ANNUAL REPORT 2011

Aalto University
School of Science

O.V. Lounasmaa Laboratory
Brain Research Unit and
Physics Research Unit
http://ltl.tkk.fi

Table of Contents

PREFACE

Low Temperature Laboratory (LTL), the predecessor of the O.V. Lounasmaa Laboratory (OVLL), was founded by Prof. Olli V. Lounasmaa in 1965 and became an independent TKK research institute in 1973. Since January 1, 2012, due to organizational changes in Aalto University, the laboratory now formally comprises two parts, the Low Temperature Laboratory (LTL; 45% of activities) and the Brain Research Unit (BRU; 55%) started in 1980. The main research fields of LTL are *ultra-low temperature physics* (35%; started in 1965) and *low temperature quantum electronics* (65%; started in 1996), whereas the research of BRU focuses on *systems-level neuroscience and human brain imaging*.

Year 2011 was the time for renewal of the national Centers of Excellence (CoE, 2006-2011) hosted by the laboratory: *CoE in Low Temperature Quantum Phenomena and Devices* (LTL) and *CoE on Systems Neuroscience and Neuroimaging* (BRU). Even though the number of the CoEs funded by the Academy of Finland was reduced, the new CoE in low temperature physics led by Prof. Jukka Pekola was able to retain its status. Compared with the previous CoE application, there is strong renewal as there are four new groups involved: Prof. Peter Liljeroth (Dept Appl. Phys., Aalto), Prof. Arttu Luukanen (VTT), Doc. Sorin Paraoanu (LTL), and Dr. Mika Sillanpää (LTL). Unfortunately, the CoE in neuroscience did not receive funding from the Academy of Finland, but this is partly compensated by Aalto's strong overall support to neuroscience.

The administration of the laboratory during the second half of 2011 was challenging because of major changes in the budgeting principles of Aalto University. First, only 70% of the basic funding was guaranteed, and second, a new depreciation scheme was introduced in which some of the old investments of the laboratory had to be covered again. At the time of writing, these problems are fortunately solved for the year 2012.

In the infrastructure call FIRI2010 by the Academy of Finland, BRU obtained investment money to upgrade the 3T MRI setup at the Advanced Magnetic Imaging Centre of the NEUROIMAGING infrastructure, while LTL got funds to renew refrigeration equipment of the national infrastructure Cryohall. The upgrade of the MRI setup was completed in November and the opening ceremony of the renewed AMI Centre was held in Nov. 29, 2011. For Cryohall, we have ordered three modern pulse-tube based dilution refrigerators, out of which one has so far been installed.

As usual, the visitor program has been very active in the laboratory. Many thanks for this goes to Prof. Matti Krusius who has been running the European Microkelvin collaboration effectively. Tero Heikkilä has been organizing the Aalto Physics Colloquium which has brought many distinguished speakers for a visit in LTL.

Few scientists of OVLL received special recognition in 2011. Prof. Nikolai Kopnin was awarded the prestigious Simon Memorial Prize. Dr. Mika Sillanpää was awarded IUPAP Young Scientist Prize in Low Temperature Physics. Academician Riitta Hari received Nokia Foundation Recognition Award 2011 and was elected an honorary member of Finnish Technical Academy. Acad. Prof. Riitta Salmelin was elected an honorary fellow of the International Society for Functional Source Imaging.

Pertti Hakonen

SCIENTIFIC ADVISORY BOARD

LTL had a Scientific Advisory Board (SAB), appointed by the Rector of TKK for the years 2006–2011. The members also served in the SABs of the Centers of Excellence of the Academy of Finland, coordinated by the LTL.

SAB for the Center of Excellence on *Low Temperature Quantum Phenomena and Devices:*

Prof. Mats Jonson, Gothenburg University, Gothenburg, Sweden. Also at School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, UK.

Prof. William Halperin, Northwestern University, Evanston, Illinois, USA

SAB for the Center of Excellence on *Systems Neuroscience and Neuroimaging:*

Prof. Chris Frith, Functional Imaging Laboratory, University College London, London, UK

Prof. Denis Le Bihan, CEA Saclay, Paris, France

Prof. Nikos K. Logothetis, MPI for Biological Cybernetics, Tübingen, Germany

PERSONNEL

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

ADMINISTRATION AND TECHNICAL PERSONNEL

Mikko Paalanen, D.Sc. (Tech.), Professor, Director of the LTL, on sick leave 1.1.2011–31.8.2011, 1.9.2011 retired
Alexander Savin, Ph.D., Technical Manager
Riikka Aura, secretary, from 05.12.2011
Teija Halme, secretary
Mia Illman, nurse (clinical neurophysiology)
Arvi Isomäki, technician
Jari Isomäki, technician
Olga Jakkola, secretary
Kirsi Susanna Jauhianen, secretary
Mari Kaarni, HR coordinator, from1.8.2011
Helge Kainulainen, technician
Marita Kattelus, radiographer (AMI)
Markku Korhonen, technician
Sari Laitila, secretary, sick leave from 25.11.2011
Ari Laiho, D.Sc. (Tech.), physicist (AMI), from 15.8.2011
Jussi Nurminen, M.Sc. (Tech.), project engineer
Arttu Ollikainen, technician, part-time, until 30.06.2011
Eerik Puska, M.Sc. (Tech.), research assistant, until 30.11.2011
Kirsi Romanoff, project planning officer, maternity leave since 21.10.2011
Petteri Räisänen, system administrator
Veli-Matti Saarinen, project engineer
Jaana Salminen, project planning officer, from 1.8.2011
Ronny Schreiber, research engineer

Katariina Toivonen, controller
Tuomas Tolvanen, computer support

SENIOR RESEARCHERS

Physics Research Unit

Thomas Aref, Ph.D.
Sung Un Cho, Ph.D.
Vladimir Eltsov, Ph.D.
Aurelien Fay, Ph.D., until 25.9.2011
Pertti Hakonen, D.Sc. (Tech.), Professor, Director of the LTL
Tero Heikkilä, D.Sc. (Tech.), Docent, Academy Researcher
Risto Hänninen, D.Sc. (Tech.)
Nikolai Kopnin, Ph.D., Professor
Matti Krusius, D.Sc. (Tech.), Professor
Dimitry Lyashenko, Ph.D.
Francesco Massel, Ph.D.
Matthias Meschke, Ph.D.
Hung Nguyen, Ph.D., from 1.7.2011
Teemu Ojanen, Ph.D.
Gheorghe-Sorin Paraoanu, Ph.D.
Jukka Pekola, D.Sc. (Tech.), Professor
Alexander Sebedash, Ph.D.
Mika Sillanpää, D.Sc. (Tech.)
Xuefeng Song, Ph.D.
Igor Todoschenko, Ph.D.
Juha Tuoriniemi, D.Sc. (Tech.), Docent
Janne Viljas, D.Sc. (Tech)
Grigori Volovik, Ph.D., Professor
Yongsoo Yoon, Ph.D., until 15.12.2011

Brain Research Unit

Riitta Hari, M.D., Ph.D., Acad. Prof., Academician, Head of the Brain Research Unit
Dalila Akkal, Ph.D., senior scientist @ aivoAALTO, until 31.1.2011
Toni Auranen, D.Sc. (Tech.)
Pamela Baess, Ph.D.
Synnöve Carlson, M.D., Ph.D., Visiting Professor
Nina Forss, M.D., Ph.D., Docent, part-time
Syed Irtiza Ali Gilani, Ph.D.
Linda Henriksson, D.Sc. (Tech.)
Yevhen Hlushchuk, Ph.D., 04.03.2011–31.10.2011
Kaisa Hytönen Ph.D., from 16.12.2011
Veikko Jousmäki, Ph.D., Docent
Miika Koskinen, Ph.D. (Tech.)
Jan Kujala, D.Sc. (Tech.), until 30.04.2011
Miiamaaria Kujala, Ph.D., until 28.2.2011
Mia Liljeström, D.Sc (Tech.)
Sanna Malinen, D.Sc (Tech.)
Catherine Nangini, Ph.D.

Lauri Nummenmaa, Ph.D., senior scientist @ aivoAALTO
Sebastian Pannasch, Ph.D.
Lauri Parkkonen, D.Sc. (Tech.), part-time
Tiina Parviainen, Ph.D., until 30.11.2011
Harri Piitulainen, Ph.D.
Elina Pihko, Ph.D., Docent
Tuukka Raij, M.D., Ph.D., from 1.9.2011
Hanna Renvall, M.D., Ph.D.
Ville Renvall, D.Sc. (Tech.)
Riitta Salmelin, D.Sc. (Tech.), Academy Professor
Mika Seppä, D.Sc. (Tech.)
Juha Silvanto, Ph.D., Docent
Claire Stevenson, Ph.D.
Simo Vanni, M.D., Ph.D., Docent
Johanna Vartiainen, D.Sc. (Tech.), on leave from 30.04.2011

GRADUATE STUDENTS – (SUPERVISORS)

Physics Research Unit

Khattiya Chalapat, M.Sc. - (Gheorghe-Sorin Paraoanu)
Vitaly Emets, M.Sc. (Tech) - (Pertti Hakonen)
Timothe Faivre, M.Sc. - (Jukka Pekola)
Anna Feshchenko, M.Sc., from 15.8.2011 - (Jukka Pekola)
Simone Gasparinetti, M.Sc. - (Jukka Pekola)
Robert de Graaf, M.Sc., until 19.5.2011 - (Matti Krusius, Vladimir Eltsov)
Petri Heikkinen, M.Sc. (Tech.) - (Matti Krusius, Vladimir Eltsov)
Jaakko Hosio, M.Sc. (Tech.) - (Matti Krusius, Vladimir Eltsov)
Janne Karimäki, M.Sc. (Tech.) - (Risto Hänninen)
Raphaél Khan, M.Sc. (Tech) - (Tero Heikkilä)
Matti Laakso, M.Sc. (Tech.) - (Tero Heikkilä)
Li Jian, M.Sc. - (Gheorghe-Sorin Paraoanu)
Pasi Lähteenmäki, M.Sc. - (Pertti Hakonen)
Ville Maisi, M.Sc. (Tech.) - (Jukka Pekola, Antti Manninen)
Matti Manninen, M.Sc. (Tech.) - (Juha Tuoriniemi)
Juha Muhonen, M.Sc. (Tech.) - (Jukka Pekola)
Mika Oksanen, M.Sc. - (Pertti Hakonen)
Joonas Peltonen, M.Sc. (Tech.), until 30.11.2011 - (Jukka Pekola)
Juha-Matti Pirkkalainen, M.Sc. (Tech.) - (Mika Sillanpää)
Antti Puska, M.Sc. (Tech.) - (Pertti Hakonen)
Juho Rysti, M.Sc. (Tech.) - (Juha Tuoriniemi)
Olli-Pentti Saira, M.Sc. (Tech) - (Jukka Pekola)
Anssi Salmela, M.Sc. (Tech.) - (Juha Tuoriniemi)
Karthikeyan Sampath Kumar, M.Sc. - (Gheorghe-Sorin Paraoanu)
Jayanta Sarkar, M.Sc. - (Pertti Hakonen)
Juha Voutilainen, M.Sc. (Tech.) - (Tero Heikkilä)

Brain Research Unit

Robert Boldt, M.D., @ aivoAALTO
Silvia Bona, Med.Lic., from 28.6.2011 - (Juha Silvanto)

Jaana Hiltunen, Phil.Lic., until 31.5.2011 - (Riitta Hari)
Lotta Hirvenkari, M.Sc. (Biol.) - (Riitta Hari, Veikko Jousmäki)
Jaakko Hotta, Med.Lic. - (Nina Forss)
Annika Hultén, M.Sc. (Psych.), until 15.5.2011 - (Riitta Salmelin, Matti Laine)
Kaisa Hytönen, M.Sc. (Tech.), @ aivoAALTO, until 15.12.2011
Antti Jalava, M.Sc. (Tech.) - (Riitta Salmelin)
Leena Karvonen, M.Sc. (Psych.) - (Riitta Salmelin)
Miiamaaria Kujala, M.Sc. (Cogn. sci), until 28.2.2011– (Riitta Hari)
Hannu Laaksonen, M.Sc. (Tech.) - (Riitta Salmelin)
Kristina Laaksonen (os. Roiha), M.D., - (Nina Forss)
Satu Lamminmäki, M.D. - (Riitta Hari)
Sanna Malinen, M.Sc. (Tech.), until 9.6.2010 - (Riitta Hari)
Anne Mandel, M.Sc. (Psychol. & Neurosci.) - (Riitta Hari)
Lauri Nurminen, M.Sc. (Psychol.) - (Simo Vanni)
Siina Pamilo, M.Sc. - (Riitta Hari)
Pavan Ramkumar, M.Sc. (Tech) - (Riitta Hari)
Fariba Sharifian, M.Sc. - (Simo Vanni)
Anni Simula, M. Sc. from 28.2.2011 - (Riitta Salmelin)

UNDERGRADUATE STUDENTS

Physics Research Unit

Samuli Autti, 24.5.–31.12.2011
Erno Damskägg, 1.6.–31.8.2011
Niklas Hietala, 10.1.–31.12.2011
Pasi Häkkinen, 1.6.–31.12.2011
Jukka–Pekka Kaikkonen, 1.1.–31.1.2011, 1.8.–31.8.2011
Ville Kauppila, 30.5.–31.12.2011
Jonne Koski, 1.1.–31.12.2011
Antti Laitinen, 1.8.–31.12.2011
Jere Mäkinen, 1.1.–31.12.2011
Teemu Nieminen, 24.5.–31.12.2011
Ville Peri, 30.5.–31.12.2011
Jaakko Sulkko, 1.1.–31.12.2011
Matti Tomi, 1.1.–31.12.2011
Antti Vepsäläinen, 1.6.–31.12.2011
Jukka Väyrynen, until 31.07.2011

Brain Research Unit

Miika Aula, 1.6.–30.6.2011
Siiri Helokunnas, 1.9.2011–31.12.2011
Aleksi Ikkala, 30.5.–31.12.2011
Mainak Jas, 2.5.–18.7.2011
Marika Kaksonen, 12.10.–31.12.2011
Mariia Keitaanniemi, 1.1.–31.5.2011
Mika Mäntykangas, 30.5.–31.12.2011
Teemu Mäntylä, 1.4.–31.7.2011
Kranti Nallamothu, 1.1.–31.12.2011
Pauliina Ojala, 1.1.–31.12.2011

Henna Roikola, 1.1.–31.1.2011
Ilmo Räisänen, 17.5.–31.12.2011
Joel Rämö, 26.5.–31.12.2011
Jukka Saari, 1.1.–31.12.2011
Timo Saarinen, 1.1.–31.12.2011
Joel Sammallahti, 1.1.–28.2.2011
Eero Smeds, 28.3.–31.7.2011
Emma Suppanen, 30.5.–31.12.2011
Heikki Tarkkila, 1.1.–31.12.2011
Mikko Tiainen, 30.5.–31.12.2011
Tuomas Tolvanen, 1.1.–31.12.2011
Sanna Tyrväinen, 10.5.–16.8.2011
Aino Valli, 30.5.–31.12.2011
Anne Virtanen, 1.2.–31.3.2011

VISITORS

MICROKELVIN VISITORS

Bunkov Yuriy, Ph.D., 29.12.2011–4.1.2012, Institut Néel, Grenoble, France
Cox Daniel, student, 13.7.–19.9., School of Physics, University of Exeter, Devon, UK
Galperine Iouri, Ph.D., 27.11.–3.12., Department of Physics, University of Oslo, Norway
Komanicky Vladimir, Ph.D., 16. –27.5., Safarik University, Institute of Physical Sciences, Kosicé, Slovakia
L´vov Victor, Prof., 29.7.– 29.8., Weizmann Institute of Science, Israel
Nyeki Jan, Ph.D., 3.–4.10., 25.10.–7.11., 16.11.–18.11., Royal Holloway University of London, UK
Sindler Michal, M.Sc., 1.3.–2.6., Charles University, Prague
Sonin Edouard, Prof., 30.8.–30.9., Hebrew University of Jerusalem, Racah Institute of Physics, Israel
Suramlishvili Nugzar, Ph.D., 16.–25.10., Newcastle University, UK

OTHER VISITORS

Alles Harry, Dr. Tech, 5.–23.6., 26.1.–13.2., 7. –21.4., University of Tartu, Institute of Physics
Birge Norman, Prof., 9.–13.11., Department of Physics and Astronomy , Michigan State University, USA
Bourguignon Mathieu, M.Sc., 4.4.–1.7., MEG-unit, ULB-hôpital Erasme, Brussels, Belgium
Brogaard Brit, Prof., 8.–11.5., Department of Philosophy, University of Missouri
Catelani Gianluigi, Ph.D., 7.–11.12., Department of Physics, Yale University, USA
Chowdhury, Golam, M.Sc., 6.–7.10., Institute for Theoretical Solid State Physics Karlsruhe Institute of Technology, Germany
Dobrovolsky Alexander, Ph.D., 8.–13.10., Lomonosov Moscow State University, Russia
Finkelstein Gleb, Ph.D., 14.–16.6., Department of Physics Physics Bldg, Duke University, USA
Flindt Christian, PhD. Dr., 12.–15.4., Institute for Theoretical Physics, University of Geneva, Switzerland

Gusikhin Pavel, M.Sc., 11.2.–21.3., Institute of Solid State Physics, Russia
Halperin William, Ph.D., 15.–18.6., Department of Physics and Astronomy, Northwestern University, USA
Hekking Frank, Prof., 1.–5.8., 31.10.–4.11., Joseph Fourier University, Grenoble, France
Isacsson Andreas, Dr, Ph.D., 28.11.–1.12., Chalmers University of Technology, Sweden
Jonson Mats, Prof., 15.–17.6., School of Engineering & Physical Sciences, Heriot-Watt University, UK
Kamleitner Ingo, Ph.D., 12.–16.12., Institute for Theoretical Condensed Matter physics, Karlsruhe Institute of Technology, Germany
Karimi, Mohammad Amin, M.Sc., 8. –10.11., University of Kurdistan, Iraq
Knowles Helena, M.Sc., 13. –23.12., University of Cambridge, UK
Lecocq Florent, Ph.D, 20.–24.6., Institut Néel, CNRS/Grenoble
Lesovik Gordey, Prof., 24.–30.5., Landau Institute Moscow RAS, Russia
Maniscalco Sabrina, Lecturer, 15.11.–16.12., School of Engineering & Physical Sciences, Heriot-Watt University, UK
Midvedt Daniel, M.Sc., 27.–30.11., Applied Physics, Chalmers University of Technology, Sweden
Molinaro Nicola, Ph.D., 5.–24.9., BCBL, Basque Center on Cognition, Brain and Language, Spain
Pascarella Annalisa, Ph.D. ., 25.9.–1.10., Univeritàdegli Studi di Verona, Italy
Pashkin Yuri, Ph.D., 26.5.–11.6., NEC Green Innovation Research Labratories, Japan
Pugnetti, Stefano, Ph. D., 7.–11.11., Scuala Normale Superiore, Italy
Tapani Riekki, M.Sc., 1.6. –31.8., Helsinki University, Finland
Saha Arjiit, Postdoctoral Fellow, 2.–3.3., Weizmann Institute of Science, Israel
Salmela Viljami, Ph.D., 16.5.–31.12., University of Helsinki, Institute of Behavioral Sciences
Schurmann Martin, MD, Ph.D., 5.–19.4., 15.–28.8., School of Psychology, University of Nottingham
Shah Vishal, Ph.D., 23.3.–31.12., University of Warwick, UK
Simula Tapio, D.Sc. (Tech), 21.–23.6., School of Physics, Monash University, Australia
Sonin Edouard, Prof., 10.–14.1., Hebrew University of Jerusalem, Racah Institute of Physics, Israel
Stroganova Tatiana, Prof., 7.–20.6., Moscow State University of Psyhology and Education, Russia
Tatler Benjamin, Lecturer, 3.–5.3., School of Psychology, The University of Dundee, UK
Varlamov Andrey, Prof., 10.–12.2., SPIN-CNR, Italy
Weber Berndt, Prof., 29.–31.5., Center for Economics and Neuroscience, University of Bonn, Germany
Wiesner Maciej, Ph.D., 3.4.–4.7., Faculty of Physics, Adam Mickiewicz University

GROUP VISITS

Bit Bang Study Tour*,* organized by Prof. Yrjö Neuvo and Dr. Sami Ylönen, MIDE, Aalto University, MIDE, Aalto University, (9.–14.1.)

Controllerien vierailu, Controllers visit (7.6.)
Aalto-yliopiston seniorikilta, 25 persons, Aalto University's previous employeers (7.6.)
Ulkomaalaisia professoreita ja tutkijoita, Various foreign professors and researchers (15.6.)
Participants of "International Discussion Meeting on Thermoelectrics and Related Functional Materials", 15 Japanese and 13 European professors, (15.6.)
Millenium Youth Camp (16.6.)
Aalto-yliopiston vaihto-opiskelijoita, Aalto University exchange students (20.9.)
Abeja ympäri suomea, students from various high schools in Finland (2.11.)
Vanhempainsitsit, parents visiting university (15.10.)
Abeja Helsingistä, high school students from Helsinki (3.11.)
Tapiolan lukio, students from Tapiola high school (15.11.)
Lohjan lukio, students from Lohja high school (17.11.)
Metropolia, visit from Metropolia (24.11.)
Porin lukio, students from Pori high school (13.12.)

INTERNATIONAL COLLABORATIONS

MICROKELVIN – European Microkelvin Collaboration

Microkelvin is an EU-funded 5-million-Euro collaborative networking project in the FP7 research infrastructures programme which is coordinated by LTL. This bottom-up integrating activity consists in addition of ten other European academic institutions and of one industrial partner, BlueFors. Its overall goal is to establish a European "ultra-low-temperature laboratory without walls". Microkelvin was planned to run until 31 March, 2013, but an application for a 6-month extension until 30 September, 2013, has been submitted to the EU Project Office in Brussels via the Project Officer Maria Douka. A future continuation of the Microkelvin concept is being planned within the EU Horizons 2020 Framework Programme.

The Microkelvin objectives can be condensed to three items: (1) To provide access to facilities with nuclear refrigeration to μK temperatures for research and educational purposes. For example during the past year 2011, Microkelvin funded the visits of 9 researchers to the laboratory for a total of 10.3 months. Altogether Microkelvin will fund more than 27 months of research visits to LTL. Owing to its popularity, the LTL share of the Microkelvin visitor programme will be completed before the middle of 2012. (2) A second goal is to open the μK range to nanophysics research. Examples of such efforts are the many workshops and user meetings where information exchange and communication between the ultra-low-temperature and nanophysics communities is developed. Another example is the development work on a fully automated nuclear cooling refrigerator so that "push-button refrigeration" would attract interest among nanophysics experimenters. (3) The Third goal is to develop refrigerators, measuring instrumentation and methods. From the LTL contribution to this work two efforts can be mentioned: the development of on-chip refrigeration and thermometry. These tunnel-junction-based devices, the superconducting coolers of S-I-N-I-S structure and the Coulomb blockade thermometer, are envisioned to become important one day as a practical platform for various types of sensors to be operated below 100 mK, for instance, in astrophysics measurements.

In 2011 Microkelvin organized a Workshop and Users Meeting in the Smolenice Castle of the Slovak Academy of Sciences 14–18 March and participated in the organization of four other international conferences with ultra-low-temperature involvement. Information on the various Microkelvin activities and on progress in its four different joint research packages can be found on the Microkelvin web site:
http://www.microkelvin.eu/

Matti Krusius, Microkelvin coordinator 2011–2013

CONFERENCES AND WORKSHOPS

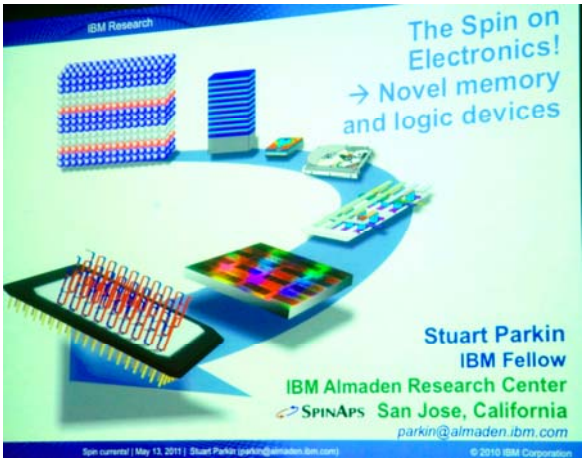
Aalto physics colloquium

Coordinator: Tero Heikkilä

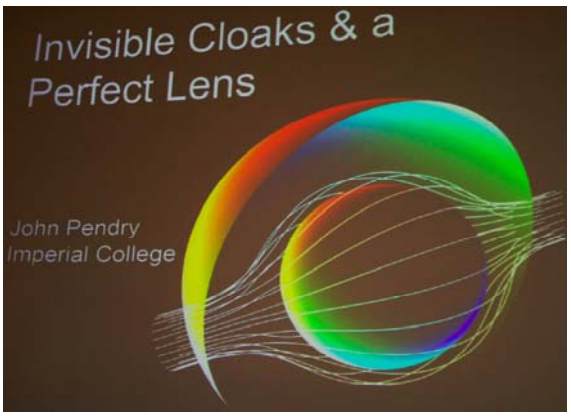
Selection committee:

- Matti Kaivola
- Risto Nieminen
- Jukka Pekola

Aalto physics colloquium is a high-level colloquium series covering all branches of physics in the Aalto University. Its aim is to invite high-level physicists from all around the world to tell about their research. The lectures are targeted to all physicists and those interested in physics. Entrance to the events is free of charge. Colloquia are organized approximatively once a month during the semesters and the invitation responsibility circulates between all physics professors on the Aalto campus. The colloquium is funded by the Aalto Department of Applied Physics, Academy of Finland, Computational Nanoscience (COMP) and Low Temperature Laboratory.



Stuart Parkin, IBM Almaden Research Center: ”*The Spin on Electronics! – Science and Technology of spin currents in nano-materials and nano-devices*”



John Pendry, Imperial College, London, UK: *"Invisible Cloaks & a Perfect Lens"*

Center of Excellence in Low Temperature Quantum Phenomena and Devices: Scientific Advisory Board Meeting

Place: Lecture Hall E, Otakaari 1, Espoo

Time: June 16, 2011

EVALUATORS
Professor Mats Jonson, Heriot-Watt Univ., UK and Gothenburg Univ., Sweden
Professor William Halperin, Northwestern University, USA

OBSERVERS

Science Advisor Antti Väihkönen, Academy of Finland
Profesor Riitta Kyrki-Rajamäki, Lappeeranta University of Technology and Academy of Finland
Executive Vice President Anne-Cristine Ritschkoff, VTT (Strategic Research)
Director Ritva Dammert, Strategic Support for Research and Education, Aalto
Professor Arttu Luukanen, VTT
Professor Peter Liljeroth, Aalto University


Center of Excellence in Low Temperature Quantum Phenomena and Devices. SAB meeting and laboratory visit.

International conference "Advanced many-body and statistical methods in mesoscopic systems"

Place: Constanta, Romania

Time: June 27-July 2, 2011,

Organizers: D. V. Anghel (IFIN-HH, Bucharest), D. Delion (IFIN-HH, Bucharest), and G. S. Paraoanu (LTL, Aalto University, Finland)

Conference proceedings editors (J. Phys., Conf. Ser. **338** (2012)): D. V. Anghel (IFIN-HH, Bucharest), D. Delion (IFIN-HH, Bucharest), and G. S. Paraoanu (LTL, Aalto University, Finland)

It has increasingly been realized in recent times that the borders separating various subfields of physics are largely artificial. This is the case for nanoscale physics, physics of lower-dimensional systems and nuclear physics, where the advanced techniques of many-body theory developed in recent times could provide a unifying framework for these disciplines under the general name of mesoscopic physics. Other fields, such as quantum optics and quantum information, are increasingly using related methods.

The 6-day conference “Advanced many-body and statistical methods in mesoscopic systems” that took place in Constanta, Romania, between 27 June and 2 July 2011 was, we believe, a successful attempt at bridging an impressive list of topical research areas: foundations of quantum physics, equilibrium and non-equilibrium quantum statistics/fractional statistics, quantum transport, phases and phase transitions in mesoscopic systems/superfluidity and superconductivity, quantum electromechanical systems, quantum dissipation, dephasing, noise and decoherence, quantum information, spin systems and their dynamics, fundamental symmetries in mesoscopic systems, phase transitions, exactly solvable methods for mesoscopic systems, various extension of the random phase approximation, open quantum systems, clustering, decay and fission modes and systematic versus random behaviour of nuclear spectra.

This event brought together participants from seventeen countries and five continents. Each of the participants brought valuable expertise in his/her field of research and, at the same time, was exposed to the newest results and methods coming from the other, seemingly remote, disciplines.

The talks touched on subjects that are at the forefront of topical research areas and we hope that the resulting cross-fertilization of ideas will lead to new, interesting results from which everybody will benefit.

We are grateful for the financial and organizational support from IFIN-HH, Ovidius University (where the conference took place), the Academy of Romanian Scientists and the Romanian National Authority for Scientific Research.

LOW TEMPERATURE PHYSICS RESEARCH

NANO group

Vitaly Emets, Aurelien Fay, **Pertti Hakonen**, Pasi Häkkinen, Antti Laitinen, Dmitry Lyashenko, Pasi Lähteenmäki, Teemu Nieminen, Antti Puska, Jayanta Sarkar, Xuefeng Song, and Matti Tomi

Visitors: H. Alles, D. Cox, Yu. Makhlin, and E. Sonin

Collaborators: H. Craighead, R. Danneau, P. Liljeroth, A. Morpurgo, S. Paraoanu, J. Parpia, P. Pasanen, B. Plaçais, S. Russo, H. Seppä, M. Sillanpää, and E. Thuneberg

The research work of the NANO group is focused on four areas: 1) Mesoscopic quantum amplifiers and qubits, 2) Quantum transport in carbon nanotubes and graphene, 3) Current fluctuations and fast dynamics in quantum circuits, and 4) Nanoelectromechanical systems. In all of these categories, our measurements are centered at microwave frequencies, involving reflection measurements for qubits, transmission measurements for AC-conductance, and two-channel noise recording for cross correlation studies.

JUNCTION AMPLIFIERS AND DYNAMICAL CASIMIR EFFECT

P. Lähteenmäki, T. Nieminen, and **P. Hakonen**

The ***dynamical Casimir effect*** was studied in a Josephson metamaterial acting as an analog of a moving mirror in vacuum.[1] The material was pumped by high-frequency external magnetic field which leads to a non-adiabatic change of the material properties and modulation in the phase of a reflected microwave signal. The material was operated in a cavity configuration to enhance the production of photons from the dynamical Casimir effect. A measurement scheme using two RF signal analyzers operating near 5.4 GHz, the resonant frequency of our metamaterial cavity, were used to collect quadrature correlations at two symmetrically positioned frequencies around the electrical resonance. Two-frequency correlations were directly observed, indicating pairwise production of photons out of the vacuum. Also, a bimodal amplitude spectrum, as predicted by theory, was observed and good correspondence between theory and experiment was found (See Figure 1).

Preparations were started to extend metamaterial investigations towards time-dependent phenomena, which would allow studies of ***"slow light"*** and ***generation of Hawking radiation***. Metamaterial samples for studying Hawking radiation were designed in collaboration with J. Hassel at VTT. At the same time, measures targeting the minimization of dielectric losses and other sample quality issues were addressed in the new designs. Altogether, the improved components should allow for effective squeezing of the vacuum and generation of spatially separated entangled photon pairs.

The very same Josephson metamaterial can be employed to construct flux-pumped parametric amplifiers. We used a series array of 250 SQUIDs embedded in the center conductor of a coplanar waveguide in a cavity configuration whose resonant

[1] P. Lähteenmäki, G. S. Paraoanu, J. Hassel, and P. J. Hakonen, *Dynamical Casimir effect in a Josephson metamaterial*, arXiv:1111.5608.

frequency could be tuned by roughly one octave from 3 GHz to 6 GHz. These devices are based on flux-tunable Josephson inductance of the SQUIDs which are operated on the dissipationless supercurrent branch. In such an operation, the amplifier (in the phase sensitive mode) does not add any extra noise. The best measurements yield a *Q*-factor of 6000 and the amplifiers display a noise temperature of around 0.4 K at 5.5 GHz, which corresponds to 1.5 $\hbar\omega$, close to the state of the art,[2] and significantly better than any commercially available amplifier.

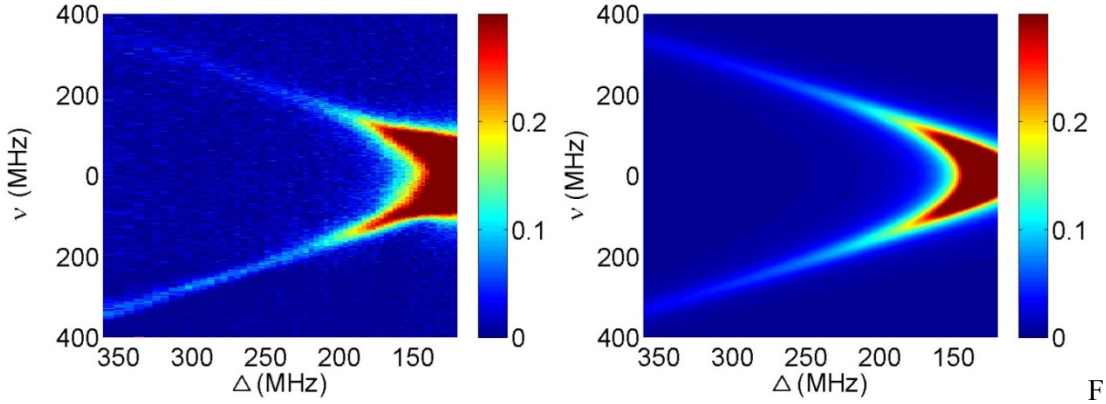


Figure 1: Left: Emitted noise around cavity resonance as a function of $\nu = \omega - \omega_d/2$ while tuning $\Delta = \omega_{res} - \omega_d/2$ measured at 50 mK using pumping frequency ω_d = 10.8 GHz. Right: The corresponding theoretical prediction; in both frames the color scale for the noise power (in dB) is cut at 0.3 dB in the vicinity of $\omega_d/2$.

BLOCH OSCILLATING TRANSISTORS (BOT)

J. Sarkar, A. Puska, and **P. Hakonen**

New options for the improvement of the Bloch oscillating transistor as a null detector for the Quantum Triangle experiment were studied. We concentrated on improving the understanding of the behaviour near the onset of hysteresis.[3] The existence of a hysteretic point can often be utilized to improve the noise characteristics of an amplifier. We have investigated such a possibility in the case of the BOT.

We scanned IV characteristics of a BOT with large, resistive environment (700 kΩ on the collector) over a broad range of Josephson energies E_J (emitter terminal) and base bias currents I_B. We observed record-large

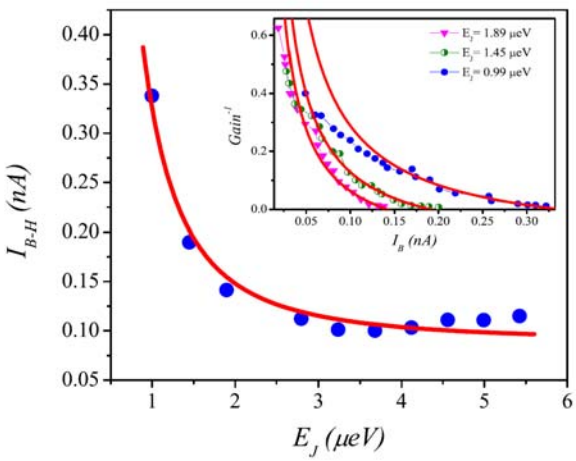


Figure 2: Hysteretic behavior of the BOT is observed above the transition curve marked in red. The circles correspond to divergence of the BOT gain as indicated in the inset. The fitted curves in both frames are based on a model where the ratio of inter- and intra band transitions changes with base current.

---

[2] N. Bergeal, *et al., Phase-preserving amplification near the quantum limit with a Josephson ring modulator*, Nature **465**, 64 (2010).

[3] J. Sarkar, A. Puska, P. Hakonen, *Dynamics of Bloch oscillating transistor near the onset of hysteresis*, to be published.

current gains for the device operation near the hysteretic point at small Josephson coupling energy. From our results for the current gain at various E_J, we determined a transition curve for the onset of the hysteresis on the E_J - I_B plane (See Figure 2). The measured transition curve ($\propto E_J^{-2}$) can be understood using the interplay of inter- and intra-band tunneling events.

SHOT NOISE AND CORRELATIONS IN MULTITERMINAL DIFFUSIVE CONDUCTORS

J. Sarkar, A. Puska, V. Emets, and **P. Hakonen**

Shot noise and cross correlation measurements in multiterminal geometries are expected to be sensitive to phase dependent phenomena and allow probing of interference/exchange effects in mesoscopic systems; the so called Hanbury-Brown Twiss experiments (HBT) form a particular category of such measurements.[4,5] We have investigated cross correlations **in diffusive multiterminal conductors**. The samples were realized using a thin film metal cross of about 1 μm in length, made of 11.5 nm thick and 60 nm wide copper wire. In our measurements performed at 4.2 K in liquid He, the shot noise seemed to vary only little between different wiring configurations, indicating a universal value of 1/3 for the Fano factor. Cross correlation measurements at small bias yielded a nearly zero but positive HBT exchange correction factor (See Figure 3). With growing bias, the HBT exchange part first saturates to a constant after which it decreases and even changes its sign when crossing over to the hot electron regime. This behavior is in line with simulations for similar structures using a computer program made by Pauli Virtanen.

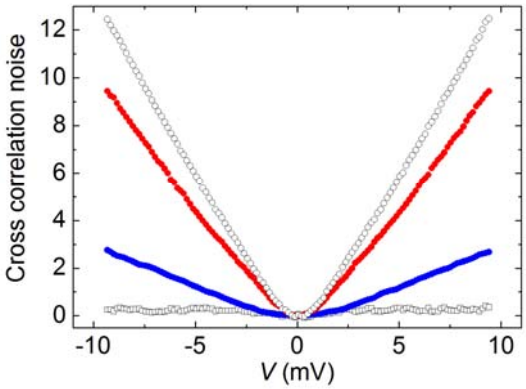


Figure 3: Current-current correlators measured in a diffusive wire cross; A (red), B (blue), and C (open circles)) configurations refers to biasing of the terminals of the sample: A and B mean that single bias voltage is applied while in C both biases A and B are applied simultaneously. Cross correlators are taken between two unbiased terminals in the three different Hanbury-Brown Twiss configurations.

