ANNUAL REPORT 2001

LOW TEMPERATURE LABORATORY (LTL)

PREFACE

Besides carefully selected scientific problems, good experimental equipment is important for the success of our laboratory. During the last five years, we have completed an intensive investment programme in research infrastructure. The Brain Research Unit has received a larger magnetically shielded room and a new 306-channel neuromagnetometer. The construction of the Advanced Magnetic Imaging (AMI) Center, initiated in 1997 and housing a 3-Tesla magnet for functional magnetic resonance imaging (fMRI), was completed in December, 2001. The Center, jointly operated by the LTL and the Department of Electrical Engineering, will be inaugurated in February 2002. In year 2001, the Nanophysics group, started in 1996 in an empty laboratory space, obtained access to its own cleanroom on the premises of the laboratory. The group has also successfully commissioned a new, fast turn-around dilution refrigerator. The investment program will never be completely finished in an experimental laboratory like LTL. However, the time has come to invest more in the personnel.

The investments in the Brain Research Unit have resulted in the growth of its personnel in our laboratory. Brain research and related activities have also emerged in other laboratories of our university. In order to strengthen this research area on the HUT campus, an institute called HUT Centrum for Neurosystems (NeuroHUT) was founded in year 1999. The idea of the institute was fathered by Academician Olli Lounasmaa in 1997. Riitta Hari has taken an active part in starting the Institute by organizing the 1st NeuroHUT seminar in August 2001. The BRU comprises today about half of our research activities. In order to reflect the multidisciplinary research profile of our laboratory, we have renamed it in the Center of Excellence Program of Academy of Finland. The new official name is Low Temperature Laboratory: Physics and Brain Research Units.

In year 2001, the scientists of the LTL have organized three scientific meetings and one winter school. Riitta Hari and the BRU organized in September 14 - 16 a Symposium “Present and Future of MEG” within the EU-sponsored Large Scale Facility Program NeuroBIRCH III. Altogether 64 scientists from 9 countries participated in this Symposium. Mikko Paalanen and Juha Tuoriniemi organized a Symposium “Ultra Low Energy Physics: Methods and Phenomenology”. It was held in January 10 - 14, 2001 and attracted 85 scientists from 11 countries. It was the third symposium in a series of meetings sponsored by ULTI I, II and III, the three consecutive European Union sponsored visitors program in physics. Pertti Hakonen co-organized a winterschool in Nanophysics in Kevo, Lapland. The school had 28 participants from 7 countries. Finally, a small symposium was organized on September 10th to honor Grigory Volovik’s contributions in theoretical physics. Several old friends were invited to share their memories about Grisha and his 25 years in science. I would like to express my sincere thanks to all those, who contributed to the success of the symposia and winter school.

Several scientists of the LTL received honors or promotions during the year. Riitta Hari was awarded the Matti Äyräpää Prize for medical excellence by the Finnish Medical Society Duodecim. Pertti Hakonen and Grigory Volovik were elected to the Finnish Academy of Sciences and Letters, Pertti as an ordinary member and Grigory as a foreign member. Mikko Paalanen was granted the Knight, First Class, of the Order of White Rose of Finland. Erkki Thuneberg was elected to the theoretical physics professorship in University of Oulu. After his promotion to the professorship, Erkki also received the annual Väisälä Prize in Physics, largely on the work done in our laboratory. Juha Tuoriniemi became a docent of magnetism in the Department of Engineering Physics and Mathematics of HUT. The whole laboratory is happy and proud about these achievements.

Mikko Paalanen

Director of the LTL

SCIENTIFIC ADVISORY BOARD

The Scientific Advisory Board has the following members:

Prof. Fernando Lopes da Silva	University of Amsterdam, The Netherlands
Prof. Michael Merzenich	University of California, San Fransisco, USA
Prof. Hans Mooij	Delft University of Technology, The Netherlands
Prof. Yrjö Neuvo	Nokia Ltd, Helsinki, Finland
Prof. Douglas Osheroff (chairman)	Stanford University, California, USA
Prof. Hans Ott	ETH, Zürich, Switzerland
Prof. Stig Stenholm	Royal Institute of Technology, Stockholm, Sweden
Prof. Semir Zeki	University College London, UK

PERSONALIA

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

SENIOR RESEARCHERS

Mikko Paalanen, Dr. Tech., Prof., Director of the LTL
Riitta Hari, M.D., Ph.D., Academy Professor, Head of the Brain Research Unit
Peter Berglund, Dr. Tech., Docent, Technical Manager
Markus Ahlskog, Dr. Tech.
Harry Alles, Dr. Tech.
Julien Delahaye, Ph.D., from May 2
Vladimir Eltsov, Ph.D.
Nina Forss, M.D., Ph.D., Docent, on leave starting from Apr 20
Pertti Hakonen, Dr. Tech., Professor
Päivi Helenius, Dr. Psych.
Matti Hämäläinen, Dr. Tech., Docent, on leave starting from Feb 1
Ole Jensen, Ph.D.
Veikko Jousmäki, Ph.D.
Kirsi Juottonen, M.D., Ph.D., until Apr 30
Tauno Knuuttila, Dr. Tech., until Aug 31
Jaakko Koivuniemi, Dr. Tech., on leave
Nikolai Kopnin, Prof.
Matti Krusius, Dr. Tech., Academy Professor
Olli Lounasmaa, Ph.D., Academician
Jyrki Mäkelä, M.D., Ph.D. Apr 1 – Nov 30
Jussi Numminen, M.D., Ph.D.
Juha Päällysaho, Ph.D.
Markku Sainio, M.D., Ph.D., until Jun 30

Stephan Salenius, M.D., Ph.D., from Apr 30
Riitta Salmelin, Dr. Tech., Docent
Alexander Sebedash, Ph.D.
Erkki Thuneberg, Dr. Tech., Docent, until Jun 30
Igor Todoschenko, Ph.D.
Juha Tuoriniemi, Dr. Tech., Docent
Minna Vihla, M.D., Ph.D.
Grigori Volovik, Ph.D., Visiting Professor

GRADUATE STUDENTS (SUPERVISORS)

Sari Avikainen, M.D.
(Riitta Hari)

Antti Finne, M.Sc. Tech., from 24.7.
(Matti Krusius)

Kirsi Juntunen, M.Sc. Tech.
(Juha Tuoriniemi)

Katri Kiviniemi, M.D., until 5.9.
(Riitta Salmelin)

Jan Kujala, M.Sc.Tech.
(Riitta Salmelin)

Juha Martikainen, M.Sc. Tech.
(Juha Tuoriniemi)

Jari Penttilä, M.Sc. Tech., until 31.3.
(Pertti Hakonen)

Tuukka Raij, M.D., from 1.4.
(Riitta Hari)

Jaakko Ruohio, M.Sc. Tech., until 30.6.
(Matti Krusius)

Mika Seppä, M.Sc. Tech.
(Matti Hämäläinen)

Mika Sillanpää, M.Sc. Tech.
(Pertti Hakonen)

Topi Tanskanen, M.Sc. Psych.
(Riitta Hari)

Reeta Tarkiainen, M.Sc. Tech.
(Pertti Hakonen)

Kimmo Uutela, M.Sc. Tech., until 30.11.
(Matti Hämäläinen)

Tiina Vuorinen, M.Sc. Tech.
(Päivi Helenius, Riitta Salmelin)

Rob Blaauwgeers, M.Sc.
(Matti Krusius)

Risto Hänninen, M.Sc. Tech.
(Erkki Thuneberg)

Juha Järveläinen, M.D.
(Riitta Hari)

Juha Kopu, M.Sc. Tech., until 30.9.
(Erkki Thuneberg)

René Lindell, M.Sc. Tech.
(Pertti Hakonen)

Lauri Parkkonen, M.Sc. Tech.
(Matti Hämäläinen)

Marjatta Pohja, M.D.
(Stephan Salenius, Riitta Hari)

Leif Roschier, M.Sc. Tech
(Pertti Hakonen)

Roch Schanen, M. Sc., until 31.1.
(Matti Krusius)

Teija Silen, M.D.
(Nina Forss, Riitta Hari)

Cristina Simões, M.Sc. Tech.
(Riitta Hari)

Antti Tarkiainen, M.Sc. Tech.
(Riitta Salmelin)

Viktor Tsepelin, M.Sc., until 9.9.
(Alexei Babkin, Harry Alles)

Janne Viljas, M.Sc. Tech.
(Erkki Thuneberg)

UNDERGRADUATE STUDENTS

Janne Antson
Sakari Arvela
Samuel Aulanko
Samuli Hakala
Pekka Huhtala
Maria Husberg
Heikki Junes
Hannu Laaksonen
Reetta Lehtonen
Sasu Liuhanen
Elias Pentti
Hanna Renvall
Timo Saarinen
Anssi Salmela
Linda Stenbacka
Johanna Uusvuori
Nuutti Vartiainen
Vesa Vaskelainen

ADMINISTRATION AND TECHNICAL PERSONNEL

Marja Holmström, laboratory administrator
Teija Halme, secretary
Antti Huvila, technician
Mia Illman, laboratory assistant
Arvi Isomäki, technician
Juhani Kaasinen, technician
Pirjo Kinanen, financial secretary
Tuire Koivisto, secretary
Markku Korhonen, technician
Sami Lehtovuori, technician
Satu - Anniina Pakarinen, project secretary
Liisi Pasanen, secretary
Kari Rauhanen, technician
Antero Salminen, technician
Ronny Schreiber, technician

VISITORS FOR EU PROJECTS

NEURO - BIRCH III (BRAIN RESEARCH)

Alary, Flamine, Dr.	INSERM Toulouse, France, 1.1. - 31.3.
Bailey, Anthony, Dr.	Insitute of Psychiatry, MRC Child Psychiatry Unit, London, UK, 2.3. - 13.3.
Baillet, Sylvain, Dr.	Cognitive Neuroscience & Brain Imaging Laboratory, Hopital de la Salpêtrière, Paris, France, 19.9.
Braeutigam, Sven, Dr.	The Open University, Milton Keynes, UK, 2.3. - 6.3., 21.11. - 25.11.
Brovelli, Andrea, M.Sc.	SISSA-ISAS, Trieste, Italy, 14.9. - 28.9.
Classen, Joseph, Dr.	University of Rostock, Neurology, Rostock, Germany, 29.10. - 3.11.
Curio, Gabriel, Dr.	Benjamin Franklin Clinic, Department of Neurology, Berlin, Germany, 10.9. - 14.9.
Montez, Teresa, M.Sc.	IBEB - FCUL, Department of Physics, Lisboa, Portugal, 23.10. - 31.12.
Schürmann, Martin, Dr.	Institut für Physiologie, Medizinische Universität zu Lübeck, Germany, 5.3. - 4.6.
Stemmer, Brigitte, Dr.	Kliniken Schmieder und Lurija Institut, Allensbach, Germany,

	6.2. - 2.3.
Swithenby, Stephen, Prof.	The Open University, Milton Keynes, UK, 22.11. - 25.11.
Wallace, Simon, Mr.	Insitute of Psychiatry, MRC Child Psychiatry Unit, London, UK, 9.3. - 13.3.

