fully superconducting L-SET, we find interesting multiphoton transitions when the system is irradiated using a drive at f = 10 - 25 GHz: the flip of the qubit is accompanied by either emission or absorption of many resonator quanta. In general terms, it looks that no selection rules apply as should be the case in weakly perturbed harmonic oscillator. Further work is in progress to elucidate these phenomena.

800 MHz SQUID AMPLIFIER

D. Gunnarsson and **P. Hakonen**

High-frequency SQUID amplifiers, with a noise temperature of 100 – 200 mK, are needed in near future for various quantum measurements in mesoscopic systems. For example, they would improve the efficiency of the read-out of reactive electrometers, like the L-SET and C-SET. In collaboration with J.S. Penttilä and M. Kiviranta at VTT, we have designed a 800 MHz SQUID amplifier which can be matched to 50 Ohms using a combination of internal and external matching circuits. The production, unfortunately, has been delayed due to the conflicting manufacturing parameters as compared with those of RSFQ logic circuits, which have been the main target area over the past two years.

COULOMB BLOCKADED JOSEPHSON JUNCTION AS A NOISE DETECTOR

D. Gunnarsson, **P. Hakonen**, T. Heikkilä, A. Paila, J. Sarkar, E. Sonin, and P. Virtanen

We have employed our Coulomb blockaded Josephson junction (CB-JJ) detector to investigate the back-action noise from a capacitively coupled superconducting SET, biased into the subgap regime as well as far to the quasiparticle branch. We can well see the modulation of Coulomb blockade in the detector as the bias point of the SSET is varied over the bias vs. gate plane. We find a span of Fano factor on the order of three, which slightly exceeds what is expected for a normal SET with single electron tunnelling: $0.5 < F < 1$. We have also searched for the third moment of shot noise but

it seems that 1/*f* noise in the parameters of the device causes too much variation over the time scales needed for the observations.

BLOCH OSCILLATING TRANSISTOR

P. Hakonen, L. Korhonen, A. Puska, and J. Sarkar

We have been developing the Bloch Oscillating Transistor (BOT) for the null detector application in the closing of the quantum metrological triangle. The goal of the development work is an easily integrable device with current noise of around 1 fA/Sqrt(Hz) at an impedance level of 1 MOhm. To reach these goals, we have replaced the NIS input junction by a SIS junction biased to the gap edge. This makes it possible to manufacture BOTs using standard three angle shadow techniques, instead of the demanding four angle evaporation employed so far. Also, theoretical simulations based on time-dependent $P(E)$ theory have been performed.

TRANSPORT IN CARBON NANOTUBES

R. Danneau, **P. Hakonen**, L. Lechner, M. Tomi, T. Tsuneta, and F. Wu

In carbon nanotubes, we have mostly investigated shot noise in MWNTs and SWNTs both in the tunneling regime as well as in quantum transport regime. The current noise measurements together with conductance can be interpreted in terms of "transmission channel fingerprints" that have been a primary analysis method in the investigations of atomic point contacts. Altogether, the noise that we measure in nanotubes is too small compared with that expected on the basis of conductance measurements. The reason for this finding is unclear at present. In semiconducting samples, our results indicate that nanotube FETs are so good that they even rival SETs as the best electrometers available today. Our second main topic is proximity induced superconductivity in nanotubes. Ti/Al leads with a superconducting transition temperature of $T_C = 0.8 - 1$ K have been found to induce superconductivity in our samples with clear hysteretic behavior under current bias.

A major milestone in our carbon nanotube work was the beginning of the CARDEQ project (**CAR**bon nanotube **DE**vices at the **Q**uantum limit) which is coordinated by LTL. This EU-STREP project, with a total funding of 1.95 million Euro, started on March 1 2006, and it will last for three years. On campus, we have continued our collaboration with the group of Prof. Esko Kauppinen (at the Center for New Materials) who have provided us with good quality CVD grown SWNT samples. In addition, we are getting samples from three foreign research groups: Prof. S. Iijima (NEC), Prof. P.-E. Lindelöf (Copenhagen), and Prof. T. Wang (Beijing).

SEMICONDUCTING NANOTUBE FET

D. Gunnarsson, **P. Hakonen**, T. Tsuneta, and F. Wu

A semiconducting nanotube FET was made out of a 6-nm-diameter, 4 μm long MWNT provided by the group of Sumio Iijima. We measured shot noise of this device at 4.2 K over the frequency range 600 – 950 MHz. The trans-conductance was found to be quite ordinary, 3 – 3.5 μS, for optimal positive and negative source-drain voltages V. For the gate referred input voltage noise, we obtain 0.2 and 0.3 $\mu V/Hz^{-1/2}$ for $V > 0$ and $V < 0$, respectively. As effective charge noise this corresponds to 2 – 3 x 10^{-5} $e/Hz^{-1/2}$. Notice that this charge noise is on the same order as what typical metallic SETs have.

SUPERCONDUCTING NANOTUBE TRANSISTOR

P. Hakonen, L. Lechner, and T. Tsuneta

We have investigated gate-controlled superconductivity in diffusive multi-walled carbon nanotubes: low frequency AC conductance was measured on a MWNT contacted using superconducting leads made of Al/Ti sandwich structure. We found proximity-induced superconductivity with measured critical currents up to I_{CM} = 1.3 nA, tunable by gate voltage down to 10 pA. The supercurrent branch displayed a finite zero bias resistance which varied as $R_0 \sim I^{\beta}$ with β = 0.74. Using IV-characteristics of junctions with phase diffusion, a good agreement is obtained with Josephson coupling energy in the long, diffusive junction model of A.D. Zaikin and G.F. Zharkov.

NOISE IN SWNT SAMPLE WITH GOOD CONTACTS

P. Hakonen, T. Tsuneta, and F. Wu

We have measured shot noise in single walled carbon nanotubes (SWNT) with good contacts at 4.2 K at low frequencies (f = 600 – 850 MHz). We find a strong modulation of shot noise over the Fabry-Perot pattern; in terms of differential Fano factor the variation ranges over 0.4 – 1.2 (see Fig. 2). The shot noise variation, in combination with differential conductance, is analyzed using two (spin-degenerate) modes with different, energy-dependent transmission coefficients. No power law dependence of shot noise, as expected for Luttinger liquids, was found in our measurement. The nanotubes employed in this work were grown on campus by the group of E. Kauppinen.

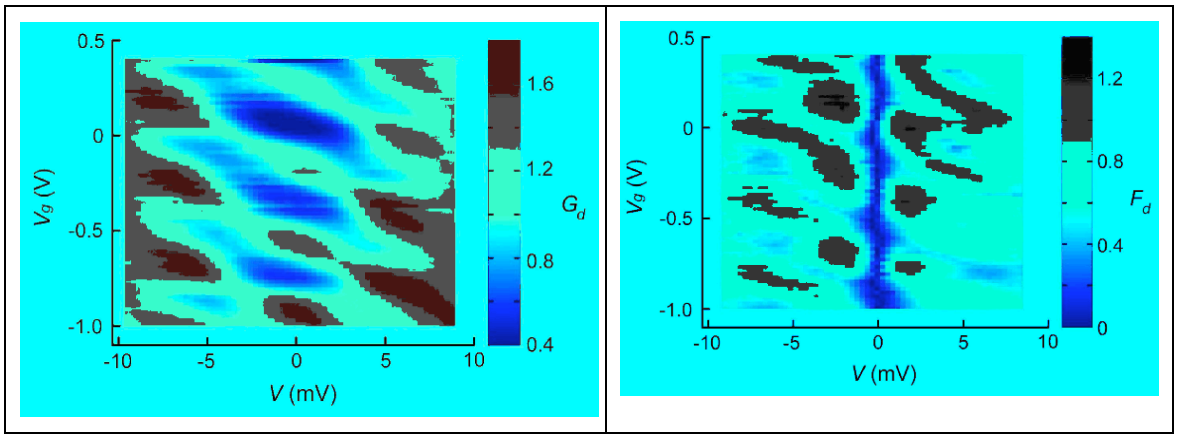

Fig. 2. a) Differential conductance on the bias vs. gate voltage plane for a SWNT sample. The conductance scale on the right is given in terms of G/G_0, where $G_0 = e^2/h$ corresponds to the conductance of one quantum channel. b) Differential Fano factor. Total F and G are obtained from these results by integration along the bias axis.

NOISE IN MWNTS

P. Hakonen, T. Heikkilä, T. Tsuneta, P. Virtanen, and F. Wu

We have investigated shot noise in many one-micron-long diffusive (CVD-grown) and semiballistic (PECVD-grown) MWNTs at 4.2 K over the frequency range 600 – 850 MHz. Our results, again, differ strongly from those expected for Luttinger liquid: we find F = 0.01 – 0.02 for free standing CVD tubes at small bias while for our on-

substrate PECVD tubes we obtain $F = 0.1 - 1$. Even though these results are not understood from the theoretical point of view, they are nevertheless good news when considering future applications of MWNT devices.

NEW LIQUID-HELIUM-FREE DILUTION REFRIGERATOR

R. Blaauwgeers and L. Lechner

In order to cope with the new demands for mK-experiments, we started in the fall of 2005 to construct a new cryostat for high frequency measurements of carbon nanotubes. This refrigerator is based on a pulse tube cooler so that no liquid helium is needed for its operation. The design has been done by Rob Blaauwgeers, who is also planning to put up a spin-off company that would sell this product commercially. The refrigerator is almost finished and 50 mK operation is expected to be reached before summer 2007.

PICO group

K. Baarman, T. Holmqvist, A. Kemppinen, L. MacDonald, M. Meschke, M. Möttönen, **J. Pekola**, J. Peltonen, O.-P. Saira, A. Savin, A. Timofeev, and J. Vartiainen

Visitors: F. Giazotto, W. Guichard, and F. Hekking

We investigate mesoscopic physics and its sensor applications. The main focus is on charge transport and thermal properties of both metallic and semiconducting nano- and microstructures. Particular research topics include electronic cooling, non-equilibrium in electronic nanostructures, (nano)thermometry, small super-conducting (Josephson) junction devices, quantized and coherent charge pumping, and noise and full counting statistics of charge transport. Samples and devices are fabricated in the clean rooms of Micronova centre for micro- and nanotechnology and of Low Temperature Laboratory, experiments at low temperatures (0.01 - 4 K) are performed likewise both in Micronova building and in the Low Temperature Laboratory.

ELECTRONIC MICRO-REFRIGERATION AND RELAXATION MECHANISMS

M. Meschke, **J. Pekola**, O.-P. Saira and A. Savin

Visitors: F. Giazotto, W. Guichard, and F. Hekking

We investigate relaxation phenomena and new electronic refrigeration methods at low temperatures down to below 50 mK. One of the key questions there is how electrons relax thermally with external heat bath and also internally. We have measured a new relaxation mechanism, electron-photon radiative coupling via a superconducting transmission line, which takes over at the very low temperatures, where electron-phonon coupling fades away.

We have studied the interplay between Coulomb effects and electronic cooling. Several new devices were proposed by us: a radio-frequency single-electron refrigerator was described, in which heat is removed by an alternating voltage at the gate, without applying external bias voltage. A DC version of this, a heat transistor, was measured and successfully characterized. A Brownian refrigerator, where, somewhat surprisingly, heat is removed by subjecting a tunnel junction to the thermal noise of a resistor was proposed and characterized.

We also try to achieve still lower temperatures by using superconductors with lower critical temperature than that of the commonly used aluminium. Thermometry at the low end of the temperature range achieved by the microrefrigerators is problematic, because no calibration can typically be reliably extrapolated into this regime: Coulomb blockade is the prime candidate to provide a way to determine temperatures in this regime.

One more line in this project is to find ways to create far from equilibrium electron energy distributions for fundamental studies but also to exploit them in refrigerator-controlled cold electron transistors.

HYSTERETIC JOSEPHSON JUNCTIONS AND DC-SQUIDS AS THRESHOLD DETECTORS OF CURRENT AND ITS STATISTICS

M. Meschke, **J. Pekola**, J. Peltonen, and A. Timofeev

Collaborator: T. Heikkilä

A Josephson junction switches from a superconducting state into a dissipative normal state when approaching its critical current. Hysteretic Josephson junctions can be used as sensitive threshold detectors to observe statistics of current, for example shot noise of mesoscopic conductors. Based on our successful experiments on the level of the second moment of noise we have now focused on higher odd moments of current fluctuations. During the past year we performed a set of experiments where, for the first time, the asymmetry of the shot noise current distribution could be detected by a Josephson junction threshold detector. The noise sources were different types of tunnel junctions. In these measurements shot noise at frequencies up to 50 GHz is observed by the on-chip detector, in contrast to conventional noise measurements where the noise source is connected to a remote detector whose bandwidth is typically much smaller. To explain the observations we developed a theoretical model which combines the effects of renonant excitation of the detector and its adiabatic response to slow current fluctuations. The model agrees with the measurements quantitatively, and simultaneously two models were proposed elsewhere whose results agree with ours within a numerical factor of order unity.

FLUX AND CHARGE CONTROLLED COOPER PAIR PUMPING

K. Baarman, A. Kemppinen, M. Möttönen, **J. Pekola**, and J. Vartiainen

Single-electron pumps are known to produce extremely accurate current sources but their yield in terms of maximum achievable current is very low, far too small to be applied in metrology. Josephson junction based Cooper pair pumps can produce larger current, but up to now they have suffered from errors, whose origins are now under investigation. We work on devices where pumping is achieved by a combined charge and flux control in a device coined “sluice”. The goals of this work are in two directions. First, there is a fundamental connection between charge pumped in an adiabatic cycle and geometric phases, in particular Berry phase. Secondly, the pumping speed and accuracy are to be optimized to make the device suitable for metrology.

We have recently measured pumped current in devices where the pump is imbedded in a superconducting loop, with another Josephson junction as a threshold detector of the pumped current in series. This allows us to observe the pumped current in a phase-biased configuration, which is needed to observe the geometric phases. In the

preliminary measurements the proof of the concept has been demonstrated, and more advanced measurements are presently going on.

In another set of experiments we optimized the sluice such that pumped currents up to 1 nA could be obtained. This is sufficient yield for a metrological pump. Now we are improving the junction configurations such that SQUIDs with better switching ratios could be inserted in a sluice in order to suppress the leakage errors. Eventually the device would serve as the current source in a metrological triangle.

SUPERCONDUCTING DIGITAL CIRCUITS - RSFQ

J. Pekola and A. Savin

Here Josephson junction control and readout circuits for very low temperature operation are being developed. We have investigated ways how to downscale the RSFQ devices to reduce heat dissipation and still maintain favourable high frequency features. We have demonstrated quantum-limited current resolution of a RSFQ comparator by this technique at sub-100 mK temperatures.

COULOMB BLOCKADE THERMOMETRY

T. Holmqvist, M. Meschke, and **J. Pekola**

Based on our long-term experience in thermal properties of mesoscopic structures and thermometry, a metrological Coulomb blockade thermometer is being developed in collaboration with Mikes. The key issue here is to find a reliable a fabrication technique for obtaining high quality opaque tunnel junctions and sufficiently large cooling fins to thermalize the device at temperatures down to 10 mK. Our recent results would indicate that the objective of a 10 mK Coulomb blockade thermometer is a realistic objective.

EXPERIMENTS ON ULTRA-SMALL NIOBIUM JUNCTIONS

J. Pekola and A. Savin

Collaborator: Yu. Pashkin, NEC Japan

Niobium single-electron transistors, embedded in an environment of long SQUID-arrays, have been fabricated at NEC by Dr. Yu. Pashkin. The idea is to test if the commonly encountered parity problems of the Nb-devices would be caused by their susceptibility to the environmental noise. Our experiments show that the Nb-devices, unlike the aluminium-based reference samples that we have measured in the same set-up, never display 2e-periodic behaviour. Several devices have been measured.

YKI group

MICROKELVIN EXPERIMENTS AT THE YKI-CRYOSTAT

Elias Pentti, Juho Rysti, Anssi Salmela, Alexander Sebedash, and **Juha Tuoriniemi**.

Two main themes were under investigation in the YKI group: superconductivity in lithium metal at the ambient pressure and technical improvements for the adiabatic melting experiment to cool dilute mixtures of helium isotopes to extremely low temperatures.

Superconductivity in lithium was unambiguously observed for the first time at the ambient pressure. The critical temperatures for our samples varied from 0.15 mK to

0.4 mK. These are the lowest observed transition temperatures for any superconductor, comparable with those of rhodium only. Interestingly, in the meantime elsewhere compressed lithium was observed to become superconducting at temperatures as high as 20 K. This, on the other hand, is the highest transition temperature for any element. The extremely high pressures in those experiments are sufficient to radically alter the conduction-electron band structure in this light alkali metal. Both of these observations are likely to rise wide attention. Lithium, being the simplest metallic system imaginable, offers good chances to theoretically trace down the essential factors determining the wide ranges of critical temperatures encountered. What is of most interest to our work, this finding finally opens up the possibility to explore the true competition between nuclear magnetism and superconductivity, as the relevant energy scales of those two distinct ordering phenomena in the two interpenetrating systems of the solid matter favorably match in this case.

The other experiment mounted on our cryostat this year was aiming to solve the shortcomings in the adiabatic melting experiment run in the previous year. We had a simplified pressure chamber with multiple superfilter filling lines to sort out the problems related to transmitting superfluid ^{4}He in and out of the cell above the melting pressure of pure ^{4}He. The three lines had somewhat different packing with silver powder and jeweler's rouge powder, and only one of them seemed to be capable of sustaining superflow with the desired rates. The new mounting of the pressure gauge for the melting curve measurements was also tested and the gauge was, in fact, used for real melting curve measurements as the function of the ^{3}He concentration during this run. We took advantage of the small size of our present experimental cell to perform solubility curve measurements for the mixtures as the function of pressure to improve the accuracy and range of earlier measurements. The limiting solubility is one of the most essential parameters of this experiment, and it was relatively poorly known at the melting pressure of the mixture. We were also able to study the phenomenon of supersaturation and the occurrence of the macroscopic quantum nucleation of the concentrated ^{3}He phase from such supersaturated solutions. Systematic observations of that had not been made above 10 bar pressure before. For a number of these measurements we employed the novel technique utilizing a quartz tuning fork resonator immersed in the helium fluid. The easy and affordable accessibility, the simplicity of the measurement and the excellent quality of the data gives good prospects for much wider utilization of such probes for a variety of measurements in the physics of helium liquids.

ROTA group

V. Eltsov, R. de Graaf, P. Heikkinen, J. Hosio, R. Hänninen, J. Kopu, **M. Krusius,** T. Ruokola, and R.E. Solntsev

Visitors: S. Boldarev, Yu.M. Bunkov, T. Chagovets, A. Golov, R.P. Haley, V. L'vov, M. Tsubota, E. Thuneberg, D. Zmeev, and H. Yano

DYNAMICS IN COHERENT QUANTUM SYSTEMS

Since 2002 this research effort has been concerned with the investigation of superfluid hydrodynamics in the intermediate temperature regime $0.4 - 0.6\,T_c$ of the isotropic helium superfluid ^{3}He-B. In 2006 we have moved to lower temperatures towards the ultimate goal – hydrodynamics in the zero temperature limit. The purpose is to exploit the properties of an unexplored superfluid – namely the isotropic fermion

superfluid ^{3}He-B – in combination with new measuring principles and techniques. This approach has proven to create fundamental new insight in the dynamics of coherent quantum systems.

INTERMEDIATE TEMPERATURES

In ^{3}He-B the damping of the motion of quantized vortex lines is a strong function of temperature. This damping is known as mutual friction dissipation which arises when a vortex (which is part of the superfluid condensate fraction) moves with respect to the cloud of normal excitations. Mutual friction controls the dynamic response of vortex lines: With large friction at high temperatures the response is rapid and regular. When friction decreases towards low temperatures, vortex motion becomes less stable, Kelvin-wave excitations appear on the lines, and the influence of nonlinear interactions increases between vortices and between a vortex and the solid boundaries which are containing the fluid.