Our experiments on fluctuations have recently been extended towards **phase fluctuations** in superconducting tunnel junctions and S-graphene-S junctions. The goal is to observe multiple phase slips in voltage noise, and first observations on these fluctuations have already been made.

---

[4] Ya. M. Blanter and M. Buttiker, *Current-current Correlations in Multiterminal Diffusive Conductors*, Phys. Rev. B **56**, 2127 (1997).

[5] E. V. Sukhorukov and D. Loss, *Noise in multiterminal diffusive conductors: Universality, nonlocality, and exchange effects*, Phys. Rev. B **59**,13054 (1999).

Electrical transport in carbon nanotubes

P. Häkkinen, L. Lechner, and **P. Hakonen**

We have developed methods to obtain suspended, ultra-clean single-walled carbon nanotubes (SWNT) grown directly across a trench between two prefabricated electrodes. Fig. 4 displays a high crystallinity SWNT suspended over a trench between superconducting Nb/Pt leads (20 nm of Pt on top of 200 nm of Nb). The SWNT was grown from a Fe/Mo/Al_2O_3 catalyst island as the last step of the fabrication process,[6] which guarantees the absence of any resist residues or other dirt. So far, all the measured devices have displayed semiconducting behavior with a total resistance ranging from 20 kΩ to ~100 kΩ. The best semiconducting samples have reached a resistance of 18 kΩ in the ON-state. When measured in ambient air, our device shows hysteric behavior in the source-drain current I_{SD} as a function of gate voltage V_G. This is caused by water molecules adsorbed on to the sample surface. When the measurement is repeated in vacuum, the hysteretic behavior is absent as expected for suspended carbon nanotube devices.[7]

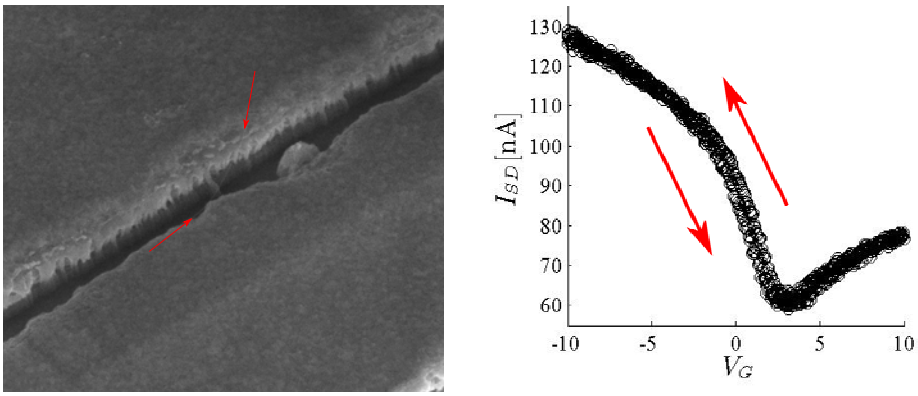


Figure 4: (a) SEM image of a single-walled carbon nanotube suspended over a pair of superconducting Nb/Pt electrodes. (b) I_{SD} as a function of V_G measured in vacuum at room temperature. No hysteretic behavior is observed, as expected for a clean, suspended SWNT. The measurement was made at 5 mV source-drain bias voltage.

Energy relaxation in graphene

A. Fay, T. Heikkilä, P. Häkkinen, J. Viljas, J. Vuotilainen, M. Tomi, and **P. Hakonen**

We have investigated **electron-electron** (e-e) and **electron-phonon** (e-ph) **interactions** in graphene at sub-Kelvin temperatures.[8,9] These phenomena have been studied using shot noise or proximity-induced supercurrents as ***built-in thermometers***.

---

[6] J. Kong, H. Soh, A. Cassell, C. Quate, and H. Dai, *Synthesis of individual single-walled carbon nanotubes on patterned silicon wafers*, Nature, **395**, 878 (1998).

[7] J. Cao, Q. Wang, D. Wang, and H. Dai, *Suspended carbon nanotube quantum wires with two gates*, Small **1**, 138 (2005).

[8] J. Voutilainen, A. Fay, P. Häkkinen, J. K. Viljas, T. T. Heikkilä, and P. J. Hakonen, *Energy relaxation in graphene and its measurement with supercurrent*, Phys. Rev. B **84**, 045419 (2011).

[9] A. Fay, R. Danneau, J. K. Viljas, F. Wu, M. Y. Tomi, J. Wengler, M. Wiesner, and P. J. Hakonen, *Shot noise and conductivity at high bias in bilayer graphene: Signatures of electron-optical phonon coupling*, Phys. Rev. B **84**, 245427/1-7 (2011).

The supercurrent thermometer allows us to probe the energy transfer at low energies (small bias voltage) while the shot noise measurements work best at large bias.

In our low energy studies, a 400-nm-long superconductor-graphene-superconductor (SGS) junction with a strongly temperature-dependent critical current was used as an electronic thermometer in a three lead sample configuration.[8] Another graphene section located on the same graphene sheet was voltage biased to heat up the electrons in graphene from 70 mK up to 600 mK. The increase in electronic temperature was observed as a drop in the critical current of the **SGS thermometer**. More exactly, this critical current depends on the electronic energy distribution function (EDF), which in the non-equilibrium situation deviates from a Fermi function. Since the e-e and e-ph interactions in graphene define the shape of the EDF, critical current becomes an effective probe of their strength. In our experiment, we find that the injected power is mainly transmitted to the superconducting leads, while the e-ph interactions remain negligible.[10] By solving the Boltzmann transport equation with the e-e scattering kernel of a two-dimensional metallic system,[11] we obtain for the characteristic e-e interaction time ~ 5 ps, one order of magnitude smaller than predicted by the theory.

In our studies for large energy transfer in diffusive graphene samples, we need to combine information both from conductivity and shot noise in order to deduce the electron-optical phonon scattering time. We have done such an analysis in bilayer graphene at high bias voltages and low bath temperature $T_0 = 4.2$ K.[9] As a function of bias, we find initially an increase of the differential conductivity, which we attribute to self-heating. At higher bias, the conductivity saturates and even decreases due to backscattering from optical phonons. The electron-phonon interactions are also responsible for the decay of the Fano factor at bias voltages $V > 0.1$ V. The high bias electronic temperature has been calculated from shot-noise measurements, and it goes up to ~1200 K at $V = 0.75$ V. Using the theoretical temperature dependence of BLG conductivity, we extract an effective electron-optical phonon scattering time $\tau_{e\text{–}op}$. In a 230-nm-long BLG sample of mobility μ =3 600 cm^2 V^{-1} s^{-1}, we find that $\tau_{e\text{–}op}$ decreases with increasing voltage and is close to the charged impurity scattering time $\tau_{imp} = 60$ fs at $V = 0.6$ V. Presently, we are extending these investigations to suspended graphene samples where the elastic scattering will be substantially reduced and the surface optical phonons are not influencing the interpretation of the shot noise results.

Shot noise experiments on suspended graphene

A. Fay, A. Laitinen, M. Oksanen, M. Tomi, and **P. Hakonen**

In 2008, we studied shot noise in single layer graphene strips (width/length = W/L = 1 - 10) at microwave frequencies at temperatures around 4.2 K. At low bias voltage, we found that, in accordance with theoretical expectations, the Fano factor ($F = S_I/2e\langle I\rangle$) measured at the charge neutrality point was close to $F = 1/3$. Those samples are believed to have been ballistic owing to their short length (200 nm), but critique against this argument has been presented. Now, we have returned back to this question using suspended samples (See Figure 5) which display mobilities $\mu > 100\,000$ cm^2 V^{-1} s^{-1}.

---

[10] J. K. Viljas, and T. T. Heikkilä, *Electron-phonon heat transfer in monolayer and bilayer graphene*, Phys. Rev. B **81**, 245404 (2010).

[11] B. L. Altshuler and A. G. Aronov, *Electron-Electron Interactions in Disordered Systems*, ed. A. L. Efros and M. Pollak, Elsevier, Amsterdam (1985).

Our new data on graphene shot noise display several features that were absent in the old, first measurements. We find a much sharper Dirac point even though the relative permittivity of the environment is substantially lower than for samples on SiO_2. Moreover, Fabry-Perot type of interference is visible which points to good quality of the samples. Figure 6 displays the measured Fano factor near the Dirac point. The general behavior agrees well with theory.[12] The spacing of oscillations vs. gate voltage appears to be different from theory which hints to parate boundary conditions compared with the theoretical calculation.

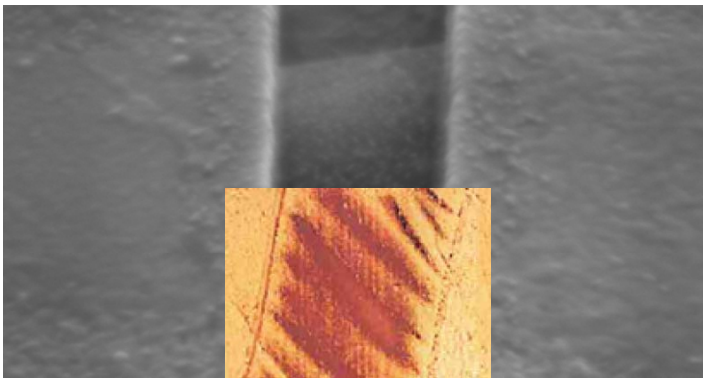


Figure 5: SEM image of a suspended graphene sample. The false-color inset displays an AFM image of another similar sample. Corrugations typical to tensioned samples are clearly visible.

In suspended monolayers, we find that the Fano-factor goes via a minimum around 1 V as a function of bias voltage. Using diffusive theory, the voltage at the minimum can be related directly to the electron - optical phonon scattering provided that this scattering is the dominant inelastic mechanism. The reason for the increasing shot noise at very large bias is that the ability of electron–phonon scattering to suppress noise starts to diminish as the maximum energy absorbed by one phonon is less than eV, and in principle, for very large V, F approaches 1/3 again.

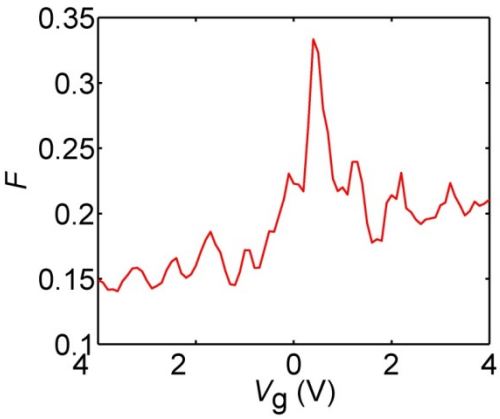


Figure 6: Fano factor measured on suspended graphene.

Mechanical graphene resonators

X. Song, A. Laitinen, D. Lyashenko, M. Oksanen, and **P. Hakonen**

Together with the NEMS group, we have investigated nanoelectromechanical systems made out of aluminum and graphene. This work is done in collaboration with the groups of Harold Craighead and Jeevak Parpia at Cornell University.

Our interest in graphene NEMS is twofold. First of all, we develop GHz graphene resonators for experiments at the quantum limit (Materials World Network, MWN). Second, we develop mechanical-resonator-based GHz filters for practical applications in mobile communications[13] (FP7 RODIN).

---

[12] J. Tworzydlo, B. Trauzettel, M. Titov, A. Rycerz, C.W.J. Beenakker, Phys. Rev. Lett. **96**, 246802 (2006).

[13] P. Pasanen, M. Voutilainen, M. Helle, X. Song, and P. J. Hakonen, *Graphene for future electronics*,

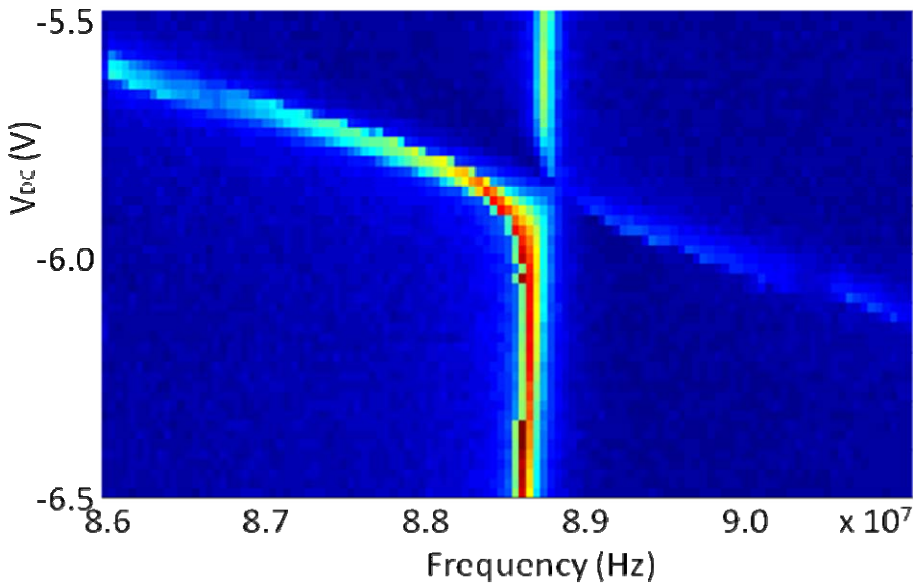


Figure 7: Mechanical mode coupling between a graphene resonator and a gold cantilever.

Based on our previous work on graphene mechanical resonators,[14,15] new challenges are brought up when considering how the resonators couple or interact with the environment, and how to improve the device/readout performance in order to experimentally reach the quantum limit.

We have observed and studied the mechanical coupling between suspended graphene and the connected gold cantilevers (See Figure 7). Mode repulsion phenomenon is noticeable when the graphene mechanical frequency is tuned to coincide with the gold cantilever resonance.

We have recently made some key improvements on our stamp transfer technique, and we can now fabricate drum-shaped graphene mechanical resonators, which have higher Q-values than the previous clamped-clamped resonators. The new devices have multi-layer structures to provide evacuation channels underneath the fully-supported graphene resonator, so that they can be measured in vacuum. Using a high-Q superconducting RF cavity, we detected thermally induced mechanical motion in a drum-shape graphene mechanical resonator at ~500mK.

In order to fabricate good quality graphene-based mechanical resonators, chemical vapor deposition (CVD) of graphene was improved. The following changes were introduced. The recipe of gas flows and temperature settings were adjusted including a significant hydrogen/methane ratio increase. Copper catalyst was treated differently: it was pre-annealed for two days to obtain larger grain size before the actual CVD pro-

---

Phys. Scr. T**146** 014025 (2012).

[14] M. A. Sillanpää, J. Sarkar, J. Sulkko, J. Muhonen, and P. J. Hakonen, *Accessing nanomechanical resonators via a fast microwave circuit*, Appl. Phys. Lett. **95**, 011909 (2009).

[15] X. Song, M. Oksanen, M. Sillanpää, H. Craighead, J. Parpia, and P. Hakonen, *Stamp transferred suspended graphene mechanical resonators for radio-frequency electrical readout*, Nano Lett. **12**, 198 (2012).

cess. After pre-annealing, electrochemical polishing helped to reduce roughness of the copper surface. All of these procedures are intended to enlarge graphene crystal size which leads to better mechanical and electrical properties, and to increase the monolayer fraction of the graphene films. The important graphene transfer issue was investigated in terms of utilizing different polymer supports for direct transfer and suspension. Fluorinated photoresist showed the best suspension results and PMMA demonstrated good abilities for preservation of graphene film from cracking.

ANALYTICS OF GRAPHENE DEVICES

A. Savin and M. Tomi

A year ago, our Raman spectrometer's (Horiba Labram HR) stage was upgraded from a manual model to a motorized stage. This modification has significantly facilitated the characterization of graphene sheets and enabled us to probe their spectroscopic properties with good lateral resolution. We have also worked towards an automated system that can locate and characterize single-layer graphene sheets on any substrate without prior optical scouting by the operator.

More recently, we have diversified the potential of our Raman spectrometer by purchasing a new laser source, an air-cooled Ar ion laser. In addition to the preexisting He-Ne laser (633 nm, 30 mW), we can now make use of two characteristic Ar wavelengths: 488 nm, 40 mW & 514 nm, 50 mW. Raman intensity being proportional to the fourth power of the incident photon's energy, we can now reach better signal-to-noise ratios in shorter measurement times, thus reducing the risk of damaging sensitive samples. Multiple wavelengths are also very beneficial when studying graphene-based materials, as their exceptional electronic and phononic properties give rise to wavelength-dependent Raman resonances.

KVANTTI group

Khattiya Chalapat, Jian Li, Karthikeyan Sampath Kumar, Robab Najafi Jabdaraghi, and **Sorin Paraoanu**

Visiting Ph.D. student (6 months): Wei-Cheng Chien (National Chung-Hsing University, Taiwan)

B.Sc. student: Antti Vepsäläinen

The main research interest in the Kvantti group has been the interaction of microwave photons with matter (in the form of superconducting circuits or nanostructured materials). Our emphasis is on phenomena that are quantum-mechanically coherent, most of them occurring when the dissipation is low enough. This justifies the effort of our group in the field of superconducting qubits. During 2011 we have continued our effort into understanding quantum-mechanical phenomena that can be demonstrated with these devices.

A NO-GO QUANTUM THEOREM

Kumar, K.S., and Paraoanu, G.S., "A quantum no-reflection theorem and the speeding up of Grover's search algorithm ", *EPL*, **93** (2011).

A number of “impossibility” results exist in quantum mechanics that illustrate the difficulty of replicating or extracting information from quantum objects. It is known for example that one cannot determine the wave function of a system by performing

measurements on a single copy. The rules of quantum physics also prohibit the cloning of unknown states as well as their reversible deleting. We have shown that a related theorem holds —it is impossible to build a machine which performs reflections about unknown states (see figure).

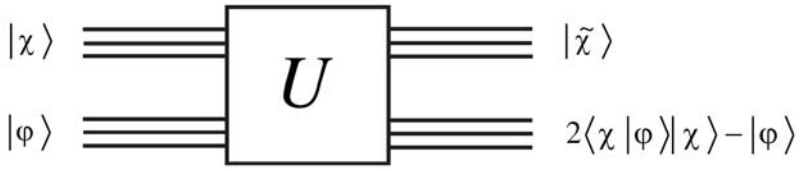


Figure: In this figure we show a generic unitary gate that performs reflections.

DECOHERENCE AND THE DARKENING OF TRANSITIONS IN A PHASE QUTRIT

Li, J., Paraoanu, G.S., Cicak, K. Altomare, F., Park, J.I., Simmonds, R.W., Sillanpää, M.A., and Hakonen, P.J., "Decoherence, Autler-Townes effect, and dark states in two-tone driving of a three-level superconducting system", *Physical Review B*, **84**, 104527 (2011).

This work is a continuation of the collaboration with the NEMS and NANO groups and with NIST on the Autler-Townes effect in a phase qubit operrated as a 3-level system. We present a detailed theoretical analysis of a multilevel quantum system coupled to two radiation fields and subject to decoherence. We concentrate on an effect known from quantum optics as Autler-Townes splitting, which has been demonstrated experimentally in a superconducting phase qubit. In the three-level approximation, we derive analytical solutions and describe how they can be used to extract the decoherence rates and to account for the measurement data. Better agreement with the experiment can be obtained by extending this model to five levels. Finally, we investigate the stationary states created in the experiment and show that their structure is close to that of dark states.

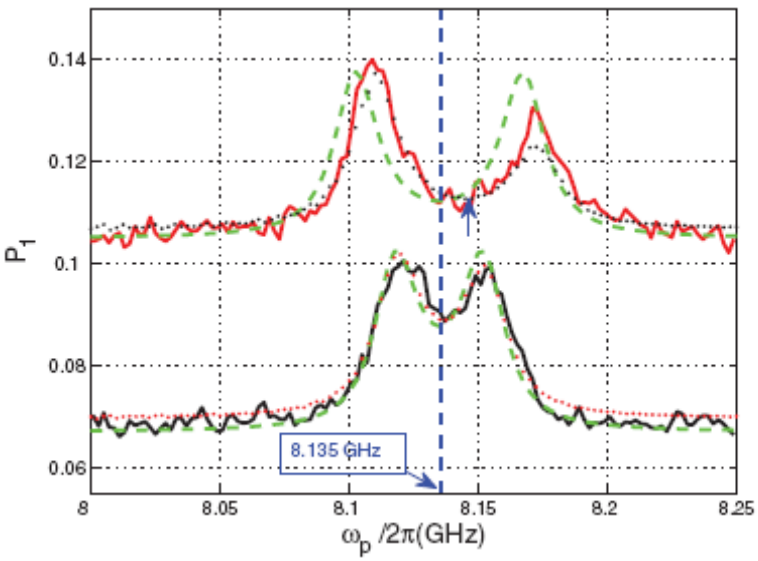


Figure: Autler-Townes splitting in a phase qubit. The experimental spectroscopy traces (solid lines) are compared to simulations of the master equation corresponding to the full five-level model, (dotted lines) with the parameters previously extracted from the spectroscopy data. The (green) dashed lines are analytical results. The inclusion of higher levels at large values of the coupling results in asymmetric Autler-Townes peaks and in the displacement of the spectroscopy curve toward higher frequencies.

FOUNDATIONS OF QUANTUM PHYSICS: REALISM AND W STATES, PARTIAL MEASUREMENTS AND THEIR REVERSAL, ETC.

Paraoanu, G.S., "Realism and Single-Quanta Nonlocality", *Foundations of Physics* **41,** 734 (2011)
Paraoanu, G.S., "Generalized partial measurements", *EPL* **93**, 64002/1-4 (2011)
Paraoanu, G.S., "Extraction of information from a single quantum", *Physical Review A* **83**, 044101/1-4 (2011)

A W state is a state in which a single quanta is delocalized over three (or more general N) sites. In principle these sites can be far away from each other, and independent measurements can be performed there. Somewhat similar to the case of the Bell inequalities and the EPR gedankenexperiment, one wonders if a mathematical relation exists to show that local realism and quantum mechanics yield different predictions. As it turns out, instead of an inequality we can derive a logical incompatibility between the two descriptions. This simply shows that there always exists a measurement output which is predictedby quantum physics but cannot be explained by any local-realistic model.

We have also studied (see Figure) the so-called partial measurements, demonstrated at UCSB a few years ago with a phase qubit. These measurements can be generalized to yield nondestructively two outputs instead of a single one. One wonders then if the state of a quantum system prepared in an unknown state can be inferred by applying a series of generalized partial measurements and reversing them (see Figure) . It turns out that the answer is negative.

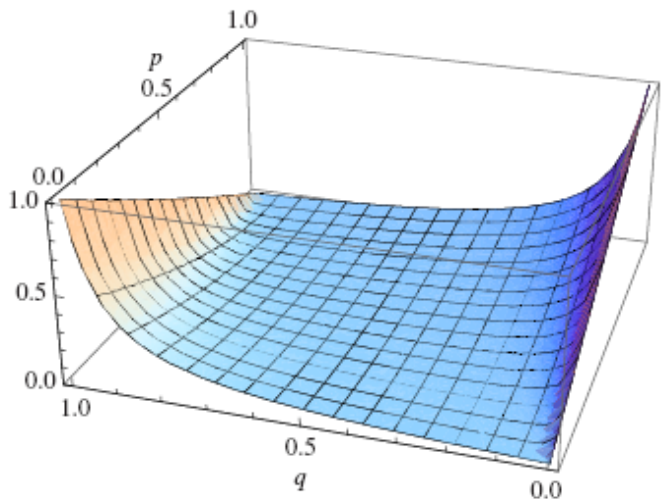


Figure: One of the matrix elements of the Fisher information associated with a partial measurement with parameters p and q.

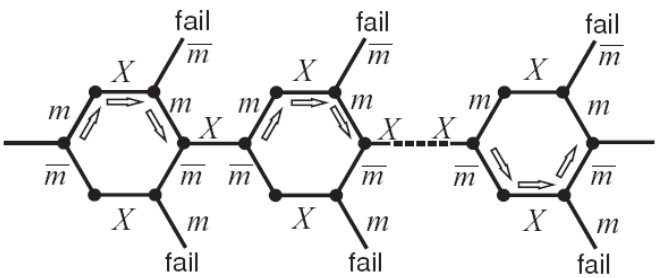


Figure: Sequence of a series of generalized partial measurements and their reversal, used to demonstrate that information cannot be extracted from single quanta.

OTHER WORKS:

Paraoanu, G.S., "Quantum Computing: Theoretical versus Practical Possibility", *Physics in Perspective*, **13**, 359–372 (2011).

G. S. Paraoanu, "Theoretical aspects of quasiparticle excitations for Bose-Einstein condensates in lattice potentials", in Quantum Mechanics, edited by Jonathan P. Groffe, Nova Science Publishers (ISBN: 978-1-61728-966-8).

EXPERIMENTS WITH THE TRANSMON

The group has been working on a particular type of qubit, called transmon, consisting of a capacitively-shunted Cooper pair box placed in an electromagnetic cavity formed by segmenting a superconducting coplanar waveguide. We have characterized one sample and gathered evidence for the so-called motional averaging effect in this system.

NEW EQUIPMENT

At the end of 2011, the S.H.E. dilution refrigerator was taken out of use. The refrigerator was made in 1979: it has been "in service" for 32 years, and the first scientist using it was Mikko Paalanen. In December 2011 the refrigerator was taken out of the pit. All the pumps, the gas handling system, and the control cabinet with the connecting cables were removed in order to reconfigure the space for a new BluFors dilution refrigerator. Two support boxes with double-plywood layers and concrete inside were designed and partially made. The installation of the new refrigerator will be a major effort in the group in 2012.

μKI group

Matti Manninen, Ville Peri, Juho Rysti, Anssi Salmela, Alexander Sebedash, Igor Todoshchenko, and **Juha Tuoriniemi**

Visitors: J. Nyeki (Royal Holloway, University of London, UK)

Collaborators: V. Tsepelin (Lancaster, UK), A. Parshin (Kapitza Institute, Moscow, Russia)

Two lines of research were maintained: 1) studies of ^{4}He-^{3}He isotopic mixtures cooled by the novel method of adiabatic melting of solid ^{4}He in superfluid ^{3}He, and 2) creation and detection of crystallization waves on the interface between solid and superfluid ^{3}He.

The experimental platform for microkelvin investigations was used to characterize the most critical components for the upcoming crystallization wave experiment. These studies were performed under realistic conditions of the planned experiments in superfluid ^{3}He – yet without presence of solid ^{3}He in the experimental cell. The operating limits of the fine interdigital capacitors with micron-range spacings were tested, and unfortunately learned to suffer from intolerable leakage currents at bias-voltage levels of just over 1 V. Such leakage current produces heating in the experimental cell, thus rendering the planned experiment infeasible. This specific problem was then examined more carefully, and means to increase the voltage tolerance by about two orders of magnitude were found. This was achieved by conditioning the virgin capacitors by elevated voltage at room temperature in presence of compressed gas beyond normal atmospheric pressure, until the leakage current was observed to cease below

limit of observation. Obviously the remnant channel for the leakage current on the chip was burnt away by this treatment without damaging the proper function of the interdigital capacitors. The subsequent tests at liquid helium environment verified the improved performance of the capacitors so prepared. Importantly, the results were reproducible and the described treatment can be given to components already installed into the experimental compartments. The significance of finding such routine is stressed by the fact that those single capacitive elements will have multiple functions in the experiment under preparation, namely controlling nucleation and position of the crystal in the cell, adjusting the contact angle between the walls and the helium crystal, and also both exciting and detecting the periodic motion of the liquid-solid interface, i.e. the crystallization waves. The gained improvements allow us now to proceed towards more advanced experimental arrangement, where ^{3}He crystals can be grown at millikelvin temperatures by means of a hydraulic compressor operated by superfluid ^{4}He. An experimental cell with two adjacent interdigital capacitors, multiple means for thermometry at the range of interest, and the said device for growing ^{3}He crystals is now being prepared. This experiment will be cooled down early next year.

The mixture experiment is still being pursued, although with somewhat reduced share, both by theoretically modelling that extraordinary physical system and, in order to conduct further measurements, by fixing the faulty components of the earlier experimental arrangement. Some essential parts of this setup will be mounted on the cryostat for testing at low temperature in parallel with the first crystallization-wave experiments.

NEMS group

Mika Sillanpää, Sung Un Cho, Juha-Matti Pirkkalainen, Maria Berdova, Jaakko Sulkko

Collaborators: R. Simmonds, S. Franssila, D. Gunnarsson

CAVITY COOLING OF NANOMECHANICAL MOTION

Mika A. Sillanpää, Francesco Massel, Sung Un Cho, Juha-Matti Pirkkalainen, Tero T. Heikkilä, and Pertti J. Hakonen

An on-chip microwave resonator can be capacitively coupled to a nanomechanical resonator, similarly as in an optical cavity with a movable end mirror. In the dispersive limit where the LC ("cavity") frequency is much higher than the mechanical frequency which usually is in the radio-frequency regime, the mechanical motion couples to the electrical frequency.

We have recently achieved a large cavity coupling energy of up to (2 pi) 2 MHz/nm for metallic beam resonators at tens of MHz. We used focused ion beam (FIB) cutting to produce uniform slits down to 10 nm, separating patterned resonators from their gate electrodes, in suspended aluminum films. We obtained a low number of about twenty thermal phonon occupation at the equilibrium bath temperature at 25 mK. The mechanical properties of Aluminum were excellent after FIB cutting and we recorded a quality factor of Q ~ 300 000 for a 67 MHz resonator at a temperature of 25 mK. We operate the nearly macroscopic mechanical modes close to the motional quantum ground state, down to 1.8 thermal quanta, achieved by back-action cooling.

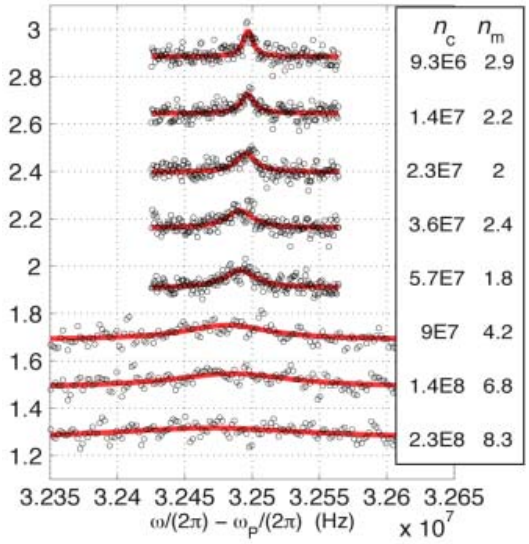
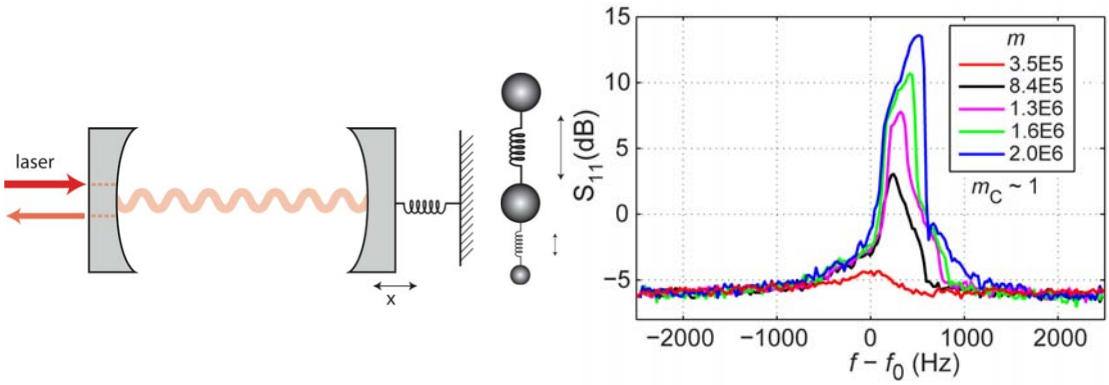


Figure: Output spectra at pump occupation increasing from top to bottom. The curves are shifted vertically by 0.3 y-axis units for clarity. The corresponding mechanical occupations are written on the right.

MECHANICAL MICROWAVE AMPLIFICATION

In a work made together with Theory and Nano groups, a possibility was demonstrated to detect and amplify microwaves near the Heisenberg uncertainty principle limit with a micromechanical device.

Our work indicates that it is possible to make a nearly noiseless amplifier based on a moving part measuring less than a tenth of the diameter of a hair. This kind of device is known as a nanomechanical resonator, resembling a miniaturized guitar string. The vibrations get amplified in an accompanying cavity, as in guitar's resonant chamber, thus launching a stronger tone that comes in. The novel type of amplifiers may offer improved performan ce for information processing in certain applications.



Left: circuit analogs of optomechanical effects offer interesting possibilities. Right: Measured gain for input microwave for values of the pump occupation number written in caption.

ROTA group

S. Autti, **V.B. Eltsov**, R. de Graaf, P.J. Heikkinen, J.J. Hosio, R. Hänninen, J. Karimäki, M. Krusius, and J. Mäkinen

Visitors: Yu.M. Bunkov (Institut Néel, CNRS, France), V.S. L'vov (The Weizmann Institute of Science, Israel) and P.M. Walmsley (University of Manchester, UK)

Collaborators: Yu.M. Bunkov, P. Hunger, V.S. L'vov, D. Schmoranzer, P.M. Walmsley, D.E. Zmeev

The main focus of the research in the ROTA group in recent years has been on the zero-temperature behavior of superfluid ^{3}He. The superfluid phases of ^{3}He are the best accessible examples of topological superfluids, and they share many common properties with topological insulators and superconductors, which have recently become very popular topics in condensed-matter physics. In year 2011 we concentrated our effort on two subjects: Vortex dynamics and dissipation in the zero-temperature limit and Majorana bound fermionic states in the cores of the quantized vortices in the B phase of superfluid ^{3}He.

The fact that in fermionic superfluids dissipation in vortex dynamics does not vanish when temperature goes to zero is already well-established (we also contributed substantially to this result). The exact nature of the dissipation processes, however, is not yet understood. Often dynamics at low temperatures is turbulent and includes complex motion of tangled and reconnecting vortices. In experiments it is generally difficult to separate effects of the energy transfer over the turbulent energy cascade and microscopic dissipation mechanisms. In our rotating ^{3}He-B sample we create and study different kind of flows, both turbulent and laminar, at the lowest temperatures. Eventually we hope to separate the energy-cascade-related and microscopic contributions to the dissipation. It is expected that the dissipation mechanisms at the lowest temperatures are intricately connected to the bound fermions in the vortex cores, owing to the presence of the zero-energy states in their spectra.

Our second line of research is connected to Bose-Einstein condensation of quasiparticles, which has also become a popular topic. In ^{3}He suitable quasiparticles are magnons. In 2011 we have been able to solve some unsettled questions concerning trapped magnon condensates in ^{3}He-B, using, in particular, control of the trapping potential provided by rotation of the sample. We have also started studies of the relaxation properties of these condensates focusing on the contribution of the vortex-core-bound fermions to the relaxation.

DYNAMICS AND DISSIPATION IN THE ZERO-TEMPERATURE LIMIT: VORTEX FRONT

J.J. Hosio, V.B. Eltsov, R. de Graaf, P.J. Heikkinen, R. Hänninen, M. Krusius, V.S. L'vov, and G. E. Volovik

Phys. Rev. Lett. **107**, 135302 (2011)

The steady-state axial propagation velocity of vortices along a long circular tube has been studied as a function of temperature T while the tube is rotating around its axis at different constant angular velocities Ω (Fig. 1). Initially, a ^{3}He-B sample is prepared which is as free of remanent vortices as possible. It is cooled in the non-rotating state to the desired temperature below 0.4 T_c. Next the cryostat is accelerated rapidly to the

chosen steady rotation velocity Ω. During the acceleration vortices are formed on the sintered heat exchanger surface and start to propagate axially along the sample tube as a well-defined front, while they simultaneously precess azimuthally with respect to the walls of the tube. The moments when the front passes through the bottom and top coils are noted by changes in the NMR response. From the time difference the velocity of the front V_f is derived.

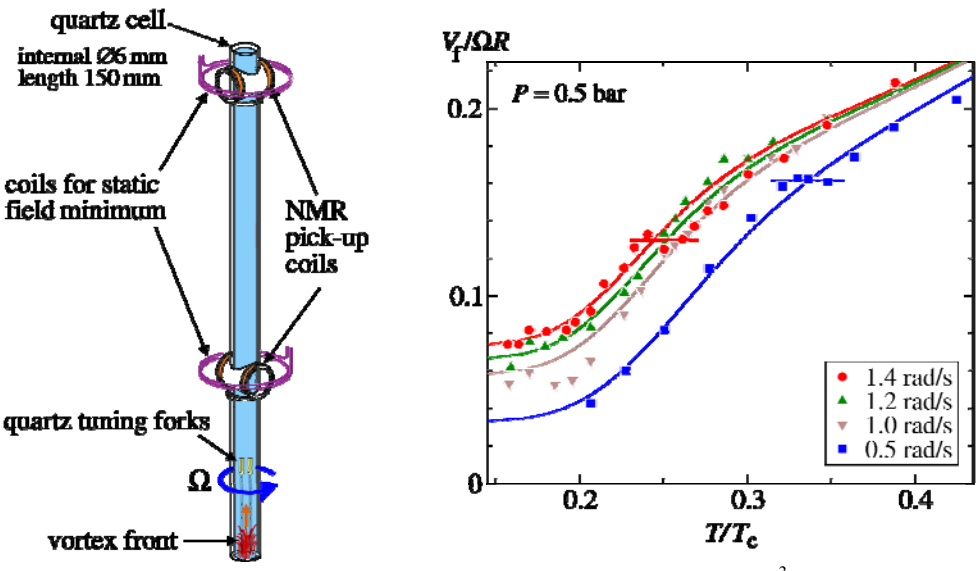


Fig. 1. *(Left)* Measuring setup in the rotating cryostat. The superfluid ^{3}He sample is contained in a circular quartz tube. The open bottom end of the tube provides the thermal contact to the sintered heat exchanger on the nuclear cooling stage. The rough surfaces of the heat exchanger allow fast vortex formation on increase of rotation. These vortices form a vortex front, propagating upwards. Two NMR receiver coils are used to time the velocity of the front. The lower section of the tube houses two quartz tuning fork oscillators which are used for temperature measurement. *(Right)* Scaled front velocity $V_f(T,\Omega)/\Omega R$. The data display two plateaus as a function of temperature: the plateau at about $0.3T_c$ may result from a bottleneck in the energy transfer from the large hydrodynamic length scales of the Kolmogorov cascade to the short length scales of the single-vortex Kelvin wave cascade. The low-temperature plateau represents the limiting dissipation in the $T \rightarrow 0$ limit.