ULTI III (LOW TEMPERATURE PHYSICS)

Balibar, Sebastien, Prof.	ENS, Paris, France, 6.6. - 10.6.
Eska, Georg, Prof.	University of Bayreuth, Germany, 25.5. - 6.6.
Haley, Richard, Dr.	Lancaster University, Physics Department, Lancaster, UK, 30.4 - 7.7.
Hekking, Frank, Prof.	CRTBT/CNRS, France, 19.4. - 22.4.
Jochemsen, Reyer, Dr.	Leiden University, Kammerligh Onnes Laboratory, Leiden, The Netherlands, 6.6. - 16.6.
Kibble, Tom, Prof.	Imperial College London, UK, 8.9. - 10.9.
Mineev, Vladimir, Prof.	CEA, DRFMC/SPSMS, Grenoble, France, 8.6. - 10.6., 8.9. - 11.9.
Pickett, George, Prof.	Lancaster University, Department of Physics, UK, 6.6. - 15.6.
Rasmussen, Finn, Prof.	Niels Bohr Institute, Oersted Laboratory, Copenhagen, Denmark, 4.1. - 14.1.
Schakel, Adriaan, Dr.	Freie Universität Berlin, Germany, 1.11. - 31.12.
Schoepe, Wilfried, Prof.	Institut für Experimentelle und Angewandte Physik, Bayreuth, Germany, 14.11. - 18.11.
Skrbek, Ladislav, Dr.	Institute of Physics ASCR, Prague, Czech Republic, 24.4. - 24.7.
Sonin, Edouard, Prof.	Hebrew University of Jerusalem, Israel, 2.2. - 5.3., 10.8. - 10.10.
Wilhelm, Frank, Dr.	LS von Delft, Sektion Physik, Ludwig-Maximilians-Universität München, Germany, 10.9. - 14.9.
Zaikin, Andrei, Dr.	Forschungszentrum Karlsruhe, Institut für Nanotechnologie, Germany, 18.4. - 22.4., 1.8. - 7.8., 10.9. - 14.9.

OTHER VISITORS

Adams, Philip, Prof.	Louisiana State University, Baton Rouge, Louisiana, USA, 7.8. - 8.8.
Alary, Flamine, Dr.	INSERM Toulouse, France, 1.4. - 30.9.
Boldarev, Sergei, Dr.	P.L. Kapitza Institute for Physical Problems, Moscow, Russia, 27.2. - 2.6.
Chapellier, Maurice, Prof.	ENS, Paris, France, 28.8.
Fogelström, Mikael, Dr.	Institute for Theoretical Physics, Chalmers and Göteborg University, Gothenburg, Sweden, 10.8.
Fujiki, Nobuya, Dr.	Kyoto University, Graduate School of Medicine, Japan, 1.1. - 8.8.
Gloos, Kurt, Dr.	University of Jyväskylä, Physics Department, Finland, 4.9.
Gross, Joachim, M.Sc.	Heinrich-Heine-University, Department of Neurology, Germany, 16.6. - 20.6., 7.8. - 14.8., 10.9. - 14.9.

Gurevich, Vadim, Dr.	Ioffe Institute, Zelenogorsk, Russia, 19.10.
Hatakenaka, Noriyuki, Prof.	NTT Basic Research Laboratories, Materials Science Laboratory, Kanagawa, Japan, 1.4. - 26.9.
Haviland, David, Prof.	The Royal Institute of Technology, Stockholm, Sweden, 7.4.
Haxby, James, Dr.	Laboratory of Brain and Cognition, National Institute of Methal Health, Bethesda, Maryland, USA, 15.2.
Inagaki, Katsuhiko, Dr.	Hokkaido University, Department of Applied Physics, Kita-ku, Japan, 24.9. - 26.10.
Ishii, Hiroumi, Prof.	Osaka City University, Sumigoshiku, Japan, 26.9. - 28.9.
Kakigi, Ryusuke, Prof.	Department of Integrative Physiology, National Institute for Physiological Sciences, Okazaki, Japan, 10.8.
Kaneko, Ken-ichi, Dr.	Kyoto University, Otolaryngology-Head and Neck Surgery, Sakyoku, Japan, 16.7. - 31.12.
Lisman, John, Prof.	Brandeis University, Waltham, Massachusetts, USA, 18.3. - 20.3.
Movsesyan, Grigor, Mr.	Yerevan Physics Institute, Armenia, 17.3. - 14.6.
Nishida, Munehiro, M.Sc.Tech.	Waseda University, Shinjuku-ku, Japan, 9.7. - 13.9.
Parpia, Jeevak, Prof.	Cornell University, Ithaca, New York , USA, 3.4. - 8.4.
Parshin, Alexander, Prof.	Kapitza Institute for Physical Problems, Moscow, Russia, 8.4. - 29.4., 5.6. - 12.6.
Pugh, Kenneth, Dr.	Department of Pediatrics, Yale University School of Medicine, New Haven, Connecticut, USA, 5.2.
Schnitzler, Alfons, Dr.	Heinrich-Heine University, Düsseldorf, Germany, 11.8. - 14.8.
Schürmann, Martin, Dr.	Institut für Physiologie, Medizinische Universität zu Lübeck, Germany, 5.6. - 31.12.
Singer, Wolf, Prof.	Max-Planck-Institut für Hirnforschung, München, Germany, 18.3. - 19.3.
Spivak, Boris, Prof.	University of Washington, Physics Department, Seattle, Washington , USA, 14.6. - 16.6.
Sveningsson, Martin, M.Sc.	Chalmers University of Technology, Gothenburg, Sweden, 3.9. - 9.9.
Takeuchi, Fumiya, Dr. Tech.	Hokkaido University, Research Institute for Electronic Science, Kita-ku, Japan, 3.1. - 2.3.
Tanda, Satoshi, Prof.	Hokkaido University, Applied Physics, Sapporo, Japan, 28.5. - 31.7.
Vachaspati, Tanmay, Prof.	Case Western Reserve University, Cleveland, Ohio, USA, 28.9. - 29.9.
Yanashita, Hidehisa, Dr.	Hiroshima, Japan, 12.3.
Zakharchenya, Boris, Dr.	Ioffe Physical-Technical Institute, Zelenogorsk, Russia, 31.10.
Ziouzine, Alexandre, Dr	Ioffe Physical-Technical Institute, St Petersburg, Russia, 22.10. - 3.11.

LOW TEMPERATURE PHYSICS RESEARCH

NANOPHYSICS RESEARCH

M. Ahlskog, J. Delahaye, **P. Hakonen**, R. Lindell, M. Paalanen, J. Penttilä, L. Roschier, M. Sillanpää, E. Sonin (v), S. Tanda (v), R. Tarkiainen

Our work in mesoscopic physics concentrates on studies of ballistic and diffusive phase-coherent electron motion supplemented by the competition between Coulomb and superconducting correlations. Approximately 2/3 of our experimental investigations are carried out on aluminum based Josephson junction nanocircuits while the remaining 1/3 deals with carbon nanotubes.

SINGLE JOSEPHSON JUNCTIONS

Macroscopic quantum phenomena are very intricate in single Josephson junctions. By varying Ohmic dissipation, a Josephson junction can be driven across a superconductor/insulator (SI) transition. In our earlier experiments we investigated this transition as a function of E_J/E_C, the ratio of Josephson coupling and Coulomb blockade energy, when the shunt resistance became smaller than about 6.5 kΩ. During the past year, we have extended these studies to deal with the influence of shot noise on the band structure. We find a strong influence by the shot noise: the Coulomb blockade in the Josephson junction is washed away. This topic is important for the understanding of dephasing in charge qubits since, ultimately, shot noise is the only unavoidable low-frequency decoherence mechanism at low temperatures.

BLOCH OSCILLATING TRANSISTOR

One candidate for a quantum non-demolition (QND) read-out device for a charge qubit is the so called Bloch oscillating transistor (BOT). A BOT is a new type of a mesoscopic transistor (three terminal device) in which a large supercurrent is controlled by a small quasiparticle current. The operating principle of a BOT utilizes the fact that, Zener tunneling up to a higher band will lead to blockade of Cooper-pair tunneling (Bloch oscillation) in a suitably biased Josephson junction. Bloch oscillation is resumed only after the junction has relaxed to the lowest band. Using a quasiparticle control current, this process can be made faster. Since, one quasiparticle triggers several cycles of Bloch oscillations, a high current gain can be achieved.