The intermediate temperature range below $0.6\,T_c$ is distinguished by the first appearance of superfluid turbulence – a sudden transition which takes place as a function of mutual friction and, surprisingly, is independent of flow velocity above some low threshold. This transition was discovered and identified in 2002-03. Our later studies have focused on the mechanisms by which the motions of a single quantized vortex in applied flow lead to the formation of a second independent vortex and ultimately, when enough vortices have formed and their interactions become possible, to turbulence. This happens below $0.6\,T_c$, but in most situations above $0.4\,T_c$. The first reports on this work were published in 2006.

LOW TEMPERATURES

In parallel with these investigations our measuring equipment, the rotating sub-millikelvin refrigerator, has been rebuilt during the recent years. As a result lower temperatures can now be achieved than before and in 2006 we started measurements in the regime $0.15 – 0.4\,T_c$. This work is concerned with vortex dynamics in this range where the quasiparticle mean free path approaches and eventually exceeds the sample dimensions so that the excitations are in ballistic flight. Here mutual friction dissipation approaches zero proportional to $\exp(-\Delta/k_B T)$ and a new question arises: Is the dissipation in vortex motion also approaching zero or do other mechanisms of dissipation exist which dominate over the vanishing mutual friction?

In a rotating column turbulence appears as a sudden burst which leaves behind the vortices needed to establish the rotating equilibrium state. From the location where the burst takes place, the vortices expand as a front in both directions along the column (Fig. 1). On an average the front travels as a time-invariant self-similar structure at a steady velocity which can be determined from the flight time measured between two NMR pickup coils along the column. In this way the initial rotating vortex-free state with large kinetic energy is replaced by a twisted vortex bundle which is already close to the final equilibrium state, except for its spiraling configuration of vortices which still has to relax to an equilibrium array of rectilinear lines. Thus the large energy difference across the propagating front is consumed by the dissipation in vortex motion within the front which in this way can be measured as a function of temperature (Fig. 2).

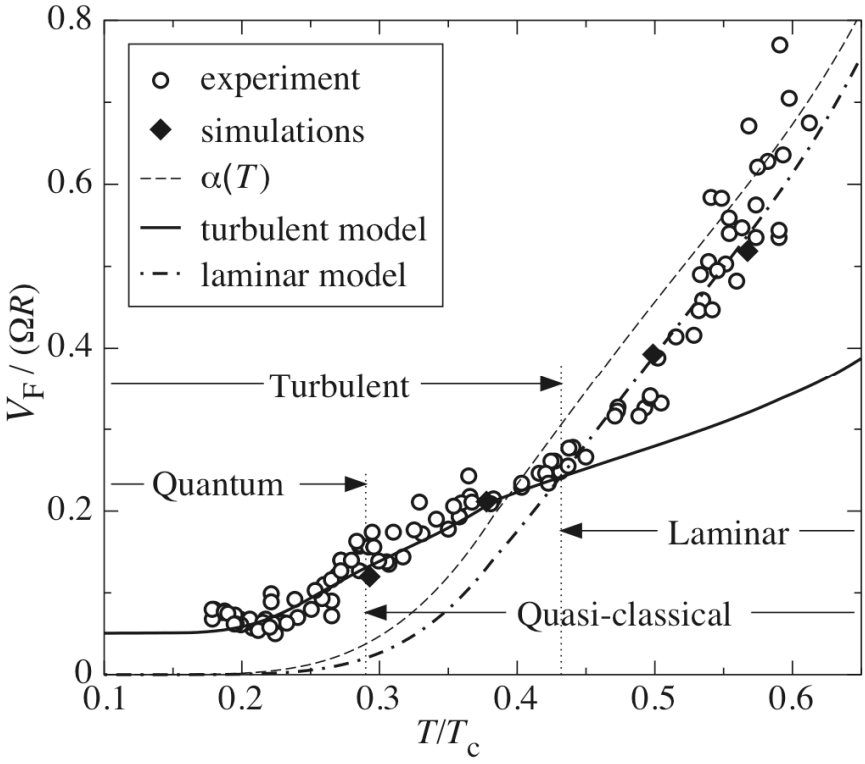

Fig. 1. Numerical calculation of vortices propagating upward along a rotating column with a solid bottom plate. Topmost *on the left* we see the sharp vortex front, followed by the twisted vortex bundle where the amount of turbulent disorder and helical spiral decreases with distance downward from the front. *On the right* we see the velocity components of the superfluid fraction, the longitudinal velocity v_{sz} and the azimuthal $v_{s\phi}$. The former is caused by the twisted configuration of the vortices. The latter arises from the polarization of the vortices along the rotation axis, which brings the superfluid component in solid-body rotation with the container walls and the normal component. The calculation has been performed on a cylinder with radius R = 1.5 mm at an angular rotation velocity Ω = 1 rad/s and a temperature $T = 0.28\ T_c$.

In Fig. 1 we see a numerical calculation of the propagating vortex front at 0.3 T_c and the twisted vortex bundle behind it. Because of the presence of both a dissipative and a reactive mutual friction force, the front rotates around the column simultaneously as it travels upwards. The spiral motion leaves the vortices behind the front in a helically twisted state. The twist is most clearly visible in Fig. 1 in the configuration of the peripheral outermost vortices in the bundle. In this calculation the column is closed off at the bottom with a solid end plate. Towards the bottom end plate the twist gradually relaxes. The longitudinal superflow component v_{sz} is generated by the twist and is seen to decrease towards the bottom end plate. The twist is continuously unwound by a sliding motion of the vortices along the end plate, both in order to maintain the boundary condition and to relax from the twisted state towards the ultimate final stable state of rectilinear lines. A most interesting feature in this calculation is the increasing turbulent disorder in the vortex line configurations when one follows them from the bottom end plate to the front.

The turbulence is largest at and behind the front and increases towards low temperatures. Rotating flow provides a strong stabilizing effect on vortices via its preference for their polarization along the rotation axis. For this reason reconnections among vortex lines are reduced and a strongly tangled configuration of lines does not

develop, in contrast to what we know about superfluid turbulence in its most well-known form, in thermal counterflow of superfluid ^{4}He.

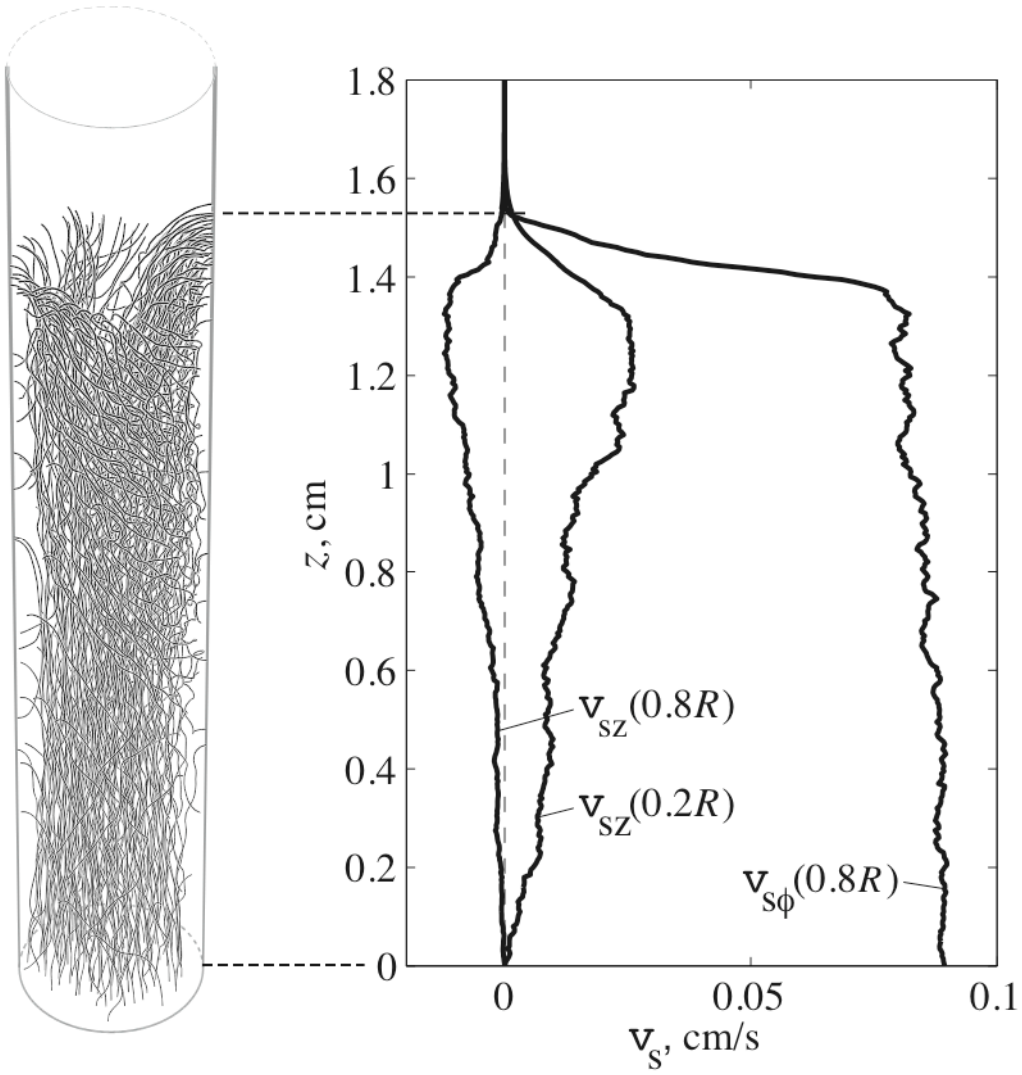

Fig. 2. Normalized velocity V_F / (ΩR) of the vortex front in the rotating column. The data points originate from NMR measurements of the flight time of the front. The curves represent theoretical models of the total dissipation which is controlled by different mechanisms over the different sections of temperature (which appear with a descriptive characterization in the plot).

In Fig. 2 the longitudinal propagation velocity of the vortex front is plotted as a function of temperature. These results provide the first direct experimental information on the dissipation in the motion of an interacting cluster of vortices, measured non-invasively from outside the rotating column over a wide temperature range. The new features are the two regions where the dissipation levels off with decreasing temperature. The first region of reduced temperature dependence just below 0.4 T_c is interpreted to arise from the development of the turbulent layer behind the front, which is apparent in Fig. 1. The second plateau below 0.2 T_c could represent a residual low temperature limit caused by Kelvin wave excitations which populate the moving vortex lines. The theoretical explanation and the fits to the measured results in Fig. 2 have been worked out by V. L'vov. In working out the understanding of these phenomena the third tool, in addition to experiment and analytical theory, is numerical simulation by means of vortex dynamics calculations. This work is carried out by R. Hänninen.

TURBULENCE IN THE BALLISTIC REGIME

Much of our joint research with the visitors has centered on a project to explore quartz tuning forks as sensors of vortex lines in rotation. Quartz tuning forks are commercial 32 kHz oscillators which are used as frequency standards in watches. Immersed in a superfluid ^{3}He bath they can be used as sensitive thermometers, especially in the temperature range of ballistic quasiparticle flight. For accurate and reproducible thermometry in the low temperature limit this has been of great importance and – next to the newly rebuilt refrigerator – is the second technical feature which has now made the low temperature regime attractive. The third step forward is promising advances in measuring methods.

The response of the tuning fork as a function of its excitation has been studied, both by recording its own signal output as well as by using a nearby second fork as sensor. This understanding is needed to evaluate the possibilities of using the fork as a detector of vortices. Promising signals have been identified, but a rigorous interpretation about their origin is still missing. This approach is of most interest in the ballistic temperature regime where the fork – with a direct reading of the quasiparticle density – is most useful. In the course of this work it has turned out that the ^{3}He-B order parameter texture and its NMR response also change with temperature below 0.3 T_c, although at first sight it could be assumed that the NMR absorption spectrum would settle to a temperature independent limiting line shape at these very low temperatures. By increasing the NMR polarizing field and the detection sensitivity, it seems now possible to extend our NMR techniques deep into the ballistic regime. This method is based on the sensitivity of the NMR absorption line shape on the presence of vortex-free flow. Finally, both NMR and fork measurements indicate that below 0.35 T_c a state of continuous turbulence can be created and studied in the presence of rotation with a time dependent angular velocity. Thus the low temperature limit appears to be a promising regime for new studies in the near future.

INTERFACE group

INTERFACES IN QUANTUM SYSTEMS

H.Alles, H. Junes, M. Manninen, and I.A. Todoshchenko

Visitors: J. Bueno, A.Ya. Parshin, and V. Tsepelin

Helium crystals provide a good model system for verification of different theoretical concepts concerning the study of all crystal surfaces and on top of that they have several interesting properties related to their quantum nature. During recent years the Interface group has been studying optically the shape and growth dynamics of ^{3}He crystals along their melting curve from the temperature of several hundreds of mK down to 0.5 mK. However, very recently the Interface group has completed very accurate measurements on the melting curve of ^{4}He. These measurements were undertaken in order to search for an evidence of superfluidity of solid ^{4}He below 0.2 K, as reported by US scientists Chan and Kim [Nature **427** (2004) 225; Science **305** (2004) 1941]. We have been able to measure the melting curve of ^{4}He in the temperature range from 400 mK down to 10 mK with the accuracy of about 0.5 μbar and we did not observe any sign of a supersolid transition [Phys. Rev. Lett. **97** (2006) 165302]. Our results are consistent with other studies, both experimental and theoretical, which have led to the conclusion that the phenomenon discovered by Chan and Kim and interpreted as the superfluidity of solid ^{4}He, is not due to intrinsic properties of solid ^{4}He and could be rather due to defects which have formed when the samples were created.

Next, we will concentrate on a search of new facets (smooth flat parts of the crystal surface) on ^{4}He crystals. The crystals will be imaged with a unique low-temperature Fabry-Pérot type interferometer with which we have obtained several original results in past when studying ^{3}He crystals. One of them is the discovery of more than ten different types of facets on the surface of a ^{3}He crystal. Theoretically, the lower the temperature, the more facets should be seen on the surface of crystals, but in the case of ^{4}He crystals only three types of facets have been found. In addition, we would like to investigate different growth mechanisms in ^{4}He crystals.

At the same time, we will prepare for further experiments with ^{3}He crystals. With our present experimental cell we have been able to cool ^{3}He crystals only down to 0.5 mK. During 2007, a new experimental cell will be constructed with which we hope to reach at least 0.2...0.3 mK. In this temperature range weakly damped crystallization waves (melting-freezing waves) are predicted to propagate on the superfluid-solid interface of ^{3}He. These waves have been observed in ^{4}He, but, if discovered in ^{3}He, they will be very unique due to their magnetic nature which is absent in ^{4}He. Our new cell will be designed in this way that we can also apply a magnetic field to the sample.

THEORY group

SPIN SUPERFLUIDITY

G. Volovik

Collaborators: Yuriy Bunkov (CNRS, France), Victor Lvov (Weizmann, Israel)

Homogeneous precession of magnetization in superfluid 3He-B is the first example of the Bose condensation of magnons in condensed matter physics [1]. This phase coherent precession has all the property of superfluidity of spins. These include in particular: spin supercurrent which transports the magnetization (analog of the mass current in superfluids and electric supercurrent in superconductors); spin current Josephson effect and phase-slip processes at the critical current; and spin current vortex -- a topological defect which is the analog of a quantized vortex in superfluids and of an Abrikosov vortex in superconductors. In 3He-B, this Bose condensate of magnons becomes unstable at very low temperature due to the parametric instability towards radiation of longitudinal spin waves [2,3]. Instead a new state of the coherent precession emerges, which has a close analogy with the Q-balls – compact objects discussed in elementary particle physics [4].

NOVEL SUPERFLUIDITY OF 3HE IN AEROGEL

G. Volovik

Collaborator: Yuriy Bunkov (CNRS, France)

Superfluid 3He-A confined in aerogel provides the first example of anisotropic superfluids, in which the long-range orientational order is destroyed by quenched random anisotropy [5]. In aerogel the random local anisotropy is produced by randomly oriented silicon strands. It is also shown that the long-range order is restored when the aerogel is sufficiently deformed. This new superfluid state will allows us to investigate new phenomena. In particular, as distinct from pure 3He-A the half-quantum vortices are stabilized in the deformed aerogel. Also the geometry of the deformed aerogel stabilizes the spin superfluidity in 3He-A -- Bose condensation of magnons, which never occurs in pure 3He-A.

QUANTUM TURBULENCE

G. Volovik

Collaborators: Sergey Nazarenko (Warwick, UK), ROTA group

Recent progress in the area of turbulence of quantized vortices, which has been obtained mainly due to the activity of the LTL, is summarized in the review papers [6], [7] and in the preface to the proceedings of the workshop on quantum and classical turbulence [8].

TOPOLOGICAL NODES IN QUASIPARTICLE SPECTRUM AND QUANTUM PHASE TRANSITIONS

G. Volovik

Many quantum condensed matter systems are strongly correlated and strongly interacting fermionic systems, which cannot be treated perturbatively. However, physics which emerges in the low-energy corner does not depend on the complicated details of the system and is relatively simple. It is determined by the nodes in the

fermionic spectrum. These nodes may occur either due to symmetry or as random nodes. The latter means that that their position in momentum space is not determined by symmetry but still they are not destroyed by perturbations. The reason for the stability of the random nodes is that they are protected by topology in momentum space. That is why in superconductors can exist stable Fermi points, Fermi lines and even Fermi surfaces. Close to the nodes the behavior of the system becomes universal, and the universality classes are determined by the toplogical invariants in momentum space. When one changes the parameters of the system, the transitions are expected to occur between the vacua with the same symmetry but which belong to different universality classes. Different types of quantum phase transitions governed by topology in momentum space have been discussed in [9], [10] and [11]. The consideration based on the momentum space topology of the Green's function is general and thus is also applicable to the vacua of relativistic quantum fields [1].

CONNECTION TO COSMOLOGY AND PARTICLE PHYSICS

G. Volovik

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There are fundamental relations between three vast areas of physics: particle physics, cosmology and condensed matter. These relations constitute a successful example of the unity of physics. Fundamental links between cosmology and particle physics, in other words, between macro- and micro-worlds, have been well established. There is a unified system of laws governing all scales from subatomic particles to the Cosmos and this principle is widely exploited in the description of the physics of the early Universe, baryogenesis, cosmological nucleosynthesis, etc. The connection of these two fields with the third ingredient of the modern physics – condensed matter – is the main goal of our program. These connections allow us to simulate the least known features of high-energy physics and cosmology: the properties of the quantum vacuum.

One of the main problems is the construction of quantum gravity. It appears that the problem of quantization of classical Einstein equations is very similar to the problem of quantization of classical hydrodynamic equations. However, classical hydrodynamics has known microscopic background. In other words, the corresponding quantum vacuum is well known in condensed matter systems. This allows us to judge using the condensed matter experience which classes of quantum gravity theories are most promising [4].

The other connections are Q-balls [4]; event horizons [13]; cosmological constant and vacuum energy [14]; and classification of relativistic quantum vacua in terms of momentum space topology [10]. The latter is now used for the development of a new scenario of neutrino oscillations in terms of the phenomenon of splitting of Fermi points.

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NONEQUILIBRIUM PROPERTIES OF MESOSCOPIC SUPERCONDUCTORS

N.B. Kopnin

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The theory of single-electron transport in Andreev wires, *i.e.* in normal conductors surrounded by a superconducting environment, has been developed. Vortices in type II superconductors and the filamentary intermediate state of type I superconductors in addition to artificially fabricated SN heterostructures are examples of such Andreev wires. Like in usual conductors, single electron transport in Andreev wires is associated with transverse modes in the normal region, though with much smaller group velocity. In disordered Andreev wires with a long mean free path, the ballistic

transport changes to diffusion. In addition to the known Andreev diffusion decreasing with an increase in the mean free path, the heat conductance includes a diffusive drift along the Andreev states produced by a small particle-hole asymmetry. The drift contribution increases with increasing mean free path, and the conductance has a minimum, leading to a peculiar re-entrant localization of transport as a function of the mean free path [1].