Below 0.4 T_c the propagating vortex configuration consists of a turbulent front and a twisted vortex cluster behind it. These precess at different azimuthal velocities. Owing to this difference in precession, reconnections are concentrated in the front where the vortices flare out towards the lateral tube wall. The axial velocity of the vortex front V_f depends, in particular, on mutual friction $\alpha(T)$ and on the number of expanding vortices $N(T,\Omega)$. Above 0.4 T_c in the laminar flow regime the axial front velocity follows a simple relation: $V_f \approx \alpha\Omega R$, where R is the radius of the sample tube. Towards low temperatures the front velocity slows down, as the mutual-friction dissipation decreases and ultimately vanishes in the ballistic regime as $\alpha(T) \propto \exp(-\Delta/T)$. However, owing to the turbulent dissipation in the front the slow-down does not follow a monotonic exponential dependence but, as seen in Fig. 1 (right), saturates below about 0.2 T_c with some non-trivial dependence before this saturation.

One particular feature is a 'shoulder', a faster change of V_f between 0.2-0.3T_c than at higher or lower temperatures. In our earlier work, the shoulder was associated with a bottleneck in the energy transfer rate along the turbulent energy cascade: The kinetic energy is pumped into the vortex flow at large length scales of order R and is then

transferred to smaller scales first over the Kolmogorov cascade of breaking eddies and then over the cascade of Kelvin waves at scales smaller than the intervortex distance. The difficulty of joining the two cascades of different physical nature may result in a bottleneck accumulation of kinetic energy at the intermediate scales.

Our latest results demonstrate a new feature of the turbulent front: Both direct measurements of the heat released in the front motion and Ω-resolved measurements of V_f prove that below $0.3T_c$ the number of vortices N behind the front falls well below the equilibrium number $N_{eq} = (2\Omega/\kappa)\,\pi R^2$, where κ is the circulation quantum. That is, the superfluid behind the front rotates at a smaller angular velocity than Ω. The reason for this decoupling is the difficulty in the angular momentum transfer from the container to the superfluid when the density of the normal component, which provides the main coupling, vanishes. Unlike the energy dissipation, quantum turbulence alone does not provide an efficient mechanism for the exchange of the angular momentum with the container walls. A simple phenomenological model of decoupling provides a reasonable fit to the $V_f(T,\Omega)$ dependence (lines in Fig. 1, right). Small plateaus at about $0.3T_c$ are not explained within this model and might still be related to the bottleneck effect.

What microscopic process is responsible for the non-zero dissipation in the zero-temperature limit remains an open question. An important development has come recently from M. Silaev [PRL **108**, 045303 (2012)], who suggested that accelerating motion of vortex cores (resulting from Kelvin waves, for example) can overheat an ensemble of the core-bound quasiparticles and leads to a finite dissipation rate even at zero temperature in the bulk. An analysis of our measurements of the dissipation in the vortex front in terms of this mechanism remains a task for the future.

BOSE-EINSTEIN CONDENSATION OF MAGNONS IN SUPERFLUID ^{3}HE-B

S. Autti, Yu.M. Bunkov, V.B. Eltsov, P.J. Heikkinen, J.J. Hosio, P.Hunger, M. Krusius, V.S. L'vov, and G. E. Volovik

Phys. Rev. Lett. **108**, 145303 (2012)

Magnons are bosonic quasiparticles in superfluid ^{3}He which are related to deflection of the magnetization from the direction of the applied magnetic field. At low temperatures there are no thermally excited magnons, but magnons, which are pumped into the system using applied rf field, have long life times, so that they can form Bose-Einstein condensates in a suitable trap. Condensation manifests itself as a long-lived coherent precession after pumping is switched off: The magnetization precesses around the applied field with a common phase in a macroscopic part of the sample, despite inhomogeneity in the magnetic field or in the order-parameter texture. Life times up to 15 min have been reported. Of great practical importance is that magnon condensates can be used to probe the quantum vacuum state of ^{3}He-B in the $T \to 0$ limit, where most conventional measuring techniques become insensitive.

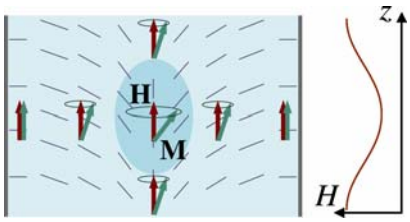


Fig. 2. Trap for the magnon condensate (dark blue) in superfluid ^{3}He-B. The trap is formed by the texture of the orbital anisotropy axis (thin lines) and the profile of the applied static magnetic field **H**. Within the condensate the magnetization **M** precesses around the magnetic field with the common phase.

In the cylindrical sample a nearly harmonic trap for magnons is created by the order-parameter texture in the radial direction and by the applied profile of the static magnetic field with a minimum in the axial direction (Fig. 2). Using the possibilities of our rotating cryostat for texture manipulation, we performed the first studies of trapped magnon condensates in ^{3}He-B with full control of the trapping potential. Several new phenomena have been discovered. First, we have found that when the number of magnons in the trap increases, the orbital texture reorients under the influence of the spin-orbit interaction and the profile of the trap gradually changes from harmonic to a square well, with walls almost impenetrable to magnons. This is the first example of Bose condensation in a box. For bosons this is the only demonstration of self-trapping, owing to the interaction of the growing number of particles with the confining quantum field. For fermions examples of self-formation of a boxlike trapping potential are the electron bubble in liquid helium and the MIT bag model of a hadron, where the asymptotically free quarks are confined within a cavity in the pionic field.

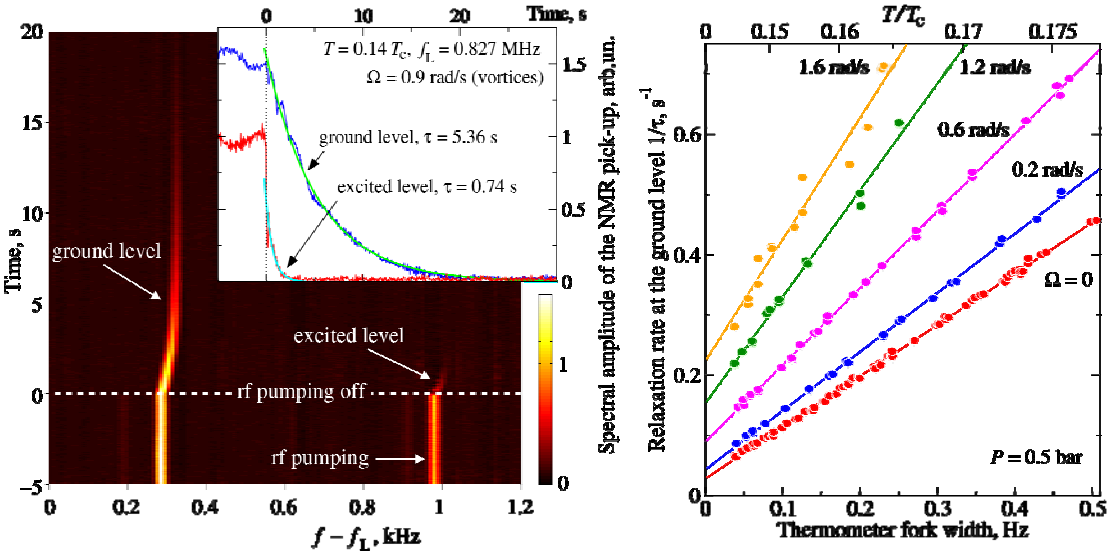


Fig. 3. *(Left)* Decay of the magnon condensate, after rf pumping is switched off at $t = 0$. The amplitude of the Fourier transform of the signal from the NMR pick-up coil is shown in the main panel. Magnons are pumped to the first radial excited level at $t < 0$, but the ground state is simultaneously populated owing to the decay of magnons from the excited state. At $t > 0$ both states decay and the frequency of precession increases as the trap responds to the decreasing magnon population. The *insert* shows the amplitudes of the two peaks and fits to the exponential decay with time constant τ. *(Right)* Relaxation rate $1/\tau$ of the ground-state condensate measured as a function of temperature at different rotation velocities with equilibrium number of vortices.

The interaction of magnons with the confining order-parameter field leads to a decreasing chemical potential of the magnon condensate with increasing number of particles. In a usual condensate of cold atoms with repulsion the dependence is opposite. Thus, unlike in the cold-atom case, one can fill a macroscopic number of magnons to an excited level in the trap, simply by scanning the chemical potential (controlled by the frequency of the applied rf pumping) downwards so that it crosses a chosen excited level in the trap. Magnons trapped on the excited level decay to the ground level, so that it becomes filled simultaneously. As can be checked by switching the pumping off, the state at the excited level supports coherent precession and thus can be called a

condensate. In Fig. 3 (left) the decay time of the precession at the excited level exceeds significantly the decoherence time in usual NMR, which is about 10 ms in these conditions. This is the first realization of Bose-Einstein condensation at the excited level of the trap. An interesting development would be to observe the Josephson coupling between the ground- and excited-level condensates during the initial phase of decay, when both condensates coexist in the trap.

The life time of the ground-state condensate in Fig. 3 (left) is not the longest achievable since the measurement has been performed in rotation with quantized vortices. We have been looking for an effect of vortices on the relaxation of the magnon condensate, motivated by the possibility to find a contribution of the vortex-core-bound fermionic quasiparticles to the relaxation. These bounds states have attracted a lot of interest recently owing to the expectation that they should have Majorana character. Our measurements of the relaxation rate as a function of temperature and rotation velocity indeed show a clear effect of rotation in the equilibrium vortex state on the relaxation (Fig. 3, right). The relaxation rate can be expressed as $1/\tau(T,\Omega) = 1/\tau_0(\Omega) + C(\Omega)\exp(-\Delta/T)$. The temperature-dependent term is evidently connected with the density of thermal quasiparticles and can be possibly attributed to the relaxation by spin diffusion through the normal component. The effect of vortices on the prefactor $C(\Omega)$ is related to the changes in the order-parameter texture: the magnon trap becomes narrower with increasing rotation velocity, the gradient of the magnon wave function increases and that enhances the spin diffusion.

More interesting is the zero-temperature value of the relaxation rate $1/\tau_0(\Omega)$. Our measurements show that the dependence of this rate on the rotation velocity and thus on the density of vortex lines is linear. Thus it can be ascribed to the contribution of vortex cores to the relaxation. Whether this contribution is caused by the Majorana fermions bound to vortex cores or by another mechanism has not been established yet.

STUDIES OF VORTEX DYNAMICS USING ANDREEV REFLECTION TECHNIQUES

J.J. Hosio, V.B. Eltsov, R. de Graaf, J. Mäkinen, M. Krusius, and D. Schmoranzer

Phys. Rev. B **84**, 224501 (2011)

Visualisation of flow is the most important experimental tool in studies of classical turbulence. In research on vortex dynamics in superfluid ^{3}He real visualisation has not been achieved yet, but there are ongoing efforts in this direction. A promising method, the so-called quasiparticle beam technique, has its physical origin in a specific interaction of bulk fermionic quasiparticles with quantized vortices. The superflow around a vortex core modifies the dispersion relation of the quasiparticles: A quasiparticle flying past a vortex feels a varying energy gap which results in a scattering process known as Andreev reflection. In the ballistic regime of quasiparticle motion if one sends a beam of quasiparticles towards a vortex, then a 'quasiparticle shadow' appears behind it. We measured for the first time Andreev reflection in a controlled geometry with a vortex cluster of known density and spatial extent. This allowed us to determine the cross-section of interaction between quasiparticles and quantized vortices and confirm its theoretical calculations.

Vortex structures can be illuminated not only by directed quasiparticle beams, but also by the background illumination, resulting from the heat leak emanating from the wall of the sample and flowing to the heat sink. The local quasiparticle density in

some position in the sample filled with moving vortex lines fluctuates with time owing to effects of vortices on the quasiparticle trajectories. (This effect would be absent in complete thermal equilibrium.) We have used this so-called quasiparticle screening to perform the first measurements of vortex dynamics in rotation using Andreev reflection techniques.

We study the spin-down of a rotating superfluid sample to rest. Originally the superfluid is in equilibrium rotation at the velocity Ω_{ini}. Then the rotation velocity of the container is quickly decreased to zero (at time $t = 0$). The superfluid continues to rotate as vortex lines slowly move to the cylindrical boundary of the sample and annihilate there. In our previous measurements of spin-down at temperatures above $0.2T_c$ using NMR techniques we found that the spin-down occurs in the laminar manner: The superfluid remains in solid-body rotation at all times and the velocity of this rotation Ω_s depends on time t as $\Omega_s(t) = \Omega_0/(1+2\alpha\Omega_0 t)$. At the lowest temperatures $\Omega_s(0) = \Omega_0 \approx \Omega_{ini}$, since the reduction of rotation velocity is fast compared to the time scale of vortex dynamics.

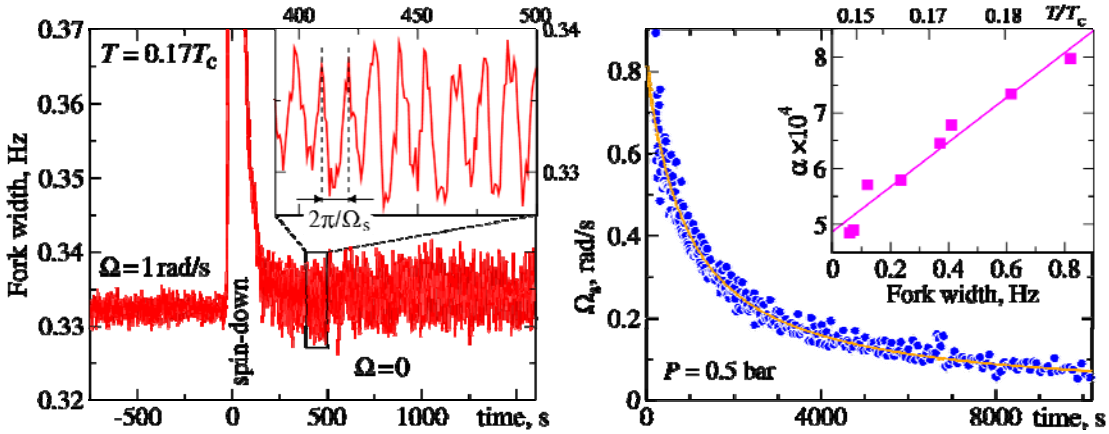


Fig. 4. Spin-down of the ^{3}He-B sample measured with Andreev reflection of thermal quasiparticles. *(Left)* Width of the thermometer fork resonance at the initial rotation velocity Ω_{ini} = 1 rad/s, during the deceleration of rotation to rest at $d\Omega/dt$=0.03 rad/s^2 and thereafter at zero rotation. The characteristic feature at Ω=0 is oscillations in the resonance width of the fork *(insert)* which are caused by variations in the quasiparticle density in the vicinity of the fork as a result of the Andreev reflection from a vortex cluster, precessing with angular velocity Ω_s. *(Right)* The dependence of Ω_s (dots) on time, elapsed after Ω=0 is reached, fits perfectly to the laminar dependence (line). This allows us to measure the dissipative mutual friction coefficient α at the lowest temperatures *(insert)*.

In the setup, where quartz tuning forks are placed inside the vortex cluster (Fig. 1, left), we have done similar measurements using quasiparticle screening. An example of the fork record is shown in Fig. 4 (left). Precession of the vortex cluster can be observed as periodic oscillations of the fork width. This precession follows the laminar dependence for hours after the stop of rotation (Fig. 4, right). From this decay the value of α can be measured down to the lowest temperatures ever (Fig. 4, right, insert). Mutual friction follows the expected exponential dependence on temperature, as does the fork width, but additionally demonstrates a non-zero limiting value in the $T \to 0$ limit. The source of this zero-temperature dissipation remains so far unexplained. It is also not established yet whether this is the same mechanisms, as the one which provides finite zero-temperature dissipation in the front motion. Another novel feature of the ultra-low-temperature measurements is that the initial part of the spin-down is

not laminar, like at $T > 0.2\ T_c$. The turbulent behaviour is demonstrated by the rapid initial drop of superfluid rotation from Ω_{ini} to $\Omega_0 \approx 0.8\ \Omega_{ini}$.

QUANTUM TURBULENCE IN TWO-PHASE SYSTEMS

P.M. Walmsley, V.B. Eltsov, P.J. Heikkinen, J.J. Hosio, R. Hänninen, and M. Krusius

Phys. Rev. B **84**, 184532 (2011)

It is believed that the interaction between quantized vortices and the sample boundaries plays an important role in the properties of quantum turbulence, especially in its onset. For example, the ubiquitous turbulence in superfluid ^{4}He is often attributed to the unavoidable pinning of vortices on the walls of the container. In superfluid ^{3}He, where sufficiently smooth walls can be prepared, laminar behaviour can be stabilized even at the lowest achievable temperatures as shown in the previous section. Despite this importance of the vortex-boundary interactions, it is often difficult to control and characterize it in the experiments. Here ^{3}He provides a unique possibility, since with a magnetic field we can stabilize the interface between A and B phases across our cylindrical sample and observe how it affects the vortex dynamics. The interaction between quantized vortices and the AB interface has been well characterized in our previous works.

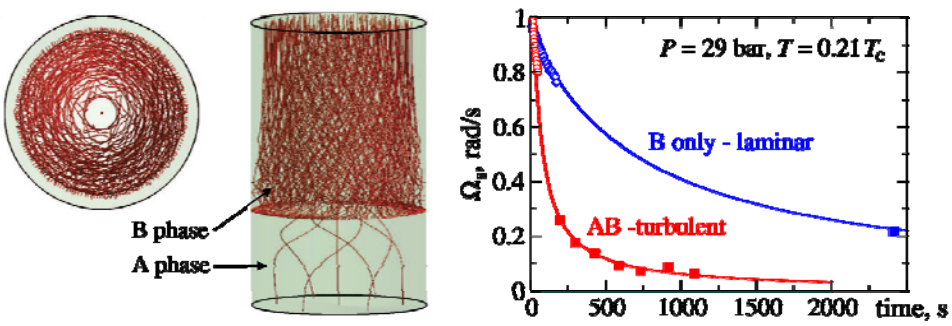


Fig. 5. Spin-down of the sample with coexisting ^{3}He-A and ^{3}He-B sections. *(Left and middle)* Calculated vortex configurations during spin-down, 30 s after a steplike reduction of Ω from 0.25 rad/s to zero in a cylinder with radius R=3 mm, top and side views. Before the spin-down vortex density in both phases was equal, but owing to a much larger friction in the A phase ($\alpha_A = 2$ in calculations) compared to the B phase ($\alpha_B = 4.3 \cdot 10^{-3}$), A phase quickly becomes void of vortices, while vortex sheet forms at the AB interface and twisted vortex state is created in the B-phase bulk. Instabilities of this vortex sheet and of the twisted state finally lead to the development of quantum turbulence in the B phase. *(Right)* Measured rotation velocity of the superfluid component in the B phase as a function of time after spin-down. The turbulent behavior of the two-phase configuration results in much faster stopping of the B phase rotation compared to the purely laminar behavior in the absence of the A phase.

In our experiments the A phase is created in the middle of the long sample column (Fig. 1, left) and splits the sample in two B-phase sections. Here we are interested in the upper section, which has contact only with the smooth walls of the sample tube. In rotation we prepare the equilibrium vortex state, where rectilinear vortices pass from the top to the bottom of the sample through the two AB interfaces. Then we quickly stop rotation and observe how the B-phase section comes to rest using NMR spectroscopy. Our pick-up coil is placed 4 cm away from the AB interface. Still, the spin-down process proceeds much faster when the A phase is present than in the case when the whole sample is filled with the B phase (Fig. 5, right). The faster response proves

that turbulence develops in the whole B-phase volume owing to the presence of the AB interface.

Our numerical calculations of vortex dynamics illuminate the source of this instability (Fig. 5, left). Its origin lies in the fact that at lower temperatures mutual friction dissipation is orders of magnitude larger in the A phase than in the B phase. Thus after the sudden stop of rotation vortices in the A phase quickly move towards the outer cylindrical boundary and annihilate there, while vortices in the B phase tend to remain at their original positions. Owing to superfluid coherence across the AB interface vortices cannot break at the interface and thus vortices on the B-phase side get strongly deformed. This deformation results in the appearance of supercurrents along vortex cores, which trigger creation and growth of Kelvin waves, reconnections and a transition to turbulence. The calculations predict that the rotation of the B phase during the decay is not solid-body-like, but the vortex density increases towards the boundary, leaving a hole close to the axis of the cylinder. Such a vortex configuration leaves a characteristic signature in the NMR spectrum, which is indeed observed in the experiment with the spin-down of the two-phase sample, but is not present in the case of only B phase. We can thus conclude that the measurements of the spin-down of the two-phase sample present the first realization of quantum turbulence where the role of vortex-boundary interaction in the dynamics is understood.

PICO group

Thomas Aref, Timothe Faivre, Anna Feshchenko, Simone Gasparinetti, Helena Knowles, Jonne Koski, Hung Nguyen, Ville Maisi (MIKES), Matthias Meschke, Juha Muhonen, **Jukka Pekola**, Joonas Peltonen, Olli-Pentti Saira, Youngsoo Yoon

Collaborators: Antti Kemppinen (MIKES), Mikko Möttönen (Dept. of Applied Physics, Aalto University), Yuri Pashkin (NEC, Japan), Paolo Solinas (Dept. of Applied Physics, Aalto University), Dmitri Averin (Stony Brook University, New York), Per Delsing (Chalmers University, Sweden), Sergey Lotkhov (PTB, Germany), Frank Hekking (CNRS Grenoble, France)

The research work of the PICO group is focused on single electron turnstiles, electronic refrigerators and superconducting circuits. In the course of this year, we implemented hybrid single electron turnstiles with improved performance for potential use in a metrological current standard. Increased activity in electronic refrigerators resulted in further progress towards a cooler platform. This cooler platform benefits from our expertise in low temperature thermometry. The superconducting quantum interference proximity transistor (SQUIPT) detector for tiny magnetic fields was further extended and advanced. Superconducting circuits involving geometric (Berry's) phases were moved forward and new progress was made in information-to-energy conversion in tunnel junction devices.

SINGLE ELECTRON TURNSTILES

V. F. Maisi, **O.-P. Saira**, Yu. A. Pashkin, J. S. Tsai, D. V. Averin, and **J. P. Pekola**, Phys. Rev. Lett. **106**, 217003 (2011).

T. Aref, **V. F. Maisi**, M. V. Gustafsson, P. Delsing, and **J. P. Pekola**, EPL **96**, 37008 (2011).

O.-P. Saira, A. Kemppinen, **V. F. Maisi** and **J. P. Pekola**, Phys. Rev. B **85**, 012504 (2012).

A. Kemppinen, S.V. Lotkhov, **O.-P. Saira**, A. B. Zorin, **J. P. Pekola**, and A. J. Manninen, APL **99**, 142106 (2011).

S. V. Lotkhov, **O.-P. Saira**, **J. P. Pekola**, and A. B. Zorin, New Journal of Physics **13**, 013040 (2011)

The hybrid single electron turnstile consisting of a normal metal island with superconducting leads (SINIS) is a leading candidate for a metrological current standard (much like the Josephson effect and Hall resistance are metrological standards for voltage and resistance, respectively). The single electron turnstile, ideally, can produce a single electron every pumping cycle. This results in an electric current proportional to the product of the electric and frequency of pumping. Obviously, error processes limit the accuracy of these turnstiles and the focus of this research is understanding and eliminating unwanted effects.

We extended our previous results on higher order Andreev tunneling currents from the DC regime to the AC regime relevant for actual pumping. This work was done in collaboration with Chalmers University in Sweden. We demonstrated control over the Andreev error effect and could suppress it by maximizing the charging energy (as expected theoretically). This research indicated that the most suitable turnstile for a metrological current standard combines high charging energy with low tunneling resistance. Such turnstiles indicate that heating effects in the superconductor are highly relevant to proper turnstile functioning.

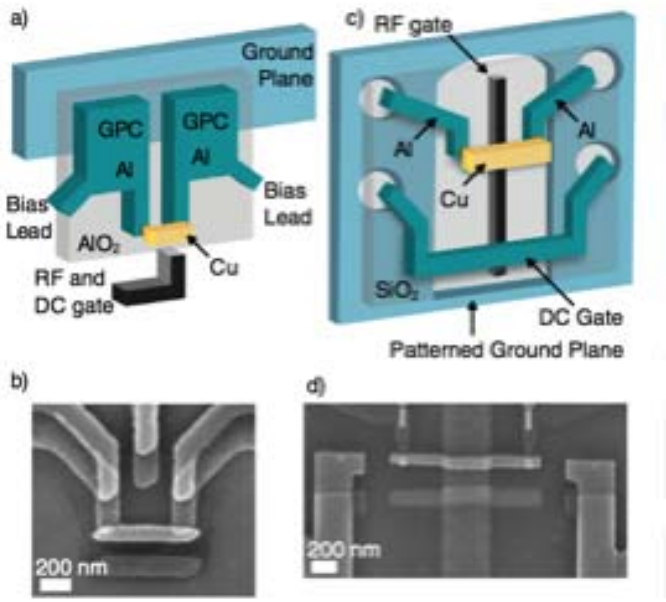


Figure 1: Single electron turnstiles used for determining AC Andreev tunneling effects. Two different designs were used.

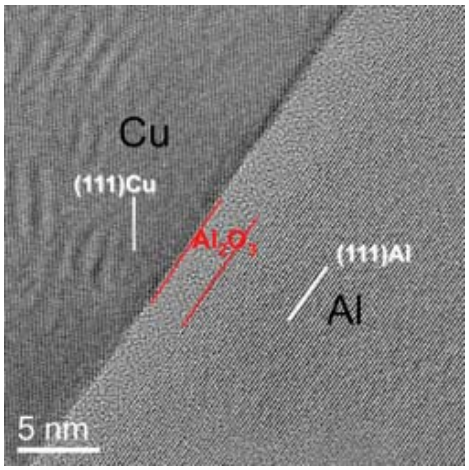


Figure 2: TEM image of aluminum oxide interface between copper and aluminum in our NIS junctions. Both the aluminum and the copper are polycrystalline. Image by Dr. Lide Yao, department of applied physics (Prof. van Dijken's group).oning.

The achievable fidelity of the turnstile, like many other nanoelectronic devices based on superconducting aluminum, is limited by either the density of residual nonequilibrium quasiparticles or the density of quasiparticle states in the gap, commonly characterized by the Dynes parameter. New experiments by our group improved the upper bounds on the density of quasiparticles and the Dynes parameter by an order of magnitude, a huge accomplishment. The typical number of the quasiparticles in the superconducting aluminum was shown to be zero, indicating that with proper shielding and quasiparticle relaxation, aluminum is a near perfect superconductor.

Additional progress on the SINIS turnstile included further improvement of hold times being reported. This demonstrated improved shielding in the MIKES cryostat which cut down on photon assisted tunneling events. Such shielding is important for implementation of a quantum metrological triangle where the standards for voltage (Josephson effect), resistance (Hall effect) and current (quite likely, the SINIS turnstile) are compared against each other. The escape processes of SINIS turnstiles were also explored in a dissipative environment to further compare them to normal metal single electron transistor (SET) devices. Finally, transmission electron microscope (TEM) characterization of the junctions combined with computational simulation of atoms is being actively pursued to improve junction quality (see image). This is a heavily collaborative effort involving also the groups of Prof. Risto Nieminen and Prof. Sebastiaan van Dijken at Aalto University.

THERMOMETRY AND ELECTRONIC COOLERS

J. T. Muhonen, **M. Meschke**, and **J. P. Pekola**, Rep. Prog. Phys. **75**, 046501 (2012)
J. T. Peltonen, M. Helle, A. V. Timofeev, P. Solinas, F. W. Hekking and **J. P. Pekola**, Phys. Rev. B **84**, 144505 (2011)
J. T. Peltonen, **J. T. Muhonen**, **M. Meschke**, N. B. Kopnin, and **J. P. Pekola**, Phys. Rev. B **84**, 220502 (2011)
J. T. Muhonen, M. J. Prest, M. Prunnila, D. Gunnarsson, V. A. Shah, A. Dobbie, M. Myronov, R. J. H. Morris, T. E. Whall, D. R. Parker and E. H. C. Leadley, APL **98**, 182103 (2011)

M. J. Prest, **J. T. Muhonen**, M. Prunnila, D. Gunnarsson, V. A. Shah, J. S. Richardson-Bullock, A. Dobbie, M. Myronov, R. J. H. Morris, T. E. Whall, E. H. C. Parker, and D. R. Leadley, APL **99**, 251908 (2011)
N. Vercruyssen, R. Barends, T. M. Klapwijk, **J. T. Muhonen**, **M. Meschke**, and **J. P. Pekola**, APL **99**, 062509 (2011)
M. Meschke, J. Engert, D. Heyer, and **J. P. Pekola**, International Journal of Thermophysics **32**, 1378 (2011)
D. Maradan, A. C. Clark, C. Scheller, K. K. Schwarzwalder, **J. P. Pekola**, D. M. Zumbuhl, L. Casparis, **M. Meschke**, arXiv 1111.1972v2 (2012)

When a NIS junction is biased properly, the bandgap of the superconductor can act as an energy filter, allowing hot electrons to leave the normal metal and cold electrons from the superconductor to enter. These junctions are known as electronic coolers or refrigerators. A review of micrometer scale refrigerators was made by our group. This review organized recent efforts on the NIS coolers in one place for effectively advancing science. The theoretical analysis of Brownian refrigeration was also extended with an eye towards possible experimental observation. In addition, we measured and demonstrated that, dependent on geometry, a magnetic field could be used to counter-intuitively enhance cooling in a NIS cooler. Enhanced electron cooling was demonstrated in a strained-silicon/superconductor tunnel junction refrigerator. This cooler showed improved cooling compared to the unstrained case. These silicon coolers were explored in collaboration with the University of Warwick in the United Kingdom.

Effective measurement of the quality of the coolers requires sensitive and accurate thermometers. We explored two different low temperature thermometers. Quasiparticle effects in superconducting resonators were explored on silicon nitride membranes and compared to effects on silicon nitride coated wafers. The resonators are extremely sensitive to small changes in phonon temperature making them excellent phonon thermometers. The other thermometer is the Coulomb blockade thermometer (CBT), based on bias voltage dependent conductance of arrays of normal metal electrodes separated by tunnel junctions. This conductance is highly sensitive to temperature. The CBT is a leading technology for a new standard of temperature at low temperatures. Our recent publication comparing CBTs to the International Temperature Scale PLTS-2000 is a strong step forward in developing the next generation of milli-Kelvin thermometry. The CBT has also been tested down to 10 mK and below.

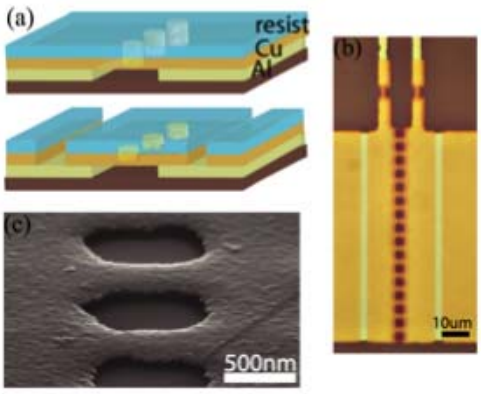


Figure 3: New fabrication process allowing large scale cooler junctions using photolithography and wet-etching rather than lift-off processing.

SQUIPT

M. Meschke, **J.T. Peltonen**, **J.P. Pekola**, and F. Giazotto, Phys. Rev. B **84**, 214514 (2011)
J. V. Koski, **J. T. Peltonen**, **M. Meschke**, and **J. P. Pekola**, APL **98**, 203501 (2011)

A superconductor in close contact to a normal metal produces a 'proximity effect' through superconducting correlations. This opens a minigap in the density of states of a the normal metal. The amplitude of the minigap can be modulated by manipulating the superconducting order parameter. We used this effect to develop the superconducting quantum interference proximity transistor (SQUIPT) which is a new type of interferometer utilizing magnetic field control of the DOS in a proximized normal metal piece in a superconducting loop.

We performed tunnel spectroscopy on a proximity Josephson junction, essentially a more advanced version of the SQUIPT. This allowed us to reach unprecedented flux sensitivities with these new devices. We also developed a new type of fabrication procedure that allows high quality aluminum oxide junctions, based on oxidation of aluminum (a superconductor) while retaining the proximity effect through a lateral approach. This opens new avenues for further development of the SQUIPT.

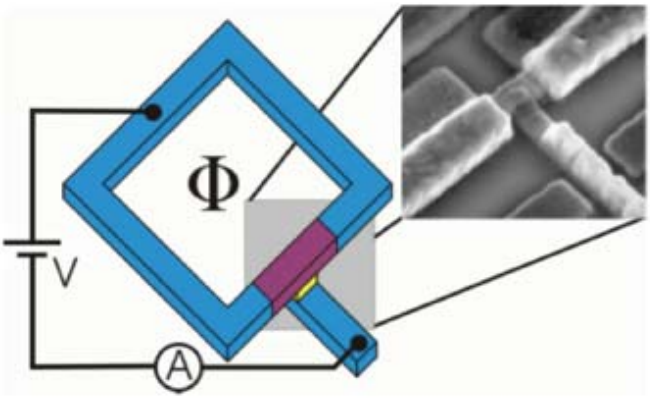


Figure 4: SQUIPT device used for tunneling spectroscopy on a proximity Josephson junction.

GEOMETRIC PHASES IN SUPERCONDUCTING CIRCUITS

P. Solinas, M. Möttönen, J. Salmilehto, and **J. P. Pekola**, Phys. Rev. B 85, 024527 (2012)
S. Gasparinetti, P. Solinas, and **J. P. Pekola**, Phys. Rev. Lett. **107**, 207002 (2011)
Y. Yoon, **S. Gasparinetti**, M. Möttönen, and **J. P. Pekola**, Journal of Low Temperature Physics **163**, 164 (2011)

The Cooper-pair sluice is a tunable superconducting single electron transistor (SET) which uses two DC superconducting quantum interference devices (SQUIDs) as tunable Josephson junctions. The Cooper-pair sluice is similar to the previously mentioned single electron turnstile but pumps Cooper pairs rather than controllably releasing single electrons. The geometric or Berry's phase of the device can be connected to the pumped Cooper-pairs. The sluice may be invaluable for development of geometric quantum computation using superconducting circuits.

Theoretical progress was made on Cooper-pair current in the presence of flux noise. This is directly connected to exploring the influence of environmental noise in the sluice. We have also explored the theoretical possibility of geometric Landau-Zener interferometry based on the Cooper-pair sluice. This is a new type of interferometry with interference patterns appearing in the pumped charge due to geometric phase effects. We considered real-world effects in our model, such as decoherence, opening

the door for possible experimental observation and verification. Our experimental studies on capacitively enhanced thermal escape in underdamped Josephson junctions were published. These may be crucial for the development of SQUID detectors in the geometric phase project. Recent experimental results include pumping of a single Cooper pair, a range of dynamics which has not been explored previously.

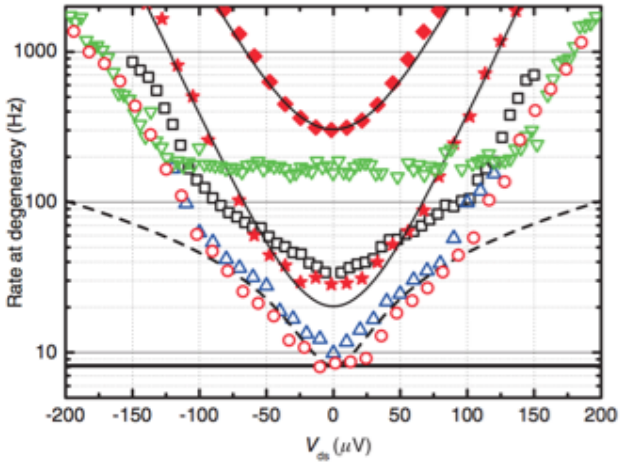


Figure 5: Rate of environmental activated events resulting from quasiparticles in the aluminum. With proper shielding, the rate is reduced to below 10 Hz, an unprecedented low frequency.

INFORMATION-TO-ENERGY AND THE JARZYNSKI EQUALITY

D. V. Averin and **J. P. Pekola**, EPL **96**, 67004 (2011)
D. V. Averin, M. Möttönen and **J. P. Pekola**, Phys. Rev. B **84**, 245448 (2011)
O.-P. Saira, **Y. Yoon**, and **J. P. Pekola** (Not yet published)

Theoretical progress was made on exploring tunnel junctions for information-to-energy conversion experiments. This type of experiments (which have seen only preliminary demonstrations in other systems) would essentially allow a Maxwell demon to use information about the system to generate work. Further analysis and regimes of applicability of the fluctuation relations were described. Experimental results verified one of these relations, the Jarzynski equality, to unprecedented accuracy.

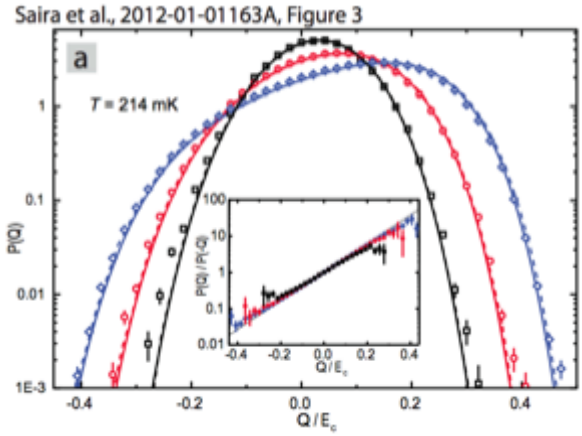


Figure 6: Comparison of measured distributions to the Jarzynski equation. The points are measured data and the solid lines are theoretical predictions. The inset shows comparison of the distribution to the more general Crooks theorem.

ADDITIONAL PROJECTS

H. Godfrin, **M. Meschke**, H.-J. Lauter, A. Sultan, H. M. Bhm, E. Krotscheck, and M. Panholzer, Nature **483**, 576 (2012)
S. Gasparinetti, F. Deon, G. Biasiol, L. Sorba, B. Beltram, and F. Giazotto, Phys. Rev. B **83**, 201306 (2011)
V. Gramich, P. Solinas, M. Möttönen, **J. P. Pekola**, and J. Ankerhold, Phys. Rev. B **84**, 052103 (2011)

Members of PICO group were also involved in a variety of external projects. A long running work on the observation of a roton collective mode in a two-dimensional Fermi liquid was published in Nature. Experiments on electron-phonon interaction in a two-dimensional electron gas microdomain probed with a quantum dot were also performed. A theoretical contribution to a measurement scheme for the Lamb shift in superconducting circuits was made.