We have investigated the simplest version of the BOT in which the base electrode is connected via an SN junction, the collector has a Cr-resistance of 50 kΩ, and on the emitter there is a Josephson junction with $E_J/E_C \sim 1$. In our first experiments we have obtained a current gain of three but we expect that values around ten can be achieved. If gain >~ 10 is realized in practice then it will be rather straight forward to build a SQUID buffer to implement a pulse amplifier for QND experiments.

SPECTROSCOPY USING INELASTIC COOPER-PAIR TUNNELING

For the energy level spectroscopy, we have developed a new type of detector which is based on inelastic Cooper pair tunneling in a mesoscopic superconducting junction. According to the phase fluctuation theory, non-coherent Cooper pair tunneling is allowed only if energy is exchanged with the surroundings. Thus, inelastic Cooper pair tunneling can be employed to study environmental modes, including transitions between energy levels of anharmonic oscillators.

We have employed Cooper-pair spectroscopy to study fundamental details of the quantum mechanical band picture of a Josephson junction. We have scanned various SQUID-loop configurations that allow for tuning of the Josephson energy by magnetic flux. Energy levels of such tunable junctions as well as their band widths have been determined. Our results can be well described by the relevant Schrödinger equation, i.e. the Mathieu equation, which shows how a Josephson junction evolves from a single harmonic oscillator in the classical limit into a periodic system with energy bands as the Josephson energy is tuned. A more careful theoretical understanding is under development in collaboration with Jens Siewert (Regensburg) and Erkki Thuneberg (Oulu).

READ-OUT CIRCUITRY FOR CHARGE QUBITS AND QUANTUM MEASUREMENTS

Quantum measurements and single shot read-out of charge qubits require shot-noise-limited SET performance. In order to meet this requirement, modeling of rf-SET operation has been continued in collaboration with the group of Robert Schoelkopf at Yale and the group of Per Delsing at Chalmers. The influence of matching between the high-impedance SET and the low-impedance first-stage HEMT has been investigated in detail. Using noise power wave formalism, a realistic analysis of the SET + HEMT system has been performed.

The best, cooled HEMT amplifiers that are commercially available nowadays have noise temperatures on the order of 2 K. As a second stage amplifier in an rf-SET charge detector, these amplifiers facilitate a charge resolution of ~ $3x10^{-6}$ e/Sqrt(Hz) and a measurement band width of 10 MHz. Better devices can be built using SQUIDs as amplifiers. We made a design for such a SQUID-amplifier with 5 MHz band in collaboration with the Microsensing group of VTT Information Technology. According to simulations, the effective noise temperature of the device is on the order of 150 mK, i.e., by a factor of ten lower than in the HEMT based systems.

TRANSPORT IN CARBON NANOTUBES

The electrical properties of carbon nanotubes depend on several factors, e.g. the number of concentric layers, number of conducting channels, disorder strength, and carrier concentrations (the level of doping), which can all vary over a wide range and which all are hard to control experimentally. In order to sort out the real correlations between these various factors, clear-cut reproducible data are needed but none have been reported in the literature so far. During the past year, we have managed to obtain such data on CVD synthesized multiwalled carbon nanotubes (MWCNT).

In comparison with arc-discharge-grown nanotubes, the CVD tubes have more curvature and bends, implicating a higher density of structural defects. These defects may act as scattering centres and increase the resistance of the tubes. Due to large scattering the Luttinger liquid model is not expected to work well for MWCNTs. Hence, these tubes provide rather unique diffusive systems to study transport in one dimension, with interesting cross-overs to 0 or 2 dimensions in certain regimes of voltage and temperature.

During the year 2001, we have significantly enhanced our ability to make low resistance contacts to CVD tubes using evaporation of gold on top of the sample. We have learned to carefully oxidize our specimens at elevated temperatures, thereby removing detrimental contaminants. In addition, we have prepared CVD grown MWCNTs by RIE-etching that halved their diameter. Normally, one expects the RIE treatment to damage conducting samples and increase their resistance substantially, but in our CVD tubes this has not been observed.

Using medium quality Au-NT contacts ($R_c \sim 5$ kΩ), we have studied the tunneling density of states for CVD-grown MWCNTs. After tunneling the electron has to penetrate the Coulomb barrier, a time-dependent self energy which reduces the tunneling probability. The self-energy has maximum value right after the tunneling and decreases as soon as the electron charge is redistributed in the nanotube. Thus, the tunneling density of states is a direct measure of the field diffusion which, in turn, depends on the impedance of the nanotube. For our experimental results, a RC transmission line model gives the best agreement. The agreement persist even with the form exp(-sqrt(V0/V)) calculated recently by Rollbühler and Grabert outside the validity range of the perturbation theory.

Nanotubes with good-quality contacts ($R_c \sim 1$ kΩ) yielded rather similar results. Hence, the bare resistance of the CVD-tubes (30 kΩ/μm) was also found to contain rather large corrections which now have to be connected with the interaction effects. At low temperatures $T = 100$ mK and at low voltages $V < 0.1$ mV, we find that our tubes act as fully zero dimensional objects, i.e., both the phase and thermal coherence lengths exceed the length of the tube. In this regime, the tube together with the contacts can be treated as a single quantum mechanical unit, comprised of a set of distinct transmission channels. This is a rather unexpected finding for heavily disordered tubes, but a good agreement is indeed found between the experimental results and the conductance corrections derived by Golubev and Zaikin for a phase-coherent conductor. In this work, we have greatly benefited from the contributions by Boris Spivak (Washington), Alexander Zaikin (Karlsruhe), and Alexander Zyuzin (Ioffe) during their visits in the LTL.

NEW FACILITIES: IN-HOUSE CLEAN ROOM AND A POWERFUL DILUTION REFRIGERATOR

The space freed from the old magnetically shielded room was converted into a small, in-house clean room of 60 m^2. The room became operational in November 2001 with all the e-beam lithography equipment. In spite of 1.5 μT_{p-p} 50 Hz noise problem, e-beam lithography has worked well in the new premises. Now, finally, all the operations of the NANO-group are concentrated under the same roof. This has enhanced our efficiency in sample fabrication substantially as well as the smoothness of information exchange within the group.

Moreover, a new powerful dilution refrigerator was received from Leiden Cryogenics in the middle of October 2001. The base temperature of the cryostat is 9 mK and the setup is equipped with a 12 Tesla magnet. After the initial cooling tests, high frequency coaxial cables working upto 26 (…40) GHz were installed on this refrigerator.

INVESTIGATIONS OF HELIUM MIXTURES AND LITHIUM METAL AT ULTRA-LOW TEMPERATURES (YKI PROJECT)

K. Juntunen, T. Knuuttila, J. Martikainen, E. Pentti, A. Salmela A. Sebedash, **J. Tuoriniemi**, J. Uusvuori.

The YKI cryostat, equipped with a Lancaster-type $^3He/^4He$-mixture cell, was kept cold constantly for almost the whole year 2001. The experiment produced excellent data about the behavior of dilute ^3He-quasiparticle gas both in the hydrodynamic and ballistic regimes by using an extremely sensitive SQUID-amplified vibrating-wire resonator. The measurements were limited to saturated-vapor pressure due to the cell filling-line problems, and data were collected at four different ^3He concentrations from 1.7 % up to the phase-separation limit of about 6.5 %. At the end of the year the cryostat was warmed and opened up in order to make changes enabling measurements at elevated pressures and at ^3He-concentrations up to 9.5 % at 1 MPa.

So far, we have made about ten successful demagnetizations with helium mixtures to below 100 μK, but no indications of the searched superfluid transition of the ^3He component have been observed. The achieved temperatures are so low that reliable direct measurement of the temperature of liquid-helium mixtures becomes practically impossible by present techniques. The model calculations of the thermal behavior of our fairly complicated experimental cell are in progress in order to help estimating the lowest attained temperature.

To further continue our $^3He/^4He$-mixture work, the preparations for an entirely new experimental approach have proceeded steadily in collaboration with Kapitza institute, Moscow. We are developing a novel method of cooling $^3He/^4He$ mixtures by adiabatic melting of solid ^4He. The method will utilize self-cooling in the liquid and so completely eliminate the enormous thermal barrier between the liquid and any external refrigerant. The cooling effect will occur due to the absorbed heat of mixing when the ^3He component will dissolve into ^4He once the ^4He crystal is allowed to melt. The copper nuclear stage of our refrigerator will be employed for pre-cooling the ^3He component below its superfluid transition temperature prior to adiabatic melting of ^4He. The experimental cell has already been designed and some essential parts have been tested at liquid-helium temperature.

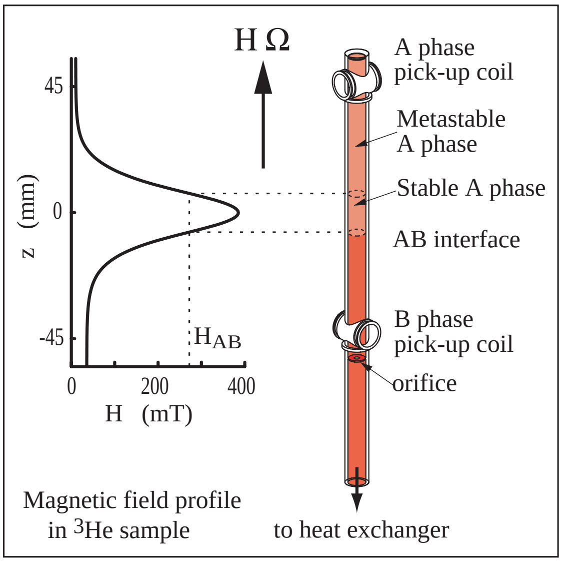
In parallel with the investigations of helium mixtures we plan to run an experiment on lithium metal. First, we shall search for its superconductivity, anticipated to occur at millikelvin regime – lithium being one of the few remaining non-superconducting non-magnetic metallic elements. In addition, lithium is an interesting nuclear magnet, and the ultimate goal is to be able to study the mutual effects arising from simultaneous superconductivity of the conduction electrons and the magnetism of the nuclear spin system. So far we have studied the problem of reliably encapsulating the reactive lithium metal while providing a sufficient thermal contact for making experiments possible even below one millikelvin.