Quantum pumping in mesoscopic structures offers a unique possibility to study and directly manipulate fundamental quantum characteristics of nanoscale devices. Usually, quantum pumps use adiabatic processes which avoid relaxation believed to smear out the quantum behaviour. We have worked out [2] a novel realization of nonequilibrium resonance charge pump through a superconductor-insulator-normal-insulator-superconductor (SINIS) junction. This realization essentially involves both the discrete level dynamics based on adiabatic variation of normal and Andreev scattering parameters of SN contacts and relaxation in continuum the latter being of crucial importance for pumping process. The dc current (pumped charge) exhibits giant peaks at rational bias voltages if the chemical potential of the normal conductor is varied in certain compliance with the Josephson frequency. The dc current peaks greatly exceed the rectification current (Shapiro steps) observed in the equilibrium state of the same junction, thus providing unambiguous manifestation of the quantum pumping effects.

STRUCTURE AND DYNAMICS OF SUPERFLUID HE-3

N.B. Kopnin

Recent new developments in superfluid hydrodynamics are reviewed [3]: (1) the interplay of different vortex structures at the first order interface between the two major superfluid He-3 phases, He-3 A and He-3 B; (2) the shear flow instability of this phase boundary, which is now known as the superfluid Kelvin-Helmholtz instability; (3) the hydrodynamic transition from turbulent to regular vortex dynamics as a function of increasing dissipation in vortex motion; and (4) the peculiar propagation of vortex lines in a long rotating column which even in the turbulent regime occurs in the form of a helically twisted vortex state behind a well-developed vortex front. The consequences and implications of these observations are discussed, as inferred from measurements, numerical calculations, and analytical work.

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NONEQUILIBRIUM AND THERMOELECTRIC EFFECTS IN NORMAL-SUPERCONDUCTING HETEROSTRUCTURES

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We have studied theoretically different types of thermoelectric and nonequilibrium effects in mesoscopic superconductor – normal-metal (S-N) heterostructures. A review written by some of us on such effects and their connection to different device concepts, such as thermometry and radiation detection, was published in Reviews of Modern Physics in March 2006 [1]. During the 2006, we have extended these studies in various directions. In collaboration with experimentalists from the Michigan State University, we showed that supercurrent can be used to tune the nonequilibrium electron energy distribution function, leading a Peltier-type effect [2]. A real Peltier effect in these devices is also attainable [s1] due to the superconducting proximity effect. Although at sub-Kelvin temperatures it may lead to cooling effects of the order of a few mK at maximum, it is still orders of magnitude larger than the analogous effect without proximity effect. We have also collaborated with the experimental group of Prof. Victor Petrashov from the Royal Holloway University of London, to study the properties of thermopower in superconducting proximity systems [s2]. In addition, we have investigated nonequilibrium effects in small superconducting islands [s3]. In particular, tuning the state of the electron system inside the superconductor allows one to vary the critical supercurrent of additional junction(s) connected to the island. This structure hence works as a transistor. The nonequilibrium or quasiequilibrium state of such structures generally depends on different types of relaxation mechanisms. At very low temperatures, the relaxation is dominated by the coupling between the electrons to the electromagnetic environment of the island. Starting from a microscopic description of such a coupling, we have rigorously derived an expression for the heat flow between electrons and photons [s4].

QUANTUM SYSTEMS, CURRENT FLUCTUATIONS AND THEIR MEASUREMENT

T. T. Heikkilä, T. Ojanen, and P. Virtanen

Collaborators: the NANO and PICO groups, P. Samuelsson (Lund University, Sweden), M. P. Stenberg, and V. Bergholm (Laboratory of Physics, TKK)

We have studied the nature of current fluctuations and their statistics and especially their measurement in mesoscopic systems. Starting from a microscopically derived quasiclassical approach, we have constructed a circuit theory of nonequilibrium current noise for incoherent mesoscopic systems [3]. In the case where an arbitrary number of superconductors at zero voltage is connected to a biased normal metal, we have also worked out a similar theory for the auto and cross correlations of the current, and in particular for their dependence on the supercurrent flowing between the superconductors [s5]. Concerning current statistics, we have investigated how the third cumulant of current fluctuations affects the Coulomb blockade [4], and how its magnitude and frequency dependence can be accessed via the quantum transition rates [5,s6]. The latter work illustrates how the effects of proper quantum-mechanical

ordering of the current operators is relevant when treating higher-order cumulants. Together with the PICO group, we have studied how the non-Gaussian noise affects the escape process of a Josephson junction [s7]. Besides the relaxation effects characterized by the transition rates, we have studied the dephasing of quantum two-level systems (quantum bits) under classical and quantum-mechanical environments [s8], and shown how, in representative particular cases, the two models can be mapped to each other.

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BRAIN RESEARCH UNIT

At the Brain Research Unit of the Low Temperature Laboratory, we address human brain functions at systems level, mainly by applying non-invasive brain imaging methods that we continuously sharpen. We design and construct stimulation and monitoring devices to create as-natural-as-possible environments for experimentation on problems of systems neuroscience. We also create well-controlled stimuli for probing selected sensory subsystems and for testing predictions from computational models.

Within this framework, we study functions of the human cerebral cortex by measuring weak magnetic fields outside the head. This method, magnetoencephalography (MEG), allows a totally non-invasive view into healthy and diseased human brains during different tasks and conditions. Our 306-channel neuromagnetometer (Vectorview, Neuromag Ltd), functional since 1998, houses 204 gradiometers and 102 magnetometers with a whole-scalp coverage. To combine functional and structural information, we typically integrate MEG data with the subject's magnetic resonance images (MRIs).

In 2006, we have continued to work extensively on MEG characterization of human sensory, motor, cognitive and language functions, both in healthy and diseased brains. In addition, we have used functional magnetic resonance imaging (fMRI) at the Advanced Magnetic Imaging (AMI) Centre of TKK. FMRI with its excellent spatial resolution complements the superb temporal resolution of MEG in tracking activation patterns and sequences in the human brain and allows accurate functional identification of brain areas. The AMI Centre operates a 3 Tesla MRI/fMRI superconducting magnet (General Electric 3T Signa) for whole-body imaging, and we continued to be the largest single user group of the Centre in 2006.

From the beginning of 2006, we constitute the core of the Center of Excellence on Systems Neuroscience and Human Brain Imaging, appointed by the Academy of Finland for years 2006–2011.

MEG AND FMRI STUDIES

AUDITORY, TACTILE, VISUAL, MULTISENSORY AND MOTOR PROCESSING

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Audiotactile interaction: In daily life, humans typically process stimuli of more than one sensory modality at the same time; one poorly understood example is audiotactile interaction. We have now shown, using auditory and vibratory stimuli during both MEG and fMRI recordings, that auditory and tactile inputs converge to the posterior auditory belt area in the superior surface of the temporal lobe.

Deactivation of the ipsilateral SI: The whole human primary somatosensory (SI) cortex is activated by contralateral tactile stimuli, but we have observed a transient deactivation of area 3b of the ipsilateral SI during long-lasting tactile stimulation. FMRI data were collected from 10 healthy adult subjects while tactile pulses were delivered in 25 s blocks to three right-hand fingers. In the contralateral SI cortex, activation [positive blood oxygenation level-dependent (BOLD) response] outlasted the stimulus blocks by 20 s, with an average duration of 45 s. In contrast, a transient deactivation (negative BOLD response) occurred in the ipsilateral rolandic cortex with an average duration of 18 s. This deactivation was not limited to the right SI but always occurred in the SI cortex ipsilateral to the stimulated hand. Moreover, the primary motor cortex (MI) contained voxels that were phasically deactivated in response to both ipsilateral and contralateral touch. — Unilateral touch of fingers is therefore associated, in addition to the well known activation of the contralateral SI cortex, with deactivation of the ipsilateral SI cortex and of the MI cortex of both hemispheres. The ipsilateral SI deactivation could result from transcallosal inhibition, whereas intracortical SI–MI connections could be responsible for the MI deactivation. The shorter time course of deactivation than activation would agree with stronger decay of inhibitory than excitatory postsynaptic potentials at the applied stimulus repetition rates.

Removal of artifacts: Magnetic interference signals often hamper analysis of neuromagnetic measurements. Artifact sources in the proximity of the sensors cause strong and spatially complex signals that are particularly challenging for the existing interference-suppression methods. We have demonstrated the performance of the temporally extended signal space separation method (tSSS) in removing strong interference caused by external and nearby sources. We recorded auditory evoked fields by artificially produced additional external interference by rotating small magnets and by nearby artifacts produced by a piece of magnetized wire on the subject's lip. After tSSS processing, even the single-trial auditory responses had a good enough signal-to-noise ratio for detailed waveform and source analysis.

CliniMEG: The activities of the 'CliniMEG' team, established at the Brain Research Unit in 1997, have since 2001 been gradually moved to the Department of Clinical Neurosciences at the Helsinki University Central Hospital. However, development of clinical applications and studies of different patient groups has continued in collaboration with colleagues at the hospital.

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PATHOPHYSIOLOGY OF ACUTE AND CHRONIC PAIN

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Chronic pain is a serious problem in clinical medicine. We have selectively stimulated with laser pulses the two nociceptive fibre systems, Aδ- and C-fibres, that correspond to the first and second pain. The first clinical tests compared cortical responses to these stimuli in patients suffering from chronic regional pain syndrome and from hemi-body pain related to recurrent herpes simplex virus infections.

We have applied, during fMRI recordings, thermal stimuli to the right and left hands with two 16 mm x 16 mm Peltier thermodes. Reponses to painful stimuli (temperatures about 47°C) vs non-painful heat stimuli (42°C) were compared both in healthy control subjectts and in patients suffering from chronic pain.

In the healthy control subjects, thermal pain activated the well-known pain circuitry in both hemispheres, including the insular cortex (IC), the secondary somatosensory cortex (SII), the striatum, and the anterior cingulate cortex (ACC). The analysis of the patients' data still continues.

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VISUAL PHYSIOLOGY AND PATHOPHYSIOLOGY

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About thirty distinct functional areas in each hemisphere participate in vision. Routing of information in this system is dynamic and processing effective. We are studying the early phase of visual processing and hope to better understand the relation between measured imaging signals, visual behaviour, and biological image analysis. We also hope to distribute knowledge to clinicians and help development of biologically inspired mechanical applications of vision.

We have developed multifocal fMRI together with Andrew James, from ANU. This method allows rapid mapping, localization, and quantification of local visual responses in the retinotopic areas. Our toolbox for generating the stimuli was recently published at the web site of Statistical Parametric Mapping. We have found that *(i)* peripheral vision can be studied with fMRI at low cost, by introducing an optical aid for near-view of the back-projection display. *(ii)* Neighbouring visual field representations in the primary visual cortex show non-linear interaction which is of neural origin. Multifocal fMRI provides an efficient tool to explore the nature of this interaction. *(iii)* Saccades and blinks activate peripheral V1 in total darkness, suggesting that central and peripheral vision may serve functionally different subsystems. *(iv)* Together with earlier evidence from other laboratories, the distinct spatial distribution of signals in human V1 from the two chromatic retinocortical channels suggest that they have different evolutionary origins. The blue-yellow channel is very old, premammalian, whereas the red-green channel has coevolved on top of high-resolution achromatic P-channel in primates.

Homonymous visual field defects are due to posterior cerebral damage, and are relatively common in elderly population.

Together with Antti Raninen, Lea Hyvärinen and Risto Näsänen, we have provided evidence that chronic cerebral blindness can be rehabilitated in elderly people, and show profound plastic changes which are due to long and intensive rehabilitation. These changes manifest as increased sensitivity of the blind field to visual stimuli, and most likely occupy a secondary pathway from the retina to cortex. In addition, these changes occupy low-level visual cortices, which have been suspected not to

have capacity for major plasticity. Together with evidence from other recent studies, these findings suggest that a large-scale rehabilitation program would benefit several persons per mille of the Western population.

After recent installation of video eye tracking system in fMRI, we have now the possibility to search for correlates of visual attention and saccade planning in the primary visual cortex. We found that the sensory response and response to attention have different topologies in the V1, suggesting that they originate from different subsystems.

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Published as SPM toolbox at http://www.fil.ion.ucl.ac.uk/spm/ext/#multifocal

BRAIN BASIS OF SOCIAL INTERACTION

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Visitors: M. Hesse, M. Longcamp, M. Schürmann, A. C. de C. Williams

Collaborators:

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Proper interpretation of the intentions of our fellow human beings is an essential ability for successful communication in the society. To explore *brain basis of intersubjective understanding*, we quantified rhythmic brain activity from subjects who were performing, seeing, or hearing the tapping of a drum membrane with the right index finger. In the actor's primary motor cortex (M1), the level of the ~20-Hz

brain rhythms started to decrease ~2 s before the action and then increased with a clear rebound peaking ~0.6 s after the tapping. A very similar time course occurred in the MI cortex of the observer: the ~20-Hz level started to suppress, although less vigorously than in the actor, on average 0.8 s before the action and was followed by a rebound that peaked with a similar latency and amplitude than after own action. When the subject just heard the tapping sound, no pre-action activation was visible in the M1 cortex, but a clear rebound, 60% of that observed during own action, peaked after the tap. The observed strikingly similar motor-cortex reactivity during the 1st and 3rd person actions expands previous data on brain mechanisms that support intersubjective understanding.

Reactions to action traces: Humans are able to recognize handwritten texts accurately despite the extreme variability of scripts from one writer to another. This skill has been suggested to rely on the observer's own knowledge about implicit motor rules involved in writing. To investigate the possible neural correlates of such an ability, we monitored with magnetoencephalography (MEG) the ~20-Hz oscillations originating from the motor cortex. The oscillations were more suppressed after visual presentation of handwritten than printed letters, indicating stronger excitation of the motor cortex to handwritten scripts. These results support the idea of embodied visual perception of handwritten scripts and the involvement of the motor cortex in the underlying action–perception link.

Reactions to sounds of walking: Sounds of human footsteps carry a vast amount of social information, which is often unconsciously noted. Using functional magnetic resonance imaging (fMRI), we now show that hearing two persons walking together activates a more widespread brain network than does hearing one person’s footsteps, which activated the left superior temporal sulcus and the left amygdala. Listening to two persons walking together activated brain areas more commonly associated with affective states and social interaction, such as the subcallosal gyrus bilaterally, the right temporal pole, and the right amygdala. These areas seem to be involved in the analysis of complex auditory social scenes. Intriguingly, single footsteps activated only the posterior STS region, suggesting that processing single vs. double actions are based on separate circuitries in the brain.

Competition among peers affects our decisions in everyday life. A buyer who bargains over a price with a seller may change his behaviour as soon as a second buyer appears on the scene. A single buyer who considers an offered price too high can always deprive the seller of his profit by rejecting the offer. With multiple buyers, such behaviour is risky as a competing buyer might accept the seller's offer. To succeed in rivalrous situations, the buyer tries to predict his competitor’s behaviour by forming beliefs about his thoughts and intentions, a process referred to as mentalizing. — We used fMRI to study brain mechanisms on which decisions under competition rely. While bargaining over a given amount of money, subjects struck a balance between maximizing personal profit and punishing unfair individuals whose offers they could accept or reject. Competition biased the subjects' decisions towards acceptance, but only when the stake on offer was attractive enough. This behavioural effect corresponded to offer-size-specific brain activation in the temporo-parietal junction (TPJ), a brain area known to be engaged when subjects attribute mental states to others. Our results imply intensified mentalizing when the competitor’s behavior is most difficult to predict and when the rewards justify the effort.

Publications

Caetano G, Jousmäki V and Hari R: Actor's and viewer's primary motor cortices stabilize similarly after seen or heard motor actions. *Proc Nat Acad Sci USA* (published in 2007).

Halko M-L, Hlushchuk Y, Hari R and Schürmann M: Mentalizing-related brain activity during financial competition reflects what is at stake. *Submitted.*

Hari R: Action–perception connection and the cortical mu rhythm. *Progr Brain Res* 2006, 159: 253–260.

Hari R: Ihmisaivojen peilautumismisjärjestelmät. Katsausartikkeli. *Duodecim* in press.

Hari R: Ovatko ajatukset aivoissamme? *TIETEESSÄ TAPAHTUU* 2006, 3: 28–30.

Hari R: Sosiaalisen vuorovaikutuksen aivoperustasta. Kirjassa *Mieli ja Aivot. Kognitiivisen neurotieteen oppikirja* (toim H Hämäläinen, M Laine, O Aaltonen ja A Revonsuo). Gummerus 2006, Luku 8.2, ss 399–405.

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Longcamp M, Tanskanen T and Hari R: The imprint of action: Motor-cortex involvement in visual perception of handwritten letters. *Neuroimage* 2006, 33: 681–688.

Saarela MV and Hari R: Listening humans walking together activates the human social brain circuitry. *Social Neurosci* under revision.

Saarela MV, Hlushchuk Y, de C Williams AC, Schürmann M, Kalso E and Hari R: The compassionate brain: Humans detect intensity of pain from another's face. *Cerebral Cortex* (published in 2007)

Schürmann M, Järveläinen J, Avikainen S, Cannon TD, Lönnqvist J, Huttunen M and Hari R: Manifest disease associated with decreased motor-cortex reactivity in twins dicordant for schizophrenia. *Br J Psychiatry* in press.

LANGUAGE PERCEPTION AND PRODUCTION

S. Aggujaro, **P. Helenius**, A. Hultén, A. Jalava, J. Kujala, H. Laaksonen, M. Liljeström, T. Parviainen, T. Saarinen, **R. Salmelin**, S. Sipponen, **P. Sivonen**, J. Uusvuori, and **M. Vihla**

Collaborators:

Department of Psychology, University of Helsinki
Department of Psychology, University of Turku
Department of Psychology, Åbo Akademi University, Turku
Departments of Psychology and Cognitive Neuroscience, University of Maastricht, The Netherlands
Centre de Recherche, Institut Universitaire de Gériatrie de Montréal, Canada
School of Psychology, Australian National University, Canberra, Australia
Department of Biology, University of Newcastle upon Tyne, United Kingdom
Department of Psychology, University of Glasgow, United Kingdom
Department of Psychology, University of Milano-Bicocca, Italy

We have studied language learning in a series of MEG studies, using picture naming. Picture naming is a simple and natural task that covers language function from perception to linguistic processing and finally to production. Nevertheless, the

correspondence between the theoretically assumed processing stages and specific loci and timing of neural activation remains poorly understood.

We used a set of categorization tasks to selectively highlight different cortical processing stages of picture confrontation, ranging from visual analysis (VIS) to semantic (SEM) and phonological access (PHON), and compared the time courses of activation in these tasks with those obtained during picture naming (NAM). Brain activity was recorded with whole-head magnetoencephalography (MEG). Following the initially similar activation patterns in occipital and parietal areas, task effects (stronger activation in NAM/PHON than in SEM/VIS) emerged after 300 ms, in the sustained activation of the left posterior temporal and bilateral inferior frontal cortex, apparently reflecting enhancement of phonological and phonetic/articulatory processing.