NEW EQUIPMENT

We moved our dry cryostat from Nanotalo to our main lab in Micronova allowing much easier access since our group is primarily located there. This enabled much more extensive use of the dry cryostat by all group members. Additional improvements in noise filtering in improved sample stages was generalized to more cryostats allowing more low-noise measurements. We began exploring different fabrication methods involving Al and Al/Mn via sputtering and chemical etching in addition to our more traditional evaporation and liftoff techniques. These included techniques for fabricating large area cooler junctions. We also began achieving TEM characterization of samples which again required changes in sample fabrication.

NANO THEORY group

Tero Heikkilä, Gil Jannes, Ville Kauppila, Nikolai Kopnin, Matti Laakso, Francesco Massel, Teemu Ojanen, Tuomas Tajakka, Grigori Volovik, Janne Viljas, Juha Voutilainen, Jukka Väyrynen

Visitors: Gianluigi Catelani (Yale University), Andreas Isacsson (Chalmers), Mohammed Amin Karimi (University of Kurdistan)

Collaborators: F.S. Bergeret (San Sebastian), H. Bouchiat (Université Paris Sud), J.C. Cuevas (Univ. Autonoma Madrid), M. Feigelman (Landau Institute Moscow), J. Kajala (Phys. Dep. Aalto), Yu. V. Nazarov (Delft Univ. Tech.), P. Nielaba (Konstanz), T. Novotny (Charles University Prague), F. Pauly (Karlsruhe), Tomi Ruokola (Phys. Dep., Aalto), P. Törmä (Phys. Dep., Aalto), P. Virtanen (University of Würzburg), Martin Zonda (Charles University Prague)

The research work of the NANO THEORY group is focused on the theoretical description of the phenomena, which take place in nanoelectronic structures. Particular emphasis is on fluctuations, heat transport, topological effects and nanomechanics.

USING MECHANICAL VIBRATIONS FOR BUILDING A NEAR-QUANTUM LIMITED MICROWAVE AMPLIFIER

Francesco Massel, Tero Heikkilä

In collaboration with the NEMS GROUP

Nature **480,** 351-354

We have explored the physics arising from the parametric coupling of a microwave cavity field with a nanomechanical resonator. We have shown that it is possible to describe the effect of the cavity on the mechanics in terms of optically-induced mechanical damping and shift in the mechanical frequency. In addition, through the linearization of the quantum Langevin equations of motion describing the dynamics of the system and its coupling to the environment, we have demonstrated that the ratio of this effective mechanical response to the bare one provides an accurate description of the microwave amplification, as observed in the experiments performed in the NEMS group. Moreover we have shown how, under appropriate conditions, this amplification can reach the quantum limit.

MANIFESTLY NON-GAUSSIAN FLUCTUATIONS IN SUPERCONDUCTOR-NORMAL METAL TUNNEL NANOSTRUCTURES

Matti Laakso and Tero Heikkilä

In collaboration with Yuli Nazarov, Kavli Institute of Nanotechnology, Delft University of Technology

Phys. Rev. Lett. **108**, 076002 (2012)

arXiv:1110.6726 (2011)

We applied the recently developed theory of temperature fluctuation statistics to a SINIS structure, where a normal metal island (N) is coupled by tunnel junctions (I) to two superconducting leads (S). We considered a structure where all the transmission eigenvalues of the tunnel junctions are small. In this case the heating due to Andreev tunneling, a process where a Cooper pair from the superconductor is converted into two quasiparticles in the normal metal, is very small, and the well-known cooling effect in NIS junctions is able to keep the normal metal island at a very low temperature. We found that when suitably driven out of equilibrium, this structure exhibits manifestly non-Gaussian fluctuations of temperature. We also proposed that by virtue of the strong temperature dependence of the electric current the fluctuations of temperature could be measured by monitoring the time-dependent electric current through the system.

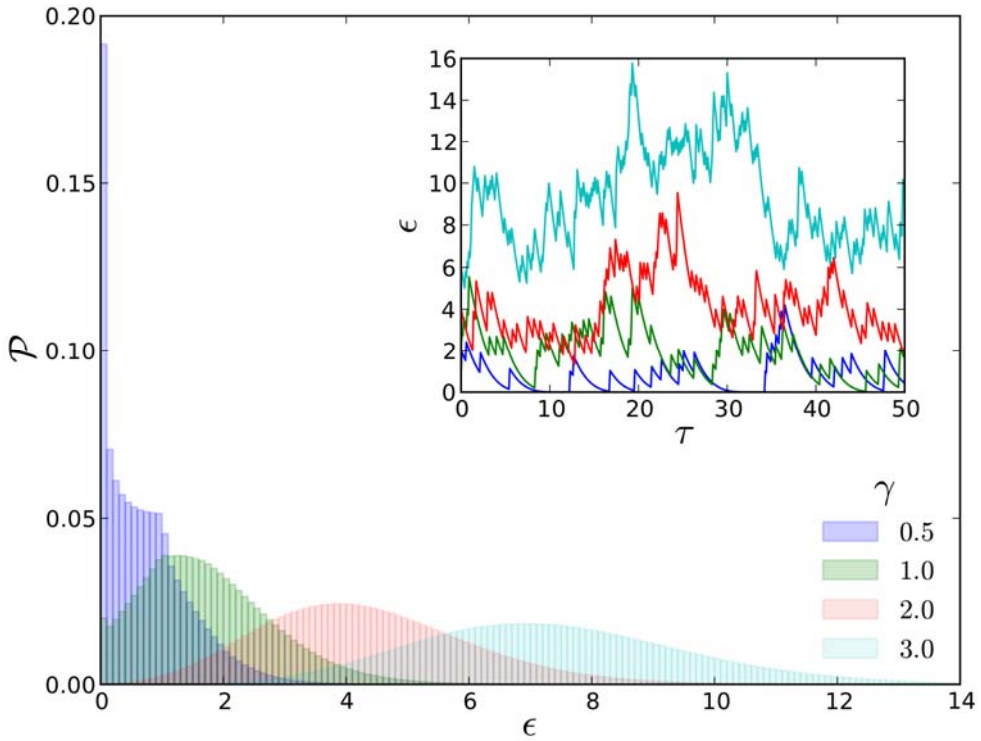


Figure 8: Probability distributions for the internal energy on the normal metal island for some Andreev tunneling rates γ. Inset shows realizations of energy timelines for each value of γ.

LOW-TEMPERATURE THERMAL TRANSPORT IN THE SPIN-BOSON MODEL

Teemu Ojanen

In collaboration with T. Ruokola (Department of Applied Physics, Aalto University)

T. Ruokola and T. Ojanen, Phys. Rev. B **83**, 045417 (2011)

The spin-boson model describes the interaction between bosonic modes and a two-level quantum system.It has been employed in a wide variety of phenomena exhibiting dissipation and loss of quantum coherence. Lately the model has found applications in a nonequilibrium setting where two bosonic reservoirs with different temperatures couple through the two-level system (TLS). These considerations are motivated by efforts to understand thermal properties of artificial molecular and nanoscale structures. The spin-boson model is interesting from the point of view of heattronics, the manipulation and control of heat in artificial nanostructures. Nonlinear elements, a two-level system being the simplest, with tunable parameters are basic building blocks for manipulation of heat flow. Possible realizations of the spin-boson thermal transport are, for example, molecular junctions coupling two phonon reservoirs or electric circuits coupled through a superconducting qubit. In the latter example the qubit can be manipulated by external fields allowing a flexible control of its properties and enabling the investigation of different transport regimes. In our work we presented a perturbative theory of thermal transport in the spin-boson model for arbitrary bath temperatures. At temperatures well above the TLS energy splitting the reservoirs can excite the system and transport is dominated by incoherent

sequential emission and absorbtion processes. In this regime the heat transport problem can be treated adequately in the lowest order approximation in the bath coupling. In analogy to electron transport, we use the word ``cotunneling'' for the virtual two-boson processes giving rise to the low temperature heat conductance. By calculating two-boson cotunneling rates we obtained an analytic description for thermal transport below the sequential-cotunneling crossover. By employing the scaling equations of the Ohmic spin-boson model we took into account renormalization of the spin-boson parameters. This enabled us to complement the perturbative results by scaling effects and extract an anomalous temperature scaling of cotunneling thermal conductance.

ELECTRICAL CONTROL AND MEASUREMENT OF SPIN PROPERTIES IN THE QUANTUM SPIN HALL EDGE STATES

Jukka Väyrynen and Teemu Ojanen

Phys. Rev. Lett. **106**, 076803 (2011)

The quantum spin Hall (QSH) insulator is a two-dimensional (2D) example of recently discovered topological insulators. Due to their special band structure arising from a strong spin-orbit interaction (SOI), topological insulators exhibit gapless surface modes forming a helical electron liquid. In the QSH state the edge supports two counter-propagating modes of opposite spin. The edge modes are protected by time-reversal symmetry, thus being robust against effects of small deformations of the sample and time-reversal invariant disorder. The existence of the QSH state has been confirmed in a series of experiments performed in HgTe quantum well structures. However, a quantitative observation of the helical structure has not been achieved yet. We studied effects of a gate-controlled Rashba spin-orbit coupling to quantum spin-Hall edge states in HgTe quantum wells. A uniform Rashba coupling can be employed in tuning the spin orientation of the edge states while preserving the time-reversal symmetry. We introduced a sample geometry where the Rashba coupling can be used in probing helicity by purely electrical means without requiring spin detection, application of magnetic materials or magnetic fields. In the considered setup a tilt of the spin orientation with respect to the normal of the sample leads to a reduction in the two-terminal conductance with current-voltage characteristics and temperature dependence typical of Luttinger liquid constrictions.

HEAT TRANSPORT IN NORMAL METAL-INSULATOR-SUPERCONDUCTOR JUNCTIONS

Ville Kauppila and Tero T. Heikkilä

We studied heat transport in NIS junctions, which can be used for thermometry and refrigeration. We concentrated especially on the case when a second normal metal is coupled to the superconductor (thus making the junction actually as NISN junction). This is due to recent findings which indicate that the otherwise bad heat conductance in superconductors can be improved by introducing quasiparticle traps to the superconductor. We found out that inverse proximity and nonequilibrium effects play an important role in heat transport properties of NISN junctions. We also found some optimal distance for the quasiparticle trap from the normal metal junction, which is for typical system parameters some 5 to 10 coherence lengths of the superconductor.

MOLECULAR DYNAMICS STUDY OF THE THERMOPOWER OF AG, AU, AND PT NANOCONTACTS

J. K. Viljas

In collaboration with F. Pauly (KIT Karlsruhe), M. Bürkle (KIT Karlsruhe), M. Dreher (University of Konstanz), P. Nielaba (University of Konstanz), and J.C. Cuevas (Autonomous University of Madrid)

Phys. Rev. B **84**, 195420 (2011)

Using molecular dynamics simulations of many junction stretching processes combined with tight-binding-based electronic structure and transport calculations, we analyze the thermopower of silver (Ag), gold (Au), and platinum (Pt) atomic contacts. In all cases we observe that the thermopower vanishes on average within the standard deviation and that its fluctuations increase for a decreasing minimum cross section of the junctions. However, we find a suppression of the fluctuations of the thermopower for the s-valent metals Ag and Au, when the conductance originates from a single, perfectly transmitting channel. Essential features of the experimental results for Au, Ag, and copper (Cu) of Ludoph and van Ruitenbeek [Phys. Rev. B 59 12290 (1999)], as yet unaddressed by atomistic studies, can hence be explained by considering the atomic and electronic structure at the disordered narrowest constriction of the contacts. For the multivalent metal Pt our calculations predict the fluctuations of the thermopower to be larger by one order of magnitude as compared to Ag and Au, and suppressions of the fluctuations as a function of the conductance are absent. Main features of our results are explained in terms of an extended single-level model.

ALTERNATING CURRENT RESPONSE OF LONG DIFFUSIVE SUPERCONDUCTOR-NORMAL METAL-SUPERCONDUCTOR JUNCTIONS

T.T. Heikkilä

In collaboration with P. Virtanen (Univ. Würzburg), F.S. Bergeret (Donostia International Physics Center, San Sebastian), J.C. Cuevas (Autonomous University of Madrid), F. Chiodi, M. Ferrier, S. Guéron, H. Bouchiat (Univ. Paris Sud), K. Tikhonov, M. Feigelman (Landau Institute, Moscow)

Phys. Rev. B **83**, 144514 (2011)
Sci. Rep. **1**, 3 (2011)

We have studied the response of long diffusive superconductor-normal metal-superconductor (SNS) junctions to high-frequency driving. Our theory, based on solving the quasiclassical Keldysh-Usadel equations in linear response to an alternating field, shows that the traditional kinetic inductance description of SNS junctions is valid only for frequencies much lower than the energy relaxation rate and the inverse diffusion time of the junction. We have also shown the new contributions to the admittance of the junction showing up at high frequencies and calculated their dependence on the temperature and the phase difference of the superconducting order parameters across the junction. These contributions are related to quasiparticle effects and non-adiabatic (dynamic) effects. Our predictions for the reactive part of the admittance are in a fair agreement with the experiments of the group from University of Paris Sud, whereas understanding the experimental results on the dissipative response would require further work.

SUPERCONDUCTING POINT CONTACTS IN THE PRESENCE OF MICROWAVE IRRADIATION

T.T. Heikkilä

In collaboration with P. Virtanen (Univ. Würzburg), F.S. Bergeret (Donostia International Physics Center, San Sebastian), J.C. Cuevas (Autonomous University of Madrid), and A. Ozaeta (Centro de Fisica de Materiales, San Sebastian)

Phys. Rev. B **84**, 054504 (2011)

We have studied the dynamics of superconducting point contacts in the presence of microwave irradiation using and comparing the results from two different approaches: two-level model describing the Andreev bound states and full numerical results based on Nazarov's boundary condition and Keldysh Green's functions. In particular, we have studied the microwave induced transitions between the different energy levels in the system, and the associated changes in the time-averaged supercurrent. We have also shown that the two-level model fails in situations when transitions to/from the continuum spectra above and below the superconducting gap need to be taken into account. Such transitions are especially relevant at non-zero temperatures, where we for example find and explain microwave-enhanced supercurrents, whose physics is particularly transparent in superconducting point contacts.

ENERGY RELAXATION AND ITS MEASUREMENT IN GRAPHENE

J. Voutilainen, J.K. Viljas, and T.T. Heikkilä

In collaboration with the NANO group

Phys. Rev. B **84**, 045419 (2011)

We have studied energy relaxation using supercurrent thermometry in graphene contacted to three superconducting contacts. One of the contacts was used to inject current into graphene, to heat the electrons in graphene, whereas the two other contacts placed close to each other were used to measure the associated changes in the electron distribution function. We have shown that the measured reduction of the supercurrent can be explained by assuming that electron-electron interactions combined with selective energy filtering in the graphene-superconductor contacts are the dominant process of energy relaxation. Our results on the energy relaxation strength agree qualitatively with the prediction from the Alt´shuler – Aronov theory frequency employed in metals, but are two orders of magnitude larger than predicted by that theory.

ULTRACOLD FERMIONIC GASES

Francesco Massel

In collaboration with the Quantum Dynamics group, Department of Applied Physics.

Phys. Rev. A **84**, 041601 (2011)
Eur. Phys. J. D **65**, 91-98 (2011)
Phys. Rev. Lett. **106**, 206401 (2011)

We have investigated the dynamical properties of ultracold fermionic gases in one-dimensional optical lattices. More specifically, we have tested the properties of two fermionic species in presence of attractive/repulsive interaction [1,2], attractive interaction and population imbalance [3]. In all situations, we simulated the unitary

time evolution following the sudden change of some characteristic parameter of the system. The simulations were performed employing a time-evolving block decimation algorithm, which allows the essentially exact simulation of ground state and dynamics of quantum systems. Our results have, on one hand, allowed us to gain insight into the spectral properties of the systems under investigation, and on the other has allowed us to formulate suggestions for experimental techniques aiming at the definition and experimental observation of exotic phases such as the Fulde-Ferrell-Larkin-Ovchinnikov phase.

NONLINEARITIES OF NANOELECTROMECHANICAL RESONATORS AND THE MACROSCOPIC QUANTUM TUNNELING OF MECHANICS

Raphaël Khan, Francesco Massel and Tero Heikkilä

In collaboration with the NEMS and NANO groups

Phys. Rev. B **84**, 195433 (2011)

We have studied the mechanical non-linearities caused by the charging energy in nanomechanical resonators coupled capacitively to a gate voltage. This coupling modifies the mechanical response, affecting both the eigenfrequency of mechanical motion, but also the non-linear properties of the mechanics, as applying a gate voltage pulls the resonator towards the gate plane. Upon large voltages, the resonator collapses in contact with the gate capacitor. Close to this pull-in threshold, the potential profile of the resonator is that of a tilted parabola. Such a profile in the presence of external noise exhibits both thermally activated escape and macroscopic tunneling behavior. Together with the NEMS and NANO groups, we have studied the possibility to observe this macroscopic quantum tunneling of mechanics. According to our predictions, the observation of macroscopic quantum tunneling is possible in carbon-based resonators, but quite challenging.

CHIRAL TOPOLOGICAL PHASES AND FRACTIONAL DOMAIN WALL EXCITATIONS IN ONE-DIMENSIONAL WIRES

Jukka Väyrynen and Teemu Ojanen

J. I. Väyrynen and T. Ojanen, Phys. Rev. Lett. 107, 166804 (2011)

According to the general classification of topological insulators, there exist one-dimensional systems that can support any number of topological phases. In this work we introduced a zigzag fermion chain with spin-orbit coupling in magnetic field and identify three distinct topological phases.

Zero-mode excitations, localized at the phase boundaries, are fractionalized: two of the phase boundaries support e/2 charge states while one of the boundaries support charge e and neutral excitations. The domain wall excitations are closely related to the Su-Heeger-Schrieffer domain wall fermions in polyacetylene. The most striking differences to the polyacetylene model include existence of three distinct phases (instead of two) and possibility to realize ±e/2 excitations that are absent in polyacetylene due to spin degeneracy.

Zigzag chains are realized in a number of systems which indicates that the studied model could be relevant, for example, in monoatomic gold chains in magnetic fields. Additionally, a continuum limit of the considered model describes narrow wires of

quantum spin Hall insulators which provides another realization of the domain wall excitations.

SINGLE-ELECTRON HEAT DIODE

Teemu Ojanen

In collaboration with Tomi Ruokola, Department of Applied Physics, Aalto University

T. Ruokola and T. Ojanen, Phys. Rev. B 83, 241404 (2011).

We introduce a functional nanoscale device, a single-electron heat diode, consisting of two quantum dots or metallic islands coupled to electronic reservoirs by tunnel contacts. Electron transport through the system is forbidden but the capacitive coupling between the two dots allows electronic fluctuations to transmit heat between the reservoirs. When the reservoir temperatures are biased in the forward direction, heat flow is enabled by a four-step sequential tunneling cycle, while in the reverse-biased configuration this process is suppressed due to Coulomb blockade effects. This suppression due to charging effects is the basis for the thermal diode effect in the system. In an optimal setup the leakage heat current in the reverse direction is only a few percent of the forward current. Experimental realization of the system generally requires subkelvin temperatures to suppress the parasitic thermal effects due to phonons.

NONEQUILIBRIUM PROPERTIES OF MESOSCOPIC SUPERCONDUCTORS

N.B. Kopnin

Collaborators: PICO group; A.S. Melnikov (Institute for Physics of mIcrostructures, Russia)

N.B. Kopnin and A.S. Melnikov, “Proximity induced superconductivity in 2D electronic systems”, Phys. Rev. B **84**, 064524 (2011).

J.T. Peltonen, J.T. Muhonen, M. Meschke, N.B. Kopnin, and J.P. Pekola, “Magnetic-field-induced stabilization of nonequilibrium superconductivity in a normal-metal/insulator/superconductor junction”, Phys. Rev. B **84**, 220504 (2011).

The approach applicable for spatially inhomogeneous and time-dependent problems associated with the induced superconductivity in low dimensional electronic systems is developed. This approach is based on the Fano-Anderson model which describes the decay of a resonance state coupled to a continuum. We consider two types of junctions made of a ballistic 2D electron gas placed in a tunnel finite-length contact with a bulk superconducting leads. We calculate the spectrum of the bound states, supercurrent, and the current-voltage curve which show a rich structure due to the presence of induced gap and dimensional quantization.

A small magnetic field is found to enhance relaxation processes in a superconductor thus *stabilizing superconductivity* in non-equilibrium conditions. In a normal-metal (N)-insulator-superconductor (S) tunnel junction, applying a field of the order of 100 μT leads to significantly *improved* cooling of the N island by quasiparticle (QP) tunneling. These findings are attributed to faster QP relaxation within the S electrodes as a result of enhanced QP drain through regions with locally suppressed energy gap due to magnetic vortices in the S leads at some distance from the junction.

STUDIES OF SUPERCONDUCTIVITY IN GRAPHENE

N.B. Kopnin

Collaborators: Theory group.

T.T. Heikkilä, N.B. Kopnin, and G.E. Volovik, "Flat bands in topological media" Pis'ma ZhETF **94**, 252-258 (2011).

N.B. Kopnin, T.T. Heikkilä, and G.E. Volovik, "High-temperature surface superconductivity in topological flat-band systems", Phys Rev. B **83**, 220503 (2011).

N.B. Kopnin, "Surface superconductivity in multilayered rhombohedral graphene: Supercurrent", Pis'ma ZhETF **94**, 81 (2011)[JETP Letters **94**, 81 (2011)].

We show that the topologically protected flat band emerging on a surface of a nodal fermionic system promotes the surface superconductivity due to an infinitely large density of states (DOS) associated with the flat band. The critical temperature depends linearly on the pairing interaction and can be thus considerably higher than the exponentially small bulk critical temperature. We discuss an example of multilayered rhombohedral graphene where a flat band can appear for the surface states in the limit of large number of layers. Formation of surface superconductivity is enhanced already for the system having N>2 layers, where the normal-state spectrum has a power-law dispersion $\varepsilon_p \sim p^N$ as a function of the in-plane momentum **p**. The DOS $\nu_p \sim \varepsilon_p^{(2-N)/N}$ has a singularity at zero energy which results in a drastic enhancement of the critical temperature. The supercurrent associated with the surface superconductivity is calculated.

TOPOLOGICAL MATTER, FLAT BANDS, ROOM TEMPERATURE SUPERCONDUCTIVITY

T.T. Heikkilä and G.E. Volovik, Dimensional crossover in topological matter: Evolution of the multiple Dirac point in the layered system to the flat band on the surface, Pis'ma ZhETF **93**, 63--68 (2011); JETP Lett. **93**, 59--65 (2011)

The dimensional crossover in the topological matter, which involves the transformation of different types of topologically protected zeroes in the fermionic spectrum, is considered. In the considered case, the multiple Dirac (Fermi) point in quasi 2-dimensional system evolves into the flat band on the surface of the 3-dimensional system when the number of atomic layers increases. This is accompanied by formation of the spiral nodal lines in the bulk. The topological quantum phase transition is discussed, at which the surface flat band shrinks and changes its chirality, while the nodal spiral changes its helicity.

G.E. Volovik, Flat band in the core of topological defects: bulk-vortex correspondence in topological superfluids with Fermi points, Pis'ma ZhETF **93**, 69--72 (2011); JETP Lett. **93**, 66--69 (2011)

The dispersionless spectrum with zero energy in the linear topological defects, vortices, is discussed. The flat band emerges inside the vortex living in the bulk medium containing topologically stable Fermi points in momentum space. The boundaries of the flat band in the vortex are determined by projections of the Fermi points in bulk to the vortex axis. This bulk-vortex correspondence for flat band is similar to the bulk-surface correspondence discussed earlier in the media with topologically protected lines of zeroes. In the latter case the flat band emerges on the surface of the system, and its boundary is determined by projection of the bulk nodal line on the surface.

T.T. Heikkilä, N.B. Kopnin and G.E. Volovik, Flat bands in topological media, Pis'ma ZhETF **94**, 252-- 258 (2011); JETP Lett. **94**, 233--239(2011)

Topological media are systems whose properties are protected by topology and thus are robust to deformations of the system. In topological insulators and superconductors the bulk-surface and bulk-vortex correspondence gives rise to the gapless Weyl, Dirac or Majorana fermions on the surface of the system and inside vortex cores. Here we show that in gapless topological media, the bulk-surface and bulk-vortex correspondence is more effective: it produces topologically protected gapless fermions without dispersion -- the flat band. Fermion zero modes forming the flat band are localized on the surface of topological media with protected nodal lines and in the vortex core in systems with topologically protected Fermi points (Weyl points). Flat band has an extremely singular density of states, and we show that this property may give rise in particular to surface superconductivity which could exist even at room temperature.

J.I. Väyrynen and G.E. Volovik, Soft topological objects in topological media, Pis'ma ZhETF **93**, 378--382 (2011); JETP Lett. **93**, 344-348 (2011)

Topological invariants in terms of the Green's function in momentum and real space determine properties of smooth textures within topological media. In space dimension D=1 the topological invariant N_3 in terms of the Green's function determines the fermion number of the 1D soliton, while in space dimension D=3 the topological invariant N_5 in terms of the Green's function determines quantization of Hall conductivity in the soliton plane within the topological insulators.

N.B. Kopnin, T.T. Heikkilä and G.E. Volovik, High-temperature surface superconductivity in topological flat-band systems, Phys. Rev. B 83, 220503(R) (2011)

It is shown that the topologically protected flat band emerging on a surface of a nodal fermionic system promotes the surface superconductivity due to an infinitely large density of states associated with the flat band. The critical temperature depends linearly on the pairing interaction and can be thus considerably higher than the exponentially small bulk critical temperature. An example of surface superconductivity in multilayered graphene with rhombohedral stacking is discussed.

M.A. Silaev and G.E. Volovik, Evolution of edge states in topological superfluids during the quantum phase transtion, Pis'ma ZhETF **95**, 29-32 (2012); JETP Lett. **95**, 25-28 (2012)

The quantum phase transition between topological and non-topological insulators or between fully gapped superfluids/superconductors can occur without closing the gap. We consider the evolution of the Majorana edge states on the surface of topological superconductor during transition to the topologically trivial superconductor on example of non-interacting Hamiltonian describing the spin-triplet superfluid 3He-B. In conventional situation when the gap is nullified at the transition, the spectrum of Majorana fermions shrinks and vanishes after the transition to the trivial state. If the topological transition occurs without the gap closing, the Majorana fermion spectrum disappears by escaping to ultraviolet, where Green's function approaches zero. This demonstrates the close connection between the topological transition without closing the gap and zeroes in the Green's function. Similar connection takes place in interacting systems where zeroes may occur due to interaction

G.E. Volovik, Flat band in topological matter: possible route to room-temperature superconductivity, arXiv:1110.4469.

Topological media are systems whose properties are protected by topology and thus are robust to deformations of the system. In topological insulators and superconductors the bulk-surface and bulk-vortex correspondence gives rise to the gapless Weyl, Dirac or Majorana fermions on the surface of the system and inside vortex cores. In gapless topological media, the bulk-surface and bulk-vortex correspondence produce topologically protected gapless fermions without dispersion - the flat band. Fermion zero modes forming the flat band are localized on the surface of topological media with protected nodal lines and in the vortex core in systems with topologically protected Fermi points (Weyl points). Flat band has an extremely singular density of states, and this property may give rise in particular to surface superconductivity which in principle could exist even at room temperature.

QUANTUM FIELD THEORY, QUANTUM GRAVITY AND THEIR ANALOGS IN CONDENSED MATTER

G.E. Volovik, Topology of quantum vacuum, draft for Chapter in proceedings of the Como Summer School on analogue gravity

Topology in momentum space is the main characteristics of the ground states of a system at zero temperature, the quantum vacua. The gaplessness of fermions in bulk, on the surface or inside the vortex core is protected by topology. Irrespective of the deformation of the parameters of the microscopic theory, the energy spectrum of these fermions remains strictly gapless. This solves the main hierarchy problem in particle physics. The quantum vacuum of Standard Model is one of the representatives of topological matter alongside with topological superfluids and superconductors, topological insulators and semi-metals, etc. There is a number of of topological invariants in momentum space of different dimensions. They determine universality classes of the topological matter and the type of the effective theory which emerges at low energy, give rise to emergent symmetries, including the effective Lorentz invariance, and emergent gauge and gravitational fields. The topological invariants in extended momentum and coordinate space determine the bulk-surface and bulk-vortex correspondence, connecting the topology in bulk with the real space. The momentum space topology gives some lessons for quantum gravity. In effective gravity emerging at low energy, the collective variables are the tetrad field and spin connections, while the metric is the composite object of tetrad field. This suggests that the Einstein-Cartan-Sciama-Kibble theory with torsion field is more relevant. There are also several scenarios of Lorentz invariance violation governed by topology, including splitting of Fermi point and development of the Dirac points with quadratic and cubic spectrum. The latter leads to the natural emergence of the Horava-Lifshitz gravity.

M.I. Katsnelson and G.E. Volovik, Quantum electrodynamics with anisotropic scaling: Heisenberg-Euler action and Schwinger pair production in the bilayer graphene, arXiv:1203.1578

Quantum electrodynamics emerging in the vacua with anisotropic scaling is discussed. Systems with anisotropic scaling were suggested by Horava in relation to the quantum theory of gravity. In such vacua the space and time are not equivalent, and moreover they obey different scaling laws, called the anisotropic scaling. Such anisotropic scaling takes place for fermions in bilayer graphene, where if one neglects the trigonal warping effects the massless Dirac fermions have quadratic dispersion. This results in the anisotropic quantum electrodynamics, in which electric and magnetic fields obey different scaling laws. The Heisenberg-Euler action and Schwinger pair production in such anisotropic QED is discussed

F.R. Klinkhamer and G.E.Volovik, Dynamics of the quantum vacuum: Cosmology as relaxation to the equilibrium state, Journal of Physics: Conference Series **314**, 012004 (2011)

The behavior of the gravitating vacuum energy density in an expanding universe is discussed. A scenario is presented with a step-wise relaxation of the vacuum energy density. The vacuum energy density moves from plateau to plateau and follows, on average, the steadily decreasing matter energy density. The current plateau with a small positive value of the vacuum energy density (effective cosmological constant) may result from a still not equilibrated contribution of the light massive neutrinos to the quantum vacuum.

M.A. Zubkov and G.E. Volovik, Topological invariants for the 4D systems with mass gap, arXiv:1201.4185.

Topological invariants for the 4D gapped system are discussed with application to the quantum vacua of relativistic quantum fields. The index theorem is proved that defines the number of massless fermions in the intermediate vacuum, which exists at the transition line between the massive vacua with different values of invariants N_5 and N_3. The considered invariants are calculated for the lattice model with Wilson fermions in quantum chromodynamics.

F.R. Klinkhamer and G.E. Volovik, Superluminal neutrino and spontaneous breaking of Lorentz invariance, Pis'ma ZhETF **94**, 731--733 (2011); JETP Lett. **94**, 673 (2011)

The existence of a superluminal neutrino can be attributed either to re-entrant Lorentz violation at ultralow energy from intrinsic Lorentz violation at ultrahigh energy or to spontaneous breaking of fundamental Lorentz invariance (possibly by the formation of a fermionic condensate). Here, the focus is on mechanisms of spontaneous symmetry breaking.

G.E. Volovik, From analogue models to gravitating vacuum, arXiv:1111.1155.

Phenomenology of quantum vacuum is discussed. Phenomenology of a macroscopic system has three sources: thermodynamics, topology and symmetry. Momentum space topology determines the universality classes of fermionic vacua. The vacuum in its massless state belongs to the Fermi-point universality class, which has topologically protected fermionic quasiparticles. At low energy they behave as relativistic massless Weyl fermions. Gauge fields and gravity emerge together with Weyl fermions at low energy. Thermodynamics of the self-sustained vacuum allows us to treat the problems related to the vacuum energy: the cosmological constant problems. The natural value of the energy density of the equilibrium the self-sustained vacuum is zero. Cosmology is the process of relaxation of vacuum towards the equilibrium state. The present value of the cosmological constant is very small compared to the Planck scale, because the present Universe is very old and thus is close to equilibrium.

G. Jannes and G.E. Volovik, The cosmological constant: a lesson from the Weyl superfluid 3He-A, arXiv:1108.5086.

Topological matter with Weyl points, such as superfluid 3He-A, provide an explicit example where the properly determined vacuum energy and the cosmological constant appearing in the effective gravity are directly connected. This is in contrast to the acoustic gravity emerging in Bose-Einstein condensates, where the value of this constant cannot be easily predicted by just looking at the ground state energy of the microscopic system from which spacetime and its dynamics should emerge. This con-

nection in the bi-metric gravity emerging in 3He-A and its relation to the graviton masses are studied, by comparison with a fully relativistic bi-metric theory of gravity. This shows that the parameter \lambda, which in 3He-A is the bi-metric generalization of the cosmological constant, coincides with the difference in the proper energy of the vacuum in two states (the nonequilibrium state without gravity and the equilibrium state in which gravity emerges) and is on the order of the characteristic Planck energy scale of the system. Although the cosmological constant is huge, the cosmological term itself is naturally non-constant and vanishes in the equilibrium vacuum. This suggests that the equilibrium state of any system including the final state of the Universe is not gravitating.

QUANTUM TURBULENCE

V.B. Eltsov, R. de Graaf, J.J. Hosio, P.J. Heikkinen, R. Hänninen, M. Krusius, V.S. L'vov and G.E. Volovik, Superfluid vortex front at T-> 0: Decoupling from the reference frame, Phys. Rev. Lett. **107**, 135302 (2011)

Steady-state turbulent motion is created in superfluid 3He-B at low temperatures in the form of a turbulent vortex front, which moves axially along a rotating cylindrical container of 3He-B and replaces vortex-free flow with vortex lines at constant density. We present the first measurements on the thermal signal from dissipation as a function of time, recorded at 0.2 T_c during the front motion, which is monitored using NMR techniques. Both the measurements and the numerical calculations of the vortex dynamics show that at low temperatures the density of the propagating vortices falls well below the equilibrium value, i.e. the superfluid rotates at a smaller angular velocity than the container. This is the first evidence for the decoupling of the superfluid from the container reference frame in the zero-temperature limit.

BRAIN RESEARCH UNIT

The research programs of the Brain Research Unit (BRU) aim to deepen the understanding of human brain function in health and disease by exploiting, developing, and integrating the most advanced spatiotemporal methods of non-invasive human neuroimaging. The research included design and construction of stimulation and monitoring devices to create versatile but controlled stimulus environments for systems neuroscience experiments. BRU comprises research groups of Human Systems Neuroscience (led by Academician Riitta Hari; CliniMEG group led by Doc. Nina Forss and instrumentation development group led by Doc. Veikko Jousmäki), Imaging Language (led by Acad. Prof. Riitta Salmelin) and Vision Systems Neuroscience (subgroups led by Doc. Simo Vanni and Doc. Juha Silvanto).

We have studied human brain function by measuring weak magnetic fields outside the head by means of magnetoencephalography (MEG). This method allows monitoring of brain dynamics totally non-invasively in healthy and diseased humans during different tasks and conditions. Our 306-channel neuromagnetometer (Elekta Neuromag, Elekta Oy), functional since 1998 and upgraded in 2008, houses 204 gradiometers and 102 magnetometers with whole-scalp coverage. To combine functional and structural information, we typically integrate MEG data with the subject's magnetic resonance images (MRIs). We also use functional magnetic resonance imaging (fMRI) at the Advanced Magnetic Imaging (AMI) Centre of the Aalto University; fMRI with its excellent spatial resolution complements the superb temporal resolution of MEG in tracking activation patterns and sequences in the human brain. The AMI Centre operates a 3-tesla MRI/fMRI superconducting magnet (Siemens MAGNETOM Skyra) for whole-body imaging.

Our MEG Core was in 2011 directed by Riitta Hari (scientific director) and Veikko Jousmäki (technical director), and the AMI Centre (owned by the Aalto University) was directed by Simo Vanni (scientific director) and Toni Auranen (technical director).

Year 2011 was the last year of our Center of Excellence on Systems Neuroscience and Neuromaging, appointed by the Academy of Finland for years 2006–2011. We formed the core of this CoE and the other partners were the AMI Centre and the Applied Electronics Laboratory of Aalto University (Prof. Raimo Sepponen), and the Neuroscience Unit of the University of Helsinki (Prof. Synnöve Carlson).

In 2011, four BRU scientists received either national or international recognition. Riitta Hari received the Nokia Foundation Award 2011, Riitta Salmelin renewed her Academy Professorship and was invited as a Fellow of the International Society for Functional Source Imaging, and Erika Kirveskari and Juha Silvanto received docentships at the University of Helsinki. Annika Hultén defended her PhD thesis; The cumulative number of BRU PhDs now increased to 47.

BRU organized in 2011 three introductory MEG training courses, each for 5 days and with both lectures and hands-on data acquisition and analysis sessions. The courses were directed by Doc. Veikko Jousmäki together with Elekta Oy, and the majority of the participants were from abroad (USA, Canada, Saudi Arabia, Denmark, UK), mainly from new sites of Elekta Oy's MEG installations. In addition, system-starts,

advanced, and on-site training sessions, altogether for 4 weeks, were organized abroad in Saudi Arabia, Australia, and Germany by BRU and Elekta Oy.

In 2011, BRU continued to participate actively in aivoAALTO, the multidisciplinary research project of comprising all three schools of the Aalto University; aivoAALTO is directed by Riitta Hari and coordinated by Doc. Elina Pihko. Doc. Nina Forss continued to direct BRU's clinical subsection CliniMEG, aiming at MEG's clinical applications in e.g. chronic pain and stroke.

BRU has continued to have a research contract with Elekta Oy.

BRU has participated actively (as Nina Forss, Riitta Hari, and Riitta Salmelin as research leaders) in the Salwe SHOK Program that aims to prevent, and treat socioeconomically important diseases; the program is financed by TEKES. Our clinically important results are translated to clinical environment also via the CliniMEG team (led by Nina Forss).

BRU assisted AMI Centre in the startup of the new 3T scanner, installed in the fall 2011.

The senior scientists have given several national and international lectures and participated in peer-reviewing of scientific publications and research grants. BRU participated in organizing fMRI School, a two day seminar on the basics of fMRI, together with the AMI Centre and the Finnish Graduate School of Brain and Mind. The school had 46 participants, from six Finnish and two Russian cities.

Synnöve Carlson organized an international TMS workshop "Multimodal transcranial magnetic stimulation (TMS) in the study of brain and cognition." in March 24–25, 2011 in Helsinki, Finland. The meeting consisted of lectures, posters and demonstrations in TMS.

Below we list our scientific achievements from 2011 in form of published papers, with abstracts from the original papers.

HUMAN SYSTEMS NEUROSCIENCE

Person years: 1 professor, 2.5 docents, 8.5 postdocs, 5.5 PhD students

1. Baess P, Horváth J, Jacobsen T, Schröger E: Selective suppression of self-triggered sounds: An ERP study. Psychophysiology 2011, 48: 1276–1283.