TOPOLOGICAL OBJECTS IN QUANTUM FLUIDS (ROTA PROJECT)

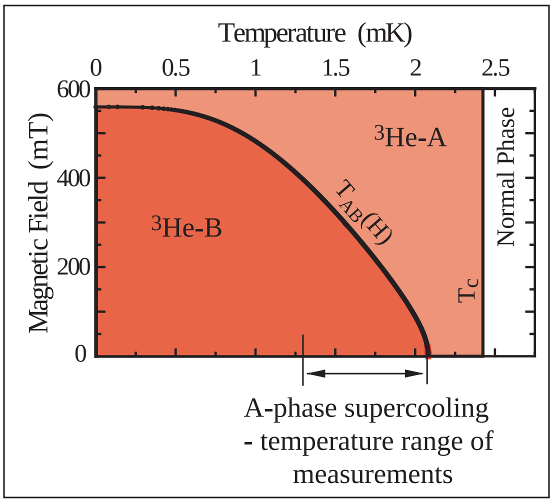
S. Arvela, R. Blaauwgeers, S. Boldarev (v), V. Eltsov, A. Finne, R. Haley (v), **M. Krusius**, G. Movsesyan (v), J. Ruohio, R. Schanen, and L. Skrbek (v)

Quantized vortex lines are well-known topologically stable linear structures in the order-parameter field of coherent macroscopic quantum systems, such as superconductors, helium superfluids, and Bose-Einstein condensates. In the quantum field of the Early Universe related linear defects may have existed, known as cosmic strings. To date the largest variety of quantized vorticity of different topology and structure has been identified in the A and B phases of superfluid helium-3. Here the study of the defects of the multi-component superfluid order-parameter field has provided a most important experimental verification of the basic principles in quantum field theory. Much of this research has been accomplished by the ROTA project.

A case in point is a new experiment which was prepared during the last two years and entered its operational phase in March 2001. In this experiment the first-order phase boundary between the A and B phases of superfluid helium-3 is magnetically stabilized to a controlled location in the sample. The measurements are performed at constant liquid pressure. Owing to supercooling of the A phase, the two-phase arrangement extends over a rather wide range in temperature. In the absence of the magnetic barrier for the AB interface, the sample can be arranged to be single phase in the same temperature regime, ie. either A or B phase. Using nuclear magnetic resonance techniques, the evolution of the quantized vorticity as a function of rotation is measured independently in the two phases. The AB interface itself is not directly monitored by this measurement, but by comparing results for single-phase and two-phase samples the interaction of the quantized vorticity with the AB interface can be determined. Such a study of a stable interface between two coherent quantum systems of different symmetry, but which are part of the same order-parameter manifold, is only possible in superfluid helium-3. The principles of the measurement setup are summarized in Fig. 1.



Experiment for stabilizing AB phase boundary



Phase diagramme of superfluid ^{3}He
at constant pressure 29.0 bar

Fig. 1. *On the right* the phase diagramme of the A and B phases of superfluid ^{3}He is shown as a function of magnetic field and temperature. *On the left* the ^{3}He sample is contained within a long smooth-walled quartz glass tube in the rotating nuclear demagnetization cryostat. The

AB interface is pushed against the magnetic barrier by cooling the sample below the A → B transition temperature.

The interest in this study rests on the large difference in the topology and structure of vortex lines in the two phases. In the B phase vortex lines are similar to the non-singular vortices in some unconventional superconductors. They have a narrow core with a radius comparable to the superfluid coherence length ($\xi \sim 10$ nm) and a single quantum of superfluid circulation trapped around the core. In the A phase the core is three orders of magnitude wider and the circulation corresponds to two quanta. For superfluid vortices it is the structural length scale of the core which determines the order of magnitude of their spontaneous critical velocity, ie. the superflow velocity required for their formation: The fat A-phase cores are easily formed at low rotation, independently of the presence of the AB boundary. In contrast the slim B-phase cores are formed in the single-phase sample only at 20 times higher rotation. Owing to a remarkable coincidence of several superfluid ^{3}He properties, in the presence of the AB interface vortex lines start to appear in the B phase section of the sample at an intermediate value of rotation which happens to be roughly by a factor of two smaller than the B phase critical velocity for the single-phase sample.

To understand this feature, we need to consider what happens at the AB phase boundary. The difference in the length scales of the vortex cores and in their circulation quanta gives rise to an energy barrier, which prevents vortex lines from crossing the AB interface. The height of the barrier decreases when the difference in the number of vortex lines in the two phases increases. Ultimately at some critical angular rotation velocity Ω_c the barrier vanishes and some vortex lines penetrate across the interface from the A-phase section to the B phase. This process occurs in sudden bursts, or instability events. The experimental signal for the events is shown in Fig. 2. We see that these bursts, where some circulation quanta from the A phase manage to break through the AB interface, consist of a small number of quanta which varies stochastically. As a function of rotation the events happen repeatedly such that the instability occurs at a constant value of superflow velocity in the B phase.

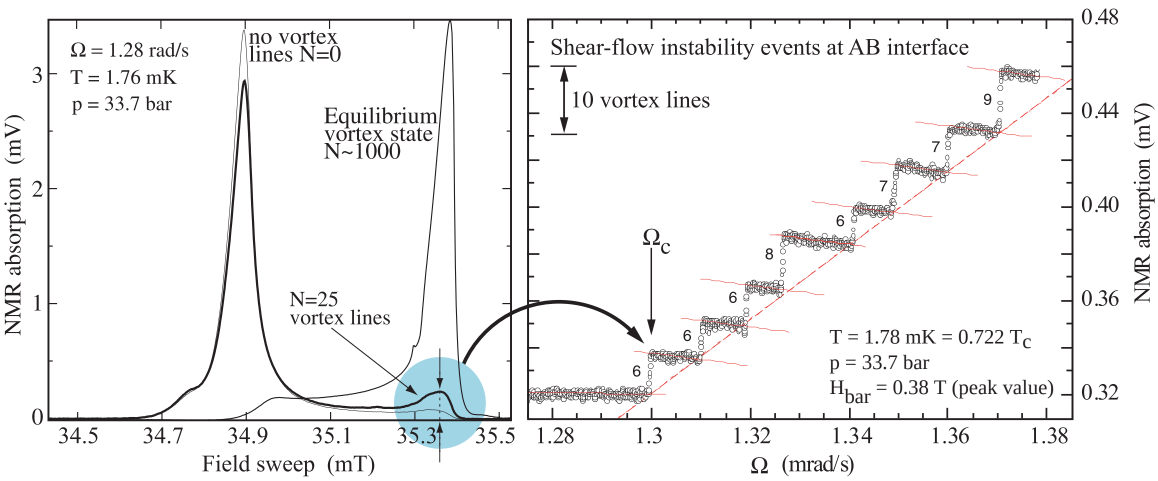


Fig. 2. *On the left* the NMR absorption spectrum of ^{3}He-B is shown as a function of the magnetic field sweep: i) equilibrium number of vortex lines (N~1000), which is the minimum energy state in rotation, ii) vortex-free state (N=0), and iii) a spectrum with a small number of vortex lines (N=25). By monitoring the small difference between the last two spectra (as indicated by the two vertical arrows), the change in the number of vortex lines can be recorded as a

function of increasing rotation. *On the right* rotation is slowly increased while a series of instability events occur, each with the indicated number of circulation quanta.

Fig. 2 proves that there exist two distinct states for the vortex lines at the rotating AB interface. The experimental observations, the hydrodynamic stability of the two states, and the topological constraints on the two types of vortex lines at the AB boundary can all be explained if the two states are assumed to be those in Fig. 3. In rotation below the instability all A-phase vortex lines bend at the AB interface parallel to the boundary and form a vortex layer. This sheet of vorticity provides the tangential discontinuity in shear flow velocities at the boundary. Once instability events have occurred, some vortex lines intersect the phase boundary and continue from one phase to the other, with a change in structure at the interface. These two hydrodynamically stable states are separated by the shear-flow instability. The main result from our work in 2001 is the discovery of this shear-flow instability in a superfluid environment. This is the closest analogue of the classic Kelvin-Helmholtz instability of ideal inviscid and incompressible fluids, which was introduced by Lord Kelvin in 1871.

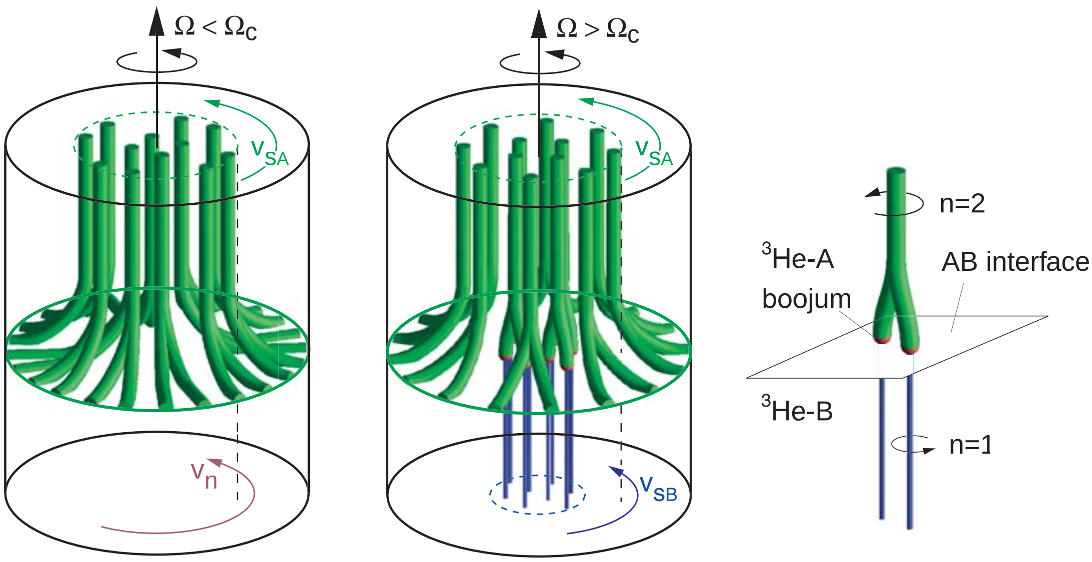


Fig. 3. The observations in Fig. 2 prove that two hydrodynamically stable states exist for vortex lines at a rotating AB boundary. *On the left* at rotation velocities below the instability all A-phase vortex lines bend parallel to the interface to form a vortex layer. *In the centre* the instability has taken place and some vortex lines intersect the AB interface. *On the right* a topologically allowed stable configuration is shown in which the intersection can occur. The A-phase vortex terminates in two non-singular point defects on the interface which are known as boojums. From these two B-phase vortex lines start.