Native language vocabulary growth forms an elementary part of linguistic capacity. While language development in children has received considerable interest, less is known about the neurocognitive mechanisms of adult word learning. In adults, information about a new item is integrated into a pre-existing, strongly cross-referenced lexical network. Vocabulary growth was examined in ten healthy participants who performed a picture naming task before and after learning. Participants successfully learned either the name, usage or both for previously unfamiliar pictures of archaic tools. Control items included archaic tools for which no information was provided, as well as familiar tools. The overall spatiotemporal sequence of activation was similar for all stimulus types. When the subjects had learned the item names, significantly increased activation (as compared with new items for which no information had been provided) was detected in the left posterior temporal cortex and along the ventral part of the central sulcus bilaterally after about 300 ms post stimulus, prior to overt vocalization. No direct effects of the newly acquired semantic knowledge (usage) were observed. However, the data suggest that the experimental context may have modulated the neural manifestation of accessing the new names. Earlier related MEG studies did not explicitly require acquisition of semantic information and showed name learning effects in the left inferior parietal cortex. We suggest that in the present context where both phonological and semantic information had to be learned, access to phonology proceeded via verbal semantics, with modulation of activation in the left posterior temporal cortex. Cortical effects of retrieval of newly learned names vs. overall familiarity of the item coincided in location and timing, indicating that the same neural network manages both learning and long-term maintenance of word forms.

In a follow-up study, we tapped into the freshly formed neural links between new and established linguistic information through categorization of the novel pictured objects. When phonological information (name) had been acquired, as opposed to when no information was available, categorization by phonological structure was accompanied by increased left temporal activation, starting at about 300 ms post stimulus onset. In contrast, no specific increase of neural activation was observed during semantic categorization of items with newly acquired semantic information (usage). The right temporal cortex showed enhanced activation from about 300 ms onwards in the phonological categorization task, notably even when only semantic information had been provided. These data point to remarkably different implementation of phonological and semantic processing at the neural level. The results also shed light

on the controversial issue of functional differences between the hemispheres as regards language processing.

Publications

Bonte M, Parviainen T, Hytönen K, Salmelin R: Time course of top-down and bottom-up influences on syllable processing in the auditory cortex. *Cerebral Cortex 2006*, 16: 115–123.

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Parviainen T, Helenius P, Poskiparta E, Niemi P, Salmelin R: Cortical sequence of word perception in beginning readers. *J Neurosci 2006*, 26: 6052–6061.

Saarinen T, Laaksonen H, Parviainen T, Salmelin R: Motor cortex dynamics in visuomotor production of speech and non-speech mouth movements. *Cerebral Cortex 2006*, 16: 212–222.

Salmelin R: Clinical neurophysiology of language: the MEG approach. *Clin Neurophysiol 2007*, 118: 237–254.

Salmelin R, Kujala J: Neural representation of language: activation vs. long-range connectivity. *Trends Cogn Sci 2006*, 10: 519–525.

Service E, Helenius P, Maury S, Salmelin R: Localization of syntactic and semantic brain responses using magnetoencephalography. *J Cogn Neurosci*, in press.

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METHODOLOGICAL DEVELOPMENT

CHARACTERIZATION OF NEURAL CONNECTIVITY WITH MEG

A. Jalava, J. Kujala, H. Laaksonen, T. Saarinen, **R. Salmelin**

Collaborators:

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Department of Biology, University of Newcastle upon Tyne, United Kingdom

Spatially distributed components of cerebral networks are assumed to connect via synchronized neuronal firing. We have developed an analysis method that facilitates identification of brain areas with correlated time courses of activation directly from MEG signals, without prior assumptions of network structure (Dynamic Imaging of Coherent Sources, DICS). The spatiotemporal pattern of areas that show more activation in one condition than in another and spatial distribution of areas that show

correlated time courses of activation provide different views into brain function. Intuitively, one might assume that the connectivity pattern represents the more fundamental underlying structure which becomes partially (or fully) discernible in activation studies.

Silent reading is an excellent cognitive task for illustrating these different views as there is a reasonable amount of both neurophysiological and hemodynamic data available, and also theoretical models for consideration. MEG and fMRI/PET activation studies have associated somewhat different brain areas with specific subprocesses of reading, possible reasons for which were briefly discussed above. Interestingly, the MEG connectivity analysis revealed a set of nodes that essentially encompassed the areas defined as active in either MEG or PET/fMRI studies. Furthermore, the connection analysis highlighted a close interplay among a set of areas typically associated with speech production and visual recognition, thus emphasizing a global nature of language processing, in agreement with the view recently advocated by an extensive meta-analysis of hemodynamic activation studies. We now seek answers to essential questions that have risen from this research, e.g., how specific the networks are to the task and input/output modality. By comparing tasks that are fundamentally different, or vary by small degrees, we seek to identify task-specific components of the networks vs. network nodes common to all or most tasks.

Publication

See previous chapter about Kujala et al (*Cerebral Cortex*, in press) and Salmelin and Kujala (*Trends Cogn Sci 2006*).

IMPROVED METHODS FOR FUNCTIONAL MRI (FMRI), DIFFUSION TENSOR IMAGING (DTI), AND VOXEL-BASED MORPHOMETRY

H. Autti, **R. Hari**, J. Hiltunen, Y. Hlushchuk, **V. Jousmäki**, S. Malinen, A.O. Mäkelä, **S. Mattila**, L. Parkkonen, V. Renvall, M. Seppä, O. Tanzer, and **A. Tarkiainen**

Visitors: H. Renvall, M. Schürmann

Collaborators:

Laboratory of Computational Engineering, TKK
Laboratory of Applied Electronics, TKK
AstraZeneca R&D Molndal, Mölndal, Sweden

Diffusion tensor imaging: We have been developing methods for diffusion-tensor imaging (DTI) to study white-matter tracts between brain areas. DTI, which is presently the only method for non-invasive visualization of fiber tracts within the living human brain, is based on monitoring of diffusion of water molecules, which within a tight fiber bundle is less limited along the fibers than perpendicular to them. — Fractional anisotropy (FA) and apparent diffusion coefficient (ADC) were measured from diffusion tensor images recorded from muscles of bovine antebrachium during the six first days of decomposition after butchery. The results show that diffusion tensor imaging can be used for quantitative monitoring of post-mortem decomposition of skeletal muscle.

ICA analysis of fMRI activation: In search for suitable tools to study brain activation in natural environments, where the stimuli are multimodal, poorly predictable and irregularly varying, we collected functional magnetic resonance imaging data from 6 subjects during a continuous 8-min stimulus sequence that comprised auditory (speech or tone pips), visual (video clips dominated by faces, hands, or buildings), and tactile finger stimuli in blocks of 6–33 s. Results obtained by independent component analysis (ICA) and general-linear-model (GLM) were compared. — ICA separated in the superior temporal gyrus one independent component (IC) that reacted to all auditory stimuli and in the superior temporal sulcus another IC responding only to speech. Several distinct and rather symmetric vision-sensitive ICs were found in the posterior brain. An IC in the V5/MT region reacted to videos depicting faces or hands, whereas ICs in the V1/V2 region reacted to all video clips, including buildings. ICA separated a prominent IC in the primary somatosensory cortex whereas the GLM-based analysis failed to show any touch-related activation. Intrinsic components, unrelated to the stimuli but spatially consistent across subjects, were discerned as well.

Spatial extent of fMRI activation: FMRI can provide millimeter-scale spatial resolution for brain imaging, but the extent of the activation is difficult to determine as the displayed data are the result of statistical inference based on noisy signals. We have reviewed the limits of spatial resolution in fMRI, including both physiological and methodological factors that restrict the analysis of the "true" extent of activation. We also carried out simulations indicating the importance of the signal-to-noise ratio (SNR) and the spatial shape of the BOLD signal for estimation of the extent of the observed fMRI activation. The effect of the SNR was smaller for sharply delineated than diffuse activations, and a similar apparent activity pattern was obtained with different combinations of signal shapes and noise levels. One way to obtain better estimates of the extent of the activated area is to increase the SNR by e.g. signal averaging.

Publications

Hiltunen J, Seppä M ja Hari R: Diffuusiotensorikuvaus hermoratojen tutkimuksessa. Katsausartikkeli. *Duodecim* 2007, *in press*.

Hiltunen J, Hari R, Jousmäki V, Müller K, Sepponen R and Joensuu R: Quantification of mechanical vibration during diffusion tensor imaging at 3 T. *Neuroimage* 2006, 32: 93–103.

Malinen S, Schürmann M, Hlushchuk Y, Forss N and Hari R: Improved differentiation of tactile activations in human thalamus and second somatosensory cortex using cardiac-triggered fMRI. *Exp Brain Res* 2006, 174: 297–303.

Malinen S, Hlushchuk Y and Hari R: Towards natural stimulation in fMRI—issues of data analysis. *Neuroimage* (published in 2007).

Mattila S, Renvall V, Hiltunen J, Kirven D, Sepponen R, Hari R and Tarkiainen A: Phantom-based evaluation of geometric distortions in functional magnetic resonance and diffusion tensor imaging. *Magn Reson Med* (published in 2007).

Renvall V, Joensuu R and Hari R: Functional phantom for fMRI, a feasibility study. *Magn Reson Imaging* 2006, 24: 315–320.

Renvall H, Renvall V, Parkkonen L and Hari R: Spatial extent of brain activation in fMRI studies: A review and theoretical considerations. Submitted.

Seppä M: High-quality two-stage resampling for 3-D volumes in medical imaging. *Medical Image Analysis*, *in press*.

Seppä M: On sub-sample accuracy with mutual-information registration. *Submitted*.

Ylipaavalniemi J, Mattila S, Tarkiainen A, Vigario P: Brains and phantoms: An ICA study of fMRI. Independent component analysis and blind signal separtation. *Lect Notes Comp Sci* 2006, 3889: 503–510.

DEVELOPMENT OF THE EXPERIMENTAL ENVIRONMENTS IN MEG AND FMRI

R. Hari, **V. Jousmäki**, H. Kainulainen, V.-M. Saarinen, R. Schreiber, J. Simola, L. Stenbacka, and **S. Vanni**

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Institute of Occupational Health, Helsinki, Finland
National Rehabilitation Center, Tokorozawa, Japan

We aim to develop and test novel, selective, and artefact-free stimulators to be used in MEG and fMRI environments. In addition, we also build simple interfaces between commercial functional brain imaging instruments and stimulators. Our novel MEG-compatible hand-held tactile stimulator was shown to elicit reproducible somatosensory evoked responses to hand and face simulation.

We have designed, tested and installed new improved solutions for auditory and visual stimulation in fMRI enviroment. An fMRI-compatible commercial thermal stimulator has been used successfully in the 3-T fMRI environment. We have also manufactured optical response pads and brush-like tactile stimulator for both MEG and fMRI studies.

Video eye tracking system MEye Tracker-LR (SensoMotoric Intruments GmbH, Teltow, Germany) was installed and adjusted by AMI personnel together with the manufacturer. The eye tracker allows a 50-Hz sampling of subject's gaze direction with about 1 degree accuracy. The adjusted parts included mirror box, camera stand, updated MEyeTracker-LR battery version, and a locally developed software "Eye Movement Visualizer", for analyzing video stimuli together with eye movements. Fiberoptic infrared light source to reduce noise level has been proposed and designed by the BRU and it is under construction by the manufacturer HP-UX workstations for analyzing MEG data have been upgraded in 2006.

Publication

Jousmäki V, Nishitani N and Hari R: Brush stimulator for functional brain imaging. *Clin Neurophysiol, under revision.*

TEACHING ACTIVITIES

COURSES

Low Temperature Physics Theory (Kyl-0.4104)

Lecturer: **Nikolai Kopnin,** visiting prof.

Teaching assistant: **Juha Voutilainen**, Mr.

Quantum Computing (Tfy 44.140.)

Lecturers: **Mikio Nakahara**, 24 hours (visiting professor, Kinki University, Japan) and **Yuriy Makhlin**, 12 hours (visiting professor, Landau Insitute for Theoretical Problems, Russia). Teaching assistant: **Teemu Ojanen**, M.Sc. Tech.

RESEARCH SEMINARS ON LOW TEMPERATURE PHYSICS AND NANOPHYSICS

Coordinators: Vladimir Eltsov, Pertti Hakonen, Tero Heikkilä, and Jukka Pekola

Matthias Eschrig, University of Karlsruhe, Germany, *Ballistic and diffusive: theory of vortices in the two-band superconductor MgB2*, Jan 27.

Yu. M. Bunkov, CRTBT-CNRS, Grenoble, France, *An experimental signature of superfluid fluctuations in 3He*, Feb 10.

Edouard Sonin, Racah Institute of Physics, Israel, *Statistics of electron tunneling*, Feb 21.

Bernie Yurke, Bell Laboratories, Murray Hill, USA, *Quantum Network Theory I: Introduction to parametric amplifiers*, Mar 1.

Anssi Salmela, LTL/HUT, Finland, *Thermometry at microkelvin range for adiabatic 3He/4He melting experiment*, Mar 7.

Bernie Yurke, Bell Laboratories, Murray Hill, USA, *Quantum behavior of parametric amplifiers*, Mar 7.

Bernie Yurke, Bell Laboratories, Murray Hill, USA, *Fermion interferometer operated as a transistor*, Mar 14.

David Gunnarsson, LTL, TKK, Finland, *Measurements of a single Cooper pair box*, Mar 21.

Igor Sosnin, Royal Holloway, University of London, UK, *Measurement of thermopower in hybrid N/S nanostructures at low temperatures*, Apr 11.

Alexander Mel'nikov, Insitute for Physics of Microstructures, Russian Academy of Sciences, Nizhny Novgorod, Russia*, Resonance energy and charge pumping through quantum SINIS contacts,* Apr 12.

Wolfgang Belzig, University of Konstanz, Germany, *Quantum Noise in Mesoscopic Systems*, Apr 20.

Vladimir Lebedev, Landau Institute, Russia, *Peculiarities of 2d turbulence,* May 4.

Pertti Hakonen, LTL, TKK, *Landau-Zener interferometry in a Cooper pair box*, May 16.

Jayanta Sarkar, Indian Institute of Science, India, *Nanostructured manganite thin films: Growth, properties, and novel applications,* May 31.

Fan Wu, LTL, TKK, Finland, *Shot noise of MWNTs*, Jun 6.

Mika Sillanpää, NIST, Boulder, U.S.A., *Josephson phase qubit research at Boulder NIST,* Jun 8.

David Gunnarsson, Teemu Ojanen, LTL, TKK, Finland, *Nano Journal Club,* Jun 13.

Pauli Virtanen, LTL, TKK, Finland, *Supercurrent-induced thermoelectric effects in NS systems*, Jun 20.

David Khmelnitskii, Cavendish Laboratory, UK, *Quantum critical point for structural phase transitions,* Jul 17.

Romain Danneau, School of Physics, University of New South Wales, Sydney, Australia, *Zeeman effect in a one-dimensional system with strong spin-orbit coupling,* Jul 18.

Lorenz Lechner, Alexander Savin, LTL, TKK, Finland, *Nano Journal Club*, Aug 1.

Tommy Holmquist, Pauli Virtanen, LTL, TKK, Finland, *Nano Journal Club*, Aug 8.

Joachim Ankerhold, University of Freiburg, Germany, *Read-out of superconducting quantum bits,* Aug 11.

Jukka Pekola, LTL, TKK, Filand, *Radio-frequency single-electron refrigerator*, Aug 15.

Victor L'vov, The Weizmann Institute of Science, Israel, *Turbulent drag reduction by dilute solution of polymers*, Aug 16.

Leonid Pryadko, University of California, Riveside, CA, USA, *Search for elusive supersolid - a theorist's viewpoin,* Aug 21.

Juha Voutilainen, Juha Vartiainen, LTL, TKK, Finland, *Nano Journal Club*, Aug 22**.**

Matti Laakso, LTL, TKK, Finland, *SISIS Josephson transistor in the nonequilibrium regime*, Aug 29.

Pertti Hakonen, Antti Kemppinen, LTL, TKK, Finland, *Nano Journal Club,* Sep 5.

Tero Heikkilä, LTL, TKK, Finland, *Quantum detectors for the third cumulant of current fluctuations,* Sep 12.

Mikko Möttönen, Fan Wu, LTL, TKK, Finland, *Nano Journal Club,* Sep 19.

Matthias Meschke, LTL, TKK, Finland, *Transport of almost one quantum of thermal conduction through superconducting lines,* Sep 26.

Taku Tsuneta, Andrey Timofeev, LTL, TKK, Finland, *Nano Journal Club,* Oct 3.

Teemu Ojanen, LTL, TKK, Finland, *Manipulating quantum noise in a SQUID*, Oct 10.

Tero Heikkilä, Antti Paila, LTL, TKK, Finland, *Nano Journal Club*, Oct 17.

Andrei Golov, University of Manchester, UK, *Vortex dynamics in superfluid 4He in T = 0 limit (I),* Oct 19.

RESEARCH SEMINARS OF THE BRU

Coordinator: Topi Tanskanen

Matti Hämäläinen, Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital - Massachusetts Institute of Technology - Harvard Medical School, USA, *MEG and EEG source modeling with accurate anatomical constraints*, Jan 5.

Miiamaaria Saarela, Brain Research Unit, LTL, HUT, Finland, Brain responses to pain observed from the faces of chronic pain patients, Jan 16.

Riitta Hari, Linda Stenbacka, and **Jan Kujala**, Brain Research Unit, LTL, HUT, Finland, *Reviews of fresh literature*, Jan 30.

Jyrki Ahveninen, Athinoula A. Martinos Center for Biomedical Imaging, MGH-MIT-HMS, USA, *Spatiotemporal imaging of human auditory cortex*, Feb 6.

Minna Vihla, Annika Hulten, Brain Research Unit, LTL, HUT, Finland, *MEG studies on vocabulary learning*, Feb 13.

Timo Honkela, Laboratory of Computer and Information Science, HUT, Finland, *Challenge of rich contexts for artificial intelligence and cognitive sciences*, Feb 20.

Veikko Jousmäki, Lauri Parkkonen, and **Nuutti Vartiainen**, Brain Research Unit, LTL, HUT, Finland, *Reviews of fresh literature*, Feb 27.

Teemu Rinne, Department of Psychology, University of Helsinki, Finland, *Involuntary attention: behavioral, ERP and fMRI results*, Mar 6.

Oguz Tanzer, TKK, Department of Engineering Physics and Mathematics and LTL/BRU, *Numerical Modeling in electro- and magnetoencephalography,* Mar 13.

Juha Valste, Suomen luonto journal, Finland, *Brain and human evolution,* Mar 20.

Jaana Hiltunen, AMI-Centre / Brain Reserch Unit, Finland, *MRI and DTI of peripheral nerves*, Mar 27.

Linda Henriksson, AMI-Centre / Brain Reserch Unit, HUT, Finland, Testing hypothesis from computational modelling and psychophysics with functional imaging, Apr 3.

Sanna Malinen, AMI-Centre / Brain Reserch Unit, HUT, Finland *Towards natural stimulation in fMRI - issues of data analysis,* Apr 3.

Jussi Perkiö, Department of Child Neurology, Hospital for Children and Adolescents, Hospital District of Helsinki and Uusimaa *Simultaneous electroencephalography and functional magnetic resonance imaging,* Apr 10.

Heather K J van der Lely, Centre for Developmental Language Disorders & Cognitive Neuroscience, Department of Human Communication Science, University College London, UK *Specific language impairment, ERP and behavioural investigations and domain-specific deficits in grammatical components (syntax, morphology, phonology): do they exist?,* Apr 19.

Matti Sintonen, Department of Philosophy, University of Helsinki, Finland *Brain Science - the Final Triumph of Mechanistic Philosophy?,* Apr 24.

Oguz Tanzer, BRU, LTL, HUT, Finland *LTL Wiki info,* Apr 25.

Vesa Kiviniemi, Department of Radiology, University of Oulu, Finland *Low frequency BOLD signal fluctuations and Brain functional connectivity,* Apr 26.

Riitta Salmelin, Mika Seppä, and **Yevhen Hlushchuk**, Brain Research Unit, LTL, HUT, Finland *Reviews of fresh literature,* May 8.

Mark L. Andermann, Laboratory of Computational Engineering, HUT, Finland *Novel tactile feature maps in rat somatosensory cortex,* May 15.