Numerous studies have shown that the N1 event-related potential (ERP) response is attenuated when it is elicited by self-initiated sounds. This N1 suppression effect is generally interpreted to reflect an internal prediction mechanism, which enables the discrimination of the sensory consequences of our own actions and those of others. The blocked design used in the forerunner studies (i.e., self- and externally initiated sounds presented in different blocks) seriously limits the relevance of these findings, because the N1 effect can simply be explained by contextual task differences. In the present study, self- and externally initiated sounds were mixed within blocks. N1 suppression was found, and its magnitude was even larger than that observed in a traditional blocked condition. This result supports the involvement of an internal prediction mechanism in the discrimination of the sensory consequences of one's own actions and those of others.

2. Blasi A, Mercure E, Lloyd-Fox S, Thomson A, Brammer M, Sauter D, Deeley Q, Barker GJ, Renvall V, Deoni S, Gasston D, Williams SC, Johnson MH, Simmons A, Murphy DG: Early specialization for voice and emotion processing in the infant brain. Current Biology 2011, 21: 1220–1224.

Human voices play a fundamental role in social communication, and areas of the adult "social brain" show specialization for processing voices and their emotional content (superior temporal sulcus, inferior prefrontal cortex, premotor cortical regions, amygdala, and insula). However, it is unclear when this specialization develops. Functional magnetic resonance (fMRI) studies suggest that the infant temporal cortex does not differentiate speech from music or backward speech, but a prior study with functional near-infrared spectroscopy revealed preferential activation for human voices in 7-month-olds, in a more posterior location of the temporal cortex than in adults. However, the brain networks involved in processing nonspeech human vocalizations in early development are still unknown. To address this issue, in the present fMRI study, 3- to 7-month-olds were presented with adult nonspeech vocalizations (emotionally neutral, emotionally positive, and emotionally negative) and nonvocal environmental sounds. Infants displayed significant differential activation in the anterior portion of the temporal cortex, similarly to adults. Moreover, sad vocalizations modulated the activity of brain regions involved in processing affective stimuli such as the orbitofrontal cortex and insula. These results suggest remarkably early functional specialization for processing human voice and negative emotions.

3. Bourguignon M, De Tiège X, Op de Beeck M, Pirotte B, Van Bogaert P, Goldman S, Hari R, Jousmäki V: Functional motor-cortex mapping using corticokinematic coherence. NeuroImage 2011, 55: 1475–1479.

We present a novel method, corticokinematic coherence (CKC), for functional mapping of the motor cortex by computing coherence between cortical magnetoencephalographic (MEG) signals and the kinematics of voluntary movements. Ten subjects performed self-paced flexion-extensions of the right-hand fingers at about 3 Hz, with a three-axis accelerometer attached to the index finger. Cross-correlogram and coherence spectra were computed between 306 MEG channels and the accelerometer signals. In all subjects, accelerometer and coherence spectra showed peaks around 3-5 Hz and 6-10 Hz, corresponding to the movement frequencies. The coherence was statistically significant ($P<0.05$) in all subjects, with sources at the hand area of the primary motor cortex contralateral to the movement. CKC appears to be a promising and robust method for reliable and convenient functional mapping of the human motor cortex.

4. Brattico E, Alluri V, Bogert B, Jacobsen T, Vartiainen N, Nieminen S, Tervaniemi M: A functional MRI study of happy and sad emotions in music with and without lyrics. Frontiers in Psychology 2011, 2: article 308, 1–16.

Musical emotions, such as happiness and sadness, have been investigated using instrumental music devoid of linguistic content. However, pop and rock, the most common musical genres, utilize lyrics for conveying emotions. Using participants' self-selected musical excerpts, we studied their behavior and brain responses to elucidate how lyrics interact with musical emotion processing, as reflected by emotion recognition and activation of limbic areas involved in affective experience. We extracted samples from subjects' selections of sad and happy pieces and sorted them ac-

cording to the presence of lyrics. Acoustic feature analysis showed that music with lyrics differed from music without lyrics in spectral centroid, a feature related to perceptual brightness, whereas sad music with lyrics did not diverge from happy music without lyrics, indicating the role of other factors in emotion classification. Behavioral ratings revealed that happy music without lyrics induced stronger positive emotions than happy music with lyrics. We also acquired functional magnetic resonance imaging data while subjects performed affective tasks regarding the music. First, using ecological and acoustically variable stimuli, we broadened previous findings about the brain processing of musical emotions and of songs versus instrumental music. Additionally, contrasts between sad music with versus without lyrics recruited the parahippocampal gyrus, the amygdala, the claustrum, the putamen, the precentral gyrus, the medial and inferior frontal gyri (including Broca's area), and the auditory cortex, while the reverse contrast produced no activations. Happy music without lyrics activated structures of the limbic system and the right pars opercularis of the inferior frontal gyrus, whereas auditory regions alone responded to happy music with lyrics. These findings point to the role of acoustic cues for the experience of happiness in music and to the importance of lyrics for sad musical emotions.

5. Calvo MG, Avero P, Nummenmaa L: Primacy of emotional vs. semantic scene recognition in peripheral vision. Cognition & Emotion 2011, 25: 1358–1375.

Emotional scenes were presented peripherally (5.2° away from fixation) or foveally (at fixation) for 150 ms. In affective evaluation tasks viewers judged whether a scene was unpleasant or not, or whether it was pleasant or not. In semantic categorisation tasks viewers judged whether a scene involved animals or humans (superordinate-level task), or whether it portrayed females or males (subordinate-level task). The same stimuli were used for the affective and the semantic task. Results indicated that in peripheral vision affective evaluation was less accurate and slower than animal/human discrimination, and did not show any advantage over gender discrimination. In addition, performance impairment in the peripheral relative to the foveal condition was greater or equivalent for affective than for semantic categorisation. These findings cast doubts on the specialness and the primacy of affective over semantic recognition. The findings are also relevant when considering the role of the subcortical "low route" in emotional processing.

6. Calvo MG, Nummenmaa L: Time course of discrimination between emotional facial expressions: the role of visual saliency. Vision Research 2011, 51: 1751–1759.

Saccadic and manual responses were used to investigate the speed of discrimination between happy and non-happy facial expressions in two-alternative-forced-choice tasks. The minimum latencies of correct saccadic responses indicated that the earliest time point at which discrimination occurred ranged between 200 and 280ms, depending on type of expression. Corresponding minimum latencies for manual responses ranged between 440 and 500ms. For both response modalities, visual saliency of the mouth region was a critical factor in facilitating discrimination: The more salient the mouth was in happy face targets in comparison with non-happy distracters, the faster discrimination was. Global image characteristics (e.g., luminance) and semantic factors (i.e., categorical similarity and affective valence of expression) made minor or no contribution to discrimination efficiency. This suggests that visual saliency of distinctive facial features, rather than the significance of expression, is used to make both early and later expression discrimination decisions.

7. Graupner ST, Pannasch S, Velichkovsky BM: Saccadic context indicates information processing within visual fixations: Evidence from event-related potentials and eye-movements analysis of the distractor effect. International Journal of Psychophysiology 2011, 80: 54–62.

Attention, visual information processing, and oculomotor control are integrated functions of closely related brain mechanisms. Recently, it was shown that the processing of visual distractors appearing during a fixation is modulated by the amplitude of its preceding saccade (Pannasch & Velichkovsky, 2009). So far, this was demonstrated only at the behavioral level in terms of saccadic inhibition. The present study investigated distractor-related brain activity with cortical eye fixation-related potentials (EFRPs). Moreover, the following saccade was included as an additional classification criterion. Eye movements and EFRPs were recorded during free visual exploration of paintings. During some of the fixations, a visual distractor was shown as an annulus around the fixation position, 100 ms after the fixation onset. The saccadic context of a fixation was classified by its preceding and following saccade amplitudes with the cut-off criterion set to 4° of visual angle. The prolongation of fixation duration induced by distractors was largest for fixations preceded and followed by short saccades. EFRP data revealed a difference in distractor-related P2 amplitude between the saccadic context conditions, following the same trend as in eye movements. Furthermore, influences of the following saccade amplitude on the latency of the saccadic inhibition and on the N1 amplitude were found. The EFRP results cannot be explained by the influence of saccades per se since this bias was removed by subtracting the baseline from the distractor EFRP. Rather, the data suggest that saccadic context indicates differences in how information is processed within single visual fixations.

8. Hari R: Magnetoencephalography: Methods and applications. In: Schomer, D.L. and Lopes da Silva, F.H. (eds.) Niedermeyer's Electroencephalography: Basic Principles, Clinical Applications, and Related Fields. 2011.

A textbook chapter.

9. Hietanen JK, Nummenmaa L: The naked truth: the face and body sensitive N170 response is enhanced for nude bodies. PLOS ONE 2011, 6: e24408.

Recent event-related potential studies have shown that the occipitotemporal N170 component—best known for its sensitivity to faces—is also sensitive to perception of human bodies. Considering that in the timescale of evolution clothing is a relatively new invention that hides the bodily features relevant for sexual selection and arousal, we investigated whether the early N170 brain response would be enhanced to nude over clothed bodies. In two experiments, we measured N170 responses to nude bodies, bodies wearing swimsuits, clothed bodies, faces, and control stimuli (cars). We found that the N170 amplitude was larger to opposite and same-sex nude vs. clothed bodies. Moreover, the N170 amplitude increased linearly as the amount of clothing decreased from full clothing via swimsuits to nude bodies. Strikingly, the N170 response to nude bodies was even greater than that to faces, and the N170 amplitude to bodies was independent of whether the face of the bodies was visible or not. All human stimuli evoked greater N170 responses than did the control stimulus. Autonomic measurements and self-evaluations showed that nude bodies were affectively more arousing compared to the other stimulus categories. We conclude that the early visual processing of human bodies is sensitive to the visibility of the sex-related features of

human bodies and that the visual processing of other people's nude bodies is enhanced in the brain. This enhancement is likely to reflect affective arousal elicited by nude bodies. Such facilitated visual processing of other people's nude bodies is possibly beneficial in identifying potential mating partners and competitors, and for triggering sexual behavior.

10. Hiltunen J, Seppä M, Hari R: Evaluation of voxel-based group-level analysis of diffusion tensor images using simulated brain lesions. Neuroscience Research 2011, 71: 377–386.

We simulated brain lesions in mean diffusivity (MD) and fractional anisotropy (FA) images of healthy subjects to evaluate the performance of voxel-based analysis (VBA) with SPM2. We increased MD and decreased FA, simulating the most typical abnormalities in brain pathologies, in the superior longitudinal fasciculus (SLF), corticospinal tract (CST), and corpus callosum (CC). Lesion sizes varied from 10 to 400 voxels (10.5 mm^3 each) and intensity changes from 10 to 100%. The VBA contained eddy current correction, spatial normalization, smoothing, and statistical analysis. The preprocessing steps changed the intensities of MD and FA lesions from the original values, and many lesions remained undetected. The detection thresholds varied between the three brain areas, and between MD and FA images. Although spatial smoothing often improved the sensitivity, it also markedly enlarged the estimated lesion sizes. Since conventional VBA preprocessing significantly affected the outcome and sensitivity of the method itself, the impact of analysis steps should be verified and considered before interpreting the findings. Our results provide insight into the sizes and intensity changes of lesions that can be detected with VBA applied to diffusion tensor imaging (DTI) data.

11. Hirvonen J, Virtanen KA, Nummenmaa L, Hannukainen JC, Honka MJ, Bucci M, Nesterov SV, Parkkola R, Rinne J, Iozzo P, Nuutila P: Effects of insulin on brain glucose metabolism in impaired glucose tolerance. Diabetes 2011, 60: 443–447.

OBJECTIVE: Insulin stimulates brain glucose metabolism, but this effect of insulin is already maximal at fasting concentrations in healthy subjects. It is not known whether insulin is able to stimulate glucose metabolism above fasting concentrations in patients with impaired glucose tolerance.

RESEARCH DESIGN AND METHODS: We studied the effects of insulin on brain glucose metabolism and cerebral blood flow in 13 patients with impaired glucose tolerance and nine healthy subjects using positron emission tomography (PET). All subjects underwent PET with both [(18)F]fluorodeoxyglucose (for brain glucose metabolism) and [(15)O]H(2)O (for cerebral blood flow) in two separate conditions (in the fasting state and during a euglycemic-hyperinsulinemic clamp). Arterial blood samples were acquired during the PET scans to allow fully quantitative modeling.

RESULTS: The hyperinsulinemic clamp increased brain glucose metabolism only in patients with impaired glucose tolerance (whole brain: +18%, P = 0.001) but not in healthy subjects (whole brain: +3.9%, P = 0.373). The hyperinsulinemic clamp did not alter cerebral blood flow in either group.

CONCLUSIONS: We found that insulin stimulates brain glucose metabolism at physiological postprandial levels in patients with impaired glucose tolerance but not in healthy subjects. These results suggest that insulin stimulation of brain glucose me-

tabolism is maximal at fasting concentrations in healthy subjects but not in patients with impaired glucose tolerance.

12. Klami A, Ramkumar P, Virtanen S, Parkkonen L, Hari R, Kaski S: ICANN/PASCAL2 challenge: MEG mind reading – overview and results. Proceedings of ICANN/PASCAL2 Challenge: MEG Mind Reading, Aalto University Publication series SCIENCE + TECHNOLOGY 2011, 29: 3–19.

This report summarizes the outcomes of the MEG mind reading challenge organized in conjunction with the International Conference on Artificial Neural Networks (ICANN) 2011, sponsored by the PASCAL2 Challenge Programme. The challenge task was to infer from brain activity, measured with MEG, the type of a video stimulus shown to the subject. Successful solutions would then allow determining, for example, whether a subject is watching football or a comedy film based on short single-trial recording of brain activity.

The challenge was organized to study the feasibility of such decoding tasks, to discuss related machine learning methods and solutions, and to promote the awareness of the interesting problem formulation. Furthermore, the challenge produced a publicly available data set that can be used for future benchmarking of decoding methods. The best participants reached high accuracy in the task, demonstrating successful brain decoding.

The collection contains a full description of the challenge and its results, as well as technical descriptions of the best three submissions written by the participants.

13. Longcamp M, Hlushchuk Y, Hari R: What differs in visual recognition of handwritten vs. printed letters? An fMRI study. Human Brain Mapping 2011, 32: 1250–1259.

In models of letter recognition, handwritten letters are considered as a particular font exemplar, not qualitatively different in their processing from printed letters. Yet, some data suggest that recognizing handwritten letters might rely on distinct processes, possibly related to motor knowledge. We applied functional magnetic resonance imaging to compare the neural correlates of perceiving handwritten letters vs. standard printed letters. Statistical analysis circumscribed to frontal brain regions involved in hand-movement triggering and execution showed that processing of handwritten letters is supported by a stronger activation of the left primary motor cortex and the supplementary motor area. At the whole-brain level, additional differences between handwritten and printed letters were observed in the right superior frontal, middle occipital, and parahippocampal gyri, and in the left inferior precentral and the fusiform gyri. The results are suggested to indicate embodiment of the visual perception of handwritten letters.

14. Malinen S, Hari R: Data-based functional template for sorting independent components of fMRI activity. Neuroscience Research 2011, 71: 369–376.

In human brain imaging with naturalistic stimuli, hemodynamic responses are difficult to predict and thus data-driven approaches, such as independent component analysis (ICA), may be beneficial. Here we propose inter-subject correlation (ISC) maps as stimulus-sensitive functional templates for sorting the independent components (ICs) to identify the most stimulus-related networks without stimulus-dependent temporal covariates. We collected 3-T functional magnetic resonance imaging (fMRI)

data during perception of continuous audiovisual speech. Ten adults viewed a video, in which speech intelligibility was varied by altering the sound level. Five ICs with strongest overlap with the ISC map comprised auditory and visual cortices, and the sixth was a left-hemisphere-dominant network (left posterior superior temporal sulcus, inferior frontal gyrus, anterior superior temporal pole, supplementary motor cortex, and right angular gyrus) that was activated stronger during soft than loud speech. Corresponding temporal-model-based analysis revealed only temporal- and parietal-lobe activations without involvement of the anterior areas. The performance of the ISC-based IC selection was confirmed with fMRI data collected during free viewing of movie. Since ISC-ICA requires no predetermined temporal models on stimulus timing, it seems feasible for fMRI studies where hemodynamic variations are difficult to model because of the complex temporal structure of the naturalistic stimulation.

15. Nummenmaa L, Hietanen JK, Calvo MG, Hyönä J: Food catches the eye but not for everyone: a BMI-contingent attentional bias in rapid detection of nutriments. PLOS ONE 2011, 6: e19215.

An organism's survival depends crucially on its ability to detect and acquire nutriment. Attention circuits interact with cognitive and motivational systems to facilitate detection of salient sensory events in the environment. Here we show that the human attentional system is tuned to detect food targets among nonfood items. In two visual search experiments participants searched for discrepant food targets embedded in an array of nonfood distracters or vice versa. Detection times were faster when targets were food rather than nonfood items, and the detection advantage for food items showed a significant negative correlation with Body Mass Index (BMI). Also, eye tracking during searching within arrays of visually homogenous food and nonfood targets demonstrated that the BMI-contingent attentional bias was due to rapid capturing of the eyes by food items in individuals with low BMI. However, BMI was not associated with decision times after the discrepant food item was fixated. The results suggest that visual attention is biased towards foods, and that individual differences in energy consumption--as indexed by BMI--are associated with differential attentional effects related to foods. We speculate that such differences may constitute an important risk factor for gaining weight.

16. Op de beeck M, Legros B, Gaspard N, Bourguignon M, Jurysta F, Van Bogaert P, Goldman S, Jousmäki V, De Tiège X: Supplementary motor cortex involvement in reading epilepsy revealed by magnetic source imaging. Epilepsia 2011, 52: e31–34.

Reading epilepsy (RE) is an idiopathic reflex epilepsy syndrome characterized by perioral myoclonic jerks (PMJs) during reading associated with left-dominant frontotemporal spike-wave discharges (SWDs). To better understand the pathophysiology of this syndrome, we studied a 45-year-old patient using magnetic source imaging (MSI). The patient underwent two whole-head magnetoencephalography (MEG) recordings (Elekta Neuromag Oy) within 2 months while reading aloud. Forty-two SWDs associated with PMJs were recorded and averaged with respect to SWDs peak power. Epileptic discharges were then reconstructed using conventional equivalent current dipoles (ECDs) modeling, distributed sources sLORETA modeling, and beamformer approach. These methods identified two brain sources located in the left supplementary motor cortex (SMC) and the left primary sensorimotor face area (PSMFA). The spatiotemporal pattern of the sources was characterized by a cross-talk between these two brain regions, with an initial source in the left SMC. This MSI in-

vestigation suggests that RE-PMJs are associated with reading-induced activation of hyperexcitable neurons in the left SMC, followed by secondary propagation to the left PSMFA producing the myoclonus.

17. Pannasch S, Schulz J, & Velichkovsky B M: On the control of visual fixation durations in free viewing of complex images. Attention, Perception, & Psychophysics 2011, 73: 1120–1132.

The mechanisms for the substantial variation in the durations of visual fixations in scene perception are not yet well understood. During free viewing of paintings, gaze-contingent irrelevant distractors (Exp. 1) and non-gaze-related time-locked display changes (Exp. 2) were presented. We demonstrated that any visual change-its onset and offset-prolongs the ongoing fixation (i.e., delays the following saccade), strongly suggesting that fixation durations are under the direct control of the stimulus information. The strongest influence of distraction was observed for fixations preceded by saccades within the parafoveal range (<5° of visual angle). We assume that these fixations contribute to the focal in contrast to the ambient mode of attention (Pannasch & Velichkovsky, Visual Cognition, 17, 1109-1131, 2009; Velichkovsky, Memory, 10, 405-419, 2002). Recent findings about two distinct "subpopulations of fixations," one under the direct and another under the indirect control of stimulation (e.g., Henderson & Smith, Visual Cognition, 17, 1055-1082, 2009), are reconsidered in view of these results.

18. Pannasch S, Selden D L, Velichkovsky B M, & Bridgeman B: Apparent phi-motion in sequences of Eisenstein's October. Gestalt Theory 2011, 33: 69–80.

To investigate the connections between psychology, aesthetics and film in the work of the Soviet director Sergei Eisenstein (1898-1948), the present work analyzes the famous machine gun sequence from October (1927). In this sequence, the viewer perceives the illusion of gunfire. To investigate whether this illusion is based on apparent phi-motion, individual shots were shown as still images, while participants had to indicate the most informative region, in terms of saliency, within each shot. The systematic distribution of the regions of highest information together with the presentation time of the shots support the idea that Eisenstein intentionally guided the viewers' attentional focus to induce the impression of apparent phi-motion.

19. Pihko E, Lauronen L, Kivisto K, Nevalainen P: Increasing the efficiency of neonatal MEG measurements by alternating auditory and tactile stimulation. Clinical Neurophysiology 2011, 122: 808–814.

OBJECTIVE: To evaluate the possible effect of intervening auditory stimulation on somatosensory evoked magnetic fields in newborns.

METHODS: We recorded auditory and tactile evoked responses with magnetoencephalography (MEG) from two groups of healthy newborns. One group (n=11) received only tactile stimuli to the index finger, the other (n=11) received alternating tactile and auditory (vowel [a:] with 300-ms duration) stimuli. The interval between subsequent tactile stimuli was always 2 s. We analyzed the equivalent current dipoles (ECDs) of the main auditory and somatosensory responses.

RESULTS: The ECDs of the tactile responses agreed with activation of the primary somatosensory cortex at 60 ms and the secondary somatosensory region at ~200 ms. The source of the auditory response (~250 ms) was clearly distinct from those to tac-

tile stimulation and in line with auditory cortex activation. The intervening auditory stimulation did not affect the strength, latency, or location of the ECDs of the tactile responses.

CONCLUSIONS: Auditory and tactile MEG responses from newborns can be obtained in one measurement session.

SIGNIFICANCE: The alternating stimulation can be used to shorten the total measurement time and/or to improve the signal to noise ratio by collecting more data.

20. Pihko E, Virtanen A, Saarinen V-M, Pannasch S, Hirvenkari L, Tossavainen T, Haapala A, Hari R: Experiencing art: the influence of expertise and painting abstraction level. Frontiers in Human Neuroscience 2011, Brain and Art, 5: Article 94.

How does expertise influence the perception of representational and abstract paintings? We asked 20 experts on art history and 20 laypersons to explore and evaluate a series of paintings ranging in style from representational to abstract in five categories. We compared subjective esthetic judgments and emotional evaluations, gaze patterns, and electrodermal reactivity between the two groups of participants. The level of abstraction affected esthetic judgments and emotional valence ratings of the laypersons but had no effect on the opinions of the experts: the laypersons' esthetic and emotional ratings were highest for representational paintings and lowest for abstract paintings, whereas the opinions of the experts were independent of the abstraction level. The gaze patterns of both groups changed as the level of abstraction increased: the number of fixations and the length of the scanpaths increased while the duration of the fixations decreased. The viewing strategies - reflected in the target, location, and path of the fixations - however indicated that experts and laypersons paid attention to different aspects of the paintings. The electrodermal reactivity did not vary according to the level of abstraction in either group but expertise was reflected in weaker responses, compared with laypersons, to information received about the paintings.

21. Rantalainen T, Klodowski A, Piitulainen H: Effect of innervation zones in estimating biceps brachii force-EMG relationship during isometric contraction. Journal of Electromyography and Kinesiology 2011, 22: 80–87.

Measuring muscle forces in vivo is invasive and consequently indirect methods e.g., electromyography (EMG) are used in estimating muscular force production. The aim of the present paper was to examine what kind of effect the disruption of the physiological signal caused by the innervation zone has in predicting the force/torque output from surface EMG. Twelve men (age 26 (SD ±3)years; height 179 (±6)cm; body mass 73 (±6)kg) volunteered as subjects. They were asked to perform maximal voluntary isometric contraction (MVC) in elbow flexion, and submaximal contractions at 10%, 20%, 30%, 40%, 50% and 75% of the recorded MVC. EMG was measured from biceps brachii muscle with an electrode grid of 5 columns×13 rows. Force-EMG relationships were determined from individual channels and as the global mean value. The relationship was deemed inconsistent if EMG value did not increase in successive force levels. Root mean squared errors were calculated for 3rd order polynomial fits. All subjects had at least one (4-52) inconsistent channel. Two subjects had inconsistent relationship calculated from the global mean. The mean root mean squared error calculated using leave one out method for the fits of the individual channels (0.33±0.17) was higher ($P<0.001$) than the error for the global mean fit (0.16±0.08). It seems that the disruption of the physiological signal caused by the innervation zone

affects the consistency of the force-EMG relationship on single bipolar channel level. Multichannel EMG recordings used for predicting force overcame this disruption.

22. Roiha K, Kirveskari E, Kaste M, Mustanoja S, Mäkelä JP, Salonen O, Tatlisumak T, Forss N: Reorganization of the primary somatosensory cortex during stroke recovery. Clinical Neurophysiology 2011, 122: 339–345.

Animal and human studies have indicated that stroke induces reorganization of the motor and somatosensory cortices. We aimed to clarify how changes in the primary somatosensory (SI) cortex correlate with stroke recovery.

METHODS: We recorded somatosensory evoked fields (SEFs) with magnetoencephalography from 15 patients with stroke affecting upper extremity motor function. The size of the hand representation in the SI cortex was calculated from the Euclidean distance between the sources of SEFs to thumb and little finger tactile stimulation. The measurements were made at 1-7 days (T0), at 1 (T1), and at 3 months (T2) after stroke, with concomitant evaluation of hand function.

RESULTS: The affected hand function was improved at T1 and T2 compared with T0 ($p<0.01$). At T1, the SI hand representation in the affected hemisphere was enlarged compared with T0 or T2 (12.6±0.8 at T1 vs. 9.6±0.8 mm at T2 and 10.2±0.8 at T2, $p<0.05$). In patients with subcortical infarction, the increase in cortical representation at T1 correlated strongly with impairment of hand function ($r=0.8$, $p<0.01$).

CONCLUSION: Reorganization of the SI cortex provokes a transient enlargement of the hand representation that normalizes as hand functions are regained.

SIGNIFICANCE: The temporal evolution of plastic changes during stroke recovery might be useful in evaluating motor recovery.

23. Schürmann M, Hlushchuk Y, Hari R: Embodied visual perception of distorted finger postures. Human Brain Mapping 2011, 32: 612–623. Bodily abnormalities in other persons often evoke an uneasy feeling, even disgust. Here, we studied the brain basis of such perceptual salience by presenting static pictures of distorted hand postures to healthy subjects during functional magnetic resonance imaging. Cortical activation sensitive to distorted (vs. natural) finger postures was found-with right-hemispheric dominance-in the primary motor cortex, postcentral somatosensory areas, amygdala, and insula, and bilaterally in the putamen. This activation pattern suggests that the instantaneous "gut feelings" during the observation of bodily distortions in others are related to embodied percepts that also involve affect-related brain areas.

24. Sudre G, Parkkonen L, Bock E, Baillet S, Wang W, Weber D: rtMEG: A real-time software interface for magnetoencephalography. Computational Intelligence and Neuroscience 2011, 2011: 327953.

To date, the majority of studies using magnetoencephalography (MEG) rely on off-line analysis of the spatiotemporal properties of brain activity. Real-time MEG feedback could potentially benefit multiple areas of basic and clinical research: brain-machine interfaces, neurofeedback rehabilitation of stroke and spinal cord injury, and new adaptive paradigm designs, among others. We have developed a software interface to stream MEG signals in real time from the 306-channel Elekta Neuromag MEG system to an external workstation. The signals can be accessed with a minimal delay (≤45 ms) when data are sampled at 1000 Hz, which is sufficient for most real-time

studies. We also show here that real-time source imaging is possible by demonstrating real-time monitoring and feedback of alpha-band power fluctuations over parieto-occipital and frontal areas. The interface is made available to the academic community as an open-source resource.

25. Tervaniemi M, Sannemann C, Nöyränen M, Salonen J, Pihko E: Importance of the left auditory areas in chord discrimination in music experts as evidenced by MEG. European Journal of Neuroscience 2011, 34: 517–523.

The brain basis behind musical competence in its various forms is not yet known. To determine the pattern of hemispheric lateralization during sound-change discrimination, we recorded the magnetic counterpart of the electrical mismatch negativity (MMNm) responses in professional musicians, musical participants (with high scores in the musicality tests but without professional training in music) and non-musicians. While watching a silenced video, they were presented with short sounds with frequency and duration deviants and C major chords with C minor chords as deviants. MMNm to chord deviants was stronger in both musicians and musical participants than in non-musicians, particularly in their left hemisphere. No group differences were obtained in the MMNm strength in the right hemisphere in any of the conditions or in the left hemisphere in the case of frequency or duration deviants. Thus, in addition to professional training in music, musical aptitude (combined with lower-level musical training) is also reflected in brain functioning related to sound discrimination. The present magnetoencephalographic evidence therefore indicates that the sound discrimination abilities may be differentially distributed in the brain in musically competent and naïve participants, especially in a musical context established by chord stimuli: the higher forms of musical competence engage both auditory cortices in an integrative manner.

26. von dem Hagen EAH, Nummenmaa L, Yu RJ, Engell AD, Ewbank MP, Calder AJ: Autism spectrum traits in the typical population predict structure and function in the posterior superior temporal sulcus. Cerebral Cortex 2011, 21: 493–500.

Autism spectrum disorders (ASDs) are typically characterized by impaired social interaction and communication, narrow interests, and repetitive behaviors. The heterogeneity in the severity of these characteristics across individuals with ASD has led some researchers to suggest that these disorders form a continuum which extends into the general, or "typical," population, and there is growing evidence that the extent to which typical adults display autistic traits, as measured using the autism-spectrum quotient (AQ), predicts performance on behavioral tasks that are impaired in ASD. Here, we show that variation in autism spectrum traits is related to cortical structure and function within the typical population. Voxel-based morphometry showed that increased AQ scores were associated with decreased white matter volume in the posterior superior temporal sulcus (pSTS), a region important in processing socially relevant stimuli and associated with structural and functional impairments in ASD. In addition, AQ was correlated with the extent of cortical deactivation of an adjacent area of pSTS during a Stroop task relative to rest, reflecting variation in resting state function. The results provide evidence that autism spectrum characteristics are reflected in neural structure and function across the typical (non-ASD) population.

27. Wenke D, Atmaca S, Holländer A, Baess P, Liebelt R, and Prinz W: What is shared in joint action? Co-representation, response conflict, and agent identification. Review of Philosophy and Psychology 2011, 2: 147–172.

When sharing a task with another person that requires turn taking, as in doubles games of table tennis, performance on the shared task is similar to performing the whole task alone. This has been taken to indicate that humans co- represent their partner's task share, as if it were their own. Task co-representation allows prediction of the other's responses when it is the other's turn, and leads to response conflict in joint interference tasks. However, data from our lab cast doubt on the view that task co-representation and resulting response conflict are the only or even primary source of effects observed in task sharing. Recent findings furthermore suggest another potential source of interference in joint task performance that has been neglected so far: Self-other discrimination and conflict related to agent identification (i.e., determining whether it is "my" or the other's turn). Based on these findings we propose that participants might not always co-represent what their partner is supposed to do, but instead co-represent that another agent is responsible for part of the task, and when it is his turn. We call this account the actor co-representation account.

IMAGING LANGUAGE

Person years: 1 professor, 0.5 docents, 4.5 postdocs, 4.5 PhD students

1. Annanmäki T, Pohja M, Parviainen T, Häkkinen P, Murros K: Uric acid and cognition in Parkinson's disease: A follow-up study. Parkinsonism & Related Disorders 2011, 17: 333–337.

Cognitive changes are common in Parkinson's disease (PD). Low plasma uric acid (UA) level is associated with risk of PD and predicts faster progression of motor symptoms in established disease. Whether UA levels predict cognitive changes has not been studied. In a crossectional study, our group has previously shown an association of plasma and urine UA levels with cognition in PD. The aim of the present controlled longitudinal study was to examine the evolution of cognitive changes and the prognostic value of the UA levels on cognition in the previously reported PD-patient cohort. Of the original 40 patients, 31 were available for follow-up after three years. Both plasma and daily urine UA levels were measured, nutrition was evaluated using 4-day dietary recall diary and cognition was assessed by a thorough neuropsychological examination including computerized tasks with Cognispeed©. The plasma and urine UA levels of the patients remained stable during the follow-up. At the same time, the rate of cognitive decline was unexpectedly slow. A statistically significant deterioration was noted in verbal fluency ($p=0.04$) and in Cognispeed©'s vigilance task ($p=0.0001$). In forward linear regression analysis only the baseline daily urine UA level contributed to verbal fluency ($p=0.01$), picture completion ($p=0.001$), block design ($p=0.006$), vigilance ($p=0.006$), subtraction ($p=0.01$) and statement verification ($p=0.04$) tasks. The implications of the study results are discussed.

2. Helenius P, Laasonen M, Hokkanen L, Paetau R, Niemivirta M: Impaired engagement of the ventral attentional pathway in ADHD. Neuropsychologia 2011, 49: 1889–1896.

In the cognitive theories of Attention Deficit Hyperactivity Disorder (ADHD) impaired behavioral adjustment has been linked to a deficit in learning to detect regulari-

ties or irregularities in the environment. In the neural level, the P3 component of event-related potential (ERP) is modulated by stimulus probability and has been suggested to index activation of the ventral attention network, which constitutes the reorienting system of the human brain. To explore the cortical basis of late positive ERP components and the engagement of the ventral attentional pathway in ADHD, we used ERP recordings complemented by spatiotemporally sensitive magnetoencephalography (MEG) measurements. We followed the activation evoked by frequent Go and infrequent NoGo stimuli in 10 ADHD adults and 13 control subjects. In the ERP recordings, a prominent positive deflection was detected after the infrequent visual stimuli (late positive component, LPC) in both subject groups. In ADHD adults the difference between the responses evoked by infrequent NoGo and frequent Go stimuli was markedly reduced compared to the control group during the LPC. The MEG recordings revealed that the activation detected during the LPC was localized bilaterally in the posterior temporal cortex. Activation of the left and right temporal regions was enhanced after infrequent NoGo stimuli in both subject groups. In ADHD adults, however, the effect of stimulus frequency was less pronounced. We suggest that the activation in the superior temporal cortices during the LPC reflects the action of ventral attention network. The engagement of this stimulus-driven reorienting system is defective in ADHD.

3. Parviainen T Helenius P Poskiparta E Niemi P, Salmelin R: Speech perception in the child brain: cortical timing and its relevance to literacy acquisition. Human Brain Mapping 2011, 32: 1–14.

Speech processing skills go through intensive development during mid-childhood, providing basis also for literacy acquisition. The sequence of auditory cortical processing of speech has been characterized in adults, but very little is known about the neural representation of speech sound perception in the developing brain. We used whole-head magnetoencephalography (MEG) to record neural responses to speech and nonspeech sounds in first-graders (7-8-year-old) and compared the activation sequence to that in adults. In children, the general location of neural activity in the superior temporal cortex was similar to that in adults, but in the time domain the sequence of activation was strikingly different. Cortical differentiation between sound types emerged in a prolonged response pattern at about 250 ms after sound onset, in both hemispheres, clearly later than the corresponding effect at about 100 ms in adults that was detected specifically in the left hemisphere. Better reading skills were linked with shorter-lasting neural activation, speaking for interdependence of the maturing neural processes of auditory perception and developing linguistic skills. This study uniquely utilized the potential of MEG in comparing both spatial and temporal characteristics of neural activation between adults and children. Besides depicting the group-typical features in cortical auditory processing, the results revealed marked interindividual variability in children.

4. Vartiainen J, Liljeström M, Koskinen M, Renvall H, Salmelin R: Functional magnetic resonance imaging blood oxygenation level-dependent signal and magnetoencephalography evoked responses yield different neural functionality in reading. Journal of Neuroscience 2011, 31: 1048–1058.

It is often implicitly assumed that the neural activation patterns revealed by hemodynamic methods, such as functional magnetic resonance imaging (fMRI), and electrophysiological methods, such as magnetoencephalography (MEG) and electroenceph-

alography (EEG), are comparable. In early sensory processing that seems to be the case, but the assumption may not be correct in high-level cognitive tasks. For example, MEG and fMRI literature of single-word reading suggests differences in cortical activation, but direct comparisons are lacking. Here, while the same human participants performed the same reading task, analysis of MEG evoked responses and fMRI blood oxygenation level-dependent (BOLD) signals revealed marked functional and spatial differences in several cortical areas outside the visual cortex. Divergent patterns of activation were observed in the frontal and temporal cortex, in accordance with previous separate MEG and fMRI studies of reading. Furthermore, opposite stimulus effects in the MEG and fMRI measures were detected in the left occipitotemporal cortex: MEG evoked responses were stronger to letter than symbol strings, whereas the fMRI BOLD signal was stronger to symbol than letter strings. The EEG recorded simultaneously during MEG and fMRI did not indicate neurophysiological differences that could explain the observed functional discrepancies between the MEG and fMRI results. Acknowledgment of the complementary nature of hemodynamic and electrophysiological measures, as reported here in a cognitive task using evoked response analysis in MEG and BOLD signal analysis in fMRI, represents an essential step toward an informed use of multimodal imaging that reaches beyond mere combination of location and timing of neural activation.

5. Virpioja S, Lehtonen M, Hulten A, Salmelin R, Lagus K: Predicting teaction times in word recognition by unsupervised learning of morphology. Artificial Neural Networks and Machine Learning - ICANN 2011. 2011, Part 1, LNCS 6791: 275–282.

A central question in the study of the mental lexicon is how morphologically complex words are processed. We consider this question from the viewpoint of statistical models of morphology. As an indicator of the mental processing cost in the brain, we use reaction times to words in a visual lexical decision task on Finnish nouns. Statistical correlation between a model and reaction times is employed as a goodness measure of the model. In particular, we study Morfessor, an unsupervised method for learning concatenative morphology.

The results for a set of inflected and monomorphemic Finnish nouns reveal that the probabilities given by Morfessor, especially the Categories-MAP version, show considerably higher correlations to the reaction times than simple word statistics such as frequency, morphological family size, or length. These correlations are also higher than when any individual test subject is viewed as a model.

VISION NEUROSCIENCE

Person years: 1.6 docents, 1.1 postdocs, 2.5 PhD students

1. Cattaneo Z, Fantino M, Silvanto J, Vallar G, Vecchi T: Tapping effects on numerical bisection. Experimental Brain Research 2011, 208: 21–28.