INTERFACES IN QUANTUM SYSTEMS

H. Alles, H. Junes, I.A. Todoshchenko, V. Tsepelin, V. Vaskelainen

Helium crystals, which exist at low temperatures and high pressures, form a beautiful model system which allows studies of purely interfacial phenomena, difficult to observe in ordinary crystals. In past the Interface Group has carried out accurate measurements on the equilibrium shape and the growth dynamics of ^{4}He crystals. During the last several years, however, our optical studies have been directed to ^{3}He crystals. For these experiments the optical scheme was modified and a Fabry-Pérot multiple-beam interferometer was designed and built inside the nuclear demagnetization cryostat. Our first task was to study the morphology and growth kinetics of ^{3}He crystals well below 1 mK where ^{3}He has small latent heat of crystallization and both liquid and solid phases have good thermal conductivity, *i.e.*, in the regime where the spins of solid ^{3}He are antiferromagnetically ordered and liquid ^{3}He is superfluid. In this regime the mobility of the superfluid-solid interface of ^{3}He starts to become comparable to the mobility of the superfluid-solid interface of ^{4}He at much higher temperatures.

As there did not exist any precise measurements on the shape of ^{3}He crystals at so low temperatures we discovered already in our first set of experiments a multitude of different types of facets when growing the crystals at 0.55 - 0.65 mK. Facets, labeled usually according to Miller indices are smooth flat faces which appear on the crystal surface in certain directions when the temperature is low enough so that the thermal energy is not washing out the cusps in the surface tension due to the periodic crystal lattice structure. Altogether 11 different types of facets were identified from which 8 types were never seen before. We measured also the growth velocities of the individual facets. Our results revealed strong anisotropy of growth kinetics and we were able therefore to extract the step energies for different facets from our data. Before our measurements only an average growth rate of ^{3}He crystals had been reported.

The interpretation of our results yielded the conclusion that in ^{3}He the coupling of the liquid-solid interface to the crystal lattice is stronger than in ^{4}He. This is surprising because so far it was believed that due to larger zero-point motion of atoms this coupling is weaker in ^{3}He. Our findings are also an experimental verification to the so called “devil’s staircase” phenomenon which was basically predicted by Landau already in the middle of last century. Landau argued that ideally at low temperatures crystals should show many different types of facets, but it has been hard to check this prediction with ordinary crystals. And even in ^{4}He which has been so useful for studies on the equilibrium crystal shape only three different types of facets have been observed. It remains to be seen whether our findings in ^{3}He trigger searches for new facets in ^{4}He as well.

Our further studies have been concentrated on the roughening transitions in ^{3}He. Our observations proved that there should at least 11 roughening transitions take place in ^{3}He crystals at higher temperatures because each type of facets has its own roughening transition temperature when it disappears from the crystal surface. So far the most extensive studies on roughening transitions have been performed in ^{4}He which is one of a very few systems where it has been possible to study the roughening transition both qualitatively and quantitatively. According to theoretical estimations the roughening transitions for all facets we have observed in ^{3}He should fall into the range well above the superfluid transition temperature (T_c = 2.5 mK at the melting pressure) where solid ^{3}He has quite large latent heat of crystallization and liquid ^{3}He has poor thermal conductivity. As a result, the dynamics of ^{3}He crystals are very slow in this temperature range like in ordinary crystals and the experimental studies on the equilibrium crystal shapes are thus difficult.

We have, however, found out that the roughening transitions for the three primary (lowest order) facets, (110), (100) and (211) in the *body centered cubic* ^{3}He crystals, fall into a narrow temperature range of 85 - 115 mK. Previously only the (110) type facets had been identified in that temperature range. Currently there is no explanation to our experimental findings as theory expects the roughening transition temperatures to differ by a factor of three for the (110) and (211) facets.

At the same time we have carried out preliminary experiments near the antiferromagnetic transition temperature of solid ^{3}He (T_N = 0.93 mK) in order to study the effect of that transition to the growth dynamics of the crystals. We have also added a vibrating wire thermometer to our experimental setup. It allows us to perform calorimetric measurements which are necessary in order to improve our setup to reach temperatures below 0.5 mK. At these ultra low temperatures we plan to measure the equilibrium shape of a faceted ^{3}He crystal which has never been done. Our results would give an additional information which hopefully will lead to a better understanding of the interfacial properties of helium crystals.

THEORY

N. Hatakenaka (v), P. Huhtala, R. Hänninen, N. Kopnin, J. Kopu, M. Nishida (v), A. Schakel (v), E. Sonin, **E. Thuneberg**, J. Viljas, **G. Volovik**

The majority of theoretical work in the LTL is closely connected to the experimental effort in the laboratory. Only a few of the ongoing theoretical projects are listed below.

SUPERFLUID ^{3}HE

The structure of the superfluid ^{3}He order-parameter field allows for the existence of various topological defects. Among the most fascinating of these are the spin-mass vortices in ^{3}He-B: composite objects containing a conventional vortex line, a disclination line with spin current, and a planar soliton tail. Spin-mass vortices can be created and identified in rotating-cylinder experiments. We have calculated numerically the order-parameter distribution of ^{3}He-B in a rotating cylinder with a single spin-mass vortex together with a nonequilibrium number of conventional vortex lines. Depending on the external conditions, the minimum of the free energy was found to correspond to one of two globally different order-parameter textures. The possibility of observing the other (previously unobserved) texture experimentally is studied. The NMR signature induced by the presence of the spin-mass vortex was also determined as a function of the rotation velocity.

Various topological objects exist also in superfluid ^{3}He-A. The simplest of these are solitons where a domain-wall separates two different but degenerate bulk states. Experimentally solitons are detected via extra satellite peaks that appear in the NMR spectrum. By looking at the absorption spectrum we may obtain information about the basic parameters of liquid ^{3}He. We have determined numerically the structure of a splay soliton and calculated the frequency and the absorption of the principal satellite peak. Additionally, we have analyzed the absorption of the higher modes and considered the effect of spin diffusion to the absorption spectrum.

An array of holes between two reservoirs of superfluid ^{3}He-B has been used to study the Josephson effect in the University of California at Berkeley. A new type of current-phase relation at low temperatures, so-called "π-state" was found. We have studied this problem theoretically assuming that the holes are small compared to the coherence length of the superfluid. It has now turned out that this model gives a very good quantitative agreement with the measurements.

An essential ingredient in the calculation is the "anisotextural" character of Josephson effect, where the large scale texture changes as a function of the Josephson phase difference.

Helmholtz instability in liquids and gases are aspects of the much larger problem of interfacial instability of the interface separating two fluids, or separating two domains of the same fluid which move with different velocities. Helmholtz instability refers to the dynamic instability of the interface of the discontinuous flow; it may be defined loosely as the instability of the vortex sheet. Many natural phenomena have been attributed to Helmholtz instability. Most familiar are generation by wind of waves in the water, whose Helmholtz instability was first analyzed by Kelvin and flapping of sails and flags analyzed by Rayleigh

However, mathematical descriptions of interfacial instability are inevitably only approximate, they often neglect viscosity. For real liquids and gases it is not easy to correlate theory with experiment. In particular, because the initial state (the plane vortex sheet) cannot be produced experimentally. Such parallel flow is not in equilibrium in a viscous fluid. What does it mean, then, to speak of their `instability'. Many of the leading ideas in the theory of instability were originally inspired by considerations about inviscid flows. But such perfect liquids do not exist in nature.

It appeared that superfluids are the only real ideal objects where these ideas can be implemented without reservations. ROTA group made the first experiment where the perfect situation for the investigation of the Helmholtz instability was achieved. The stable nondissipative initial state, the vortex sheet between two superfluids, was prepared, and the critical velocity of instability of the vortex sheet was manifested by formation of vortices. We modified the theory of Helmholtz instability to the case of two-fluid dynamics in superfluids. The obtained criterion for the instability is in a good agreement with experimental data for critical velocity.

The topological defects formed at early-Universe phase transitions may have cosmological implications. In cosmology, reliable observational input to test these ideas is scarce and the ability to perform controlled experiments is of course absent. However, such transitions exhibit many generic features that are also found in rapid symmetry-breaking transitions in 3He-B under neutron irradiation. We made extensive numerical and analytical studies of the process of defect formation using the time-dependent Ginzburg-Landau (TDGL) model. It was shown that vortex nucleation in superfluid 3He-B by rapid thermal quench in the presence of superflow is also dominated by interfacial instability, a transverse instability of the moving normal-superfluid interface. The instability threshold is found analytically as a function of supercurrent density and the front velocity. The dynamics of vortex evolution at long times after the quench is investigated.

CONDENSED MATTER AND COSMOLOGY

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

This connection allows us to simulate the least known features of high-energy physics and cosmology: the properties of the quantum vacuum. In particular, the vacuum energy estimated using the methods of particle physics is now in huge disagreement with modern cosmological experiments. This is the cosmological constant problem. A major advantage of condensed matter is that it is described by a quantum field theory in which the properties of the quantum vacuum are completely known from first principles: they can be computed (at least numerically) and they can be measured experimentally in a variety of quantum condensed matter systems, such as quantum liquids, superconductors, superfluids, ferromagnets, etc.