Päivi Helenius, Brain Research Unit, LTL, HUT, Finland, *Language development and language learning impairments,* May 22.

Johanna Uusvuori, Brain Research Unit, LTL, HUT, Finland, *Cortical processing of spoken and written words,* May 22.

Christoph Braun, Christopher Moore, Håkan Olausson, Matias Palva, Gina Caetano, Veikko Jousmäki, and **Mark Andermann**, *Dynamic Somatosensory Receptive Fields,* Sep 4.

Gina Caetano, Annika Hultén, Hannu Laaksonen, and **Sanna Malinen**, Brain Research Unit, LTL, HUT, Finland, *Meeting reports: HBM highlights*, Sep 11.

Lauri Parkkonen, Miiamaaria Saarela, and **Simo Vanni**, Brain Research Unit, LTL, HUT, Finland, *Meeting reports: Biomag, RIKEN, VSS*, Sep 18.

Sini Sipponen, Brain Research Unit, LTL, HUT, Finland, *What are averaged evoked responses made of? Computing variability of responses,* Sep 25.

Silvia Aggujaro, Brain Research Unit, LTL, HUT, Finland, *Neural processing of morphologically complex words,* Sep 25.

Lauri Nurminen, AMI / BRU, LTL, HUT, Finland, *Spatial frequency sensitivity of early visual cortices*, Oct 2.

Linda Stenbacka, AMI / BRU, LTL, HUT, Finland *Central luminance flicker can activate peripheral visual field representations*, Oct 2.

Linda Henriksson, Ville Renvall, and **Topi Tanskanen**, AMI/BRU, LTL, HUT, Finland, *Reviews of fresh literature,* Oct 9.

Laura Kauhanen, and **Tapio Palomäki**, LCE, HUT, Finland, *Brain computer interfaces*, Oct 16.

Gina Caetano, BRU, LTL, HUT, Finland *Actor's and observer's primary motor cortices stabilize similarly after both seen and heard motor actions*, Oct 23.

Jan Kujala, Topi Tanskanen, and **Johanna Uusvuori**, BRU, LTL, HUT, Finland, *Meeting reports: SFN*, Oct 30.

Carolyn Norris, Language Services, University of Helsinki, Finland, *Academic writing*, Nov 8.

Anssi Peräkylä and **Douglas Maynard**, Department of Sociology, University of Helsinki, Finland; Department of Sociology, University of Wisconsin, USA *Structures of social interaction: conversation analytical perspective*, Nov 20.

Maarit Aro, AMI/BRU, LTL, TKK, Finland Functional magnetic resonance imaging during natural viewing (MA), Nov 27.

Henri Autti, AMI/BRU, LTL, TKK, Finland *Voxel-based morphometry ,* Nov 27.

Simo Vanni, AMI/BRU, LTL, TKK, Finland *Current view on early vision,* Dec 4.

Hannu Heiskala, Jorvi Hospital, Helsinki University Central Hospital, Finland *MRI in learning disabilities,* Dec 11.

Kalle Palomäki, Laboratory of Computer and Information Science, TKK, *Neuromagnetic studies on sound localization*, Dec 19.

SPECIAL ASSIGNMENTS

Kurt Baarmann, *Preparing PDR cryostat for measurement of Cooper pair pump*. Instructor: Prof. **Jukka Pekola**

Kurt Baarmann, *Measurement of critical current density of superconducting aluminium thin film wires*. Instructor: Prof. **Jukka Pekola**

Petri Heikkinen, *Frequency drag torque of frictionless rotation in liquid and gaseous helium*. Instructor: Prof. **Matti Krusius**

Liisa Helle, *Simultaneous measurement of two interacting subjects: MEG/EEG study*. Instructor: M.Sc. **Lauri Parkkonen**

Jaakko Hosio, *Nonlinear damping of vibrating objects in He3-B*. Instructor: Prof. **Matti Krusius**

Matti Laakso, *SISIS Josephson transistor in the nonequilibrium regime*. Instructor: Docent **Tero Heikkilä.**

Matti Manninen, *Vibrating wire measurements in superfluid 4He on the melting curve down to 10 mK* , Instructor: Dr. **Harry Alles**

Taru Suortti, *Optimizing the settings of diffusion tensor imaging (DTI) for visualization of peripheral nerves with tractography*. Instructors: Phil.lic. **Jaana Hiltunen** and Prof. **Riitta Hari**.

Taru Suortti, *q-space MRI*. Instructor: Phil.lic. **Jaana Hiltunen**.

ACADEMIC DEGREES

DIPLOMA THESES

Ricardo Gutierrez, *Variability of single-trial cortical somatosensory responses in magnetoencephalographic recordings*. Final work. BRU, TKK. Instructor: Professor **Riitta Hari**.

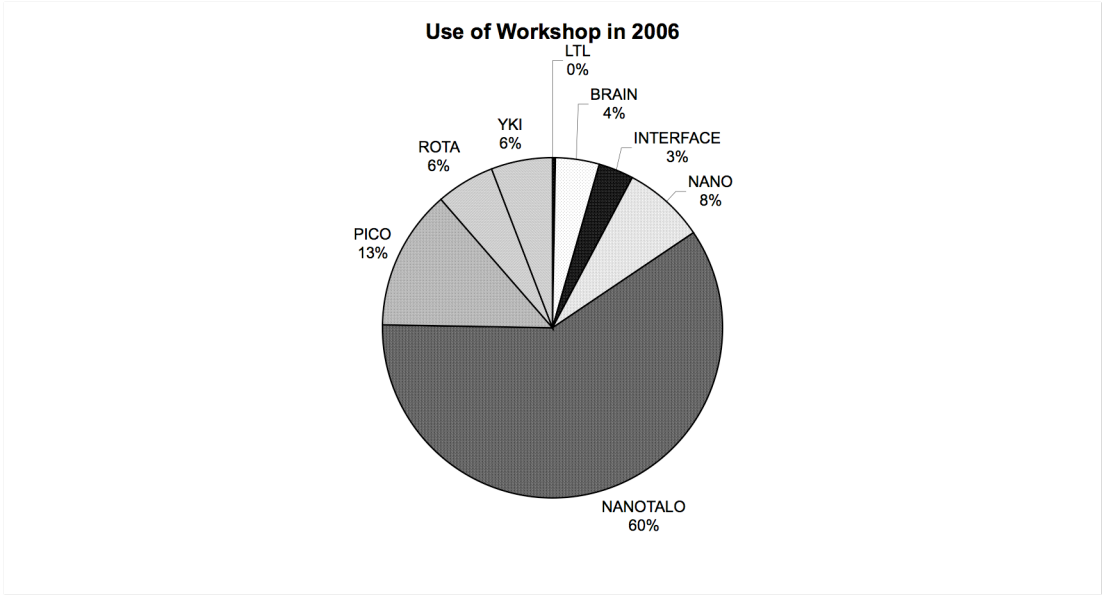
Tomi Ruokola graduated as M.Sc. from the Department of Engineering Physics and Mathematics on November 22nd. His diploma thesis *Phase boundary in superfluid ^{3}He as on analog model for black hole* was done in the LTL. Supervisor: Professor **Risto Nieminen.** Instructor: Dr **Juha Kopu**.

Anssi Salmela graduated as M.Sc. from the Department of Engineering Physics and Mathematics on February 3rd. His diploma thesis *Thermometry at microkelvin range for ^{3}He/ ^{4}He adiabatic melting experiment* was done in the LTL. Supervisor: Professor **Pekka Hautojärvi**. Instructor: Docent **Juha Tuoriniemi**.

TECHNICAL SERVICES

MACHINE SHOP

Seppo Kaivola, Juhani Kaasinen, Markku Korhonen

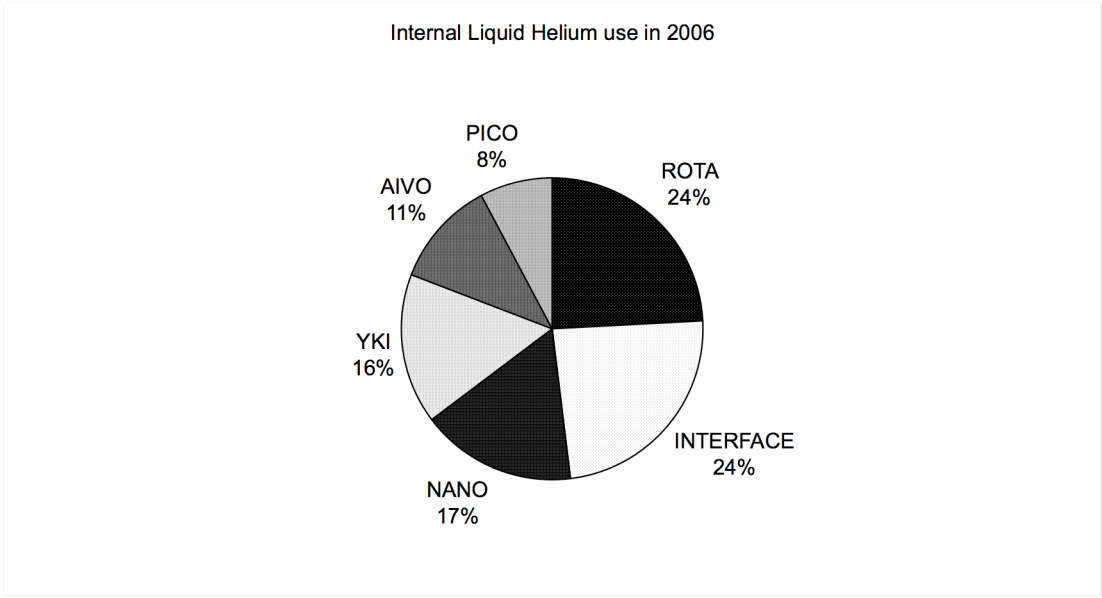


The distribution of workshop usage - Total hours was 1811 h

CRYOGENIC LIQUIDS

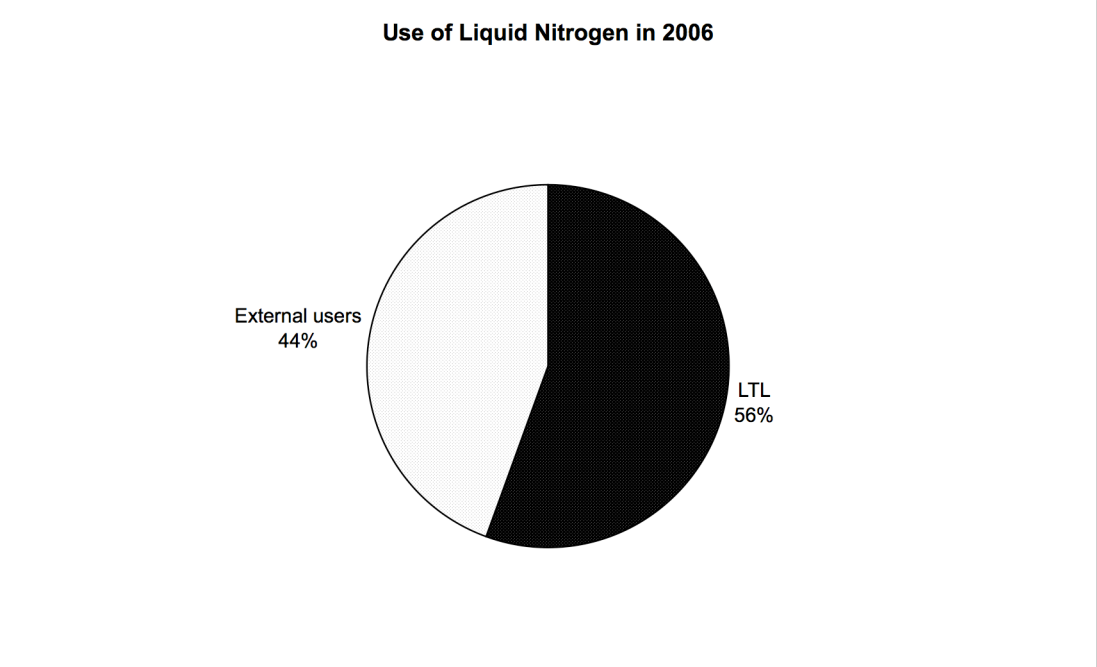
A. Isomäki and A. Huvila

Liquid helium



The total amount of liquid helium purchased was 45563 l and the user distribution is depicted above. 8% of the total amount was sold to external users.

Liquid nitrogen



Total production of liquid nitrogen was 45 000 l.

ACTIVITIES OF THE PERSONNEL

AWARDS AND HONORS

Riitta Hari has won the 2nd Erkki Kivalo prize from the Neurology Foundation 1.11.

Erika Kirveskari has won the W.A. Cobb young investigator award, (International Federation of Clinical Neurophysiology) 10.9.

Sanna Malinen has won the 2nd Prize in the European fMRI contest "*Brains at work*", organized by GE Healthcare. Sanna's work was "*Towards natural stimulation in fMRI – issues of data analysis*" 1.3.

PERSONNEL WORKING ABROAD

Isomäki

Institute of Physics of the University of Tartu, Estonia, 10. - 15.11. Installation of the old LTL Helium liquefier

Jousmäki

- University of Pittsburgh Medical Centre, University, Pittsburgh, Pennsylvania, USA, 16. - 20.1.
- Elekta Neuromag System Start-up, Cambrigde, England, 10. - 13.12.
- Elekta Neuromag System System Intergration, Leipzig, Germany, 13. - 15.12.

Lechner

Ecole Normale Supérieure Laboratoire Pierre Aigrain, Paris, France, 1.11. - 7.12.

Tanskanen

MRC Cognition and Brain Sciences Unit / Elekta Neuromag Oy, Research Center, Cambridge, UK, 7. - 15.12.

Vartiainen, J.

European summer school of Nanosciences and Nanotechnology, France, 3 weeks

CONFERENCE PARTICIPATION AND LABORATORY VISITS

Alles

Oral presentation, *Helium crystals and quantum fluctuations (in Estonian)*, Tallinn, Estonia (22.2.)

Caetano

Poster, *Stabilization of the observer's primary motor cortex*, 12th Annual Meeting of the Organization for Human Brain Mapping, Florence, Italy (11. - 15.6.)

Poster, *Stabilization of the observer's primary motor cortex after seen motor actions*, 12th Annual Meeting of the Organization for Human Brain Mapping, Florence, Italy (11. - 15.6.)

Invited talk, *Audiotactile interactions*, International Symposium on Dynamic Somatosensory Receptive Fields, Helsinki University of Technology (Otaniemi Campus, Espoo), Finland (13.8.)

de Graaf

Poster, *Turbulence in superfluid 3He-B*, Non-equilibrium statistical mechanics and turbulence, University of Warwick, UK (15. - 21.7.)

Poster, *Turbulence in superfluid 3He-B*, Cryoschool 2006, Dordrecht, The Netherlands (18. - 27.9.)

Eltsov

Invited talk, *The transition in the vortex dynamcis of superfluid 3He-B*, EPS 21st General Conference of the Condensed Matter Division, Dresden, Germany (26. - 31.3.)

Invited talk, *New vortex state in rotating superfluids*, Laboratory Cosmology, Leiden, Netherlands (4. - 9.9.)

Forss

Participation, Bridging to the Future-Stroke Rehabilitation, Gothenburg, Sweden (24. - 26.4.)

Invited talk, *Reorganization in CRPS*, SASP, Stockholm, Sweden (4. - 6.5.)

Hakonen

Oral presentation, *MWCNTs as building blocks in nanoelectronics*, CARDEQ kick-off meeting, Regensburg, Germany (2. - 4.3.)

Oral presentation, *Non-equilibrium states and CNT- rf-SETs*, CARDEQ kick-off meeting, Regensburg, Germany (2. - 4.3.)

Oral presentation, *Prospects of S/CNT/S-devices as detectors*, CARDEQ kick-off meeting, Regensburg, Germany (2. - 4.3.)

Oral presentation, *Welcome address*, CARDEQ kick-off meeting, Regensburg, Germany (2. - 4.3.)

Invited talk, *Landau-Zener interferometry in a Cooper pair box*, Quantum Coherence, Noise and Decoherence in Nanostructures, Dresden, Germany (15. - 26.5.)

Invited talk, *Coulomb blockaded Josephson junction as a noise detector*, MESO06, Chernogalovka, Russia (13. - 19.6.)

Invited talk, *Landau-Zener interferometry in a Cooper pair box*, Spin and Qubit 2006, Copenhagen, Denmark (20. - 22.6.)

Invited talk, *Mach-Zehnder interferometry in a superconducting charge qubit*, 8th International Conference on Materials and Mechanisms of high Tc superconductivity, Dresden, Germany (9. - 14.7.)

Invited talk, *Single Electron Transistors: progress towards the quantum limit*, International Conference on Superlattices, Nano-structures, and Nano-devices, Istanbul, Turkey (30.7. - 4.8.)

Invited talk, *Mach-Zehnder interferometry in a superconducting charge qubit*, 8th International Conference on Materials and Mechnaisms of Superconductivity and High Temperature Superconductivity, Dresden, Germany (9. - 14.7.)

Invited talk, *Landau-Zener interferometry in a Cooper pair box*, Recontres du Vietnam, Hanoi, Vietnam (6. - 12.8.)

Lecture, *Towards quantum measurements with Josephson junctions*, ENS, Paris, France (4.12.)

Visit, Ecole Normale Superieure, Paris, France (3. - 5.12.)

Hari

Invited plenary talk, *Brains made visible: An introduction to modern brain imaging*, Brain, Music, and Education, Helsinki, Finland (13.1.)

Participation, Viestit perille; henkilöstökoulutus, Nummela, Finland (2. - 3.2.)

Invited plenary talk, *Aivosta ja ajattelusta (About brain and thinking)*, Suomen kulttuurirahaston vuosijuhla; juhlapuhe, Helsinki, Finland (27.2.)

Oral presentation, *Aivokuvantamisesta ja systeemisestä neurotieteestä*, Aivoviikon 2006 lehdistötilaisuus, Helsinki, Finland (14.3.)

Invited talk, *Aivoista ja ajattelusta -- aivokuvantamisen näkymiä*, Aivoviikon 2006 käynnistytilaisuus, Helsinki, Finland (16.3.)

Oral presentation, *Brain basis of social interaction*, Opening seminar of the Academy of Finland NEURO program, Helsinki and Tuusula, Finland (6. - 7.4.)

Invited talk, *Basics of MEG, fMRI, and DTI*, Nordic Congress of Clinical Neurophysiology, NCCN 2006, Helsinki, Finland (21. - 24.5.)

Invited talk, *Brains, bodies, and minds: Challenges of modern brain imaging*, CORTEX Inaugural Symposium (Cooperation in Research and Training for European Excellence in the Neurosciences), Helsinki, Finland (1. - 3.6.)

Invited plenary talk, *The role of human brain imaging in cognitive neuroscience*, The Second Biennial Conference on Cognitive Science (CogSci2006), St. Petersburg, Russia (9. - 13.6.)

Invited plenary talk, *Past, present, and future of MEG in cognitive neuroscience*, 12th Annual Meeting of the Organization of Human Brain Mapping, Florence, Italy (11. - 15.6.)

Invited talk, *Brain oscillations associated with motor activity (Postgraduate course)*, EEG – Generation and Interpretation, Kuopio, Finland (28. - 30.8.)

Invited talk, *Introduction*, Dynamic Somatosensory Receptive Fields, Espoo, Finland (4.9.)

Invited talk, *Reading brains and minds: An introduction to modern brain imaging*, Science, Art and Technology, Helsinki, Finland (7. - 9.9.)

Lecture, *Ihmisaivojen kuvantaminen (Human brain imaging)*, Lääketieteen perusopetus/Biomedicum, Helsinki, Finland (20.9.)

Lecture, *Functional brain imaging*, Functional neuroanatomy lecture series; Neuroscience Institute of the University of Helsinki, Helsinki, Finland (21.9.)