Numerical magnitude is believed to be represented along a mental number line (MNL), and there is evidence to suggest that the activation of the MNL affects the perception and representation of external space. In the present study, we investigated whether a spatial motor task affects numerical processing in the auditory modality. Blindfolded participants were presented with a numerical interval bisection task, while performing a tapping task with either their left or right hand, either in the fronto-central, fronto-left, or fronto-right peripersonal space. Results showed that tap-

ping significantly influenced the participants' numerical bisection, with tapping in the left side of space increasing the original tendency to err leftward, and tapping to the right reducing such bias. Importantly, the effect depended on the side of space in which the tapping activity was performed, regardless of which hand was used. Tapping with either the left or right hand in the fronto-central space did not affect the participants' bias. These findings offer novel support for the existence of bidirectional interactions between external and internal representations of space.

2. Kilpeläinen M, Nurminen L, Donner K: Effects of mean luminance changes on human contrast perception: Contrast dependence, time-course and spatial specificity. PLOS ONE 2011, 6: e17200/1–9.

When we are viewing natural scenes, every saccade abruptly changes boththe mean luminance and the contrast structure falling on any given retinal location. Thus it would be useful if the two were independently encoded by the visual system, even when they change simultaneously. Recordings from single neurons in the cat visual system have suggested that contrast information may be quite independently represented in neural responses to simultaneous changes in contrast and luminance. Here we test to what extent this is true in human perception. Small contrast stimuli were presented together with a 7-fold upward or downward step of mean luminance (between 185 and 1295 Td, corresponding to14 and 98 cd/m2), either simultaneously or with various delays (50–800ms). The perceived contrast of the target under the different conditions was measured with an adaptive staircase method. Over the contrast range 0.1–0.45, mainly subtractive attenuation was found. Perceived contrast decreased by 0.052 ± 0.021 (N = 3) when target onset was simultaneous with the luminance increase. The attenuation subsided within 400 ms, and evenfaster after luminance decreases, where the effect was also smaller. The main results were robust against differences in target types and the sizeof the field over which luminance changed. Perceived contrast is attenuated mainly by a subtractive term when coincident with a luminance change. The effect is of ecologically relevant magnitude and duration; in other words, strict contrast constancy must often fail during normal human visual behaviour. Still, the relative robustness of the contrast signal is remarkable in view of the limited dynamic response range of retinal cones. We propose a conceptual model forhow early retinal signalling may allow this.

3. Koivisto M, Railo H, Revonsuo A, Vanni S, Salminen-Vaparanta N: Recurrent processing in V1/V2 contributes to categorization of natural scenes. Journal of Neuroscience 2011, 31: 2488–2492.

Humans are able to categorize complex natural scenes very rapidly and effortlessly, which has led to an assumption that such ultra-rapid categorization is driven by feedforward activation of ventral brain areas. However, recent accounts of visual perception stress the role of recurrent interactions that start rapidly after the activation of V1. To study whether or not recurrent processes play a causal role in categorization, we applied fMRI-guided transcranial magnetic stimulation on early visual cortex (V1/V2) and lateral occipital cortex (LO) while the participants categorized natural images as containing animals or not. The results showed that V1/V2 contributed to categorization speed and to subjective perception during a long activity period before and after the contribution of LO had started. This pattern of results suggests that recurrent interactions in visual cortex between areas along the ventral stream and striate cortex play a causal role in categorization and perception of natural scenes.

4. Nurminen L, Peromaa T, Laurinen P: Surround suppression and facilitation in the fovea: Very long-range spatial interactions in contrast perception. Journal of Vision 2011, 10: 1–13.

Surround modulation of perceived contrast has been almost exclusively studied in short-range conditions, i.e., in situations where a tiny gap, at most, separates center from surround. Existing long-range studies suggest that suppression extends to 12-cycle distance, whereas facilitation of perceived contrast is suggested to arise from visual field regions enclosing the center. In V1 neurons, however, long-range surround modulation involves both suppression and facilitation. Thus, we investigated short- and long-range surround modulation by measuring the perceived contrast of a center in the presence of a surround either near (0.3 cycles, 0.1 degree) or far (19.8 cycles, 6.6 degrees) from the center. This study demonstrates that in addition to the well-known suppression, surround modulation involves remarkably long-range facilitation of perceived contrast. At low center contrasts, the long-range facilitation was stronger than the long-range suppression, whereas at high center contrast we found mainly long-range suppression. Because the current models of perceived contrast could not account for our data, we considered our results in the context of models developed for surround modulation in V1 neurons. However, neither mechanistic nor phenomenological models proved satisfactory. Moreover, with the current knowledge, it seems that straightforward pooling of V1 neurons' responses cannot account for surround modulation of perceived contrast.

5. Renzi C, Vecchi T, Silvanto J, Cattaneo Z: Overlapping representations of numerical magnitude and motion direction in the posterior parietal cortex: A TMS-adaptation study. Neuroscience Letters 2011, 490: 145–149.

The human posterior parietal cortex (PPC) is involved in the encoding of both visual motion and numerical magnitude. In non human primates, neurons have been found in PPC that are selective for both motion direction and magnitude. Whether such neurons also exist in human PPC is not known. Here we investigated this hypothesis using state-dependent transcranial magnetic stimulation (TMS). Participants were adapted to a specific motion direction (either leftward or rightward), after which they performed a magnitude comparison task, with TMS applied at the onset of each trial. Our hypothesis was that neurons tuned to leftward motion may also be sensitive to small magnitudes and neurons tuned to rightward motion may also be sensitive to large magnitudes, a mapping that may have developed via spatial attentional mechanisms. Our results supported this view by showing that the effect of PPC TMS on small and large numbers depended on the motion direction being adapted, thus suggesting that there may be a functional overlap in neuronal representations of motion direction and numerical magnitude in human PPC.

6. Silvanto J, Rees G: What does neural plasticity tell us about role of primary visual cortex (V1) in visual awareness? Frontiers in Psychology 2011, 2: 6.

The complete loss of visual awareness resulting from a lesion to the primary visual cortex (V1) suggests that this region is indispensable for conscious visual perception. There are however a number cases of conscious perception in the absence of V1 which appear to challenge this conclusion. These include reports of patients with bilateral V1 lesions sustained at an early age whose conscious vision has spontaneously recovered, as well as stroke patients who have recovered some conscious vision with

the help of rehabilitation programs. In addition, the phenomenon of hemianopic completion and percepts induced by brain stimulation suggest that V1 may not be necessary for conscious perception in all circumstances. Furthermore, that the visual abilities in the cat are associated with the recovery of normal extrastriate tuning properties rather than emulation of V1 functions suggests that there is nothing unique about the functional properties of this region in visual awareness. Rather, the dramatic effect of a V1 lesion on visual awareness may be due to its role in providing the majority of extrastriate visual input, the loss of which abolishes normal neural responsiveness throughout the visual cortex.

7. Schwarzkopf DS, Silvanto J, Rees G: Stochastic resonance effects reveal the neural mechanisms of transcranial magnetic stimulation. Journal of Neuroscience 2011, 31: 3143–3147.

Transcranial magnetic stimulation (TMS) is a popular method for studying causal relationships between neural activity and behavior. However, its mode of action remains controversial, and so far there is no framework to explain its wide range of facilitatory and inhibitory behavioral effects. While some theoretical accounts suggest that TMS suppresses neuronal processing, other competing accounts propose that the effects of TMS result from the addition of noise to neuronal processing. Here we exploited the stochastic resonance phenomenon to distinguish these theoretical accounts and determine how TMS affects neuronal processing. Specifically, we showed that online TMS can induce stochastic resonance in the human brain. At low intensity, TMS facilitated the detection of weak motion signals, but with higher TMS intensities and stronger motion signals, we found only impairment in detection. These findings suggest that TMS acts by adding noise to neuronal processing, at least in an online TMS protocol. Importantly, such stochastic resonance effects may also explain why TMS parameters that under normal circumstances impair behavior can induce behavioral facilitations when the stimulated area is in an adapted or suppressed state.

8. Soto D, Mäntylä T, Silvanto J: Working memory without consciousness. Current Biology 2011, 21: R912–913.

Working memory allows individuals to maintain information in the focus of the mind's eye in the service of goal-directed behavior. Current psychological theories (for example, Baddeley's influential model of working memory), computational models and neurobiological accounts of working memory are based on the assumption that working memory operates on consciously represented information. Models of the capacity limits of working memory are silent on this issue. While there has been some suggestion that working memory may be engaged by incidental exposure to visible items, current understanding indicates that the encoding of information in working memory, maintenance, retrieval and use in decision making of working memory operate on the contents of consciousness. But no study to date has investigated working memory processing for unconscious information. Here we show that observers can encode a subliminal orientation cue, maintain it ‘on-line’ even in the presence of visible distracters, and perform above chance in subsequent explicit discrimination, namely, whether a supraliminal orientation probe was tilted clockwise or counterclockwise relative to the earlier unconscious cue. Our findings challenge the currently held view that working memory processes are contingent on conscious awareness.

9. Tadin D, Silvanto J, Pascual-Leone A, Battelli L: Improved motion perception and impaired spatial suppression following disruption of cortical area MT/V5. Journal of Neuroscience 2011, 31: 1279–1283.

As stimulus size increases, motion direction of high-contrast patterns becomes increasingly harder to perceive. This counterintuitive behavioral result, termed "spatial suppression," is hypothesized to reflect center-surround antagonism-a receptive field property ubiquitous in sensory systems. Prior research proposed that spatial suppression of motion signals is a direct correlate of center-surround antagonism within cortical area MT. Here, we investigated whether human MT/V5 is indeed causally involved in spatial suppression of motion signals. The key assumption is that a disruption of neural mechanisms that play a critical role in spatial suppression could allow these normally suppressed motion signals to reach perceptual awareness. Thus, our hypothesis was that a disruption of MT/V5 should weaken spatial suppression and, consequently, improve motion perception of large, moving patterns. To disrupt MT/V5, we used offline 1 Hz transcranial magnetic stimulation (TMS)-a method that temporarily attenuates normal functioning of the targeted cortex. Early visual areas were also targeted as a control site. The results supported our hypotheses and showed that disruption of MT/V5 improved motion discrimination of large, moving stimuli, presumably by weakening surround suppression strength. This effect was specific to MT/V5 stimulation and contralaterally presented stimuli. Evidently, the critical neural constraints limiting motion perception of large, high-contrast stimuli involve MT/V5. Additionally, our findings mimic spatial suppression deficits that are observed in several patient populations and implicate impaired MT/V5 processes as likely neural correlates for the reported perceptual abnormalities in the elderly, patients with schizophrenia and those with a history of depression

10. Vanni S, Rosenström T: Local non-linear interactions in the visual cortex may reflect global decorrelation. Journal of Computational Neuroscience 2011, 30: 109–124.

The classical receptive fields in the primary visual cortex have been successfully explained by sparse activation of relatively independent units, whose tuning properties reflect the statistical dependencies in the natural environment. Robust surround modulation, emerging from stimulation beyond the classical receptive field, has been associated with increase of lifetime sparseness in the V1, but the system-wide modulation of response strength have currently no theoretical explanation. We measured fMRI responses from human visual cortex and quantified the contextual modulation with a decorrelation coefficient (d), derived from a subtractive normalization model. All active cortical areas demonstrated local non-linear summation of responses, which were in line with hypothesis of global decorrelation of voxels responses. In addition, we found sensitivity to surrounding stimulus structure across the ventral stream, and large-scale sensitivity to the number of simultaneous objects. Response sparseness across voxel population increased consistently with larger stimuli. These data suggest that contextual modulation for a stimulus event reflect optimization of the code and perhaps increase in energy efficiency throughout the ventral stream hierarchy. Our model provides a novel prediction that average suppression of response amplitude for simultaneous stimuli across the cortical network is a monotonic function of similarity of response strengths in the network when the stimuli are presented alone.

ATTENTION AND MEMORY

Person years: 1 professor, 1.5 postdocs, 4.5 PhD students

(NSU group led by Prof. Synnöve Carlson at the University of Helsinki; these publications are related to our CoE activities)

1. Näätänen R, Kujala T, Kreegipuu K, Carlson S, Escera C, Baldeweg T, Ponton C: The mismatch negativity: An index of cognitive decline in neuropsychiatric and neurological diseases and in aging. A review. Brain 2011, 134: 3435–3453.

Cognitive impairment is a core element shared by a large number of different neurological and neuropsychiatric diseases. Irrespective of their different aetiologies and symptomatologies, most appear to converge at the functional deficiency of the auditory-frontal cortex network of auditory discrimination, which indexes cognitive impairment shared by these abnormalities. This auditory-frontal cortical deficiency, and hence cognitive decline, can now be objectively measured with the mismatch negativity and its magnetic equivalent. The auditory-frontal cortical network involved seems, therefore, to play a pivotal, unifying role in the different abnormalities. It is, however, more likely that the dysfunction that can be detected with the mismatch negativity and its magnetoencephalographic equivalent manifests a more widespread brain disorder, namely, a deficient N-methyl-D-aspartate receptor function, shared by these abnormalities and accounting for most of the cognitive decline.

2. Savolainen P, Carlson S, Boldt R, Neuvonen T, Hannula H, Hiltunen J, Salonen O, Ma YY, Pertovaara A: Facilitation of tactile working memory by top-down suppression from prefrontal to primary somatosensory cortex during sensory interference. Behavioural Brain Research 2011, 219: 387–390.

Tactile working memory (WM) is improved by increasing top-down suppression of interfering sensory processing in S1 via a link from the middle frontal gyrus (MFG) to S1. Here we studied in healthy subjects whether the efficacy of top-down suppression varies with submodality of sensory interference. Navigated stimulation of the MFG-S1 link significantly improved tactile WM performance when accompanied by tactile but not visual interference of memory maintenance.

3. Vuontela V, Carlson S: Development of neural mechanisms of working memory. In: (eds.) Wiley Encyclopedia of Electrical and Electronics Engineering, vol. 12 2011.

A textbook chapter.

TEACHING ACTIVITIES

COURSES

Low Temperature Physics: Basics of Cryoengineering (Tfy-3.4801)
Lectures: Doc. **Juha Tuoriniemi**
Teaching assistant: *M.Sc.* **Juho Rysti**

Thermal effects at nano-scale, European School On Nanosciences & Nanotechnologies, Grenoble, France, 21 Aug. - 10 Sep.
Lectures: **Jukka Pekola**

fMRI School 2011. April 4-5
Organisers Dr. **Linda Henriksson** (BRU) and Doc. **Simo Vanni** (BRU and AMI Centre)
Lecturers: Dr. Toni Auranen, (AMI Centre), Dr. Irtiza Gilani (AMI Centre), Dr. Linda Henriksson (BRU), Lic.Phys. Jaana Hiltunen (BRU), Dr. Miika Koskinen (BRU), Dr. Sanna Malinen (BRU), Dr. Lauri Nummenmaa (BRU, BECS, and University of Turku), M.Sc. Lauri Nurminen (BRU), Dr. Ville Renvall (BRU), Doc. Simo Vanni (BRU and AMI Centre).

Current Avenues of Eye-Gaze Tracking. One-day Symposium, Aalto SCI organized by **Riitta Hari**, **Sebastian Pannasch** and **Elina Pihko** on March 4, 2011. 70 participants.

Course in Noninvasive Methodologies to Study Whole Brain Function on Oct 19–22, 2011, Saint Petersburg, Russia. Lectures (N = 6) about fMRI method by **Linda Henriksson** and **Simo Vanni**

MS workshop "*Multimodal transcranial magnetic stimulation (TMS) in the study of brain and cognition*", March 24–25, 2011 in Helsinki, Finland. Lectures, posters and demonstrations in TMS, organized by **Synnöve Carlson**

RESEARCH SEMINARS ON LOW TEMPERATURE PHYSICS AND NANOPHYSICS

Coordinators: Vladimir Eltsov, Tero Heikkilä, and Sorin Paraoanu

Edouard Sonin Hebrew University of Jerusalem, Israel	*Quantum spin Hall Effect in topological insulators*	Jan 12
Edouard Sonin Hebrew University of Jerusalem, Israel	*Discussion on vortex dynamics and turbulence*	Jan 13
Ville Maisi MIKES and LTL-Aalto, Finland	*Andreev tunneling in SINIS turnstiles*	Jan 18
Juha Muhonen LTL-Aalto, Finland	*Strain control of e-ph coupling in a many-valley semiconductor*	Jan 25
Janne Viljas LTL - Aalto, Finland	*Self heating and nonlinear current-voltage characteristics*	Feb 1
Tomi Ruokola Dept. of Applied Physics, Aalto Univ., Finland	*Single-electron heat diode*	Feb 8
A. A. Varlamov Institute of Superconductivity and Innovative Materials SPIN- CNR, Rome, Italy	*New approach in the description of Nernst effect*	Feb 10
Jian Li LTL-Aalto University, Finland	*Motional averaging in a superconducting transmon qubit*	Feb 25
Teemu Ojanen	*Electrical control of spin properties of*	Mar 4

LTL-Aalto, Finland	*topological insulator edge states*	
Olli-Pentti Saira LTL-Aalto, Finland	*Is aluminum a perfect superconductor?*	Mar 11
Raphael Khan LTL - Aalto, Finland	*Observing quantum tunnelling in NEMS (nanoelectromechanical systems)*	Mar 18
Antti Puska LTL - Aalto, Finland	*Journal club*	Mar 25
Pasi Lähteenmäki LTL - Aalto, Finland	*Dynamical Casimir effect and its implementations in superconducting circuits*	Apr 8
Christian Flindt University of Geneva, Switzerland	*Current fluctuations in nano-scale systems*	Apr 14
Francesco Massel LTL - Aalto, Finland	*Microwave amplification in nanomechanical systems*	Apr 15
Thomas Aref LTL - Aalto, Finland	*Journal Club*	Apr 29
Jukka Väyrynen LTL - Aalto, Finland	*A quest for chiral topological insulators*	May 6
Jukka Pekola LTL - Aalto, Finland	*Statistics of the generated heat in driven single-electron transitions*	May 13
Robert Jan de Graaf Low Temperature Laboratory	*Dissertation:*	May 18
Khattiya Chalapat LTL - Aalto, Finland	*3D-assembly from lithographic nanocrystalline metal film*	May 20
Gordey Lesovik Landau Institute for Theoretical Physics, Russian Academy of Sciences, Russia	*Correlations in quantum conductors -- postselection and violation of the Tsirelson bound for Bell inequality*	May 24
Ken Elder Oakland University, U.S.A.	*Pattern Selection in Strained Film Growth*	May 27
Gleb Finkelstein Duke University, U. S. A.	*Resonant Level in a Dissipative Environment: a Possible Quantum Phase Transition*	Jun 15
Mats Jonson University of Gothenburg, Gothenburg, and Heriot-Watt University, Edinburgh, Scotland , Sweden and U.K.	*"Hot", spin-polarized electrons injected into a magnetic point contact - a new photon source*	Jun 17
Bill Halperin Dept. of Physics and Astronomy, Northwestern University, USA	*Superfluid 3He in Aerogel: Overview and Recent NMR Experiments*	Jun 17
Florent Lecocq Institut Neel, CNRS Grenoble, France	*Quantum dynamics in a dcSQUID: From a phase qubit to a 2D quantum oscillator*	Jun 21

Tapio Simula Monash University, Australia	*Vortex waves in Bose-Einstein condensates*	Jun 22
Frank Hekking Joseph Fourier University, Grenoble, France	*Persistent currents in a one-dimensional bosonic ring*	Aug 3
Nikolai Kopnin Landau Institute and LTL/Aalto University, Russia,Finland	*High-temperature surface superconductivity in multilayered rhombohedral graphene*	Aug 25
Hung Nguyen LTL, Finland	*Progress on electronic cooling using micro-sized SINIS junctions*	Sep 1
Karthikeyan S. Kumar LTL- Aalto, Finland	*Quantum integral estimation algorithm*	Sep 8
Sergey Vasiliev University of Turku, Finland	*Magnons in Spin-polarized Atomic Hydrogen Gas*	Sep 13
Juha Pirkkalainen LTL - Aalto, Finland	*Hybrid-QED: Mechanical resonator coupled to a transmon qubit*	Sep 15
Edouard Sonin Hebrew University of Jerusalem, Israel	*Propagating and precessing vortex front in the laminar regime*	Sep 22
Pertti Hakonen LTL- Aalto, Finland	*Electrical transport and inelastic scattering in mono- and bilayer graphene*	Sep 29
Mikko Möttönen Dept. of Applied Physics - Aalto, Finland	*Single-electron shuttle based on a silicon quantum dot*	Oct 6
Matti Laakso LTL - Aalto, Finland	*Manifestly non-Gaussian fluctuations in SINIS structures*	Oct 13
Nugzar Suramishvili Newcastle University, UK	*Numerical simulations of the interaction between thermal quasiparticles and a three-dimensional vortex structure in superfluid 3He-B*	Oct 18
Vitaly Emets LTL - Aalto, Finland	*Spin injection to graphene*	Oct 20
Raphael Khan Low Temperature Laboratory, Aalto University, Finland	*Mode coupling in NEMS (electromechanical systems)*	Oct 27
Olli-Pentti Saira Low Temperature Laboratory, Aalto University, Finland	*High-fidelity readout of heat fluctuations in a driven single-electron box*	Nov 3
Amin Karimi Kurdistan University, Iran	*Quantum Conductance in MWNT networks by MCBJ technique*	Nov 8
Norman O. Birge Michigan State University, U.S.A.	*Spin-triplet supercurrent in ferromagnetic Josephson junctions*	Nov 10
Joonas Peltonen Low Temperature Laboratory, Finland	*Fluctuations, relaxation and proximity effect in superconducting circuits*	Nov 11

Mika Sillanpää Low Temperature Laboratory, Aalto University, Finland	*Radiation-pressure-induced coupling of mechanical resonators*	Nov 17
Tero Heikkilä Low Temperature Laboratory, Aalto University, Finland	*Electron-photon coupling in an SNS junction*	Nov 24
Andreas Isacsson Chalmers University of Technology, Sweden	*Cat states in nonlinear graphene resonators*	Dec 1
Gianluigi Catelani Department of Physics, Yale University, U.S.A.	*Quasiparticle effects in superconducting qubits*	Dec 8
Seth Putterman UCLA, USA	*Light from Gas Bubbles, X-Rays from Peling Tape and Fusion from Crystals*	Dec 13

RESEARCH SEMINARS OF THE BRU

Simo Monto BECS	*Studying brain connectivity with MEG/EEG*	Jan 17
Annika Hultén BRU	*BBQ*	Jan 31
Hanna Renvall BRU	*Searching for genetic correlates of auditory evoked responses*	Feb 14
Juhani Dabek BECS	*MEG-MRI hybrid brain imaging*	Mar 14
Leena Karvonen BRU	*Picture naming: Neural dynamics of sequence and priming*	Mar 28
Harri Piitulainen (BRU) and **Mathieu Bourguignon** BRU, visiting from Université libre de Bruxelles	*Corticokinematic coherence (CKC) as tool to study cortical systems associated to voluntary movements, and CKC phenomenon using a spatial filter approach and a group level analysis*	Apr 11
Elli Vuokko BRU	*Neural correlates of small and large number enumeration*	May 2
Maija Pihlajamäki Department of Neurology, Kuopio University Hospital	*Memory encoding in aging and Alzheimer´s disease*	May 16
Bernd Weber Center for Economics and Neuroscience, University of Bonn	*Biology of social preferences*	May 30
Synnöve Carlson BRU & Neuroscience Unit, Institute of Biomedicine/Physiology, University of Helsinki	*Experience-dependent brain plasticity: processing of auditory and tactile information in the early blind*	Jun 13
Matti Hämäläinen	*Similarities and Differences between*	Aug 4

Martinos Center for Biomedical Imaging; Harvard Medical School; MGH	*MEG and EEG: Implications to Source Estimation and Multi-Modal Imaging*	
Riitta Hari BRU	*First steps of MEG—a personal account*	Aug 29
Various speakers BRU	*Reports of BRU summer students*	Sep 12
Nicola Molinaro Basque Center of Cognition (BCBL), Brain and Language, Spain	*Building up expectations based on what we know*	Sep 22
Nelli Salminen BECS	*Representations of auditory space in human cortex*	Sep 26
Diana Röttger Koblenz-Landau University, Germany	*HARDI Data Exploration and Applications to Neurosurgical Planning*	Oct 10
Jussi Numminen HUCH	*Normal findings in brain MRI that mimic abnormality or disease*	Oct 24
Masamichi Hayashi Institute of Biomedicine/Physiology, University of Helsinki	*Numerosity-time interactions in the human brain*	Nov 7
Karin Rosenkranz Department of Cognitive and Clinical Neuroscience, Central Institute of Mental Health, University of Heidelberg, Germany	*Modulation of proprioceptive integration in the motor cortex: Effects on human motor learning and clinical symptoms in musicians dystonia?*	Nov 21
Various speakers BRU	*PhD student project presentations*	Dec 12
Mika Seppä BRU, AivoAALTO	*Voxlab demo*	Dec 19

SPECIAL ASSIGNMENTS

Pasi Häkkinen, *Chemical vapor deposition setup for graphene and single-walled carbon nanotube growth.* Aalto University, Bachelor degree. Supervisor: Prof. **Pertti Hakonen**

Ville Kauppila, *Electronic transport in few-layer graphene.* Instructor: D.Sc. **Tero Heikkilä**

Ville Kauppila, *Heat transport in normal metal-insulator-superconductor junctions.* Instructor: D.Sc. **Tero Heikkilä**

Jere Mäkinen, *Thermal transport simulation in the ballistic regime of 3He-B*. Instructor: Dr**. Vladimir Eltsov**

Ville Peri, *Preparation of an interdigital capacitor for high voltage and ultra-low temperature experiments.* Aalto University, Bachelor degree. Instructor: M.Sc**. Matti Manninen**.

Jani Saarenpää, *Raman Spectroscopy and Conductivity Measurements on Hydrogenated Graphene.* Instructor: Prof. **Peter Liljeroth**

Eero Smeds, *Luonnollista kosketusta ja käsien liikettä sisältävien videoärsykkeiden vaikutus kosketusvasteisiin tuntoaivokuorella*, University of Helsinki, BM Thesis. Supervisor: Acad. Prof. **Riitta Hari**.

ACADEMIC DEGREES

DIPLOMA THESES

Berdova Maria graduated as M.Sc. from Lappeenranta University of Technology on August 14th. Her diploma thesis *Nanomechanical resonator made out aluminium membrane* was done in the LTL. Supervisor: Dr. **Mika Sillanpää**. Instructor: MSc. **Juha-Matti Pirkkalainen**.

Liiri Tiina graduated as M.A. from the Faculty of Behavioural Sciences, Helsinki University, on September 6th. "*Tavoiteperustainen aivoaktivaation säätely kasvoihin ja maisemiin valikoivasti reagoivilla alueilla työmuistitehtävän aikana*". Supervisors: **Synnöve Carlson** and Teija Kujala (Univ Helsinki).

Pamilo Siina graduated as M.Sc.Tech. from the School of Electrical Engineering on April 4th. Her diploma thesis *Spatio-temporal segregation of brain circuitries activated during movie viewing* was done in BRU. Instructors: **Sanna Malinen** and **Riitta Hari**. Supervisor from Aalto-SCI: Prof. Mikko Sams.

Virtanen Anne graduated as M.Sc. from the Department of Philosophy, History, Culture and Art Studies, Helsinki University. Her thesis "*Taidekuvat asiantuntijan ja maallikon silmin. Kokeellista estetiikan tutkimusta ja tulosten tarkastelua filosofisen estetiikan valossa*" was done in BRU. Supervisors: Arto Haapala (Univ Helsinki), **Elina Pihko** and **Riitta Hari**.

Väyrynen Jukka as M.Sc. from the Department of Physics of University of Helsinki on April 4th. His diploma thesis *The Gradient Expansion and Topological Insulators* was done in the LTL. Supervisor: Prof. Kari Rummukainen. Instructor: Dr. **Teemu Ojanen**.

PH.D. DISSERTATIONS

Annika Hultén defended her Ph.D. thesis *Neural correlates of language learning in adults* on April7th, 2011. Her opponent was Dr. Matthew Davis, MRC Cognition and Brain Sciences Unit, Cambridge, UK, and supervisors Prof. Matti Laine and Acad. Prof. **Riitta Salmelin**.

Rob de Graaf defended his Ph.D. thesis *Dynamics of quantized vortices in applied flow in superfluid 3He-B* on May 18th, 2011. His opponent was Prof. S.N. Fisher, Lancaster University, UK, supervisor Prof. Matti Kaivola and instructor Prof. **Matti Krusius**.

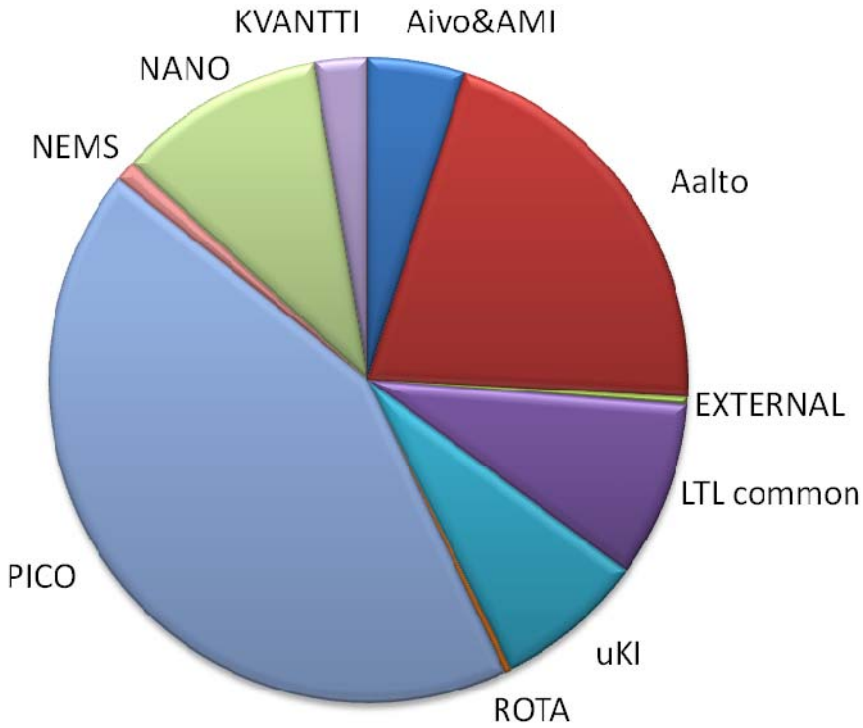
Joonas Peltonen defended his Ph.D. thesis *Fluctuations, relaxation and proximity effect in superconducting circuits* on November 11th, 2011. His opponent was Prof. Norman Birge, Michigan State University, USA, supervisor Prof. Matti Kaivola and instructor Prof. **Jukka Pekola**.

TECHNICAL SERVICES

MACHINE SHOP

Seppo Hiltunen, **Arvi Isomäki**, Hannu Kaukelin, Markku Korhonen, and Jari Isomäki

Our machine shop is a joint unit of Department of Electrical Engineering (Seppo Hiltunen), Low Temperature Laboratory (Arvi Isomäki, Markku Korhonen, and Jari Isomäki) and Department of Engineering Physics (Hannu Kaukelin).



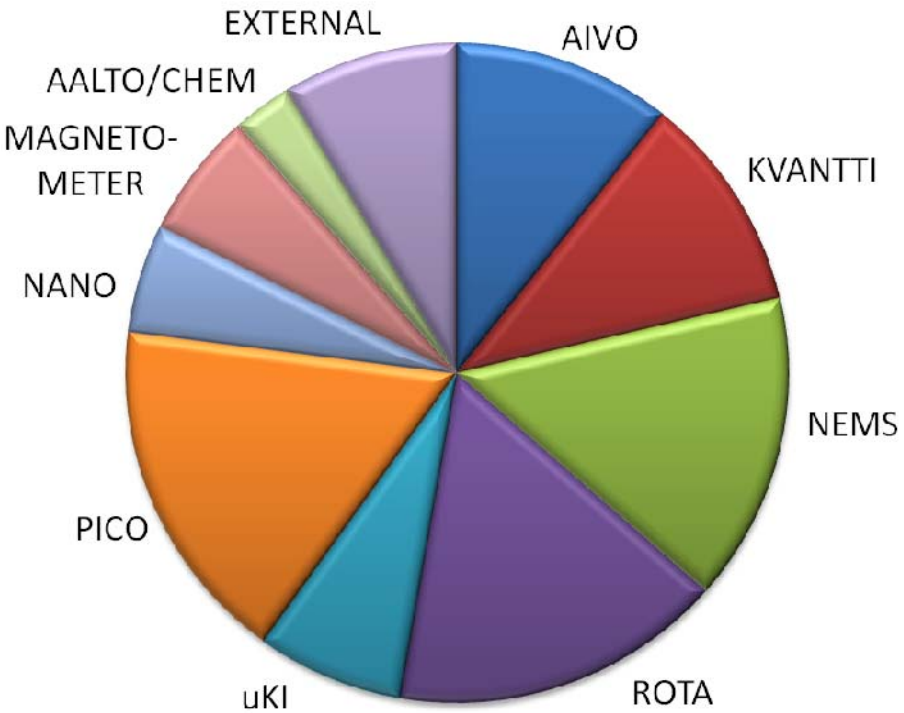
The distribution of workshop usage.

CRYOGENIC LIQUIDS

Arvi Isomäki, Hannu Kaukelin, and Jari Isomäki

Liquid helium

The total amount of liquid helium purchased was 66913,6 *l* and 51 120 *l* were delivered to the users. The losses of liquid He were 23,6 %. The user distribution is depicted below. 11,5% of the liquid He delivered to the users was sold to external users (EXTERNAL and AALTO/CHEM).



Liquid nitrogen

Significant part of liquid nitrogen (~45%) was used for compressed nitrogen gas system in Nanotalo. Total amount of liquid nitrogen purchased was 71 220 kg.

ACTIVITIES OF THE PERSONNEL

AWARDS AND HONORS

Hari Riitta, Nokia Foundation Research Award 2012

Kopnin Nikolai, The 2011 Simon Memorial Prize

Sillanpää Mika, IUPAP Young Scientist Prize in Low Temperature Physics (2011)

PERSONNEL WORKING ABROAD

Auranen Toni, ISMRM, Scientific Workshop: UHF Systems and Applications, Lake Louise, Alberta, Canada, 20. - 23.2.

Auranen Toni, Siemens AB, Healthcare Sector; Visit related to upcoming research collaboration agreement in fMRI/MRI between Siemens and Aalto, Private Company, Erlangen, Germany, 12. - 13.9.

Faivre Timothe, QNET project, Chalmers University, Goteborg, sweden, 1. - 28.11.

Gasparinetti Simone, CEA, measurements within EU project MicroKelvin, Research Center, Grenoble, France, 23.2. - 1.3.

Gilani Irtiza, Ultra-high field MRI workshop hosted by International society of magnetic resonance in medicine (ISMRM), Lake Louise, Calgary, Canada, 19. - 24.2.

Gilani Irtiza, Annual meeting of the international society of magnetic resonance in medicine (ISMRM), Montreal, Canada, 6. - 13.5.

Hari Riitta

- Karolinska Institut, University, Stockholm, Sweden, 20. - 24.3.
- MGH Martinos Center & MIT McGovern Institute, Boston, USA, 3. - 5.5.
- The Human Brain Project Core Consortium Meeting, Other, Lausanne, Switzerland, 29.11. - 1.12.

Heikkilä Tero, Heriot-Watt University, Edinburgh, United Kingdom, 12. - 14.9.

Jousmäki Veikko

- Brains back to Brussels, Hõpital Erasme, University, Bruxelles, Belgium, 18. - 21.1, 5. - 8.7.
- Elekta Oy, Elekta Neuromag System Integration, King Fahad Medical City, Riyadh, Saudi Arabia, 24. - 28.1, 25.2. - 3.3, 9. - 16.9.
- Elekta Oy, Elekta Neuromag Advanced Training at Heinrich Heine Universität, Private Company, Düsseldorf, Germany, 4. - 8.4.
- Oxford Centre for Human Brain Activity (OHBA) Department of Psychiatry, University of Oxford Warneford Hospital, Oxford, United Kingdom, 30. - 31.5.
- Elekta Oy, Elekta Neuromag System Start at Swinburne University of Technology, Melbourne, Victoria, Australia, 26.9. - 3.10.

Kopnin Nikolai, Argonne National Laboratory, Research Center, Argonne, Illinois, USA, 10. - 23.4.

Laiho Ari, Siemens AB, Healthcare Sector; Visit related to upcoming research collaboration agreement in fMRI/MRI between Siemens and Aalto, Erlangen, Germany, 12. - 13.9.

Malinen Sanna, New York University, USA, 10. - 10.5.

Mandel Anne, Working abroad, University of Princeton, University, Princeton, US, 2. - 9.5.

Nangini Catherine, Indian Institute of Management, Delhi University, Delhi, Bangalore, India, 9. - 14.1.

Ojanen Teemu, University of Harward, UK, 10.10.2011 - 1.7.2012.

Pannasch Sebastian, Donders Institute, Nijmegen, Netherlands, 17. - 21.4.

Parkkonen Lauri

- Princeton University, Physics Department, Princeton, New Jersey, USA, 9.5.
- New York University, Neurolinguistics Lab, New York, USA, 10.5.
- New York University, Department of Psychology and Center for Neural Science, University, New York, USA, 10.5.

Parviainen Tiina, Univeristy of Oxford, UK, 1.1. - 30.11.

Pekola Jukka

- State University of NY, Stony Brook, Stony Brook, USA, 5. - 26.1.
- LT26 conference organization, Research Center, Beijing, China, 17. - 20.4.

- Heriot Watt University, Edinburgh, Scotland, 12. - 14.9.
- Scuola Normale Superiore, Pisa, Italy, 29. - 30.9.

Peltonen Joonas, Macroscopic Quantum Coherence Lab., RIKEN / NEC Green Innovation Labs. Tsukuba, Japan, 28.7.2011 - 16.1.2012.

Renvall Hanna, University of Maastricht, research visit, Maastricht, The Netherlands, 11. - 14.4.

Renvall Ville, Siemens Healthcare, Cary, NC, USA, 22. - 26.8.

Salmelin Riitta, Washington University in St. Louis; member of the External Advisory Panel for the NIH/Human Connectome Project consortium, St. Louis, MO, USA, 12. - 13.1.

Sillanpää Mika, Heriot-Watt University, Edinburgh, Great Britain, 12. - 14.9.

CONFERENCE PARTICIPATION AND LABORATORY VISITS

Aref

Oral presentation, *Single Electron Turnstiles: Improving Performance for a Quantum Metrological Current Standard*, APS March Meeting 2011, Dallas, Texas, USA (21.3. - 25.4.)

Poster, *Observation of Andreev Tunneling Effects in Current Pumping with SINIS turnstiles*, 26th International Conference on Low Temperature Physics, Beijing, China (10. - 17.8.)