The analogy between the quantum vacuum in particle physics and in condensed matter could give an insight into trans-Planckian physics and thus to help in solving the cosmological constant problem. We have shown that the analog of the cosmological constant in equilibrium quantum liquids is exactly zero without any fine-tuning. This is the result of the stability of the quantum vacuum. Only deviations from the homogeneous equilibrium state of the quantum vacuum are gravitating.

Using our condensed matter experience we investigated the properties of quantum vacuum inside the black hole. The stable vacuum state inside the black hole can exist if we use the Painlev_-Gullstrand description of the black hole, which has explicit violation of the time reversal symmetry and the superluminal dispersion of the particle spectrum at high energy, which is introduced in the free-falling frame. Such choices are inspired by the analogy between the quantum vacuum and the ground state of quantum liquid, in which the event horizon for the low-energy fermionic quasiparticles also can arise. The quantum vacuum under such conditions is characterized by the Fermi surface, which appears behind the event horizon. Our conclusion is that if the stable nonradiating black hole exists, the Fermi surface behind the horizon would be the necessary attribute of its vacuum state.

The idea that our Universe lives on a brane embedded in higher dimensional space is popular at the moment. It is the further development of an old idea of extra compact dimensions introduced by Kaluza and Klein. Branes can be represented by topological defects, such as domain walls (membranes) and strings. It is supposed that we live inside the core of such a defect. We discuss the origin of matter within the 3+1 brane, the domain wall between the two vacua in 4+1 space-time. We do not assume relativistic invariance in 4+1 space-time, or any special form of the 4+1 action. The only input is that the fermions in bulk are fully gapped and are described by nontrivial momentum-space topology. Then the 3+1 wall between such vacua contains chiral 3+1 fermions (fermion zero modes). The bosonic collective modes in the wall form the gauge and gravitational fields. In principle, this universality class of fermionic vacua can contain all the ingredients of the Standard Model and gravity

VORTEX DYNAMICS

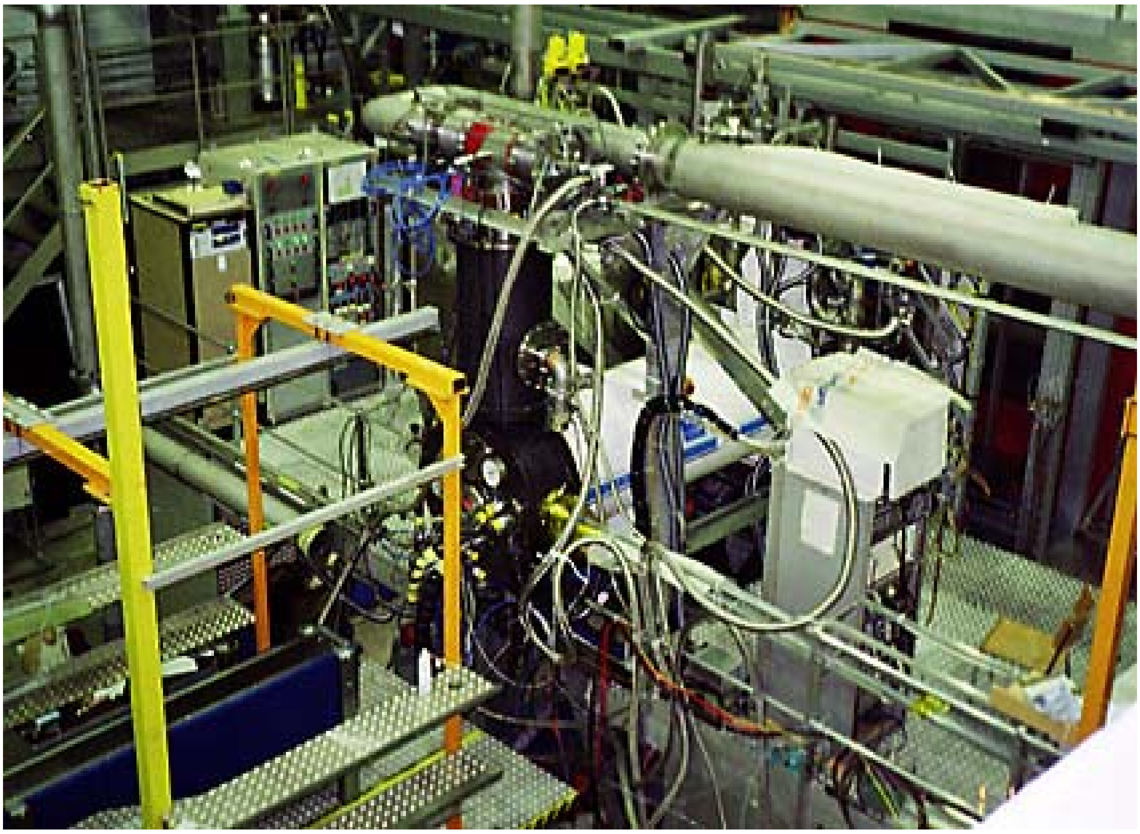
The vortex dynamics in superfluid Fermi systems is considered further. The forces acting on moving vortices and especially the transverse force was a matter of confusion for quite a time. The reason is that the most essential contribution to the vortex dynamics comes from fermion zero modes, excitations bound to the moving vortex. The equations of the vortex dynamics, which include all the forces and the inertial term associated with fermion zero modes have been formulated. Using the microscopic theory of nonstationary superconductivity the semi-classical Boltzmann equation has been derived, which is suitable for quasiparticles with energies also above the gap edge. They were also applied to derivation of electrodynamics of clean pinning-free type II superconductors in the mixed state. The condition of the vortex cyclotron resonance was found. There is a fundamental reason why this resonance does not comply with the Kohn theorem.

Professor Kopnin has published the monograph `Theory of Nonequilibrium Superconductivity' (Oxford University Press, 2001), which presents the basic ideas of modern microscopic theory of nonequilibrium superconductivity.

COMPASS SPIN POLARISED TARGET

P. **Berglund** and J. **Koivuniemi**

The COMPASS experiment at CERN made significant progress during the year 2001. Intensive tuning and setting up work was needed to get the spectrometer running. Some of the installation work continued until September in the experimental zone. Data was sucessfully collected in the end of October with completed spectrometer in stable conditions. The target reached a world record polarisation of +58 % and -48 % at 2.5 T field.



The dilution refrigerator and the old SMC magnet have been modified for COMPASS in building 888 at CERN.

During February and March the LHC/ECR/Cryolab participated in setting up, construction, leak checking and testing of the pumping system consisting of 8 roots blowers in series for the 3He circulation and a roots pump system for the 4He cooling. The pumping lines from the pump room to target platform were finished and leak tested. At the same time mixture inventory was made. 1387 l of NTP 3He gas and 7198 l of NTP 4He gas were found. The dilution cryostat was operated using test isolation vacuum with 80 K radiation shield only. It reached minimum temperature of 0.25 K even in these conditions. In this test it became clear that the cryostat is superleak tight and no major problems were expected in its operation. After the beam time the cooling power of the cryostat was measured to be about 30 mW at 0.1 K and 1 W at 0.4 K. The behaviour is similar to the measurements in the SMC. Thus the performance of the heat exchangers had not deteriorated during the 3 year storage of the dilution cryostat when the SMC experiment had finished.

The major problem for the target has been the superconducting magnet made by Oxford Instruments. The magnet project has had serious technical problems and difficulties in filling the agreed specifications. It has been delayed by several years. In March it was clear that the Oxford magnet will not be ready for the run 2001 starting in the middle of July. Thus the collaboration decided to use the old magnet from the SMC experiment. The target acceptance was then compromised from 180 mrad (Oxford magnet) to 69 mrad. To use the SMC magnet the mechanical mounting on the target platform had to be modified. A new microwave cavity with thin 0.1 mm Cu microwave stopper was manufactured at CERN workshop. After major effort between CERN and Saclay the testing and setting up of the complete magnet system was finished in the beginning of August. The magnet was then cooled down to 100 K with LN2. After that the target material from Bochum (6LiD) was loaded inside the dilution chamber. The magnet and dilution cryostat were both cooled to LHe temperature. The magnet was successfully operated at the end of the August. Soon after this the target material was polarised for the first time. At the end of September routine polarisation reversal by field rotation was started with frequency of 3 times/day.

BRAIN RESEARCH UNIT

Functions of the human cerebral cortex have been studied by measuring magnetic fields from outside of the head. The magnetoencephalographic (MEG) method allows totally non-invasive studies of healthy and diseased human brain during different tasks and conditions. Our 306-channel neuromagnetometer (Vectorview, Neuromag Ltd), functional since 1998, houses 204 gradiometers and 102 magnetometers with a whole-scalp coverage. To combine functional and structural information, we typically integrate MEG data with the subject's magnetic resonance images (MRIs). Since 1994, an important part of the research has been done in collaboration with European scientists visiting the laboratory through the Neuro-BIRCH (Biomagnetic Research Center in Helsinki) Large-Scale Facility, financed by the European Union. The third funding period of the Large-Scale Facility (Neuro-BIRCH III) started in April 2000 and will continue until March 2003.

AUDITORY SYSTEM

R. Hari, N. Fujiki(v), V. Jousmäki, K.I. Kaneko(v), **J. Mäkelä**, L. Parkkonen, T. Raij, H. Renvall, and M. Schürmann(v)

DYSLEXIA

We have previously shown that dyslexics are slow in processing auditory and visual stimuli presented in rapid succession. Moreover, a recent psyschophysical study indicated a left-sided “minineglect”, preference of the right visual field in temporal order and illusory line motion experiments. Consequently, we have suggested that these temporal processing deficits are due to sluggish attentional shifting (SAS). This framework has now been largely elaborated in a review article and several future experiments to test the SAS theory have been proposed.