Invited plenary talk, *Keynote: The social brain*, 17th Meeting ISBET (Internat Soc for Brain Electromagn Topography), "Imaging the Brain in the Life Span", Chieti, Italy (27. - 30.9.)

Invited talk, *Mitä kuvantaminen kertoo aivotoiminnoista*, Finska Läkarsällskapet, kokous, Helsinki, Finland (12.10.)

Invited plenary talk, *Miten uudet kuvantamismenetelmät ovat muuttamassa käsitystämme aivojen toiminnasta*, 3. valtakunnalliset Neurologiapäivät, Tampere, Finland (2.11.)

Oral presentation, *Brain Research Unit*, PERCEPT EU project kickoff meeting, Dresden, Germany (4. - 6.11.)

Invited talk, *Sosiaaliset aivot - neurotieteen seuraava haaste (The social brain - the next challenge of neuroscience)*, Suomalaisen tiedeakatemian kokous "Lääketieteen futurologiaa", Helsinki, Finland (13.11.)

Participation in an internet conference about ethics in neuroscience, Meeting of Minds online expert panel on neuroscience, Internet (28.11.)

Invited talk, *Timing in human social cognition and interaction*, PENS/Hertie Winter School on Brain Basis of Social Interaction: From Concepts to Imaging, Kitzbühel, Austria (10. - 17.12.)

Heikkilä

Poster, *Quantum transitions in nonequilibrium environments*, XL Physics Days, Tampere, Finland (9. - 11.3.)

Invited talk, *Nonequilibrium and thermoelectric effects in proximity structures*, Spin Physics in Superconducting Heterostructures, Bad Honnef, Germany (9. - 13.12.)

Helenius

Participation, Lasten visuospatiaaliset hahmotusvaikeudet, Helsinki, Finland (6.10.)

Participation, Dyslexia as a challenge, Helsinki, Finland (20.11.)

Hiltunen

Invited talk, *Diffuusiotensorikuvaus 3 Teslan magneettikuvauslaitteella*, OYS radiologian klinikan Tiedettä ja tutkimusta -seminaari, Oulu, OYS, radiologian klinikka, Suomi (16.5.)

Oral presentation, *DTI of periheral nerves and brain's white matter tracts*, Nordic Congress of Clinical Neurophysiology (NCCN 2006), Helsinki, Finland (23.5.)

Poster, *Diffusion tensor imaging of distal periheral nerves*, Human Brain Mapping 2006, Firenze, Italy (11. - 15.6.)

Participation, 12th Kuopio Bio-NMR Workshop on Magnetic Resonance Imaging and Spectroscopy as Tools to Study Neurodegeneration in vivo, Kuopio, Finland (11. - 13.12.)

Holmqvist

Participation, XL Physics Days, Tampere, Finland, (9. - 11.3.)

Poster, *RSFQ circuits for sub Kelvin Temperatures*, XL Physics Days, Tampere, Finland (9. - 11.3.)

Visit: Royal Holloway College, University of London, University, London, United Kingdom, 3. - 13.7.

Hosio

Poster, *Quartz tuning fork as probe of quantum liquids*, XL Physics Days, Tampere, Finland (9. - 11.3.)

Hultén

Oral presentation, *Accessing newly acquired phonological and semantic information: an MEG study*, the Architecture of Language, HBM Satelite Meeting, Pisa, Italy (8. - 10.6.)

Poster, *Accessing newly acquired phonological and semantic information: an MEG study*, Human Brain Mapping, Firenze, Italy (11. - 15.6.)

Hänninen

Oral presentation, *Numerical simulations on vibrating wire turbulence in superfluid helium*, International Symposium on Quantum Fluids and Solids 2006, Kyoto, Kyoto University, Japan (1. - 6.8.)

Poster, *Numerical simulations on vibrating wire turbulence in superfluid helium*, International Symposium on Quantum Fluids and Solids 2006, Kyoto, Kyoto University, Japan (1. - 6.8.)

Poster, *Crab vortex ring and finite amplitude Kelvin waves*, International Symposium on Quantum Fluids and Solids 2006, Kyoto, Kyoto University, Japan (1. - 6.8.)

Invited talk, *Vortex dynamics and quantum turbulence in superfluid 3He under rotation: Propagating vortex front*, Workshop on Quantum Turbulence, Gainesville, USA (16. - 17.11.)

Oral presentation, *Transition to turbulence and its dependence on vortex damping in superfluids*, The 2006 APS Division of Fluid Dynamics, 59th Annual Meeting, Tampa Bay, USA (19. - 21.11.)

Jousmäki

Lecture, *MEG overview*, System Start Training UPMC, Pittsburgh, PA, USA (17. - 20.1.)

Lecture, *Overview of data analysis*, System Start Training UPMC, Pittsburgh, PA, USA (17. - 20.1.)

Lecture, *Overview of more advanced functionality to data analysis*, System Start Training UPMC, Pittsburgh, PA, USA (17. - 20.1.)

Invited talk, *New tactile stimulators MEG/fMRI*, Nordic Congress of Clinical Neurophysiology, Helsinki, Finland (21. - 24.5.)

Poster, *Hand-held brush stimulator for functional brain imaging*, XXVIII International Congress of Clinical Neurophysiology, Edinburgh, Scotland (10. - 14.9.)

Docent lecture, *Kuulo- ja tuntoaistien vuorovaikutuksista*, Luonnontieteiden ja ympäristotieden tiedekunnan tiedekuntaneuvoston kokous, Kuopio, Finland (26.10.)

Junes

Poster, *Measurements of the step energy on melting 3He crystals around 1 mK*, XL Physics Days, Tampere, Finland (9. - 11.3.)

Kirveskari

Invited talk, *MEG and EEG in pain research*, Nordic Conference of Clinical Neurophysiology: Satellite Symposium on Pain Research, Helsinki, Finland (20. - 24.5.)

Invited talk, *Effect of pain on motor cortical functions*, Biomag 2006, Vancouver, Canada (20. - 23.8.)

Invited talk, *Neuromagnetic responses to vowels vs. tones reveal hemispheric lateralization*, XXVIII International Congress of Clinical Neurophysiology, Edinburgh, Great Britain (10. - 14.9.)

Kopnin

Invited talk, *Resonant charge pumping through quantum SINIS contact*, Landau Days 2006, Chernogolovka, Moscow region, Russia (26. - 29.6.)

Invited talk, *Giant oscillations of energy levels in mesoscopic superconductors*, The 11th International Workshop on Vortex Matter, Wrocław, Poland (3. - 9.7.)

Invited talk, *Resonance energy and charge pumping through quantum SINIS contacts*, The 8th International Conference on Materials and Mechanisms of Superconductivity and High Temperature Superconductors (M2S-HTSC-VIII), Dresden, Germany (9. - 14.7.)

Kopu

Visit, Dr. Richard Haley, Lancaster University, Lancaster, UK (30.1. - 2.2.)

Krusius

Invited talk, *Onset temperature of turbulence in superfluid 3He-B*, International Conference on Quantum Fluids and Solids QFS 2006, Kyoto University, Kyoto, Japan (1. - 6.8.)

Poster presentation, *Dynamic remnant vortices in superfluid 3He-B*, International Conference on Quantum Fluids and Solids QFS 2006, Kyoto University, Kyoto, Japan (1. - 6.8.)

Poster presentation, *Vortex instability, generation of new vortices, and onset of turbulence in rotating 3He-B*, International Conference on Quantum Fluids and Solids QFS 2006, Kyoto University, Kyoto, Japan (1. - 6.8.)

Lecture, *Vortex formation and dynamics in superfluid 3He-B*, Seminar of the physics department, Osaka City University, Osaka, Abiko, Osaka, Abiko, Japan (9.8.)

Lecture, *Transition to turbulence and the dynamics of quantized vortex lines in superfluid 3He-B*, Seminar of the physics department, Kinki University, Osaka, Osaka, Japan (10.8.)

Lecture, *Topological defects of 3He superfluids*, Seminar of the physics department, Kinki University, Osaka, Osaka, Japan (10.8.)

Invited talk, *Vortex structure and dynamics in 3He superfluids*, COSLAB 2006 Workshop of the European Science Foundation Research Programme Cosmology in the Laboratory, Leiden University, Lorentz Center, (4. - 9.9.)

Kujala

Invited talk, *MEG and language studies*, Science of Aphasia VII, Alghero, Sardinia, Italy (7. - 12.9.)

Poster, *Phase coupling in a cerebro-cerebellar network at 8-13 Hz during reading*, Society for Neuroscience 2006, Atlanta, Georgia, USA (14. - 18.10.)

Participation, Dynamical Neuroscience XIV, Atlanta, Georgia, USA (12. - 13.10.)

Visit, Department of Cognitive Neuroscience, Faculty of Psychology, University of Maastricht, The Netherlands (21. - 24.11.)

Laaksonen

Poster, *A method for spatiotemporal characterization of rhythmic brain activity*, Human Brain Mapping 2006, Florence, Italy (11. - 15.6.)

Lechner

Invited talk, *Quantum supercurrent transistors in carbon nanotubes*, CARDEQ Meeting, Regensburg, Germany (2. - 6.3.)

Oral presentation, *Proximity induced superconductivity in multiwalled Carbon Nanotubes*, VIth Rencontres du Vietnam, Hanoi, Vietnam (6. - 13.8.)

Participation, Application and Commercialization of Nanotechnology, Lammi, Finland (21. - 25.8.)

MacDonald

Visit, Eindhoven University of Technology, Dordrecht, Eindhoven, The Netherlands, (18. - 27.9.)

Malinen

Participation, Computational and Systems Neuroscience 2006, Salt Lake City, USA (5. - 10.3.)

Poster, *Towards natural stimulation in fMRI — comparison of analysis methods*, Human Brain Mapping, Florence, Italy (11. - 15.6.)

Poster, *Natural stimulation in fMRI — comparison of ICA and SPM*, Mining Brain Dynamics A Tutorial Workshop on Independent Component Analysis in Neuroimaging, Bergen, Norway (4. - 5.9.)

Poster, *Natural stimulation in fMRI — comparison of analysis methods*, PENS-Hertie Winter School, Kitzbühel, Austria (10. - 17.12.)

Mattila

Poster, *Phantom for measuring distortions in fMRI and DTI*, Human Brain Mapping, Florence, Italy (11. - 15.6.)

Meschke

Oral presentation, *Observation of heat transport through a superconducting line*, 6th Rencontres du Vietnam: Nanophysics: From Fundamentals to Applications, Hanoi, Vietnam (6. - 12.8.)

Möttönen

Oral presentation, *Measurement scheme for Berry phase in superconducting circuits*, XL Physics Days, Tampere, Finland (9. - 11.3.)

Ojanen

Oral presentation, *On-chip element to create squeezed states*, International School of Fundamentals of Nanoelectronics, Keszthely, Hungary (27.8. - 1.9.)

Paalanen

Invited talk, *Postgraduate studies in a center of excellence*, Teacher Symposion, Kokkola, Central Ostrobothnia Polytechnic (COP), Finland (21. - 22.8.)

Participation, IUPAP Working Group in Nanoscience, Szeged, Hungary (7.9.)

Lecture, *Quantum circuits: Novel phenomena and applications*, Physics Department, University of Heidelberg, Heidelberg, Germany (8.12.)

Lecture, *Who killed Schrödinger's cat: Quantum electronic circuits*, Meeting of the Society of Natural Philosophers, Helsinki, Finland (12.12.)

Parkkonen

Lecture, *MEG/EEG instrumentation and experiment design*, Human Brain Mapping, 12th Annual Meeting, Florence, Italy (11. - 15.6.)

Poster, *A light-weight magnetic shield: performance in real MEG measurements*, 15th International Conference on Biomagnetism, Vancouver, Canada (20. - 26.8.)

Oral presentation, *Signals from human occipital visual areas reflect percepts of an ambiguous figure*, Society for Neuroscience, Annual Meeting 2006, Atlanta, GA, USA (14. - 18.11.)

Pekola

Invited talk, *Josephson junction threshold detectors for current fluctuations*, MS+S2006 Mesoscopic superconductivity and spintronics, Kanagawa, Japan (27.2. - 2.3.)

Invited talk, *Electronic micro-refrigeration and thermometry*, DPG spring meeting and 21st General Conference of the EPS Condensed Matter Division, Dresden, Germany (27. - 31.3.)

Lecture, *Superconducting nanodevices*, Radiotekniikan tutkijaseminaari, Espoo, TKK, Finland (12.4.)

Invited talk, *Measurement of current fluctuations by Josephson junction threshold detector*, ULTI users' meeting Quantum Phenomena at Low Temperatures, Lammi, Finland (21. - 26.4.)

Invited talk, *Measuring current fluctuations by Josephson junction threshold detector*, 366. WE-Heraeus-Seminar: Qubits and Macroscopic Quantum Coherence: From Superconducting Devices to Ultra-cold Gases, Bad Honnef, Germany (7. - 11.5.)

Invited talk, *Observation of radiative cooling of electrons through superconducting leads*, Quantum Coherence, Noise and Decoherence in Nanostructures, Dresden, Germany (15. - 26.5.)

Invited talk, *Observation of electron-photon energy relaxation of normal metal*, Mesoscopic and Strongly Correlated Electron Systems - 4, Nanoscale Superconductivity and Magnetism, Chernogolovka, Russia (14. - 19.6.)

Lecture, *Nanoelectronics*, Lammi Nanotechnology Summerschool, Lammi, Finland (21. - 25.8.)

Pentti

Poster, *Cooling dilute 3He-4He mixtures by adiabatic melting of 4He at submillikelvin temperatures*, XL Physics Days, Tampere, Finland (9. - 11.3.)

Renvall

Visit, GE Healthcare, Private Company, Slough, England, (5. - 7.4.)

Saarela

Invited talk, *Sosiaalisten aivojen toiminnallinen kuvantaminen*, Avoin yliopisto, Helsinki, (5. - 10.4.)

Visit, Riken Brain Science Institute, Research Center, Tokyo, Japan (23.7. - 5.8.)

Poster, *Listening human co-walking activates brain's social circuitry*, Neuroscience 2006, Atlanta, USA (14. - 18.8.)

Poster, *Brain activation during observing acute pain in faces of patients with chronic pain*, Psykologia 2006 congress, Tampere, Finland (23. - 25.8.)

Poster, *Listening humans walking together activates brain's social circuitry*, Pens/Hertie winterschool: Brain Basis of Social Interaction, Kitzbühel, Austria (10. - 17.12.)

Saarinen

Participation, PERCEPT EU project kickoff meeting, Dresden, Germany (4. - 6.11.)

Salmelin

Visit, The Wellcome Trust, Neurosciences and Mental Health Funding Committee, Private Company, London, United Kingdom (27.2. - 1.3., 9. - 11.5. and 11. - 13.10.)

Invited talk, *Language in the brain - time matters*, Brain Awareness Week, Helsinki Collegium of Advanced Studies. II. Cognitive Neuroscience: Short-term, long-term and linguistic information processing, Helsinki, Finland (16.3.)

Invited talk, *Neurocognitive basis of language learning in children vs. adults*, Neuro Programme Opening Seminar, Tuusula, Finland (6. - 7.4.)

Invited talk, *MEG in cognitive neuroscience*, Human Brain Mapping 12th Annual Meeting, Florence, Italy (11. - 15.6.)

Invited comment, *Senior committee discussion: Technical innovations for studying brain and language*, Science of Aphasia VII. Neurocognition of language, Alghero, Sardinia (7. - 12.9.)

Invited plenary talk, *Language in the brain - matters of time*, 3rd International Brain-Computer Interface Workshop and Training Course, Graz, Austria (21. - 24.9.)

Invited plenary talk, Keynote: *Language in the brain: timing, location and connectivity*, 17th Meeting of the International Society for Brain Electromagnetic Topography (ISBET2006), Chieti, Italy (27. - 30.9.)

Invited talk, *Brain, timing and dyslexia*, Dyslexia as a Challenge: Genetics, Neuroscience and Psychology of Dyslexia, Helsinki, Finland (20.11.)

Visit, Maastricht University, The Netherlands, 21. - 24.11.

Participation, EU Thematic Seminar on Women, Science and Decision-Making, Helsinki, Finland (4.12.)

Savin

Invited talk, *Superconducting digital circuits at millikelvin temperatures: implications of dissipation on design priorities*, Nanoscale Superconductivity and Magnetism - NSM2006, Leuven, Belgium (6. - 8.7.)

Participation, Second Periodic Review of Project RSFQUBIT, Brussels, Belgium (13. - 14.11.)

Sebedash

Poster, *Adiabatic melting of 4He crystal in superfluid 3He at sub-millikelvin temperatures*, QFS2006, Kyoto, Japan (1. - 6.8.)

Sillanpää

Invited talk, *Landau-Zener interferometry in a Cooper pair box*, March Meeting 2006 of the American Physical Society, Orlando, USA, (13. - 17.3.)

Solntsev

Poster, *Dynamic remnant vortices and superfluid turbulence in 3He-B.*, Cryoschool 2006, Dordrecht, Holland (18. - 27.9.)

Poster, *Onset temperature of turbulence in superfluid 3He-B.*, Cryoschool 2006, Dordrecht, Holland (18. - 27.9.)

Tanskanen

Participation, Dynamical Neuroscience XIV, Atlanta, USA (12. - 13.10.)

Poster, *Variability of single-trial MEG responses indicates graded rather than categorical cortical responses to faces*, Society for Neuroscience Annual Meeting, Atlanta, USA (14. - 18.10.)

Timofeev

Participation, The 2nd Capri Spring School on Transport in Nanostructures, Capri island, Italy (2. - 9.4.)

Poster, *Wide band detection of the third moment of shot noise by a Josephson junction*, Quantum Electromechanical Systems - 2, Morro Bay, California, USA (13. - 15.12.)

Todoshchenko

Invited talk, *Direct measurements of the step energy in 3He crystals*, International Symposium on Quantum Fluids and Solids, QFS-2006, Kyoto, Japan (1. - 6.8.)

Poster, *Melting curve of 4He down to 10 mK*, International Symposium on Quantum Fluids and Solids, QFS-2006, Kyoto, Japan (1. - 6.8.)

Uusvuori

Oral presentation, *Cortical dynamics of access to meaning and sound form in reading vs. speech perception*, Neuroscience 2006, Atlanta, USA (11. - 19.10.)

Vanni

Invited talk, *Visual neurophysiology*, Seminar of clinical neurosciences at TYKS, Turku, Finland (7.3.)

Poster, *Multifocal fMRI shows spatial interactions in human primary visual cortex*, Vision Sciences Society, Sarasota, USA (5. - 10.5.)

Invited talk, *Functional identification of visual cortices*, Nordic Congress of Clinical Neurophysiology, Helsinki, Finland (21. - 24.5.)

Invited talk, *Multifocal fMRI of human visual cortex*, Collaboration – The acquisition of an analysis tool "Grenoble Institute of Neuroscience", Grenoble, Ranska (12. - 15.11.)

Vartiainen, J.

Poster, *Cooper pair pumping in SQUID arrays*, Mesoscopic Superconductivity and Spintronics, Atsugi, NTT R&D center, Japan (26.2. - 2.3.)

Visit, NEC, Research Center, Tsukuba, Japan (3. - 4.3.)

Participation, European summer school of Nanosciences and Nanotechnology, Research Center, Grenoble, France (27.8. - 16.9.)

Vartiainen, N.

Lecture, *Aivojen toiminnallinen kuvantaminen - ikkuna aivoihin*, University of the Third Age at the University of Helsinki, Helsinki, Finland (15.2.)

Invited talk, *Noxious laser and thermode stimulation*, Nordic Congress of Clinical Neurophysiology, Helsinki, Finland (21. - 24.5.)

Oral presentation, *Cortical processing of touch and pain in chronic pain patients*, ISBET 2006, Chieti, Italy (27. - 30.9.)