Baess, oral presentation, *My partner is also in my mind: The impact of social setting on early stimulus processing*, Alpine Brain Imaging Meeting, Champery, Switzerland (9. - 14.1.)

Chalapat, oral presentation, *Self assembly of three dimensional nanostructures - particle trapping*, 45th Annual Meeting of Finnish Physical Society, 2nd Nordic Physics Meeting, Helsinki, Finland (29. - 31.3.)

Eltsov

Invited talk, *Turbulent and laminar dynamics of superfluid 3He-B at low temperatures*, 26th International Conference on Low Temperature Physics (LT26), Beijing, China (11. - 17.8.)

Invited talk, *Spin-up, spin-down and propagation of turbulent fronts in superfluids*, Workshop on classical and quantum trubulence, Abu Dhabi, UAE (2. - 5.5.)

Oral presentation, *Turbulent and laminar dissipation in vortex front motion in 3He-B below 0.3Tc*, Microkelvin user meeting, Smolenice, Slovakia (14. - 18.3.)

Poster, *Bose-Einstein condensation of magnons in 3He-B and interaction with vortices*, International Conference on Ultra Low Temperature Physics – ULT 2011, Daejeon, Korea (19. - 22.8.)

Emets

Participation, The Capri Spring School on Transport in Nanostructures 2011, (10. - 17.4.)

Participation, Cryocourse 2011, Grenoble, France (18. - 27.9.)

Fay

Poster, *Electron-electron and electron-phonon interactions in graphene*, Rencontres de Moriond, La Thuile, Italy (13. - 20.3.)

Poster, *electron-optical phonon interactions in bilayer graphene*, LT 26, Beijing, China (10. - 17.8.)

Forss

Participation, 14th European Congress on Clinical Neurophysiology and 4 th International Congress on TMS and DCS, Rome, Italy (20. - 25.8.)

Gasparinetti

Poster, *From Adiabatic to Nonadiabatic Charge Pumping in a Phase-Biased Cooper-Pair Sluice*, 26th International Conference on Low Temperature Physics (LT26), Beijing, China (10. - 17.8.)

Participation, *Geometric Landau-Zener interferometry*, Geomdiss project review meeting, Pisa, Italy (30.9.)

Gilani

Poster, *Biophysical Principles and Models of SSFP Functional MRI Contrast Mechanisms in the Brain at High and Ultra-High Magnetic Fields*, Presentation (Educational E-Poster) at Annual Conference of ISMRM 2011, Montreal, Canada (7. - 13.5.)

Poster, *Optimal Sampling and Reconstruction Patterns for Magnetic Resonance Inverse Imaging and MR-Encephalography*, Presentation (Educational E-Poster) at Annual Conference of ISMRM 2011, Montreal, Canada (7. - 13.5.)

Poster, *Accuracy and Precision in Quantitative Rotating Frame Relaxometry at High and Ultra-High Magnetic Fields*, Presentation (Educational E-Poster) at Annual Conference of ISMRM 2011, Montreal, Canada (27.5.)

Hakonen

Invited talk, *Current-current correlations and exchange effects in multiterminal diffusive conductors*, XLVI Recontres de Moriond "Quantum Mesoscopic Physics", La Thuile, Italy (13. - 20.3.)

Invited talk, *Proximity-induced superconductivity in nanocarbons*, Advanced many-body and statistical methods in mesoscopic systems, Constanta, Romania (27.6. - 2.7.)

Invited talk, *Dynamical Casimir effect in a Josephson metamaterial*, 26th International Conference on Low Temperature Physics (LT26), Beijing, China (10. - 17.8.)

Invited talk, *Dynamical Casimir effect in a Josephson metamaterial*, Workshop on quantum spintronics II, Ottiolu, Italy (2. - 6.10.)

Oral presentation, *Recent graphene work in Helsinki*, RODIN collaboration meeting, Brussels, Belgium (5.4.)

Hari

Invited talk, *Aivotutkimus—tieteenalojen sulatusuuni*, Mielen ja kehon eliksiirit SHOK-hankkeen kickoff-seminaari, Espoo, Finland (24.1.)

Invited talk, *Juhani Hyvärinen Lecture: Studying brain function in naturalistic conditions*, Multimodal Transcranial Magnetiec Stimulation in the Study of Brain and Cognition 2011, Helsinki, Finland (25.3.)

Invited talk, *Aivotutkimus tieteenaloja rikkomassa*, Seitsemännet LUMA tiede- ja teknologiapäivät (& valtakunnallinen videointi), Helsinki, Finland (6.4.)

Invited talk, *Time scales of human brain function*, Brain Mapping seminar, Athinoula A. Martinos Center, Massachussets General Hospital, Boston, USA (4.5.)

Invited talk, *Dynamics of brain function during social interaction: The role of neuromagnetic recordings*, Face to Face, Brain to Brain. Exploring the mechanisms of dyadic social interactions., Princeton, USA (9.5.)

Invited plenary talk, *How we understand each other: A neuroscientist's view (Keynote speech)*, EuroCogSci 2011, Sofia, Bulgaria (21. - 24.5.)

Invited plenary talk, *Towards two-person neuroscience*, ICANN 2011 (international Conference on Artificial Neural Networks), Espoo, Finland (15.6.)

Invited talk, *Time scales in human brain function: Insights from neuromagnetic recordings*, MindLab Guest Lecture, Aarhus, Denmark (21.6.)

Invited talk, *Discussant in Panel on The Science's View of Humans (Tieteen ihmiskuva)*, Metodifestivaali (2nd Methods Festival in Finland), University of Tampere, Tampere, Finland (30.8.)

Invited talk, *Magnetoencephalography (MEG) in the study of human brain function*, Perspectives in Medical Diagnostics and Therapy: New Concepts and Techniques Symposium on the developments in medical imaging and related techniques by the Kungliga Vetenskapsakademien., Stockholm, Sweden (8.9.)

Invited talk, *Mirroring Systems of the Human Brain*, The ESF Quantitative Methods in the Social Sciences 2 (QMSS2) workshop on Combining biology *and* social science *in* life course studies, Helsinki, Finland (9.9.)

Invited talk, *Aivot aalloilla*, Syystreffit 2011, Espoo, Finland (22.9.)

Invited talk, *Aivot askarruttavat*, Academia populi - Tiedettä kaikille (Suomen Akatemia), Helsinki, Finland (27.10.)

Invited talk, *Kädet ja aivot*, Matematiikan, luonnontieteen *ja* teknologian opetuksen tutkimuksen päivät 2011, Helsinki, Finland (28.10.)

Invited talk, *Käsillä tekemisen voima*, TEDx Helsinki, Helsinki, Finland (17.11.)

Invited talk, *Neurotieteen näkökulmia ihmisten väliseen vuorovaikutukseen (Views of neuroscience into human social interaction)*, Neuropsykoanalyysin teemapäivä 2011. Helsinki Lecture (4 hours). Helsingin pyskoterapiayhdistys ry, Helsinki, Finland (19.11.)

Lecture, *Miksi aivotutkija on kiinnosstunut elokuvasta?*, Aivot ja elokuva; aivoAALTO-projektin järjestämä yleisötilaisuus kv. aivoviikon kunniaksi, Helsinki, Finland (15.3.)

Participation, *Työpaja (työpaketti 302)*, Mielen ja kehon eliksiisit SHOK-hankkeen kickoff-seminaari, Espoo, Finland (24.1.)

Participation, 148th Annual Meeting of the National Academy of Sciences USA, Washington DC, USA (30.4. - 3.5.)

Participation, *member of panel discussion*, Tutkimus, riskinotto ja epäonnistuminen - paneeli, Espoo, Finland (13.10.)

Heikkilä

Invited talk, *Spin Heat Accumulation and Its Relaxation in Spin Valves*, Materials Research Society Spring Meeting, San Francisco, USA (25. - 29.4.)

Invited talk, *Spin Heat Accumulation and Its Relaxation in Spin Valves*, Spin Caloritronics III, Leiden, the Netherlands (9. - 13.5.)

Invited talk, *High-temperature surface superconductivity in topological flat band systems*, Highlights in quantum condensed matter physics, San Sebastian, Spain (17. - 23.6.)

Invited talk, *Quantum mechanics of mechanical systems: micromechanical oscillator close to the quantum ground state*, MatSurf symposium, Turku, Finland (18.10.)

Heikkinen

Poster, *Magnon Condensation and Its Application to Studies of Vortices in 3He-B*, Physics Days 2011, The 45th annual meeting of the Finnish Physical Society, The second Nordic physics meeting, Helsinki, Finland (29. - 31.3.)

Poster, *Magnon Condensation and Its Application to Studies of Vortices in 3He-B*, New Trends in Quantum Matter With Cold Atoms and Molecules, São Carlos, Brazil (4. - 14.4.)

Participation, The European Advanced Cryogenics Course, Chichilianne and Grenoble, France (18. - 27.9.)

Henriksson, invited talk, *Three lectures on fMRI*, Noninvasive methodologies to study whole brain function, St.Petersburg, Russia (19. - 22.10.)

Hirvenkari, invited talk, *Gaze-direction-based MEG averaging*, Symposium on current avenues of eye-gaze tracking, Espoo, Finland (4.3.)

Hosio

Oral presentation, *Thermal Detection of Laminar and Turbulent Dissipation in Vortex Motion in Superfluid 3He-B at UltralowTemperatures*, Physics Days 2011, The 45th annual meeting of the Finnish Physical Society, The second Nordic physics meeting, Helsinki, Finland (29. - 31.3.)

Poster, *Dissipation in Superfluid Vortex Front Motion at T->0*, New Trends in Quantum Matter With Cold Atoms and Molecules, São Carlos, Brazil (4. - 14.4.)

Poster, *Propagation of Quasiparticles in a cluster of Vortices in Superfluid 3He-B*, 26th International Conference on Low Temperature Physics (LT26), Beijing, China (10. - 17.8.)

Poster, *Vortex Studies with Quasiparticle Beam Techniques in Rotating Superfluid 3He-B*, ULT2011, Daejeon, South Korea (19. - 22.8.)

Hotta, participation, 7th Congress of the European Federation of IASP Chapters (EFIC), Hampurg, Germany (21. - 24.9.)

Hultén, participation, Latin American School for Education, Cognitive and Neural Sciences, San Pedro de Atacama, Chile (7. - 18.3.)

Hytönen

Lecture, *Neuroeconomics - Valuation and Learning*, A course on Behavioral and Experimental Economics, School of Economics, Aalto University, Helsinki, Finland (28.2.)

Lecture, *Theories and Models*, Minor course "Neuroeconomics: How the Brain Decides", Rotterdam School of Management, Rotterdam, The Netherlands (15.9.)

Hänninen

invited talk, *Vortex filament simulations in the zero temperature limit: Kelvin wave cascade*, Smolenice Workshop of the European Microkelvin Collaboration, Smolenice, Slovakia (14. - 18.3.)

Poster, *Kelvin Spectrum for a Harmonically Driven Vortex at Low Temperatures*, 26th International Conference on Low Temperature Physics (LT26), Beijing, China (10. - 17.8.)

Poster, *Spin-Down of the Superfluid Component of 3He-B in Different Geometries*, 26th International Conference on Low Temperature Physics (LT26), Beijing, China (10. - 17.8.)

Jannes, oral presentation, *Hawking tunneling and boomerang behaviour of massive particles with E<m*, Spanish Relativity Meeting, Madrid, Spain (29.8. - 2.9.)

Jousmäki, oral presentation, *Magnetoenkefalografia kliinisenä työkaluna*, Sairaalafyysikoiden seminaarisarja 2011, Kuopio, Kuopion yliopistollinen sairaala, Suomi (14.2.)

Kirveskari, invited talk, *Localization of epileptic focus using MEG and EEG*, University Hospital, Turku, Finland (18.11.)

Kopnin

Invited plenary talk, *Vortex Dynamics in Superconductors and Fermi Superfluids*, International Conference on Low temperature Physics LT26, Beijing, China (10. - 17.8.)

Oral presentation, Induced superconductivity in two dimensional electron systems, Landau Days 2011, Moscow, Chernogolovka, Russia (27. - 29.6.)

oral presentation, *High-temperature surface superconductivity in multilayered rhombohedral graphene*, International Workshop on Complex Phenomena in Superconductors and Magnetic Systems, Øystese, Norway (29.8. - 2.9.)

Krusius

Invited talk, *NMR on trapped magnon condensates in rotating superfluid 3He*, Microkelvin workshop 2011, Smolenice, Slovakia (14. - 18.3.)

Invited talk, *Review of Microkelvin activities*, Microkelvin workshop 2011, Smolenice, Slovakia (14. - 18.3.)

Oral presentation, *Transition to turbulence*, Abu Dhabi Workshop on Classical and Quantum Turbulence, Abu Dhabi, United Arab Emirates (2. - 5.5.)

Lecture, *Jäähdyttäminen ja matalien lämpötilojen fysiikka*, Rakennusinsinööriliiton seniorien vierailu kylmälaboratorriossa, Nanotalo, Otaniemi, Finland (14.4.)

Laakso

Oral presentation*, Giant current fluctuations in an overheated single-electron transistor*, APS March Meeting, Dallas, Texas, USA (21. - 25.3.)

Poster, *Statistics of temperature fluctuations in superconductor-normal metal tunnel structures*, The 26th International Conference on Low Temperature Physics (LT26), Beijing, People's Republic of China (10. - 17.8.)

Laaksonen, poster, *Spatial relationship between MEG evoked responses and rhythmic activity in a picture naming task*, 17th Annual Meeting of the Organization for Human Brain Mapping, Quebec, Canada (26.6. - 30.8.)

Laiho, invited talk, *Electrolyte-Gated Organic Thin-Film Transistors*, UMK Colloquium, Espoo, Finland (9.11.)

Li

Poster, *Decay and generation of entanglement in coupled, driven systems with bipartite decoherence*, 26th International Conference on Low Temperature Physics (LT26), Beijing, China (10. - 17.8.)

Poster, *Experimental demonstration of motional averaging in a transmon*, 26th International Conference on Low Temperature Physics (LT26), Beijing, China (10. - 17.8.)

Liljeström

Poster, *Cortico-cortical connectivity differs for action versus object naming*, Neurobiology of language conference, Annapolis, MD, USA (9. - 11.11.)

Poster, *Cortico-cortical connectivity differs for action versus object naming*, Society for Neuroscience Annual Meeting, Washington, DC, USA (11. - 17.11.)

Lyashenko, poster, *High-frequency suspended graphene resonators for tunable filters*, IWEPNM, Kirchberg in Tirol, Austria (26.2. - 5.3.)

Lähteenmäki, invited talk, *Josephson junction based amplifiers*, European Microkelvin Collaboration 2011, Smolenice, Slovakia (14. - 18.3.)

Mandel, invited talk, *Magnetoencephalography. To whom and for what?*, Research seminar in the Department of Biomedical Engineering, Tallinn, Tallinn University of Technology, Technomedicum, Estonia (1.3.)

Malinen

Poster, *FMRI correlates of essential movie-content extraction by and automatic algorithm and an expert viewer*, Opportunities and challenges in social neuroscience, Utrecht, Netherlands (21. - 23.3.)

Participation, Face To Face, Brain To Brain, Princeton, USA (6. - 7.5.)

Massel

Invited talk, Microwave amplification in nanomechanical systems, 26th International Conference on Low Temperature Physics, Beijing, China (15.9.)

Lecture, *Expansion dynamics in the D Hubbard model*, 26th International Conference on Low Temperature Physics, Beijing, China (10. - 17.8.)

Meschke

Oral presentation, *On chip nanocoolers*, MICROKELVIN 2011 WORKSHOP, Smolenice, Slovakia (14. - 18.3.)

Oral presentation, *Coupling of an Electric Circuit to Phonon and Photon Environments*, Materials Research Society Fall Meeting, Hynes Convention Center, Boston, MA, USA (27.11. - 2.12.)

Oral presentation, *Tunnel spectroscopy of a proximity Josephson junction*, CMMP11, Manchester, UK (13. - 15.12.)

Participation, Partnering meeting for the EMRP SRTs13 "Implementing the new kelvin", London, NPL, UK (21.6.)

Muhonen

Oral presentation, *Electronically cooled platform*, Microkelvin 2011: The Smolenice Workshop, Smolenice, Slovakia (14. - 18.3.)

Oral presentation, E-fridge annual review meeting, University of Warwick, Coventry, United Kingdom (26. - 28.10.)

Mäkinen

Poster, *Simulation* of *ballistic quasiparticle transport* in *rotating superfluid 3He-B*, Physics days 2011, Helsinki, Finland (29. - 31.3.)

Participation, Cryocourse 2011, Grenoble, France (18. - 27.9.)

Nummenmaa, lecture, *Emotional contagion facilitates social interaction by synchrnonizing brain activity across individuals*, HBM 2011 meeting, Quebe City, Canada (26. - 30.6.)

Ojanen

Oral presentation, *Electrical manipulation and measurement of spin in quantum spin Hall edge states*, American Physical Society march meeting 2011, Dallas, United states (20. - 24.3.)

Poster, *Electrical manipulation of spin properties of quantum spin Hall edge states*, Workshop and School on topological aspects of condensed matter physics, trieste, Italy (26.6. - 9.7.)

Oksanen

Poster, *Graphene Mechanical Resonators for Circuit QED*, GraphITA 2011, L'Aquila, Italy (15. - 18.5.)

Participation, RODIN project meeting, Delft, Netherlands (19. - 20.9.)

Pannasch

Poster, *Apparent Phi-Motion In Sequences Of Eisenstein's October*, VSS 2011, Naples, FL, USA (6. - 11.5.)

Poster, *Ambient and focal processing in free viewing of meaningful images: A combined MEG and eye-tracking study*, 16th European Conference on Eye Movements, Marseille, France (21. - 25.8.)

Paraoanu

Oral presentation, *Quantum technologies and quantum computing: superconducting quantum bits as simulators of atoms interacting with fields*, Advanced many-body and statistical methods in mesoscopic systems, Constanta, Romania (27.6. - 2.7.)

Poster, *Spin-asymmetric Josephson effect in ultracold Fermi gases*, LT 26 China, Beijing, China (10. - 17.8.)

Poster, *Dynamic Autler-Townes effect, decoherence, and dark states in a phase qubit*, LT 26 China, Beijing, China (10. - 17.8.)

Participation, NGS-NANO meeting, Tampere, Finland (3. - 4.10.)

Participation, FQXI conference, Bergen&Copenhagen, Norway&Denmark (27.8. - 1.9.)

Parkkonen

Invited plenary talk, *Quo vadis, MEG?*, MEG and Challenges of Modern Neuroscience, Salt Lake City, Utah, USA (29.4.)

Participation, Face to Face, Brain to Brain: Exploring the Mechanisms of Dyadic Social Interaction, Princeton, New Jersey, USA (6. - 7.5.)

Participation, Magnetoencephalography International Consortium on Alzheimer's Disease (MAGIC-AD). Investigators' Meeting, Salt Lake City, Utah, USA (27. - 28.4.)

Pekola

Invited plenary talk, *Coupling of electrical circuits to photon, phonon and electron environments*, The 7th « Rencontres de Moriond » on Quantum Mesoscopic Physics, La Thuile, Italy (13. - 20.3.)

Invited talk, *Coupling of an electric circuit to environment and statistics of generated heat in driven single-electron transitions,* Thermodynamics: Can macro learn from nano?, Lund, Sweden (23. - 25.5.)

Invited talk, *Andreev current and photon-assisted tunneling as error processes in a hybrid single-electron turnstile*, Advanced many-body and statistical methods in mesoscopic systems, Constanta, Rumania (27.6. - 2.7.)

Invited talk, *Real-time observation of discrete Andreev tunneling events*, 7th international workshop on magnetism and superconductivity at the nanoscale, Coma Ruga, Spain (2. - 8.7.)

Invited talk, Residual quasiparticles, *Andreev current and photon-assisted tunneling in Coulomb blockaded normal-superconductor junctions*, Superconducting hybrids: from conventional to exotic, Villard de Lans, France (7. - 10.9.)

Invited talk, *Fluctuation relations in driven single-electron transitions: theory and preliminary experiments*, 24th Marian Smoluchowski symposium on statistical physics, Zakopane, Poland (17. - 22.9.)

Invited talk, *Single-electron counting in quantum metrology and in statistical mechanics*, Nanoscience Days, Jyväskylä, Finland (27. - 28.10.)

Invited talk, *Work, heat and fluctuation relations in single-electron transport*, Kapitza seminar, Moscow, Kapitza Institute, Russia (22.12.)

Invited talk, *Heat transport in nanostructures*, seminar, Chernogolovka, Landau Institute, Russia (23.12.)

Oral presentation, *Real-time observation of discrete Andreev tunneling events - influence on a single-electron turnstile and electron coolers*, 26th International Conference on Low Temperature Physics (LT26), Beijing, China (10. - 17.8.)

Lecture, *Single-electron counting in quantum metrology and in statistical mechanics*, Department colloquium at University of Geneva, Geneva, Switzerland (17. - 20.10.)

Lecture, *Single-electron counting for quantum metrology*, Department seminar, Chernogolovka, Institute for Solid State Physics, Russia (21.12.)

Participation, Kick-off meeting of Q-NET Marie Curie Initial Training Network, Grenoble, France (10.5.)

Peltonen

Poster, *Detecting the third cumulant of shot noise with a hysteretic Josephson junction*, Symposium on Quantum Phenomena and Devices at Low Temperatures, Espoo, Finland (28. - 30.3.)

Poster, *Thermal conductance by the inverse proximity effect in a superconductor*, LT26, Beijing, China (10. - 17.8.)

Participation, Introduction to Quantum Systems and Devices, Espoo, Finland (15. - 18.6.)

Piitulainen

Invited talk, *Effects of mechanical loading of muscle and its recovery*, Ravivalmennuksen A-seminaari, Suomen Hippos ry, Ypäjä, Finland (9.11.)

Oral presentation, *Multi-channel surface electromyography characteristics during maximal dynamic contractions*, The XXIII Congress of the International Society of Biomechanics (ISB), Brussels 3.–7.7., Belgium (3. - 7.7.)

Participation, International symposium: Exercise and Nutrition: Focus on Muscle and Adipose Tissue, Jyväskylä, Finland (30.11. - 2.12.)

Pirkkalainen

Poster, *Hybrid circuit QED with micromechanical resonator*, QIPC 2011, Zurich, Switzerland (5. - 9.9.)

Poster, *Electromechanically induced microwave amplification*, Physics Days, Helsinki, Finland (29. - 31.3.)

Raij, poster, *Brain-imaging findings converge on dysfunctional self-referential processing in schizophrenia*, Annual meeting of American Psychiatric Association 201, Honolulu, USA (5. - 9.5.)

Ramkumar

Invited talk, *How you see is why I get*, Scientific visit, Pittsburgh, USA (7. - 10.11.)

Invited talk, *How you see is why I get*, Scientific visit, Chicago, USA (17. - 18.11.)

Poster, *Independent Component Analysis of Fourier Energies: characterizing long-range cortico-cortical interactions in magnetoencephalography (MEG) data*, Society for Neuroscience, Washington DC, USA (11. - 16.11.)

Poster, *How does the brain represent visual scenes? A neuromagnetic scene categorization study*, Neural Information Processing Systems Workshop on Machine Learning in Neuroimaging, Sierra Nevada, Spain (16. - 17.12.)

Participation, Annual Lindau Nobel Laureate Meeting 2011, Lindau, Germany (26.6. - 1.7.)

Renvall Ville

Poster, Insensitivity to echo time in certain task-negative and task-positive fMRI responses in humans suggests a BOLD-independent effect, Society for Neuroscience 2011, Washington D.C., USA (12. - 16.11.)

Renvall Hanna

Invited talk, *Aivokuvantaminen - poikkitieteellistä tutkimusta pa(r)h(a)immillaan*, Suomalaisen tiedeakatemian junioriklubi, Helsinki, Finland (21.2.)

Oral presentation, Human auditory cortical responses are regulated by the TRAPPC9 and ROBO1 genes, Society for Neuroscience 2011, Washington DC, USA (12. - 16.11.)

Poster, Human auditory cortical responses are regulated by the TRAPPC9 and ROBO1 genes, Neurobiology of Language 2011, Washington DC, USA (10. - 11.11.)

Participation, The 11th International Conference on Cognitive Neuroscience, Mallorca, Spain (25. - 29.9.)

Roiha, participation, 14th European Congress on Clinical Neurophysiology and 4th International Congress on Transcranial magnetic stimulation, Centro Congressi, Europa, Rome, Italia (20. - 25.6.)

Rysti

Oral presentation, *Search for Superfluidity in 3He-4He Mixtures*, Physics Days 2011, Helsinki, Finland (29. - 31.3.)

Poster, *Search for Superfluidity in 3He-4He Mixtures*, São Paulo School of Advanced Science, São Carlos, Brazil (4. - 14.4.)

Poster, *Melting Pressure of Saturated Helium Mixture at Temperatures Between 10 mK and 0.5 K*, LT 26, Beijing, China (10. - 17.8.)

Poster, *Search for Superfluidity in 3He-4He Mixtures*, ULT 2011, Daejeon, Korea (19. - 22.8.)

Saarinen

Poster, *Functional network elements in patterned hand movements and writing*, Neurobiology of Language Confrence 2011, Annapolis, United States (10. - 11.11.)

Poster, *Functional network elements in patterned hand movements and writing*, Neuroscience 2011 - Annual Meeting of Society for Neuroscience, Washington DC, United States (12. - 16.11.)

Saira

Invited talk, *Quasiparticle transport measurements in attoampere scale in metallic devices*, The 26th International Conference on Low Temperature Physics, Beijing, Conference (10. - 17.8.)

Oral presentation, *High-fidelity readout of heat fluctuations in a driven single-electron box*, Condensed Matter and Materials Physics (CMMP11), Manchester, UK (13. - 15.12.)

Participation, Physics orientation day at LUT for Russian students, Lappeenranta, Finland (28. - 29.4.)

Salmelin

Invited plenary talk, *Cortical dynamics of language knowledge and language learning*, 10th International Symposium of Psycholinguistics, San Sebastian, Spain (13. - 16.4.)

Invited talk, *Time-resolved crain imaging of language perception*, Biosynteesi XI (Biosynthesis XI), Helsinki, Finland (12. - 13.5.)

Invited plenary talk, *MEG and fMRI as probes of language perception and production*, NFSI & ICBEM 2011 (8th International Symposium on Noninvasive Functional Source Imaging of the Brain and Heart and the 8th International Conference on Bioelectromagnetism), Banff, Canada (13. - 16.5.)

Invited talk, *Kielen kuvantaminen ja neurokirurgia? (Neuroimaging of language and neurosurgery?)*, Töölön sairaalan neurokirurgien perjantaiseminaari, Helsinki, Finland (27.5.)

Invited talk, *Time-resolved brain imaging and the neuroscience of language*, Neuroscience Finland 2011. Imaging in Neuroscience: From Molecules to Human Interaction, Turku, Finland (9.9.)

Invited talk, *Cortical dynamics of language knowledge and language learning*, Training Cognition: Behavioral and Neural Mechanisms, Turku, Finland (4. - 5.10.)

Invited talk, *MEG- realities and possibilities*, Wellcome Trust Scientific Meetings - Next Generation Brain Imaging Technologies, London, UK (25. - 26.10.)

Lecture, *MEG in cognitive neuroscience*, Integrative Neuroscience Course, Helsinki, Finland (7.10.)

Participation, Neurobiology of Language Conference (NLC 2011), Annapolis, MD, USA (10. - 11.11.)

Participation, Society for Neuroscience Annual Meeting (Neuroscience 2011), Washington, DC, USA (11. - 16.11.)

Sampath Kumar, poster, *A Race Against the Grover search algorithm*, Physics Days 2011, Helsiniki, Finland (29. - 31.3.)

Seppä, poster, *Voxlab - A Visualization Tool for Multi-Modal Inter-Subject Neuroimaging*, SfN, Neuroscience 2011, Washington, USA (12. - 16.11.)

Sillanpää

Invited talk, *Electromechanical microwave amplification and Nanomechanical resonator cooled down close to the motional ground state*, Advanced many-body and statistical methods in mesoscopic systems, Constanta, Romania (27.6. - 2.7.)

Invited talk, *Electromechanical microwave amplification and Nanomechanical resonator cooled down close to the motional ground state*, 26th International Conference on Low Temperature Physics (LT26), Beijing, China (10. - 17.8.)

Invited talk, *Towards quantum limited electromechanical microwave amplication*, Condensed Matter and Materials Physics (CMMP11) conference, Manchester, Great Britain (12. - 15.12.)

Oral presentation, *Electromechanically induced microwave amplification*, and Nanomechanicalresonator cooled down close to the motional ground state, The 7th Rencontres de Moriond on Quantum Mesoscopic Physics, La Thuile, Italy (13. - 20.3.)

Oral presentation, *Electromechanical microwave amplification and Nanomechanical resonator cooled down close to the ground state*, Quantum Information Processing and Communication (QIPC) 2011, Zurich, Switzerland (5. - 9.9.)

Lecture, *Quantum mechanics of mechanical systems*, Brown bag seminar of the department of applied physics, Espoo, Finland (1.4.)

Simula, poster, *Phonological learning in adults in a familiar and an unfamiliar phonological system*, Training Cognition: Behavioral and Neural Mechanisms, Turku, Finland (4. - 5.10.)

Song

Oral presentation, *Graphene mechanical resonator for electrical cavities*, Graphene Week 2011: Fundamental Science of Graphene and Applications of Graphene-Based Devices, Obergurgl, Austria (24. - 29.4.)

Poster, *Approaching the quantum limit on a graphene mechanical resonator*, 26th International Conference on Low Temperature Physics (LT26), Beijing, China (10. - 17.8.)

Stevenson, poster, *Task-related fMRI connectivity modulations during action and object naming*, 17th Annual Meeting of the Organization on Human Brain Mapping, Quebec City, Canada (26. - 30.6.)

Todoshchenko

Invited talk, *Anisotropy of c-facet of hcp solid 4He*, 26th International Conference on Low Temperature Physics, Beijing, China (10. - 17.8.)

Poster, *Surface of 4He crystal: high order facets and anisotropy of the c-facet*, ULT-2011: New Frontiers of Low Temperature Physics, Daejeon, Korea (19. - 22.8.)

Tomi, poster, *Shot Noise in Superconductor-Graphene-Superconductor Junctions*, Physics Days 2011, Helsinki, Finland (29. - 31.3.)

Tuoriniemi

Poster, *Mode analysis for a quartz tuning fork coupled to acoustic resonances of fluid in a cylindrical cavity*, The 26th International Conference on Low Temperature Physics, Beijing, China (10. - 17.8.)

Poster, *Quartz tuning forks used in studies of helium mixtures*, New Frontiers of Low Temperature Physics ULT2011, Daejeon, South Korea (18. - 22.8.)

Vanni

Invited talk, *Three lectures about the fMRI method*, Noninvasive methodologies to study whole brain function, St.Petersburg, Russia (19. - 22.10.)

Lecture, *Preoperative retinotopic mapping*, Seminar for neurosurgeons, Helsinki, Finland (20.5.)

Invited talk, *Imaging surround modulation in human visual cortex*, Moscow, Russia (23.6.)

Vartiainen, invited talk, *Aivokuvantaminen kroonisessa kivussa*, Suomen fysiatriyhdistyksen vuosikokous, Tuohilampi, Finland (28.1.)

Viljas, invited talk, *Self heating and nonlinear current voltage characteristics in bilayer graphene*, visit, Oulu, University of Oulu, Finland (27.4.)

Volovik

Invited talk, *Nodal topological matter and flat bands*, seminar at Landau Institute, Chernogolovka, Russia (1.4.)

Invited talk, *Quantum vacuum as condensed-matter system: emergent physical laws and dark energy*, seminar at Space Research Institute, Moscow, Russia (21.2.)

Invited talk, *Topological matter*, workshop of European Microkelvin Collaboration, Microkelvin-2011, Smolenice, Slovakia (14. - 18.3.)

Invited talk, *Topological bound states in 3D media with Weyl points: 1D flat band on the vortex axis and Fermi arc on the surface*, seminar at Landau Institute, Chernogolovka, Russia (3.6.)

Invited talk, *Universe in a helium droplet*, A.B. Migdal memorial conference «Advances in Theoretical Physics», Chernogolovka, Russia (25. - 26.6.)

Invited talk, Nodal *topological matter and flat bands*, Landau Days — 2011, Chernogolovka, Russia (27. - 29.6.)

Invited talk, *Gapless topological matter and flat bands*, TOPOLOGICAL ASPECTS OF CONDENSED MATTER PHYSICS, Trieste, Italy (3. - 9.7.)

Invited talk, *Flat bands in nodal topological matter*, Symposium on Theoretical and Mathematical Physics, St. Petersburg, Russia (10. - 14.7.)

Invited talk, *Topological semimetals: from Standard Model to flat band*, workshop on Quantum Field Theory aspects of Condensed Matter Physics, Frascati, Italy (6. - 9.9.)

Invited talk, *Bosonic analog of the electron bubble: ground-state and non-ground-state BEC of magnons in superfluid 3He-B*, Seminar at Landau Institute, Chernogolovka, Russia (16.9.)

Invited plenary talk, *Flat band in topological matter: possible route to room-temperature superconductivity*, 4th International Conference "Fundamental Problems of High-Temperature Superconductivity" (FPS'11), Zvenigorod, Russia (3. - 7.10.)

Invited plenary talk, *Topological matter in terms of momentum-space topology*, workshop on Topological Materials, Grenoble, France (25. - 28.10.)

Invited talk, *Momentum space topology: from graphene to Standard Model and back*, seminar at Institute of Theoretical and Experimental Physics, Moscow, Russia (16.11.)

Lecture, *Topology, thermodynamics and dynamics of quantum vacuum*, Analogue Gravity, Como, Italy (15. - 21.5.)

Volovik, participation, Editorial Board meeting of the journal JETP Letters, Moscow, Russia (17.2., 31.3., 2.6., 23.6., 15.9., 6.10., 29.12.)

Volovik, participation, meeting of dissertation council of Landau Institute, defence of PhD by M.A. Bershtein, Chernogolovka, Russia (30.6.)

Volovik, participation, Dissertations Council Meeting of Landau Institute, defence of second doctor thesis by Yu. I. Sezonov, Chernogolovka, Russia (30.12.)

Voutilainen

Poster, *Energy relaxation in graphene*, Graphene Week 2011, Obergurgl, Austria (24. - 29.4.)

Poster, *Inelastic interactions in graphene*, LT26, Beijing, China (10. - 18.8.)

Väyrynen, poster, *Electrical manipulation of spin properties of quantum spin Hall edge states*, Workshop and School on topological aspects of condensed matter physics, Trieste, Italy (26.6. - 9.7.)

EXPERTISE AND REFEREE ASSIGNMENTS

Chalapat

Referee: International Journal of Electronics and Communications

Hakonen

Position of trust in scientific organizations:

- Coordinator, European Science Foundation, Collaborative Research Project "Entangled spin pairs in graphene", 1.6.2010 - 31.5.2013
- Steering group member, ESF, Quantum Spin Coherence and Electronics (QSpiCE), Strasbourg, France, 1.9.2009–31.8.2012
- Reviewer of FP7 project SOLID: Solid state systems for quantum information processing, QUIE2T Quantum Information Entanglement-Enabled Technologies Coordinated Action, FET Proactive, Warsaw, Poland, 13. - 15.4.

Membership in distinguished societies:

- Finnish Academy of Sciences and Letters
- Fellow member, American Physical Society
- Academia Europaea

Chairman of the conference or organising committee: Co-chair of the program committee on Cryogenic Techniques and Applications, 26th International Conference on Low Temperature Physics (LT26), Beijing, China, 10. - 17.8.

Chairman of the session:

- Qubits with cavity electrodynamics circuits, quantum entanglement with itinerant charge and spin, XLVI Recontres de Moriond "Quantum Mesoscopic Physics", La Thuile, Italy, 13. - 20.3.
- Novel mixed topics, Advanced many-body and statistical methods in mesoscopic systems, Constanta, Romania, 26.6. - 2.7.
- Nanowires / Nanotubes, 26th International Conference on Low Temperature Physics (LT26), Beijing, China, 10. - 16.8.

Referee:

- Journal of Applied Physics
- Journal of Low Temperature Physics
- Nature
- Nature Physics
- Physica E

Reviewer of a grant application: Emmy Noether Programme, DFG, Germany (1.3.)

Statement for the appointment of a professor: Experimental condensed matter, Lancaster University, Physics department, Lancaster, England, 18.1.

Hari

Leader position in a scientific organization:

- Chief physician, Dept. Clin. Neurophysiology, HUSLAB, HUCH (part-time), ad June 2011
- Director of the Centre of Excellence of the Academy of Finland on “Systems Neuroscience and Neuroimaging”
- Director of the aivoAALTO research project comprising all three schools of the Aalto University
- Millennium Prize — Member of the International Selection Committee, Technology Academy Finland

Member of distinguished societies:

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

Chairman of the conference or organising committee: Aivot ja elokuva - yleisätilaisuus (järjestäjä aivoAALTO-projekti), Helsinki, Finland, 15. - 15.3.

Chairman of the session:

- Tieteentekijän arki (The everyday life of a scientist), Tieteen Päivät 2011 (The Finnish Science Days 2011), Helsinki, Finland, 12. - 12.1.
- Current avenues of eye-gaze tracking, Espoo, Finland, 4. - 4.3.

Organising a conference: aivoAALTO SAB meeting (organized with Elina Pihko), Majvik, Kirkkonummi, Finland, 1. - 1.4.

Organising a conference at TKK: Current avenues of eye-gaze tracking (BRI, aivoAALTO, & FGSN), Espoo, Finland, 4. - 4.3.

Editor of scientific journal:

- PNAS (visiting Member Editor), USA several times

Member of the editorial board:

- Cerebral Cortex, Oxford Journals
- Neuroscience Research, Elsevier

Interview:

- Interview, Akateemikko etsii ihmismieltä, Satakunnan kansa, Alma Media, Newspaper, Finland, 13.3.
- Interview, Akateemikko etsii ihmismieltä, Satakunnan kansa, Aaamulehti, Pohjolan Sanomat ja Lapin Kansa, Newspaper, Finland, 14.3.
- Ajantasa (aivotoiminnan dekoodauksesta), YLE, Radio, Helsinki, Finland, 3.10.
- Nokian Säätiö palkitsi ... (Nokian Ääni), Nokia Foundation, Electronic, Espoo, Finland, 10.11.

Referee:

- Autism Research
- Clinical Neurophysiology
- Cerebral Cortex
- Duodecim
- EuroCogSci 2011 conference papers
- Journal of Visualized Experiments
- Neuroscience Research
- Neuropsychologia
- PLOS One
- PNAS
- Science Translational Medicine
- Trends in Cognitive Science

Opponent: Ivana Konvalinka: “Interaction minds, brains, and bodies. Behavioural, neural, and physiological mechanism of joint action in social interaction”, Aarhus University, Faculty of Health Sciences, Århus, Denmark, 20.6.