To further elucidate the underlying sensory problems, we have been running MEG experiments on adult dyslexics who listen to various sound sequences. Noise/square-wave sequences, mimicking transitions from a fricative consonant to a vowel, were presented binaurally once every 1.1 s and the cortical responses were recorded with a whole-scalp neuromagnetometer. The auditory cortex was less reactive to acoustical changes in dyslexics than in control subjects, as was evident from the weaker responses to the noise/square-wave transitions. The results demonstrate deficient processing of acoustic changes presented in rapid succession within tens to hundreds of milliseconds. The observed differences could be related to insufficient triggering of automatic auditory attention, resulting from a general deficiency of the magnocellular system.

In another study, we applied an oddball sequence that consisted of binaural 50-ms tones: the standards (86% of all) were 1000 Hz in frequency and the two deviants, each with probability of 7%, were of 920 Hz and of 1080 Hz. The mismatch fields (MMFs) elicited by the deviant sounds were weaker in dyslexics than in control subjects in the left hemisphere. This finding suggests a deficiency in the triggering mechanisms of automatic auditory attention. The results are in line with electric scalp recordings that have shown diminished mismatch responses in children with learning problems and in dyslexic adults.

MIND'S EAR IN A MUSICIAN: WHERE AND WHEN IN THE BRAIN

Trained musicians were presented with visual notes and instructed to imagine the corresponding sounds. Brain activity specific to the auditory imagery task was observed, first as enhanced activity of left and right occipital areas (average onset 120-150 ms after the onset of the visual stimulus), then spreading to the midline parietal cortex (precuneus) and to such extra-occipital areas that were not activated during the visual control condition (e.g. the left temporal auditory association cortex, and the left and right premotor cortices). The latest activations, with average onset latencies of 270-400 ms clearly separate from the earliest ones, occurred in the left sensorimotor cortex and the right inferotemporal visual association cortex. These data imply a complex temporospatial activation sequence of multiple cortical areas when musicians recall firmly established audiovisual associations.

BINAURAL HEARING

We recently introduced a novel “frequency-tagging” method to follow monitoring of inputs from each ear to the auditory cortices of both hemispheres. The method relied on labeling of continuous 1-kHz tones with amplitude modulation that was of different frequency in the left and right ear. Both hemisphere and ear-specific information was obtained on binaural interaction by analyzing the cortical MEG signals both in frequency and time domain. Now we are studying the binaural interaction with the frequency-tagging method by presenting stimuli of different intensities to the two ears and by experimenting with the effects of the modulation frequency. This type of parametric information will be required when the method will in the near future be applied to patients with congenital hearing deficits.

BRAINSTEM AUDITORY EVOKED FIELD: MEG SIGNALS FROM DEEP STRUCTURES

Extracranial neuromagnetic signals originate mainly from the superficial brain structures due to their proximity and the fact that external magnetic field diminishes when the current source approaches the center of a spherically symmetric conductor. Thus, it has been questionable whether deep sources, e.g., brainstem or thalamus, are accessible in MEG measurements. We have shown by measuring brainstem auditory evoked fields (BAEFs) that with a low-noise neuromagnetometer such responses are indeed detected in a relatively short measurement without applying spatial filters constructed from *a priori* information. The most prominent BAEF response coincides with wave V of the BAEP (in 7 subjects the average latency was 5.5 ms, and average peak amplitudes were 4.7 fT and 0.23 µV). The magnetic counterparts of BAEP waves I-III are also detectable in many of the subjects. In the same study, the signal-to-noise values were 6.1 for the magnetometers and 9.3 for EEG. The SNRs of the gradiometer channels were substantially lower. The attained signal-to-noise ratio is likely to be sufficient for modelling and localization of the generators at least in selected subjects Thus, a reliable measurement of BAEFs is possible with state-of-the-art magnetometers. This suggests that also other activity in the deep brain structures may be detected and visualized by MEG in a completely data-driven manner.

SOMATOSENSORY SYSTEM

F. Alary(v), **N. Forss, R. Hari**, M. Illman, O. Jensen, V. Jousmäki, K. Juottonen, **J. Mäkelä**, M. Pohja, T.T. Raij, H. Renvall, M. Sainio, S. Salenius, R. Schreiber, T. Silén, C. Simões, and N. Vartiainen

FUNCTIONS OF THE SECOND SOMATOSENSORY CORTEX SII

Our previous MEG studies have shown that the human SII cortex responds to both contra- and ipsilateral stimulation and that bilateral integration of tactile input from the two hands seems to be an important feature of the human SII cortex. Some previous studies have suggested hemispheric differences in the activation strength of SII cortices; in healthy subjects median nerve stimuli activate more strongly the left than the right SII cortex, regardless to the side of stimulation. We have now recorded cortical responses to simultaneous left- and right-sided stimulation of the median nerves at the wrists in both right-handed and left-handed subjects. The SII cortex cortex was activated significantly more strongly in the left than the right hemisphere both in right- and left-handed subjects. The left SII thus seems to be strongly involved in processing of tactile stimuli.

We have constructed and applied a new mechanical device to activate predominantly the proprioceptive afferents. This air-pressure-operated device produced calibrated extension of 19 degrees of the index fingers of both hands. The earliest activation occurred in the primary somatosensory cortex around 30–80 ms and the later activation at 75–175 ms at the SII cortex, again with left-hemisphere dominance. Thus the left SII seems to have a predominant role in the proprioceptive processing as well.

The left-hemisphere dominance of SII activation has been recently observed also after electric non-painful stimulation of the dorsal penile nerve (DPN). DPN stimulation resulted in relatively stronger SII than SI responses than what is observed after tibial or median nerve stimulation.

TACTILE PROCESSING IN DYSLEXIC ADULTS

Experiments have been started to probe the possible timing defects of dyslexic subjects in tactile processing; the first study focuses on cortical recovery cycles of touch-evoked responses. Preliminary results indicate different hemispheric balance in the recovery of somatosensory responses in dyslexic and control subjects.

SOMATOSENSORY PROCESSING IN ULD

Unverricht-Lundborg disease (ULD) is an autosomal recessive inherited disorder, characterized by myoclonic jerks and tonic-clonic seizures. A homozygous minisatellite expansion mutation in the gene encoding cystatin B accounts for the majority of ULD cases in the world. Direct mutation detection has enabled specific diagnostics and carrier diagnostics in ULD. We have previously observed in patients with Unverricht-Lundborg type progressive myoclonus epilepsy giant reponses at SI — apparently indicating hyperexcitability, ipsilateral SI responses as a result of abnormal callosal conduction (and probably related to higher risk for generalized seizures), and absent SII responses probably reflecting deficient bilateral tactile integration and/or sensorimotor integration.

Although heterozygous mutation carriers are typically healthy, some of them may suffer from myoclonic jerks. We have recently evaluated clinical symptoms and sensorimotor cortical activation in six ULD carriers with myoclonic jerks. The somatososensory cortical processing and cortical control of muscle contraction of the symptomatic ULD carriers did not differ from asymptomatic ULD carriers or from control subjects.

CORTICAL REORGANIZATION DURING CHRONIC PAIN

Several previous imaging studies have shown that cortical areas that are activated to nociceptive stimuli are also part of the somatosensory cortical network that processes innocuous tactile input. Furthermore, many patients with chronic pain report changes in tactile sensitivity of the affected area. We have studied, in collaboration with colleagues at the ORTON hospital, how chronic pain affects central processing of tactile input. We examined, both clinically and with MEG, six patients suffering from complex regional pain syndrome (CRPS) of the upper limb. Tactile stimulation of the index finger elicited an initial activation at 65 ms in the contralateral SI cortex, followed by activation of the ipsi- and contralateral SII cortices at about 130 ms. The SI responses were 25–55% stronger to stimulation of the painful than the healthy side. The distance between SI representations of thumb and little finger was significantly shorter in the hemisphere contralateral than ipsilateral to the painful upper limb. In addition, reactivity of the 20-Hz motor cortex rhythm to tactile stimuli was altered in the CRPS patients, suggesting decreased inhibition of the primary motor cortex. These results imply that chronic pain may alter central tactile and motor processing.

LASER-EVOKED ACUTE PAIN

Characterization of cortical responses to highly selective noxious stimuli is necessary for understanding pain processes, creating new procedures for pain treatment, and for improving clinical assessment of abnormal pain sensitivity. Short laser pulses seem to provide highly selective and well controllable noxious stimuli, easily applicable even when the temporal accuracy of stimulus delivery is essential. We have recently purchased a thulium-YAG stimulator (BLM 1000 Tm:YAG®, Baasel Lasertech, Starnberg, Germany) and delivered with it brief laser stimuli (1 ms in duration, 2000 nm in wavelength) on the hand dorsum. The laser beam was conducted to the magnetically shielded room via an optic fiber.

We have characterized cortical responses elicited by painful laser stimuli applied to hand dorsum by focusing on the effects of interstimulus interval on the responses and on comparison of the activated brain areas with those responding to nonpainful tactile stimuli. The first MEG responses to the painful laser stimuli peaked at 150–200 ms at the contralateral primary somatosensory (SI) cortex and simultaneously at the secondary somatosensory (SII) cortices bilaterally. The responses increased strongly in amplitude from interstimulus intervals of 0.5 s to 4 s and thereafter remained saturated up to intervals of 16 s. In the SI and SII cortices, the activation areas did not systematically differ between painful laser stimuli and non-painful tactile stimuli delivered to the same skin area. The results imply that much shorter ISIs are feasible in experimental pain research than previosly applied.