Virtanen

Oral presentation, *Supercurrent-induced temperature gradient across a nonequilibriums SNS Josephson junction*, XL Physics Days, Tampere, Finland (9. - 11.3.)

Oral presentation, *Supercurrent-induced thermoelectric effects in super-conductor/normal metal systems*, Quantum Coherence, Noise and Decoherence in Nanostructures, Dresden, Germany (21. - 26.5.)

Poster, *Thermoelectric effects in NS heterostructures*, 374. WE-Heraeus-Seminar on "Spin Physics of Superconducting Heterostructures", Physikzentrum, Bad Honnef, Germany (9. - 13.12.)

Volovik

Participation, Editorial Board Meeting of JETP Letters, Moscow, Russia (9.2.)

Invited talk, *Quantum phase transitions from topology in momentum space*, seminar at Laue-Langevin Institute, Grenoble, France (15.3.)

Invited talk, *Problems of dark energy: Condensed matter approach*, seminar at CRTBT, Grenoble, France (16.3.)

Invited talk, *From superfluids to vacuum of relativistic quantum fields*, 21-st EPS Conference of Condensed Matter Division, Dresden, Germany (26. - 28.3.)

Editorial Board Meeting of JETP Letters, Moscow, Russia (6.4.)

Invited talk, *Topological defects in real and momentum spaces*, seminar at Institute of Experimental and Theoretical Physics, Moscow, Russia (25.5.)

Invited talk, *Topological defects in real and momentum spaces*, seminar at Landau Institute, Chernogolovka, Russia (26.5.)

Invited talk, *Black-hole and white-hole horizons in superfluids*, Landau Days 2006, Chernogolovka, Russia (26. - 28.6.)

Chairman of Editorial Board Meeting of JETP Letters, Moscow, Russia (6.7.)

Invited talk, *Vacuum energy: Myths and reality*, Marcel Grossmann Meeting MG11, Berlin, Germany (24. - 29.8.)

Invited talk, *Universality classes of fermionic vacua from topology in momentum space topology in momentum space*, Marcel Grossmann Meeting MG11, Berlin, Germany (24. - 29.8.)

Editorial Board Meeting of JETP Letters, Moscow, Russia (31.8.)

Invited talk, *From superfluids to vacuum of relativistic quantum fields*, conference Laboratory Cosmology, Leiden, The Netherlands (4. - 9.9.)

Invited talk, *Is there crisis in theoretical physics because of Lambda-term problem?*, Seminar in Sternberg Astronomical Institute, Moscow State University, Moscow, Russia (18.9.)

Invited talk, *Topological defects in superfluid 3He and their counterparts in other systems*, "Solitons and Nonlinear Phenomena in Degenerate Quantum Gases", Cuenca, Spain (26. - 30.9.)

Invited plenary talk, *Quantum phase transitions in momentum space Quantum Phase transitions in momentum space*, International Conference on Fundamental Problems of High-Temperature Superconductivity, Zvenigorod, Russia (9. - 13.10.)

Invited talk, *Cosmological constant and vacuum energy: myths and reality*, seminar of the high-energy group of Institute of Theoretical and Experimental Physics, Moscow, Russia (17.10.)

Invited talk, *What is the natural value of cosmological constant?*, Seminar on Problems of Measurability in Quantum Gravity and of Dark Part of Universe is dedicated to the 100th Anniversary of Matvey P. Bronstein, St. Petersburg, Russia (30.11. - 2.12.)

Editorial Board Meeting of Journal JETP Letters, Moscow, Russia (7.12.)

Voutilainen

Oral presentation, *Nonequilibrium phenomena in multiple normal-superconducting tunnel heterostructures*, XL Physics Days, Tampere, Finland (9. - 11.3.)

Wu

Invited talk, *Electron-phonon coupling of carbon nanotubes. Shot noise of multiwalled carbon naotubes.* CARDEQ kick-off meeting, Regensburg, Germany (2. - 6.3.)

EXPERTISE AND REFEREE ASSIGNMENTS

Alles

Chairman of the session: Quantum Solids and Mixtures, Quantum Phenomena at Low Temperatures (ULTI User meeting), Lammi, Finland, 21. - 26.4.

Interview: Tieteen viikko, YLE Radio1, Helsinki, Finland, 22.11

Referee:

- Europhysics Letters
- Journal of Low Temperature

Caetano

Interview: RTP, TV, Portugal, 20.12.

Forss

Chairman of the session: Biomag 2006, Vancouver, Canada, 20. - 26.8.

Member of the organising committee: Biomag 2006, Vancouver, Canada, 20. - 26.8.

Gunnarsson

Referee: Journal of Low Temperature Physics, Springer, Netherlands, Netherlands

Hakonen

Chairman of the session: Recontres du Vietnam, Hanoi, Vietnam, 6. - 12.8.

Chairman of the conference or organising committee: CARDEQ kick-off meeting, Regensburg, Germany, 2. - 4.3.

Opponent: Kasper Grove-Rasmussen, Electronic Transport in Single Wall Carbon Nanotubes, University of Copenhagen, Niels Bohr Institute, Copenhagen, Denmark, 20.6.

Statement for the appointment of a professor: Habilitation, Universite d'Orsay (Paris 11), Physics, Paris, Orsay, France, 5.12.

Referee: Nature

Hari

Leader position in a scientific organization:

- Director of Advanced Magnetic Imaging Centre (AMI), TKK
- Adjunct professor, Neuroscience Center, Univ. of Helsinki.
- Chief physician, Dept. Clin. Neurophysiology, HUSLAB, HUCH (part-time)
- Member of medical advisory board, General Electric, General Electric Health Care (Europe; 3T MRI devices), Italy, 1.1.2006 - 31.12.2007.
- Coordinator of functional Brain Mapping, Finland-Taiwan Scientific Cooperation in the Academy of Finland, Bilateral Exchange Programme, Taiwan, 1.1. - 31.12.

Member of a distinguished society:

- National Academy of Sciences of the USA
- Finnish Academy of Sciences and Letters
- Academia Europaea

Chairman of a conference or organising committee:

- Dynamic somatosensory receptive fields, Espoo, Finland, 4.9.
- BIOMAG2008, Japan, 8.11. - 31.12. Co-chair of Program Committee

Chairman of the session:

- Nordic Congress of Clinical Neurophysiology, NCCN 2006, Helsinki, Finland, 21. - 24.5.

- Task- and State-Dependent Representations in Somatosensory Cortex, Dynamic somatosensory receptive fields, Espoo, Finland, 4.9.
- Painful and Speaking Brain, 17th Meeting ISBET (Internat Soc for Brain Electromagn Topography), "Imaging the Brain in the Life Span", Chieti, Italy, 27. - 30.9.

*Professional award***:** Erkki Kivalo –recognition award and lecture, Neurologiasäätiö, Neurologiapäivät, Tampere, Finland, 1.11.

Editor of a scientific journal: PNAS, National Academy of Sciences USA, (visiting editor 4 times in 2006)

Member of the editorial board:

- Neuroscience Research, Elsevier
- Brain Topography, Springer
- NeuroImage, Elsevier

Statements for the appointment of a professor:

- Professor in Psychology, University of Wales, Bangor, School of Psychology, Bangor, United Kingdom
- Reader, University College London, London, United Kingdom
- Professor of Psychology, University of Glasgow, Department of Psychology, Glasgow, Scotlant, UK

Interviews:

- Lehdistötilaisuus/Opening of the AF NEURO Programme, Newspaper, Helsinki and Tuusula, 6.4.
- Special report: fMRI, MEG probe our thoughts, Medicalphysicsweb.Org Newswire (Week 41); http://medicalphysicsweb.org/research/26079, Magazine, 10.10.
- Ylen aamu-TV, YLE, TV, Helsinki, Finland, 16.3.

Organizing conferences:

- Nordic Congress of Clinical Neurophysiology, Helsinki, Finland, 21. - 24.5. Co-organizer of the whole meeting; organizer of the imaging session
- PENS/Hertie Winter School on Brain Basis of Social Interaction: From Concepts to Imaging, Kitzbühel, Austria, 10. - 17.12. (single organizer)

Referee:

- Brain and Language
- Journal of Neuroscience
- Nature Neuroscience
- Nature Reviews of Neuroscience
- Neuroimage
- Neuroimage
- Trends in Cognitive Science,

Heikkilä

Member of the organising committee: Quantum Phenomena at Low Temperatures, Lammi, Finland, 21. - 26.4.

Editor: Journal of Low Temperature Physics, Springer, Netherlands

Referee:

- Physical Review B, American Physical Society, USA
- Physical Review Letters, American Physical Society, USA
- Journal of Low Temperature Physics, Springer, Netherlands

Helenius

Referee: Neuroimage, Elsevier

Jousmäki

Referee:

- NeuroImage, Elsevier, London, Great Britain,
- Biomed central, Biomed Central

Junes

Participation: Quantum Phenomena at Low Temperatures (ULTI User Meeting), Lammi, Finland, 21. - 26.4.

Kirveskari

Chairman of the sessions:

- New clinical MEG applications, Biomag 2006, Vancouver, Canada, 20. - 24.8.
- Intraoperative monitoring of spinal cord functional integrity, Nordic Conference of Clinical Neurophysiology, Helsinki, Finland, 21. - 24.5.
- Intraoperative neuromonitoring, Nordic Conference of Clinical Neurophysiology: Satellite symposium, Helsinki, Finland, 21. - 24.5.

Member of the organising committee: New clinical MEG applications, Biomag 2006, Vancouver, Canada, 20. - 24.8.

Award: W.A. Cobb Young Investigator Award, Edinburgh, Great Britain, 10.9.

Referee: Clinical Neurophysiology, Elsevier, Ireland

Kopnin

Member of the Scientific Board: Landau Institute for Theoretical Physics of the Russian Academy, Russia, 1.1.2006 - 31.12.2007.

Opponent: Dimitrova O.V., "Superconductivity and spin transport in two-dimensional electronic systems with a spin-orbital interaction", Landau Institute for Theoretical Physics, Moscow, Russia, 30.6.

Kopu

Referee:

- Physica Scripta, The Royal Swedish Academy of Sciences, Stockholm, Sweden
- Eur. Phys. J. B, EDP Sciences

Krusius

Chairman of the sessions:

- Topological defects in superfluid 3He, Workshop COSLAB 2006 of the European Science Foundation Research Programme Cosmology in the Laboratory, Leiden University, Lorentz Center, The Netherlands, 4. - 9.9.
- Superfluid 3He - session II, International Conference on Quantum Fluids and Solids QFS 2006, Kyoto University, Kyoto, Japan, 1. - 6.8.
- Section on Physics and Astronomy, Finnish Academy of Sciences and Letters

Member of the board: European Physical Society, Low Temperature Physics, France, 1.1. - 31.12.

Chairman: Finnish Academy of Sciences and Letters, Dept. of Physics, Finland, 1.1. - 31.12.

Member:

- Finnish Academy of Sciences and Letters
- Academia Europea
- Fellow member, American Physical Society
- Finnish Physical Society
- Individual ordinary member, European Physical Society
- Member of the editorial board, Physica B: Condensed Matter, Elsevier, The Netherlands
- Institute of Physics, UK
- Advisory Editorial Board, Physica B: Condensed Metter
- Member of International Program Advisory Committee, International Symposium on Quantum Fluids and Solids – QFS2006, Kyoto, 1-6 Augusta, 2006
- Member of the Board, Low Temperature Section, Condensed Matter Division, European Physical Society

Referee:

- Physical Review Letters
- Physical Review B
- Journal of Low Temperature Physics
- Europhysics Letters
- Engineering and Physical Sciences Research Council (UK)
- Royal Society (UK)
- University of Manchester (UK)
- University of Lancaster (UK)
- University of California (Berkeley)
- Physics Today

Malinen

Award: 2nd Prize, "Brains at work", European fMRI contest, General Electric, 1.3.

Paalanen

Position of trust in scientific organizations:

- Chairman of Comission C5, International Union of Pure and Applied Physics (IUPAP), College Park, Maryland, International, 1.11.2005 - 1.11.2008.

- Coordinator of ULTI, European Comission/LTL, Transnational Access to Research Infrastructure, FP6 of European Commission, Espoo, Finland, 1.4.2004 - 31.3.2008.
- Member of the Steering Board, Helsinki University of Technology, Advanced Magnetic Imaging Center, Espoo, Finland, 1.1.2005 - 31.12.2007.
- Steering Committee, European Science Foundation, ESF Programme on Arrays of Quantum Dots and Josephson Junctions, Strasbourg, France, 1.1.2004 - 31.12.2006.
- FinnSight 2015, Tekes and Academy of Finland, Panel on Materials, Helsinki, Finland, 1.1.2005 - 31.12.2006.
- Selection Committee, London Prize, Duke University, USA, 1.1.2005 - 31.12.2008.
- Steering Board, Chalmers University of Technology, CARAMEL, a nanotube research consortium, Gothenburg, Sweden, 1.1.2005 - 31.12.2007.
- Steering Committee, University of Twente, ESF-sponsored PiShift Network, Twente, The Netherlands, 1.1.2005 - 31.12.2006.
- Board, Biomedicum, Helsinki, Finland, 1.1. - 31.12.
- Chairman of ULTI User Meeting, Lammi, Finland, 21. - 26.5.
- Organising Committee of Finnish Physics Days 2007, 1.1. - 31.12.
- Organising Committee of Ultracold NanoMatter 14-16.2.2008, Toronto, Canada, 1. - 1.1.
- Working Group, International Union of Pure and Applied Physics (IUPAP), 1.1. - 31.12.

Editor: Journal of Low Temperature Physics, Springer, New York, USA

Pre-examiner: Pradip Khatua, *Hall effect in ion-beam sputtered Fe/Cr giant magnetoresistive multilayers*, Indian Institute of Technology, Kanpur, India

Statement for the appointment of a professor in physics,

- The State University of New Jersey, Department of Physics, Piscataway, New Jersey, USA
- University of Florida, Department of Physics, Gainesville, Florida (twice)
- Texas A&M, Department of Physics, College Station, Texas, USA
- Monach University, School of Physics, Clayton, Australia

Interviews:

- Does Supersolid 4He exist?, YLE, Radio, Helsinki, Finland, 10.8.
- Otaniemen tiedeyhteisö metrologian peruskysymysten äärellä, Mikes Magazine, Espoo, Finland, 24.10.

Reviewer of grant applications:

- Royal Society Research Fellowship Awards, London, UK
- Engineering and Physical Sciences Research Council, London, UK

Referee: Phys Rev Letters

Pekola,

Member of the editorial board: Journal of Low Temperature Physics, Springer,

Research visit: CNRS, Grenoble, France, 5. - 9.2.

Chairman of the session: Mesoscopic and strongly correlated electron systems - 4, Nanoscale superconductivity and magnetism, Chernogolovka, Russia, 14. - 19.6.

Board member: Nanodev consortium (SSF), Chalmers Tekniska Högskolan and Kungliga Tekniska Högskolan, Gothenburg, Sweden, 1.1. - 31.12.

Opponent: Silvia Corlevi, Quantum effects in nanoscale Josephson junction circuits, Kungliga Tekniska Högskolan, Physics, Stockholm, Sweden, 9.6.

Reviewer of a grant application: Suomen kulttuurirahasto, Helsinki, Finland

Referee:

- Applied Physics Letters
- Journal of Low Temperature Physics
- Physical Review B
- Physical Review Letters
- Science

Salmelin

Committee Member: The Wellcome Trust, Cognitive and Higher Systems Funding Committee, London, United Kingdom, 22.9.2005 - 22.9.2006.

Chair of the sessions:

- Imaging techniques I - EEG, MEG and Optical Imaging, Human Brain Mapping 12th Annual Meeting, Florence, Italy, 11. - 15.6.
- MEG/EEG Course, Human Brain Mapping 12th Annual Meeting, Florence, Italy, 11. - 15.6.
- Language and Memory, 17th Meeting of the International Society for Brain Electromagnetic Topography (ISBET2006), Chieti, Italy, 27. - 30.9.

Member of the organising committee: the 17th Meeting of the International Society for Brain Electromagnetic Topography (ISBET2006), Chieti, Italy, 27. - 30.9.

External reviewer: The Wellcome Trust, Academic Advisory Committee, London, UK, 21. - 21.6.

Editor: Human Brain Mapping, Wiley, 22.11.

Member of the editorial board: NeuroImage, Elsevier, 31.12.

Opponent, Alard Roebroeck: "Magnetic resonance imaging investigations of directed influence in the brain", Maastricht University, Department of Psychology, Maastricht, The Netherlands, 23.11.

Referee:

- Neuroimage
- Journal of Cognitive Neuroscience
- Cerebral Cortex,
- Nature Neuroscience

Savin

Pre-examiner: Lasse Taskinen "Thermal properties of mesoscopic wires and tunnel juntions", University of Jyväskylä, Jyväskylä, Finland, 9.6.

Tanskanen

Interview: Päivä kuussa; teema "sillä silmällä", YleQ, Mari Keinänen, Radio, Helsinki, Finland, 14.2.

Referee:

- Neuroimage, Academic Press, United States
- Cortex, Masson, Italy

Tuoriniemi

Editor of Cryogenics, Global

Vanni

Referee:

- Human Brain Mapping
- European Journal of Neurology
- Journal of Neuroscience
- Neuroimage

Reviewer of a grant application: Wellcome Trust, England

Vartiainen J.

Referee:

- Physical Review B, APS, New York, USA
- Physical Review Letters, APS, New York, USA
- Quantum Information & Computation, Rinton Press, Paramus, NJ, USA

Vartiainen N.

Interview: Kylmää tietoa aivoista, Mediuutiset, Newspaper, Espoo, Helsinki, 19.5.

Volovik

Member: “Laboratory Cosmology” Conference Organising Committee, Scientific Coordinator, Lorentz Center, Leiden University, Leiden, Holland, 4. - 9.9.

Organizer: Eleventh Marcel Grossmann Meeting on General Relativity at the Freie Universität Berlin, 23. – 29.7.

Session chairman:

- Analog Models of and for General Relativity, Marcel Grossmann Meeting MG11, Berlin, Germany, 24. - 29.7.
- Fundametal Problems of High Temperature Superconductivity, Zvenigorod, Russia, 9. - 13.10.
- Seminar on Problems of Measurability in Quantum Gravity and of Dark Part of Universe is dedicated to the 100th Anniversary of Matvey P. Bronstein, St. Petersburg, Russia, 30.11. - 2.12.

Chairman: European Science Programme, Belgium, 1.2.2006 - 1.12.2007.

Editor:

- Physical Review Letters, DAE (Divisional Associate Editor)
- Journal of Low Temperature Physics, Guest Editor

Member of the editorial board: JETP letters, Pleiades Publishing Inc., Russia

Opponent: M.V. Zverev, *Single-particle degrees of freedom in strongly correlated Fermi systems*, Kurchatov Institute, Institute of General and Nuclear Physics, Moscow, Russia, 1.6.