Reviewer of a grant application: Intercalary Evaluation of the Research Unit - Instituto e Biofisica e Engenharia Biomédica (IBEB) da Faculdade de Ciências da Universidade de Lisboa October 2011 (Advisory Board Report), Portugal (2.11.)

Statement for the appointment of a professor: Associate Prof. with tenure, Montreal Neurological Insitute, Montreal, Canada, 18.4.

Heikkilä

Chairman of the session: nanoscale Heat Transfer -Thermoelectrics, thermophotovoltaics, and Emerging Thermal Devices, Materials Physics Society Spring Meeting, San Francisco, USA, 25. - 29.4.

Referee:

- Journal of Low Temperature Physics
- Physical Review Letters

Helenius

Member of scientific associations: Cognitive Neuroscience Society

Referee: NeuroImage

Henriksson

Referee: Brain Stimulation

Hultén

Interview: Så bearbetar hjärnan språk, Forum för ekonomi och teknik, Magazine, Helsinki, Finland, 28.4.

Hytönen

Referee:

- Journal of Neuroscience
- Emotion

Hänninen

Chairman of the session: Session VI, Discussion, More about simulations of quantum turbulence, Classical and Quantum Turbulence Workshop, Abu Dhabi, United Arab Emirates, 2. - 5.5.

Referee:

- Physical Review E
- Journal of Low Temperature Physics

Kirveskari

Member of scientific associations:

- International Society of Intraoperative Neurophysiology
- Society for the Advancement of Clinical MEG

Kopnin

Member of the scientific board: Landau Institute for Theoretical Physics of the Russian Academy of Science, Russia.

Member of dissertation council: Landau Institute for Theoretical Physics of the Russian Academy of Science, Russia.

Chairman of the session: 12a-D Superconducting Devices/Qubits III, International conference on Low Temperature Physics LT26, Beijing, China, 10. - 17.8.

Krusius

Membership in distinguished societies:

- Finnish Academy of Sciences and Letters
- Academia Europea
- Fellow member, American Physical Society
- Institute of Physics, UK

Member of scientific associations:

- Finnish Physical Society
- Individual ordinary member, European Physical Society

Organising a conference at TKK: Rakennusinsinöörien seniorien vierailu kylmälaboratoriossa, Nanotalo, Otaniemi, Finland, 14.4.

Chairman of the session:

- Microkelvin networking activities, Microkelvin workshop 2011, Smolenice, Slovakia, 14. - 18.3.
- Rakennusinsinööriliiton seniorien vierailu kylmälabotatoriossa, Nanotalo, Otaniemi, Finland, 14. - 14.4.
- Laminar and turbulent regimes in classical and quantum rotating flows, Abu Dhabi Workshop on Classical and Quantum Turbulence, Abu Dhabi, United Arab Emirates, 2. - 5.5.

Referee:

- Phys. Rev. B, Phys. Rev. Lett., J. Low Temp. Phys.

Reference assessments:

- Lancaster University, Leiden University

Kujala Jan

Referee:

- Journal of Neuroscience
- Human Brain Mapping
- Neuroimage

Malinen

Referee:

- Biological Psychiatry
- Human Brain Mapping
- PNAS

Paalanen

Position of trust in scientific organizations:

- Coordinator of MICROKELVIN, FP7 network of 12 low temperature laboratories funded by EC in transnational infrastructure program, Espoo, Finalnd
- Member of Steering Board, Helsinki University of Technology, Advanced Magnetic Imaging Center, Espoo, Finland, 1.1.2005–31.12.2011.
- Member of Board, Instrumentarium Foundation, Helsinki, Finland
- Chairman of evaluation panel PE3, starting grant applications, European Research Council, Bruessels, Belgium, 1.1.2008 - 31.12.2011.
- Member, EURAMET, European Association of National Metrology Institutes, Research Council, Teddington, England, 1.1.2007 - 31.12.2016.

Editor of scientific journal: Journal of Low Temperature Physics

Membership in distinguished societies:

- Finnish Academy of Sciences and Letters
- Finnish Academy of Technical Sciences
- Fellow member, American Physical Society
- Academia Europaea
- The Royal Academy of Arts and Scences in Göteborg

Member of scientific associations: Finnish Physical Society

Pannasch

Referee:

- Brain Research
- International Journal of Human-Computer Studies
- i-Perception
- PLoS ONE
- PNAS

Paraoanu

Position of trust in scientific organizations:

- Advisory Board Member, Lifeboat Foundation (Physics Panel), USA

*Organising a conference:*Advanced many-body and statistical methods in mesoscopic systems, Constanta, Romania, 27.6. - 2.7.

Membership of the organising committee: Foundation of Quantum Physics kick-off meeting, Brussels, Belgium, 10. - 12.4.

Referee:

- Europhysics Letters
- Europhysics Journal D
- Digital Signal Processing
- Physical Review Letters

Parkkonen

Referee:

- Human Brain Mapping
- Neuroimage
- PNAS

Pekola

Leader position in a scientific organization:

- President, Finnish Physical Society, Finland, 1.4.2009 - 31.3.2011
- Member of the board, Finnish Physical Society, Finland, 1.4.2011 - 1.3.2012.
- Chairman, Micronova Advisory Board
- Advisory board member, Karlsruhe Institute of Technology, DFG, Center for Functional nanostructures, CFN, Karlsruhe, Germany, 1.5.2011 - 31.12.2012.

Position of trust in scientific organizations: Member of the committee, IUPAP, C5, 1.1.–31.12.

Membership in distinguished societies:

- Finnish Academy of Sciences and Letters
- Finnish Academy of Technical Sciences

Member of scientific associations: Finnish Physical Society

Editor of scientific journal: Journal of Low Temperature Physics

Chairman of the conference or organising committee: Chair of the program committee on Electronic Quantum Transport in Condensed Matter, 26th International Conference on Low Temperature Physics (LT26), Beijing, China, 10. - 17.8.

Opponent: Florent Lecocq, Dynamique quantique dans un dcSQUID: du qubit de phase à l'oscillateur quantique bidimensionnel, University of Joseph Fourier, Physics, Grenoble, France, 11.5.

Referee: Nature

Reviewer of a grant application:

- SFB 631, DFG, Germany, Germany (22.2.)
- ERC Starting grant (panel member), EU, (1.10.)

Pihko

Referee: NeuroImage

Piitulainen

- European Journal of Applied Physiology
- European Journal of Sport Science

Raij

Referee: Acta psychiatrica scandinavica

Interview: Psykoosilääkettä jumalharhoihin?, Kirkko ja Kaupunki, Magazine, Finland, 29.8.

Renvall Hanna

Referee:

- Journal of Neuroscience
- Developmental Science
- Human Brain Mapping
- Neuroimage

Renvall Ville

Member of scientific associations: Academy Club for Young Scientists of the Finnish Academy of Science and Letters

Salmelin

Membership in distinguished societies:

- Fellow of the International Society for Functional Source Imaging
- Finnish Academy of Sciences and Letters
- Academia Europaea

Editor of scientific journal: Human Brain Mapping, Wiley, New York, USA

Member of the editorial board: Brain Topography, Springer

Position of trust in scientific organizations:

- Member of Scientific Advisory Board, University of Oxford, Oxford Centre for Human Brain Activity (OHBA), Oxford, United Kingdom, 1.10.2010 - 31.12.2013.
- Member of External Advisory Panel, Washington University, NIH/Human Connectome Project Consortium Washington University & University of Minnesota, St. Louis, MN, USA, 1.10.2010 - 31.12.2015.

Referee: Nature Neuroscience

Savin

Referee:

- Journal of Low Temperature Physics
- Semiconductor Science and Technology

Sillanpää

Position of trust in scientific organizations: Evaluator, EU FP7, Evaluation panel member of FET Open QNEMS., Brussels, Belgium, 1.11.2010 - 7.11.2011.

Referee:

- Nature Communications
- Microelectronic Engineering
- Physical Review B
- Physical Review Letters

Silvanto

Member of editorial board: Frontiers in Perception Science

Referee:

- Cortex
- European Journal of Neuroscience
- Experimental Brain Research
- Journal of Neuroscience
- Human Brain Mapping
- Frontiers in Psychology
- NeuroImage
- Neuropsychologia
- Perception
- PLoS ONE

Pre-examiner of a doctoral thesis: Lorena Chanes, École des Neurosciences de Paris, INSERM UMR, CNRS UMR, Paris, France, 15.12.

Todoshchenko

Referee: Journal of Physics: Conference Series

Tuoriniemi

Member of the editorial board: Cryogenics

Referee: Journal of Physics: Conference Series

Chairman of the session: THz and Nanomechanical Technologies, The 26th International Conference on Low Temperature Physics, Beijing, China, 10. - 17.8.

Reviewer of a grant application: BlueSky and Young Researchers Programmes, French National Research Agency, France (22.3.)

Interview: Tunne sää: pakastettua elämää, Yle TV1, TV, Espoo, Finland, 9.10.

Vanni

Leader position in a scientific organization: Board member, Finnish Brain Research Society, Finland, 18.3.2009–17.3.2012.

Referee:

- Human Brain Mapping
- Journal of Vision
- Journal of the Optical Society of America A
- PLoS ONE

Vartiainen Johanna

Referee:

- Brain and Language
- Journal of Cognitive Neuroscience

Vartiainen Nuutti

Referee: PLoS ONE

Volovik

Membership in distinguished societies:

- Deutsche Academie der Naturforscher Leopoldina (the German Academy of Sciences Leopoldina)
- Finnish Academy of Sciences and Letters

Editor:

- JETP Letters
- Physical Review Letters, Divisional Associate Editor

Member of the editorial board:

- JETP Letters
- Physical Review Letters

Position of trust in a scientific organization: Member, Simon Prize, Selection Committee, Institute of Physics, UK, 1.7.2010 - 31.8.2011.

Chairman of the session:

- Workshop of European Microkelvin Collaboration, Microkelvin-2011, Smolenice, Slovakia, 14. - 18.3.

- Editorial Board meetings of JETP Letters, Moscow, Russia, 21. - 21.4. and 17. - 17.11.
- Analogue Gravity, Como, Italy, 15. - 21.5.
- A.B. Migdal memorial conference «Advances in Theoretical Physics», Chernogolovka, Russia, 25. - 26.6.
- Landau Days — 2011, Chernogolovka, Russia, 27. - 29.6.
- Workshop and School on Topological Aspects of Condensed Matter Physics, Trieste, Italy, 3. - 9.7.
- 4th International Conference "Fundamental Problems of High-Temperature Superconductivity" (FPS'11), Zvenigorod, Russia, 3. - 7.10.
- 3He, Topological Materials, Grenoble, France, 25. - 28.10.

Statement for the appointment of a professor: Permanent assistant professor of physics, Universidade Estadual Paulista (Unesp), Instituto de Fisica Teorica, Sao Paulo, Brazil, 2.1.

Opponent: M.A. Zubkov, Application of nonperturbative methods to investigation of field-theoretical models of strong, electroweak and gravitational interactions, Institute for Experimental and Theoretical Physics, Moscow, Russia, 11.10.

Reviewer of a grant application: NSF, USA (9.1.)

Interview: Nashi so Lvom Novozhenovyim: Grigory Volovik & Lyudmila Kol, NTV MIR, TV, Moscow, Russia, 19.3.

PUBLICATIONS

BRAIN

1. Annanmäki T, Pohja M, Parviainen T, Hakkinen P and Murros K, Uric acid and cognition in Parkinson's disease: A follow-up study. *Parkinsonism & Related Disorders* 2011, 17: 333-337.
2. Baess P, Horváth J, Jacobsen T and Schröger E, Selective suppression of self-triggered sounds: An EEG study. *Psychophysiology* 2011, 48: 1276-1283.
3. Blasi A, Mercure E, Lloyd-Fox S, Thomson A, Brammer M, Sauter D, Deeley Q, Barker G J, Renvall V, Deoni S, Gasston D, Williams S C, Johnson M H, Simmons A, Murphy D G, Early specialization for voice and emotion processing in the infant brain. *Current Biology* 2011, 21: 1220-1224.
4. Bourguignon M, De Tiège X, Op de Beeck M, Pirotte B, Van Bogaert P, Goldman S, Hari R and Jousmäki V, Functional motor-cortex mapping using corticokinematic coherence. *NeuroImage* 2011, 55: 1475–1479.
5. Brattico E, Alluri V, Bogert B, Jacobsen T, Vartiainen N, Nieminen S and Tervaniemi M, A functional MRI study of happy and sad emotions in music with and without lyrics. *Frontiers in Psychology* 2011, 2: article 308, 1-16.
6. Calvo M G, Avero P and Nummenmaa L, Primacy of emotional vs. semantic scene recognition in peripheral vision. *Cognition & Emotion* 2011, 25: 1358-1375.
7. Calvo M G, Nummenmaa L, Time course of discrimination between emotional facial expressions: the role of visual saliency. *Vision Research* 2011, 51: 1751–1759.
8. Cattaneo Z, Fantino M, Silvanto J, Vallar G and Vecchi T, Tapping effects on numerical bisection. *Experimental Brain Research* 2011, 208: 21-28.
9. Graupner S T, Pannasch S, Velichkovsky B M, Saccadic context indicates information processing within visual fixations: Evidence from event-related potentials and eye-movements analysis of the distractor effect. *International Journal of Psychophysiology* 2011, 80: 54-62.
10. Halko M -L, Hytönen K, Poikkeavaa käyttäytymistä?In Book: . *Kansantaloudellinen aikakausikirja* 2011, 107:4: 392-401.
11. Hari R, Magnetoencephalography: Methods and applicationsIn Book: . *Niedermeyer's Electroencephalography: Basic Principles, Clinical Applications, and Related Fields.* 2011: 865–900.
12. Hari R, Book Title: Esipuhe Johannes Lehtosen kirjaan "Tietoisuuden ruumiillisuus. Mieli, aivot ja olemassaolon tunne". 2011.
13. Helenius P, Laasonen M, Hokkanen L, Paetau R and Niemivirta M, Impaired engagement of the ventral attentional pathway in ADHD. *Neuropsychologia* 2011, 49: 1889-1896.
14. Hietanen J K and Nummenmaa L, The naked truth: the face and body sensitive N170 response is enhanced for nude bodies. *PLOS ONE* 2011, 6: e24408.
15. Hiltunen J, Seppä M and Hari R, Evaluation of voxel-based group-level analysis of diffusion tensor images using simulated brain lesions. *Neuroscience Research* 2011, 71: 377-386.

16. Hirvonen J, Virtanen K A, Nummenmaa L, Hannukainen J C, Honka M J, Bucci M, Nesterov S V, Parkkola R, Rinne J, Iozzo P, Nuutila P, Effects of insulin on brain glucose metabolism in impaired glucose tolerance. *Diabetes* 2011, 60: 443-447.
17. Hultén A, Neural correlates of language learning in adultsThesis, 2011.
18. Kallio S, Hyönä J, Revonsuo A, Sikka P and Nummenmaa L, The existence of a hypnotic state revealed by eye movements. *PLOS ONE* 2011, 6: e26374.
19. Kilpeläinen M, Nurminen L, Donner K, Effects of mean luminance changes on human contrast perception: Contrast dependence, time-course and spatial specificity. *PLOS ONE* 2011, 6: e17200/1-9.
20. Klami A, Ramkumar P, Virtanen S, Parkkonen L, Hari R, Kaski S, ICANN/PASCAL2 challenge: MEG mind reading – overview and results. *Proceedings of ICANN/PASCAL2 Challenge: MEG Mind Reading, Aalto University Publication series SCIENCE + TECHNOLOGY* 2011, 29: 3-19.
21. Koivisto M, Railo H, Revonsuo A, Vanni S, Salminen-Vaparanta N, Recurrent processing in V1/V2 contributes to categorization of natural scenes. *Journal of Neuroscience* 2011, 31: 2488-2492.
22. Longcamp M, Hlushchuk Y and Hari R, What differs in visual recognition of handwritten vs. printed letters? An fMRI study. *Human Brain Mapping* 2011, 32: 1250–1259.
23. Malinen S and Hari R, Data-based functional template for sorting independent components of fMRI activity. *Neuroscience Research* 2011, 71: 369–376.
24. Nummenmaa L, Hietanen J K, Calvo M G and Hyönä J, Food catches the eye but not for everyone: a BMI-contingent attentional bias in rapid detection of nutriments. *PLOS ONE* 2011, 6: e19215.
25. Nurminen L, Peromaa T, Laurinen P, Surround suppression and facilitation in the fovea: Very long-range spatial interactions in contrast perception. *Journal of Vision* 2011, 10: 1-13.
26. Näätänen R, Kujala T, Kreegipuu K, Carlson S, Escera C, Baldeweg T and Ponton C, The mismatch negativity: An index of cognitive decline in neuropsychiatric and neurological diseases and in aging. A review. *Brain* 2011, 134: 3435-3453.
27. Op de beeck M, Legros B, Gaspard N, Bourguignon M, Jurysta F, Van Bogaert P, Goldman S, Jousmäki V, De Tiège X, Supplementary motor cortex involvement in reading epilepsy revealed by magnetic source imaging. *Epilepsia* 2011, 52: e31-34.
28. Pannasch S, Schulz J, & Velichkovsky B M, On the control of visual fixation durations in free viewing of complex images. *Attention, Perception, & Psychophysics* 2011, 73: 1120-1132.
29. Pannasch S, Selden D L, Velichkovsky B M, & Bridgeman B, Apparent phi-motion in sequences of Eisenstein's October. *Gestalt Theory* 2011, 33: 69-80.
30. Parviainen T Helenius P Poskiparta E Niemi P and Salmelin R, Speech perception in the child brain: cortical timing and its relevance to literacy acquisition. *Human Brain Mapping* 2011, 32: 1-14.
31. Pihko E, Lauronen L, Kivisto K, Nevalainen P, Increasing the efficiency of neonatal MEG measurements by alternating auditory and tactile stimulation. *Clinical Neurophysiology* 2011, 122: 808-814.
32. Pihko E, Virtanen A, Saarinen V -M, Pannasch S, Hirvenkari L, Tossavainen T, Haapala A and Hari R, Experiencing art: the influence of expertise and

painting abstraction level. *Frontiers in Human Neuroscience* 2011, Brain and Art, 5: Article 94 (10 pages).

33. Renzi C, Vecchi T, Silvanto J, Cattaneo Z, Overlapping representations of numerical magnitude and motion direction in the posterior parietal cortex: A TMS-adaptation study. *Neuroscience Letters* 2011, 490: 145-149.
34. Roiha K, Kirveskari E, Kaste M, Mustanoja S, Makela J P, Salonen O, Tatlisumak T, Forss N, Reorganization of the primary somatosensory cortex during stroke recovery. *Clinical Neurophysiology* 2011, 122: 339-345.
35. Savolainen P, Carlson S, Boldt R, Neuvonen T, Hannula H, Hiltunen J, Salonen O, Ma Y Y and Pertovaara A, Facilitation of tactile working memory by top-down suppression from prefrontal to primary somatosensory cortex during sensory interference. *Behavioral Brain Reserch* 2011, 219: 387-390.
36. Schwarzkopf D S, Silvanto J, Rees G, Stochastic resonance effects reveal the neural mechanisms of transcranial magnetic stimulation. *Journal of Neuroscience* 2011, 31: 3143-3147.
37. Schürmann M, Hlushchuk Y and Hari R, Embodied visual perception of distorted finger postures. *Human Brain Mapping* 2011, 32: 612-623.
38. Silvanto J and Rees G, What does neural plasticity tell us about role of primary visual cortex (V1) in visual awareness? *Frontiers in Psychology* 2011, 2: 6.
39. Soto D, Mäntylä T and Silvanto J, Working memory without consciousness. *Current Biology* 2011, 21: R912-913.
40. Sudre G, Parkkonen L, Bock E, Baillet S, Wang W and Weber D, rtMEG: A real-time software interface for magnetoencephalography. *Computational Intelligence and Neuroscience* 2011, 2011: 327953.
41. Tadin D, Silvanto J, Pascual-Leone A, Battelli L, Improved motion perception and impaired spatial suppression following disruption of cortical area MT/V5. *Journal of Neuroscience* 2011, 31: 1279-1283.
42. Tervaniemi M, Sannemann C, Nöyränen M, Salonen J and Pihko E, Importance of the left auditory areas in chord discrimination in music experts as evidenced by MEG. *European Journal of Neuroscience* 2011, 34: 517-523.
43. Vanni S and Rosenström T, Local non-linear interactions in the visual cortex may reflect global decorrelation. 2011, 30: 109-124.
44. Vartiainen J, Liljeström M, Koskinen M, Renvall H, Salmelin R, Functional magnetic resonance imaging blood oxygenation level-dependent signal and magnetoencephalography evoked responses yield different neural functionality in reading. *Journal of Neuroscience* 2011, 31: 1048-1058.
45. Virpioja S, Lehtonen M, Hulten A, Salmelin R and Lagus K, Artificial Neural Networks and Machine Learning - ICANN 2011. 2011, Part 1, LNCS 6791: 275-282.
46. von dem Hagen E A H, Nummenmaa L, Yu R J, Engell A D, Ewbank M P, Calder A J, Autism spectrum traits in the typical population predict structure and function in the posterior superior temporal sulcus. *Cerebral Cortex* 2011, 21: 493-500.
47. Wenke D, Atmaca S, Holländer A, Baess P, Liebelt R,and Prinz W, What is shared in joint action? Co-representation, response conflict, and agent identification. *Review of Philosophy and Psychology* 2011, 2: 147-172.

NANO

48. Alles H, Aarik J, Aidla A, Fay A, Kozlova J, Niilisk A, Pars M, Rahn M, Wiesner M, Hakonen P, Sammelselg V, Atomic layer deposition of HfO2 on graphene from HfCl4 and H2O. *Central European Journal of Physics* 2011, 9: 319-324.
49. Fay A, Danneau R, Viljas J K, Wu F, Tomi M Y, Wengler J, Wiesner M and Hakonen P J, Shot noise and conductivity at high bias in bilayer graphene: Signatures of electron-optical phonon coupling. *Physical Review B* 2011, 84: 1-7. (NANO).
50. Lechner L, Gaass M, Paila A, Sillanpaa M A, Strunk C, Hakonen P J, Microwave reflection measurement of critical currents in a nanotube Josephson transistor with a resistive environment. *NANOTECHNOLOGY* 2011, 22: 125203/1-4.
51. Sun Z X, Hamalainen S K, Sainio J, Lahtinen J, Vanmaekelbergh D, Liljeroth P, Topographic and electronic contrast of the graphene moire on Ir(111) probed by scanning tunneling microscopy and noncontact atomic force microscopy. *Physical Review B* 2011, 83: 081415/1-4.
52. Voutilainen Juha and Fay Aurelien and Häkkinen Pasi and Viljas Janne K and Tero T Heikkilä and Hakonen Pertti J, Energy relaxation in graphene and its measurement with supercurrent. *Physical Review B* 2011, 84: 045419.

NEMS

53. Massel F, Heikkilä T T, Pirkkalainen J -M Cho S U, Saloniemi H, Hakonen P J and Sillanpää M A, Microwave amplification with nanomechanical resonators. *Nature* 2011, 480: 351–354.
54. Sillanpää M A, Khan R, Heikkilä T T and Hakonen P J, Macroscopic quantum tunneling in nanoelectromechanical systems. *Physical Review B* 2011, 84: 195433.

KVANTTI

55. Kumar K S and Paraoanu G S, A quantum no-reflection theorem and the speeding up of Grover's search algorithm. *EPL* 2011, 93: 20005/1-4.
56. Li J, Paraoanu G S, Cicak K Altomare F, Park J I, Simmonds R W, Sillanpää M A and Hakonen P J, Decoherence, Autler-Townes effect, and dark states in two-tone driving of a three-level superconducting system. *Physical Review B* 2011, 84: 104527.
57. Paraoanu G S, Realism and Single-Quanta Nonlocality. *Foundations of Physics* 2011, 41: Paraoanu GS.
58. Paraoanu G S, Generalized partial measurements. *EPL* 2011, 93: 64002/1-4.
59. Paraoanu G S, Extraction of information from a single quantum. *Physical Review A* 2011, 83: 044101/1-4.
60. Paraoanu G S, Quantum Computing: Theoretical versus Practical Possibility. *Physics in Perspective* 2011, 13: 359–372.

PICO

61. Aref T, Maisi V F, Gustafsson M V, Delsing P, Pekola J P, Andreev tunneling in charge pumping with SINIS turnstiles. *EPL* 2011, 96: 37008/1-6.
62. Averin D V and Pekola J P, Statistics of the dissipated energy in driven single-electron transitions. *EPL* 2011, 96: 67004/1-5.
63. Averin Dmitri V, Möttönen Mikko and Pekola Jukka P, Maxwell's demon based on a single-electron pump. *Physical Review B* 2011, 84: 245448/1-5.
64. Chan K W, Möttönen M, Kemppinen A, Lai N S, Tan K Y, Lim W H and Dzurak A S, Single-electron shuttle in a silicon quantum dot. *Applied Physics Letters* 2011, 98: 212103/1-3.
65. Costelle L, Pirojenko A, Tuboltsev V, Savin A, Mizohata K and Räisänen J, Spin-glass magnetism of surface rich Au cluster film. *Applied Physics Letters* 2011, 99: 022503.
66. Gasparinetti S and Solinas P and Pekola J P, Geometric Landau-Zener Interferometry. *Physical Review Letters* 2011, 107: 207002.
67. Gasparinetti S, Deon F, Biasiol G, Sorba L, Beltram B and Giazotto F, Probing the local temperature of a two-dimensional electron gas microdomain with a quantum dot: Measurement of electron-phonon interaction. *Physical Review B* 2011, 83: 201306/1-4.
68. Gramich V, Solinas P, Möttönen M, Pekola J P and Ankerhold J, Measurement scheme for the Lamb shift in a superconducting circuit with broadband environment. *Physical Review B* 2011, 84: 052103/1-7.
69. Kamleitner I, Solinas P, Müller C, Shnirman A and Möttönen M, Geometric quantum gates with superconducting qubits (VA: T311 20% ja VA: 304 80%). *Physical Review B* 2011, 83: 214518/1-6.
70. Kemppinen A, Lotkhov S V, Saira O -P, Zorin A B, Pekola J P, Manninen A J, Long hold times in a two-junction electron trap. *Applied Physics Letters* 2011, 99: 142106/1-3.
71. Koski J V, Peltonen J T, Meschke M and Pekola J P, Laterally proximized aluminum tunnel junctions. *Applied Physics Letters* 2011, 98: 203501/1-3.
72. Kuopanportti P, Huhtamäki J A M, Möttönen M, Size and dynamics of vortex dipoles in dilute Bose-Einstein condensates. *Physical Review A* 2011, 83: 011603/1-4 (R).
73. Lotkhov S V, Saira O P, Pekola J P, Zorin A B, Single-charge escape processes through a hybrid turnstile in a dissipative environment. *New Journal of Physics* 2011, 13: 013040/1-14.
74. Maisi V F, Saira O -P, Pashkin Yu A, Tsai J S, Averin D V and Pekola J P, Real-Time Observation of Discrete Andreev Tunneling Events. *Physical Review Letters* 2011, 106: 217003/1-4.
75. Matsuzaki Y, Solinas P, Möttönen M, Entanglement generation between unstable optically active qubits without photodetectors. *Physical Review A* 2011, 84: 032338/1-5.
76. Meschke M, Engert J, Heyer D, Pekola J P, Comparison of Coulomb Blockade Thermometers with the International Temperature Scale PLTS-2000. *International Journal of Thermophysics* 2011, 32: 1378-1386.
77. Meschke M, Peltonen J T, Pekola J P, Giazotto F, Tunnel spectroscopy of a proximity Josephson junction. *Physical Review B* 2011, 84: 214514/1-5.

78. Muhonen J T, Prest M J, Prunnila M, Gunnarsson D, Shah V A, Dobbie A, Myronov M, Morris R J H, Whall T E, Parker E H C and Leadley D R, Strain dependence of electron-phonon energy loss rate in many-valley semiconductors. *Applied Physics Letters* 2011, 98: 182103.
79. Peltonen J, Fluctuations, relaxation and proximity effect in superconducting circuitsThesis. *Low Temperature Laboratory* 2011: 207.
80. Peltonen J T, Helle M, Timofeev A V, Solinas P, Hekking F W, Pekola J P, Brownian refrigeration by hybrid tunnel junctions. *Physical Review B* 2011, 84: 144505/1-14.
81. Peltonen J T, Muhonen J T, Meschke M, Kopnin N B and Pekola J P, Magnetic-field-induced stabilization of nonequilibrium superconductivity in a normal-metal/insulator/superconductor junction. *Physical Review B* 2011, 84: 220502.
82. Pietilä V and Möttönen M, Phase transitions in dipolar spin-1 Bose gases. *Physical Review A* 2011, 84: 013605/1-13.
83. Prest M J, Muhonen J T, Prunnila M, Gunnarsson D, Shah V A, Richardson-Bullock J S, Dobbie A, Myronov M, Morris R J H, Whall T E, Parker E H C and Leadley D R, Strain enhanced electron cooling in a degenerately doped semiconductor. *Applied Physics Letters* 2011, 99: 251908.
84. Ruokokoski E, Pietilä V and Möttönen M, Ground-state Dirac monopole. *Physical Review A* 2011, 84: 063627/1-5.
85. Salmilehto J and Möttönen M, Superadiabatic theory for Cooper pair pumping under decoherence. *Physical Review B* 2011, 84: 174507/1-11.
86. Satrapinski A, Hahtela O, Savin A M, Novikov S and Lebedeva N, Temperature dependence of Pd thin film cryo resistors. *IEEE Transactions on Instrumentation and Measurement* 2011, 60: 2469-2473.
87. Tuboltsev V, Savin A, Sakamoto W, Hieno A, Yogo T, Raisanen J, Spin-glass behavior of nanocrystalline multiferroic bismuth ferrite lead titanate. *Journal of Materials Chemistry* 2011, 21: 781-788.
88. Tuboltsev V, Savin A, Sakamoto W, Hieno A, Yogo T and Räisänen J, Nanomagnetism in nanocrystalline multiferroic bismuth ferrite lead titanate films. *Journal of Nanoparticle Research* 2011, 11: 5603-5613.
89. Vercruyssen N, Barends R, Klapwijk T M, Muhonen J T, Meschke M and Pekola J P, Substrate-dependent quasiparticle recombination time in superconducting resonators. *Applied Physics Letters* 2011, 99: 062509.
90. Yoon Y, Gasparinetti S, Möttönen M and Pekola J P, Capacitively Enhanced Thermal Escape in Underdamped Josephson Junctions. *Journal of Low Temperature Physics* 2011, 163: 164-169.

ROTA

91. de Graaf R, Eltsov V B, Heikkinen P J, Hosio J J, Krusius M, Textures of Superfluid He-3-B in Applied Flow and Comparison with Hydrostatic Theory. *Journal of Low Temperature Physics* 2011, 163: 238-261.
92. de Graaf R J, Dynamics of quantized vortices in applied flow in superfluid 3He-BThesis, 2011.
93. Eltsov V B, de Graaf R, Krusius M and Zmeev D E, Vortex core contribution to textural energy in 3He-B below 0.4 Tc. *Journal of Low Temperature Physics* 2011, 162: 212-225.

94. Heikkinen P J, Bunkov Yu M, Eltsov V B, de Graaf R, Hosio J J, Hunger P, Krusius M and Volovik G E, Magnon condensation and its application to studies of vortices in 3He-B. *Proceedings of the XLV Annual Conference of the Finnish Physical Society and the Second Nordic Physics Meeting* 2011: 382.
95. Hosio J, Eltsov V B de Graaf R and Krusius M, Thermal detection of laminar and turbulent dissipation in vortex motion in superfluid 3He-B at ultralow temperatures. *Proceedings of the XLV Annual Conference of the Finnish Physical Society and the Second Nordic Physics Meeting* 2011: 83.
96. Hosio J J, Eltsov V B, de Graaf R, Heikkinen P J, Hänninen R, Krusius M, L'vov V S and Volovik G E, Superfluid Vortex Front at T -> 0: Decoupling from the Reference Frame. *Physical Review Letters* 2011, 107: 135302/1-4.
97. Hosio J J, Eltsov V B, de Graaf R, Mäkinen J, Krusius M and Schmoranzer D, Propagation of thermal excitations in a cluster of vortices in superfluid 3He-B. *Physical Review B* 2011, 84: 224501/1-6.
98. Mäkinen J T, Eltsov V B, de Graaf R, Hosio J and Krusius M, Simulation of ballistic quasiparticle transport in rotating superfluid 3He-B. *Proceedings of the XLV Annual Conference of the Finnish Physical Society and the Second Nordic Physics Meeting* 2011, 1: 241.
99. Walmsley P M, Eltsov V B, Heikkinen P J, Hosio J J Hänninen R and Krusius M, Turbulent vortex flow responses at the AB interface in rotating superfluid 3He-B. *Physical Review B* 2011, 84: 184532/1-7.

THEORY

100. Pauly F, Viljas J K, Burkle M, Dreher M, Nielaba P and Cuevas J C, Molecular dynamics study of the thermopower of Ag, Au, and Pt nanocontacts. *Physical Review B* 2011, 84: 195420.
101. Barbado L C, Barceló C, Garay L J and Jannes G, The trans-Planckian problem as a guiding principle. *Journal of High Energy Physics* 2011, 11: 112.
102. Barceló C, Garay L J and Jannes G, Quantum Non-Gravity and Stellar Collapse. *Foundations of Physics* 2011, 41: 1532-1541.
103. Bergeret F S and Virtanen P and Ozaeta A and Heikkilä T T and Cuevas J C, Supercurrent and Andreev bound state dynamics in superconducting quantum point contacts under microwave irradiation. *Physical Review B* 2011, 84: 054504.
104. Chiodi F, Ferrier M, Tikhonov K, Virtanen P, Heikkilä T T, Feigelman M, Guéron S and Bouchiat H, Probing the dynamics of Andreev states in a coherent Normal/Superconducting ring. *Scientific Reports* 2011, 1: 3.
105. Heikkilä T T and Volovik G E, Dimensional crossover in topological matter: Evolution of the multiple Dirac point in the layered system to the flat band on the surface. *JETP Letters* 2011, 93: 59-65.
106. Heikkilä T T, Kopnin N B and Volovik G E, Flat bands in topological media. *Pis'ma v Zhurnal Éksperimental'noi i Teoreticheskoi Fiziki (JETP Letters)* 2011, 94: 252.
107. Hänninen R and Schoepe W, Dynamical scaling of the critical velocity for the onset of turbulence in oscillatory superflows. *Journal of Low Temperature Physics* 2011, 164: 1-4.
108. Jannes G, Hawking radiation, *JETP Letters 2011, 94: 18-21.*

109. Jannes G, Maïssa P, Philbin T G and Rousseaux G, Hawking radiation and the boomerang behaviour of massive modes near a horizon. *Physical Review D* 2011, 83: 104028.
110. Kajala J, Massel F and Törmä P, Expansion dynamics of the Fulde-Ferrell-Larkin-Ovchinnikov state. *Physical Review A* 2011, 84: 041601.
111. Kajala J, Massel F and Törmä P, Expansion Dynamics in the One-Dimensional Fermi-Hubbard Model. *Physical Review Letters* 2011, 106: 206401.
112. Kajala J, Massel F and Törmä P, Collision of one dimensional (1D) spin polarized Fermi gases in an optical lattice. *European Physical Journal-Special Topics* 2011: 1-8.
113. Klinkhamer F R and Volovik G E, Dynamics of the quantum vacuum: Cosmology as relaxation to the equilibrium state. *Journal of Physics: Conference Series* 2011, 314: 012004.
114. Klinkhamer F R and Volovik G E, Superluminal neutrino and spontaneous breaking of Lorentz invariance. *JETP Letters/Pis'ma v Zhurnal Éksperimetal'noi i Teoreticheskoi Fiziki* 2011, 94: 731-733.
115. Kopnin N B and Heikkilä T T and Volovik G E, High-temperature surface superconductivity in topological flat-band systems. *Physical Review B* 2011, 83: 220503(R).
116. Ojanen T, Topologiset materiaalit - kiinteän aineen uudet eksoottiset olomuodot. *Arkhimedes* 2011: 5, 15.
117. Ruokola T and Ojanen T, Thermal conductance in a spin-boson model: Cotunneling and low-temperature properties. *Physical Review B* 2011, 83: 045417/1-6.
118. Viljas J K and Fay A and Wiesner M and Hakonen P J, Self heating and nonlinear current-voltage characteristics in bilayer graphene. *Physical Review B* 2011, 83: 205421.
119. Virtanen P, Bergeret F S, Cuevas J C and Heikkilä T T, Linear AC response of diffusive SNS junctions. *Physical Review B* 2011, 83: 144514.
120. Volovik G E, Flat band in the core of topological defects: Bulk-vortex correspondence in topological superfluids with Fermi points. *JETP Letters* 2011, 93: 66-69.
121. Väyrynen J I and Ojanen T, Electrical manipulation and measurement of spin properties of quantum spin Hall edge states. *Physical Review Letters* 2011, 106: 076803.
122. Väyrynen J I and Ojanen T, Chiral topological phases and fractional domain wall excitations in one-dimensional chains and wires. *Physical Review Letters* 2011, 107: 166804.
123. Väyrynen J I and Volovik G E, Soft topological objects in topological media. *JETP Letters* 2011, 93: 344-348.

μKI

124. Pentti E, Rysti J, Salmela A, Sebedash A and Tuoriniemi J, Studies on Helium Liquids by Vibrating Wires and Quartz Tuning Forks. *Journal of Low Temperature Physics* 2011, 165: 132-165.

125. Rysti J, Tuoriniemi J, Sebedash A, Salmela A, Search for Superfluidity in 3He-4He Mixtures. *Proceedings of the XLV Annual Conference of the Finnish Physical Society and the Second Nordic Physics Meeting* 2011: 84.
126. Salmela A, Sebedash A, Rysti J, Pentti E, Tuoriniemi J, Osmotic pressure of He-3/He-4 mixtures at the crystallization pressure and at millikelvin temperatures. *Physical Review B* 2011, 83: 134510/1-8.
127. Salmela A, Tuoriniemi J and Rysti J, Acoustic Resonances in Helium Fluids Excited by Quartz Tuning Forks. *Journal of Low Temperature Physics* 2011, 162: 678-685.
128. Todoshchenko I A Manninen M S and Parshin A Ya, Anisotropy of c facets of 4He crystal. *Physical Review B* 2011, 84: 075132.