PUBLICATIONS

BRAIN

1. Bonte, M., Parviainen, T., Hytönen, K., and Salmelin, R., *Time course of top-down and bottom-up influences on syllable processing in the auditory cortex*, Cerebral Cortex, **16**, p. 115-123 (2006).
2. Caetano, G. and Jousmäki, V., *Evidence of vibrotactile input to human auditory cortex*, NeuroImage, **29**, p. 15-28 (2006).
3. Furey, M.L, Tanskanen, T., Beauchamp, M.S., Avikainen, S., Uutela, K., Hari, R., and Haxby, J.V., *Dissociation of face-selective cortical responses by attention*, Proceedings of the National Academy of Sciences of the United States of America (PNAS), **103**, 4, p. 1065-1070 (2006).
4. Hari R., *Ubuntun jäljillä*, Suomen Lääkärilehti, 33/2006, p. 3229 (2006).
5. Hari R., *Hermoston biosähköiset ja biomagneettiset perusilmiöt*, Kliininen neurofysiologia, p. 26-34 (2006).
6. Hari R., *MEG:n kliiniset sovellutukset*, Kliininen neurofysiologia, p. 378-381 (2006).
7. Hari, R., *Ovatko ajatukset aivoissamme?*, Tieteessä tapahtuu, **3/2006**, p. 28-30 (2006).
8. Hari, R., *Virtalähteen paikannus hermokudoksessa*, in Book: Kliininen neurofysiologia, p. 35-48 (2006).
9. Hari, R., *MEG:n perusteet ja rekisteröinti*, in Book: Kliininen neurofysiologia, p. 364-368 (2006).
10. Hari, R., *MEG aivotutkimusvälineenä*, in Book: Kliininen neurofysiologia, p. 369-377 (2006).
11. Hari, R., *Action-perception connection and the cortical mu-rhythm*, in Book: Prog Brain Res, Chapter 17, Jan 2006, vol. 159, p. 253-260 (2006).
12. Hari, R., *Magnetoenkefalografia*, in Book: Mieli ja Aivot, Kognitiivisen neurotieteen oppikirja, p. 111-117 (2006).
13. Hari, R., *Sosiaalisen vuorovaikutuksen aivoperusta*, in Book: Mieli ja aivot, Kognitiivisen Neurotieteen Oppikirja, p. 399-405 (2006).
14. Hiltunen J., Hari, R., Jousmäki, V., Müller K., Sepponen R., and Joensuu R. , *Quantification of mechanical vibration during diffusion tensor imaging at 3 T*, NeuroImage, **32**, p. 93-103 (2006).

15. Hlushchuk, Y. and Hari, R., *Transient suppression of ipsilateral primary somatosensory cortex during tactile finger stimulation*, The Journal of Neuroscience, **26**, 21, p. 5819-5824 (2006).

16. Kauhanen, L., Nykopp, T., and Sams, M., *Classification of single MEG trials related to left and right index finger movements*, Clinical Neurophysiology, **117**, p. 430-439 (2006).

17. Kauhanen, L., Nykopp, T., Lehtonen, J., Jylänki, P., Heikkonen, J., Rantanen, P., Alaranta, H., and Sams, M., *EEG and MEG brain-computer interface for tetraplegic patients*, IEEE Transactions on Neural Systems and Rehabilitation Engineering, **14**, 2, p. 190-193 (2006).

18. Kirveskari, E., Salmelin, R., and Hari, R, *Neuromagnetic responses to vowels vs. tones reveal hemispheric lateralization*, Clinical Neurophysiology, **117**, p. 643-648 (2006).

19. Korvenoja, A., Kirveskari, E., Aronen, H.J., Avikainen, S., Brander, A., Huttunen, J., Ilmoniemi, R.J., Jääskeläinen, E., Kovala, T., Mäkelä, J.P., Salli, E., and Seppä, M., *Sensorimotor cortex localization: Comparison of magnetoencephalography, functional MR imaging, and intraoperative cortical mapping*, Radiology, **241**, p. 213-222 (2006).

20. Kujala, J., Pammer, K., Cornelissen, P., Roebroeck, A., Formisano, E., and Salmelin, R., *Phase coupling in a cerebro-cerebellar network at 8-13 Hz during reading*, Cerebral Cortex, advanced access published Aug. 22, 2006, p. 1-10 (2006).

21. Kylliäinen, A., Braeutigam, S., Hietanen, J.K., Swithenby, S.J., and Bailey, A.J., *Face and gaze processing in normally developing children: A magnetoencephalographic study*, European Journal of Neuroscience, **23**, p. 801-810 (2006).

22. Kylliäinen, A., Braeutigam, S., Hietanen, J.K., Swithenby, S.J., and Bailey, A.J., *Face- and gaze-sensitive neural responses in children with autism: a magnetoencephalography*, European Journal of Neuroscience, **24**, p. 2679-2690 (2006).

23. Lemm, S., Curio, G., Hlushchuk, Y. and Müller, K.-L., *Enhancing the signal-to-noise ratio of ICA-based extracted ERBs*, IEEE Transactions on Biomedical Engineering, **53**, p. 601-607 (2006).

24. Longcamp, M., Tanskanen, T., and Hari, R., The imprint of action: *Motor cortex involvement in visual perception of handwritten letters*, NeuroImage, **33**, p. 681-688 (2006).

25. Malinen, S., Schurmann, M., Hlushchuk, Y., Forss, N., and Hari, R., *Improved differentiation of tactile activations in human secondary somatosensory cortex and thalamus using cardiac-triggered fMRI*, Experimental Brain Research, **174**, p. 297-303 (2006).

26. Mäkelä, J.P., Forss, N., Jääskeläinen, J., Kirveskari, E., Korvenoja, A., and Paetau, R.,, *Magnetoencephalography in neurosuregery*, Neurosurgery, **59**, 493-510, p. (2006).

27. Näsänen, R., Ojanpää, H., Tanskanen, T., and Päällysaho, J., *Estimation of temporal resolution of object identification in human vision*, Experimental Brain Research, **172**, p. 464-471 (2006).

28. Parviainen, T., Helenius, P., Poskiparta, E., Niemi, P., and Salmelin, R., *Cortical sequence of word perception in beginning readers*, The Journal of Neuroscience, **26**, May 31, p. 6052-6061 (2006).

29. Pääkkönen A., Könönen, M. Eskola, H. Jousmäki, V. and Huttunen J., *Herätevasteet ja funktionaalinen kuvantaminen*, Kliininen neurofysiologia, p. 348-362 (2006).

30. Raij, T.T., *Kipu - todellista vai kuviteltua? Pääkirjoitus.*, Duodecim 2006, 122, p. 751-752 (2006).

31. Renvall, V., Joensuu, R. and Hari R., *Functional phantom for fMRI: a feasibility study*, Magn Reson Imaging, **24**, 3, p. 315-320 (2006).

32. Saarinen, T., Laaksonen, H., Parviainen, T., and Salmelin, R., *Motor cortex dynamics in visuamotor production of speech and non-speech mouth movements*, Cerebral Cortex, **16**, p. 212-222 (2006).

33. Salmelin, R. and Kujala, J., *Neural representation of language: Activation versus long-range connectivity*, Trends in Cognitive Sciences, **10**, 11, p. 519-525 (2006).

34. Schürmann, M., Caetano, G., Hlushchuk, Y., Jousmäki, V., and Hari, R., *Touch activates human auditory cortex*, NeuroImage, **30**, p. 1325-1331 (2006).

35. Sivonen, P., Maess, B., and Friederici, A.D., *Semantic retrieval of spoken words with an obliterated initial phoneme in a sentence context*, Neuroscience Letters, **408**, p. 220-225 (2006).

36. Sivonen, P., Maess, B., Lattner, S., and Friederici, A.D., *Phonemic restoration in a sentence context: Evidence from early and late ERP effects*, Brain Research, **1121**, p. 177-189 (2006).

37. Sorrentino, A., Parkkonen, L., Piana, M., Massone, A.M., Narici, L., Carozzo, S., Riani, M., and Sannita, W.G., *Modulation of brain and behavioral responses to cognitive visual stimuli with varying signal-to-noise rations*, Clinical Neurophysiology, **117**, p. 1098-1105 (2006).

38. Vanni, S., *Näköjärjestelmä ja visuaalinen havaintomailma*, in Book: Mieli ja Aivot, Kognitiivisen neurotieteen oppikirja, p. 146-156 (2006).

39. Vanni, S., Henriksson, L., Viikari, M., and James, A.C., *Retinotopic distribution of chromatic responses in human primary visual cortex*, European Journal of Neuroscience, **24**, p. 1821-1831 (2006).

40. Vihla, M., Laine, M., and Salmelin, R., *Cortical dynamics of visual/semantic vs. phonological analysis in picture confrontation*, NeuroImage, **33**, p. 732-738 (2006).

41. Ylioja, S., Carlson, S., Raij, T.T., and Pertovaara, A., *Localization of touch versus heat pain in the human hand: A dissociative effect of temporal parameters on disciminative capacity and decision strategy*, Pain, **121**, p. 6-13 (2006).

CERN

42. Ageev, E.S., Berglund, P., and COMPASS Collaboration, *Gluon polarization in the nucleon from quasi-real photoproduction of high- pT hadron pairs*, Physics Letters B, **633**, p. 25-32 (2006).

INTERFACE

43. Alles, H., *Külmalabor kui Suure Paugu katsepolügoon*, Horisont, 5/2006, p. 32-38 (2006).

44. Junes, H.J., Alles, H., Parshin, A.Ya., Todoshchenko, I.A., and Tsepelin, V., *Measurements of the step energy on melting 3He crystals around 1 mK*, Proceedings of the XL Annual Conference of the Finnish Physical Society, p. 33 (2006).

45. Todoshchenko, I.A., Alles, H., Bueno, J., Junes, H.J., Parshin, A.Ya., and Tsepelin, V., *Melting curve of 4He: No sign of a supersolid transition down to 10 mK*, Physical Review Letters, **97**, p. 165302/1-4 (2006).

46. Todoshchenko, I.A., Alles, H., Junes, H.J., and Parshin, A.Ya., *On the growth dynamics of 4He crystals near the first roughening transition*, AIP Conference Proceedings (LT24), **850**, p. 337-338 (2006).

NANO

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APPENDIX 1

Report on the Progress of the Finnish Centre of Excellence "Low Temperature Phenomena and Quantum Devices"

This CoE continues support of the Low Temperature Laboratory at HUT and incorporates a strategic alliance with the Quantronics group at VTT as well as a strong collaboration with MIKES. Previously both the Low Temperature Laboratory and the Brain Research Unit were funded as a single CoE. Now the BRU is funded as a separate CoE, and this is a very positive development. The new structure of the Low Temperature Phenomena and Quantum Devices CoE (2006-2011) has great future potential for both sustaining international leadership in basic research and promoting links to industry in an optimal way.

Organisation of Evaluation

This evaluation is based on a site visit which took place on Thursday November 9th 2006. Prior to this visit the following documentation was made available:

Annual Report of Low Temperature Laboratory CoE 2005
Activity Report and Research Plan (2005-2009), dated October 2006.
CoE application (January 2005)
Publications of the Finnish Academy of Sciences (FAS) as background material.

The site visit took the form of

A presentation by the FAS of the CoE and the mission of the SAB
An overview by the director of the CoE and its activities.
Oral presentations (nine) of past activities and future plans by group leaders.
A presentation from MIKES on its collaboration with the CoE
A visit to the construction site of the new laboratory
Presentation on developments on cryogen-free and automated low temperature systems
Extended tour of Cryohall with detailed poster presentations by graduate students.

The site visit was organised most efficiently and was very helpful to the SAB.

Overview of CoE

The CoE currently consists of six groups ROTA, INTERFACE, YKI, NANO, PICO, QUANTRONICS (VTT). A major impending development is the relocation of the activities of the first 5 groups to a newly refurbished laboratory in September 2007. The opportunity will be taken to merge the INTERFACE and YKI groups. Clean room facilities (class 10,000) will be relocated to the new building. This facility importantly provides an environment in which graduate students can fully engage and train in nanofabrication and currently produces 90% of the samples used. In addition the QUANTRONICS and PICO group (50%) are located in the MICRONOVA Centre for Micro and Nanotechnology in a separate building, but close to LTL. This arrangement gives access to a high quality nanofabrication suite, promotes internal collaboration, and future industrial applications.

We were particularly impressed by the planning of the laboratory relocation. It is clear that refurbishment of an existing building to accommodate the CoE was creating problems, such as limitations on space for installation of services and unexpected surprises revealed by excavation work. Additional high expertise technical support has been arranged to assist with the move. The opportunity is being taken to upgrade cryostats with automatic gas-handling systems designed at LTL.

It appeared to us that a good opportunity now exists to enhance the core facilities of the CoE. Thus if the possibility exists to provide institutional (eg TKK) or other support for this relocation with further equipment upgrades requested by LTL (an example might be

a new dilution refrigerator for research on quantum devices) then this would be very timely and fully supported by the SAB.

The evolution of the CoE over the period 1996 to 2005 shows a steady growth in activity on Quantum Devices. International leadership in Quantum Fluids and Solids is well established and sustained by recent achievements and future plans. Research in Quantum Devices (both fundamental quantum phenomena and applications) has also established international leadership. In all areas of activity the CoE has high international visibility. The SAB strongly feels that overall manpower levels in this CoE should be maintained, despite the planned national reduction in public employees. It was also felt important to maintain the level and quality of in-house technical support.

The merger of the INTERFACE and YKI groups is a delicate issue which is being handled sensitively. Both groups have a high level of recent achievement and extremely interesting future plans, which go beyond the laboratory relocation. This is discussed in more detail later in this report.

The standards set by the CoE for self-assessment of its impact are rigorous and it continues to meet them. Most notable are the number of Physical Review Letters and five publications in even higher impact factor journals (such as Nature and Reviews of Modern Physics) in the past year. In both cases the CoE provides about 20% of the total Finnish output. A new trend is the number of patents granted (26 in 2005-2006), which reflects very positively on the restructuring of the CoE. Additional highlights include prestigious invited talks at the American Physical Society March Meeting in 2007. The international visibility of all activities of the CoE is very high.

The plan to spin out a new company (Aivon Ltd) in the area of superconducting electronics is very exciting. The strategy described by the Quantronics (VTT) group on approaches to the relationship between basic/applied research and real world applications, the doctrine of proactive invention and innovation, was very interesting and appeared sound. Given this and the strong synergies with other groups (PICO and NANO) the prospects for exploiting the work of the CoE, for technology transfer and applications satisfying real needs seem excellent.

All the groups of the CoE maintain an extensive network of international collaborations which impacts positively on the output of the CoE. The EU funded Large scale Facility is funded until 2008 and arrangements post-2008 are under investigation. The NANO and PICO groups also participate in EU funded networks.

Theory Programme
The theory programme is not really a separate programme, but rather the theoretical support is embedded in the group structure of the CoE. Theory support for the NANO and PICO teams has been significantly strengthened by the appointment of Heikkilä to an Academy Research Fellowship. Theory support for the ROTA group has been weakened by the move of Thuneberg away from Helsinki, and this should be addressed. The international status of the theory group is extremely high (eg award of Simon prize to Volovik). The INTERFACE group relies on theory support from Parshin, which seems to work well. Nevertheless, the desirability of theoretical activities overall to have a broader local impact, raised in assessments of the previous CoE, is still a matter for consideration.

ROTA group
The essence of superfluidity is behaviour under rotation. The early recognition of this fact in Helsinki and the historical achievements of the group are enormous and have dominated the field [recent review article 2006]. The work benefits from extensive

international collaboration/visitor programme. Nevertheless the future promises a very rich seam of new science, with profound implications far beyond ^{3}He, in particular new insights into the unsolved problem of turbulence. Modifications to the cryostat now allow lower temperatures to be achieved and open a new fertile area: vortex dynamics in the ballistic quasiparticle regime in both the A and B phases. We confidently expect important new insights of wide ranging impact to emerge from this work. In our opinion securing the long term future of this activity should be a high priority for the CoE.

YKI group
The capability of this group to cool metallic samples into the microkelvin regime is unsurpassed, and is a technical expertise that it is important to protect. The most significant recent achievement of the group is the observation of superconductivity in lithium; since lithium is rather a simple metal this work is likely to have a high impact when published in an appropriate journal. Most recent efforts have focussed on a strikingly novel approach to cooling isotopic helium mixtures in the search for superfluidity. This really is a holy grail of low temperature physics; the mixture of fermionic and bosonic superfluids. Indeed the comparison with cooled dilute alkali gases, very different systems, is potentially very fruitful. The work of the group is promising, and it is recognised that many design improvements are possible. We encourage a determinedly adventurous, rather than excessively incremental, approach aimed at a step change improvement in cooling performance.

INTERFACE group
The group has a leading international position in the study of interfaces in helium crystals. These are unsurpassed model systems for the investigation of crystal growth and also exhibit quantum effects in the growth. Several groups world-wide are pursuing this area, the importance of which was recognised by an important review article (Rev Mod Phys) co-authored by the Helsinki group. The set-up within the CoE, to optically study helium crystals below 1mK, meets huge technical challenges and is unique. The recent proposal that crystals of ^{4}He are supersolids has excited a great deal of interest. Characteristically the Helsinki group has responded rapidly to the challenge, and through high precision measurements of the melting curve found no evidence for such a transition; this work is an important marker in the field. Up to the planned laboratory move the group will focus on new real-time studies of ^{4}He crystal growth. Future studies will involve work to lower temperatures on ^{3}He crystals, using a technically improved set-up (cryostat and new cell), to look for predicted crystallisation waves. Cooling to the required temperatures poses a significant technical challenge, which is beginning to be addressed. If found these novel crystallisation waves would be an exciting phenomenon.

Proposed merger of YKI and INTERFACE groups
Both groups are operating at an extremely high technical level, have cutting edge expertise, have a good track record of recent achievements and exciting future plans. Of these future plans, the search for superfluidity in helium mixtures is the most risky; possibly this is a challenge best met by an international collaboration if additional funding could be secured.

PICO group
Only four years after it was established at LTL this group has already carved out an internationally leading position for itself in the highly competitive field of mesoscopic physics and quantum devices. The remarkable publication record since 2005, which includes two articles in Nature and one in Reviews of Modern Physics, is one indicator of their success. Building on work that lead to perhaps the first commercial product based on the Coulomb blockade phenomenon – a primary thermometer for the 20 mK to 50 K

regime – the group has gone on to study heat transport mechanisms and refrigeration in nanoscale structures at low temperatures. The recent observation of single-mode quantized heat conduction by photons is particularly impressive. Other activities focus on devices based on Josephson junctions in the quantum limit and studies of noise and counting statistics in mesoscopic conductors. We are confident that this group will continue to produce results that are at the very front of the field. Their plans for pursuing electronic refrigeration down to 10 mK seem quite realistic and the collaboration with MIKES and the QUANTRONICS group may well lead to the first current standard based on single charge manipulation - the holy grail of metrology these days.

NANO group
This group has been instrumental in the gradual shift of the research focus of the LTL from quantum fluids and solids towards quantum devices that started when the present director took office. The remarkably smooth and successful process of partially "reinventing" LTL is to the credit of not only the LTL management and the NANO (and PICO) groups, however, but to all of LTL. The NANO group does frontline research on mesoscopic quantum amplifiers, current fluctuations and fast electron dynamics in phase coherent systems, and also on quantum transport in carbon nanotubes. Recent internationally well received results include a direct observation of the so called Josephson capacitance, which is entirely due to the curvature of the energy bands in a "Cooper-pair box" and is relevant in the context of quantum computing, and studies of induced superconductivity in carbon nanotubes. The group has ambitious plans for future research connected to all their projects and we fully expect that they will continue to produce results at a very high level. They enjoy good contacts with strong groups outside Finland and in particular we expect that their work on quantum transport in nanotubes will benefit from the recently started EU project on "Carbon nanotube devices a the quantum limit", which Hakonen coordinates.

QUANTRONICS (VTT) group
This group, the Applied Quantum Electronics Group at VTT, is a great asset for the CeO, providing as it were an interface between academic research and industry – by no means a trivial function. At the same time we believe the CeO is important for the QUANTRONICS group by enabling them to put more effort into long term research (even with matching funding from the VTT itself). Our impression is that the collaboration between the QUANTRONICS, NANO and PICO groups already works very well indeed and that it covers rather a broad range of projects. Research has so far focused on the development of quantum circuit compatible superconducting electronics and on superconducting detector systems. The work on superconducting bolometers for passive THz imaging seems particularly interesting and potentially useful. The group also works on room temperature applications of carbon nanotubes and metallic nanoparticles. A spinoff company, Aivon, has been established to commercialize SQUID developments. We are convinced that the QUANTRONICS group will be an important link to commercialization of ideas developed within the CeO.

London, 23 February 2007 Gothenburg, 23 February 2007

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