PERTURBATION DYNAMICS FOR SENSORIMOTOR 10- AND 20-HZ RHYTHMS

We have analyzed pertubation dynamics of the sensorimotor 10- and 20-Hz rhythms in response to a series of paired electric median nerve stimuli. Stimulus-related power modifications (suppression followed by rebound) in these two frequency bands were analysed either as conventional averages or as subaverages formed from the upper/lower 20% of a distribution where single trials had been sorted according to increasing power of the rhythms 300 - 600 ms after the first stimulus in a pair. Only in 1 out of 7 subjects the power level of sensorimotor rhythms was directly related to amplitudes of the somatosensory evoked fields, and only deflections peaking after the thalamocortical input deflection were modified as a function of pre-stimulus 10-Hz power. The perturbation dynamics of the sensorimotor rhythms exhibited a substantial intertrial variance which, however, are effective only at a time scale larger than 600 ms.

MOTOR FUNCTIONS

R. Hari, **O. Jensen**, V. Jousmäki, M. Pohja, and **S. Salenius**

CORTEX-MUSCLE COHERENCE

We have previously found that rhythmic ~20-Hz (and during strong contraction ~40-Hz) activity, generated in the primary motor cortex, is coherent with motor unit firing of isometrically contracting muscle. The delays between cortex and different muscles agree with the corresponding cortex-muscle conduction times. Both 20- and 40-Hz cortical rhythms thus seem to drive motor unit firing in contracting muscles. In a recent study we observed that also 6—12 Hz activity is frequently coherent with motor unit firing of contralateral upper limb muscles during isometric postural contractions. In contrast, we found little evidence for correspondence between the contralateral EMG and the MEG recorded over the primary sensorimotor region during phasic movements, implicating that the sensorimotor cortex is differentially involved in physiological force and action tremor at the wrist.

Our previous studies have demonstrated motor-cortex rhythmic interaction for upper and lower limb muscles. We have now also shown that such interaction occurs for trunk muscles, i.e. for paraspinal and abdominal muscles, with the sources for the coherent cortical activity following the motor homunculus. For abdominal muscles, motor unit activity was found to be coherent with primary motor cortex activity bilaterally.

We have also investigated (in collaboration with Roger Lemon and James Kilner) task-dependent modulations in coupling between neuronal oscillators in the motor system during a bimanual precision grip task. We found significant task-related modulation of coherence between EMG and contralateral MEG for the hand involved in the task but notably also for the other hand, which was involved in a simple steady grip. No significant ipsilateral MEG-EMG coherence was observed in the 15—30 Hz passband for either hand. We conclude that these results suggest that the cortical oscillators in the two sensorimotor cortices are independent to some degree but that they share a common mechanism that attenuates the cortical power in both hemispheres in the 15—30 Hz range during movements of one hand. These results are consistent with the hypothesis we have previously proposed that oscillatory activity in the motor system could be important in recalibrating the sensorimotor network during changes in the motor state that occurs in the transition from movement to steady grip.

In collaboration with Japanese colleagues (the Human Brain Research Center and the Departments of Neurology and Neurosurgery of Kyoto University Graduate School of Medicine) we have shown that, in addition to primary motor areas, also nonprimary motor areas are involved in a rhythmic interaction with both motor unit firing and each other during isometric contraction. We studied the coherence between the supplementary motor and primary sensorimotor areas (SMA and S1-M1) with electrocorticographic recordings in intractable epilepsy patients. Coherence between the SMA proper and M1 started to increase 0.9 s before movement onset and peaked 0.3 s after the movement. We found no systematic difference in the time course or the peak value of coherence within the SMA (SMA proper vs pre-SMA) or within the primary sensorimotor cortex (S1 vs M1). The phase difference between different sensorimotor areas was near-zero or inconsistent. The observed increase of oscillatory interaction between different motor areas before and during voluntary movements probably reflects multiregional functional interactions.

When measuring cortex-muscle coherence it is in many cases important to control and change the force of the isometric muscle contraction. For this purpose we have developed a device in which the force of contraction is recorded continously and visually showed to the subject. This allow us to investigate cortex-muscle coherence as a function of force level. Preliminary results have revealed a systematic increase in 40-Hz coherence with force level.

MIRROR MOVEMENTS

We recorded magnetoencephalographic (MEG) and electromyographic (EMG) signals during unilateral and bilateral isometric contractions of hands and feet from a 15-year old male who has congenital mirror movements in hands. Regardless of the side of voluntary unilateral movement, the MEG from the contralateral motor cortex was coherent with EMG from both hands. There was no such functional connection to the other hemisphere. The EMGs from both hands were coherent during both unilateral and bilateral movements; this EMG–EMG coherence could be explained solely by cortical activation. We suggest that our subject's mirror movements result from activation of an ipsilateral corticospinal projection, with involvement of additional mechanisms at the subcortical, brainstem, or spinal level.

GABAERGIC TRANSMISSION, MU RHYTHM AND COHERENCE

During rest, the human sensorimotor cortex produces spontaneous mu rhythm consisting of 10 Hz and 20 Hz frequencies. Coherence between motor cortex and muscle is strong in the 15-25 Hz band during isometric muscle contraction. To address how the spontaneous mu rhythm is related to cortico-muscle coherence, we recorded whole-scalp magnetoencephalogram (MEG) and surface electromyogram (EMG) from eight subjects during rest and isometric muscle contraction before and after administering benzodiazepine (Diapam; 4-7.5 mg). Benzodiazepine upregulates GABAergic synaptic transmission. As shown in previous studies, the power of the 15—25 Hz rhythm increased with the administration of benzodiazepine. The most prominent sources of the benzodiazepine-induced rhythm were in the primary motor cortex, suggesting that the motor cortex is a primary effector site of benzodiazepines. The mean frequency of the rhythm decreased with benzodiazepine. These findings are consistent with recent computational models predicting that a cortical network of GABAergic interneurons is responsible for synchronizing the neuronal firing which generates the beta-band rhythm. The administration of benzodiazepine did not produce systematic changes in the cortico-muscle coherence nor in its strength or peak frequency. Thus, the 15—25 Hz component of the mu rhythm and the cortico-muscle coherence appear to have at least in part different functional correlates.

NEURAL BASIS OF VISUAL PERCEPTION AND VISION-RELATED BRAIN ACTIVATION

R. Hari, T. Montez, J. Päällysaho, and T. Tanskanen

TIMING OF CONTOUR INTREGRATION IN HUMAN VISUAL CORTICES

Visual cortical cells at the first processing stages have spatially limited receptive fields, and further processing, such as figure-ground segregation and the perception of global contours and shapes, therefore requires integration of information from the local processes. To study the time course of this integration, we recorded from 7 healthy adults whole-scalp neuromagnetic responses to arrays of 140 high-contrast (57%) Gabor patches (sf 4.8 c/deg, sd 0.1 deg). In the contour stimuli, a proportion of the patches was oriented either along or orthogonally to a global circular contour; in the no-contour stimuli all patches were oriented randomly. The stimuli appeared abruptly on an average gray (90 cd/m2) background and remained visible for 500 ms. The early cortical responses, starting at 60–-80 ms, did not differ between the categories, but at 130 ms, on average, the responses to the contour and no-contour stimuli separated. The earliest and most pronounced differences were observed in the medial posterior brain areas. The difference tended to start later and be smaller when the local elements were oriented orthogonally to the contour, rather than along it. This modulation resembles the contextual effects observed in monkey V1 and V2. Both cortical responses and RTs showed that contour processing is facilitated when local orientation is tangential to the global path orientation.

EFFECT OF BAND-PASS FILTERED NOISE ON CORTICAL FACE RESPONSES

Psychophysical studies have shown that the human face recognition system utilizes only a limited band of the spatial frequencies (sfs) present in facial images. To find cortical responses that would show a similar tuning, we recorded whole-scalp neuromagnetic responses to facial images that contained narrow-band spatial noise (10 noise bands with central sfs from 2 to 45 c/image). The signal-to-noise ratio was 0.74 across all sfs and made recognition impossible around the 16 c/image condition, but easy in the low and high sf conditions. The stimuli (mean luminance 130 cd/m^2) appeared abruptly on an average gray background for 0.5 s once every 2.5 s, and stimuli with different noise sfs were presented in random order. The subject had to respond to an image of a target person. The strongest modulation by noise sf occurred in the 150-200 ms temporo-occipital responses: The largest signals were elicited by the noiseless and lowest-sf noise stimuli. The signals decreased as a function of increasing noise sf until they disappeared at the medium sfs, and increased again at the highest frequencies. The 80-110 ms midoccipital responses showed a different pattern, being weak for the lowest noise sfs, then increasing as a function of sf, and attenuating at the highest noise sfs. These results show that the

150—200 ms temporo-occipital response resembles behavioral face recognition in its sensitivity to noise sf, and could thus reflect processes that are critical for the recognition of faces.

SHIFTING ATTENTION BETWEEN OBJECT CATEGORIES

Shifting attention from one component of a complex visual stimulus to another is associated with a performance cost, as indicated by an increased reaction time on the first trial following a shift. In collaboration with scientists from NIH, Bethesda, we have tested the hypothesis that this response cost is associated with diminished perceptual selectivity. We measured stimulus-specific MEG responses to attended and unattended stimuli on the first, second and third trials after a shift. The subjects performed a delayed match-to-sample task while viewing images made of superimposed faces and houses and selectively attending to either the face or house component. Blocks of trials involved either no attention shift (attend to faces only or attend to houses only) or cued shifts of attention. Distinct late responses (>200 ms) in occipitotemporal sites were associated with attend-to-faces and attend-to-houses in the no shift conditions; these responses served as baseline measures to evaluate the shifting condition. The response on the first trial after shifting attention to houses was more similar to the baseline attend-to-faces response and migrated towards the baseline attend-to-houses response on subsequent trials. Similarly, responses observed on the first three trials after shifting attention to faces migrated towards the baseline attend-to-faces condition. These results suggest that the performance cost associated with shifting the focus of selective attention is associated with diminished selectivity of perceptual processing that resolves over successive trials.

MEG CORRELATES OF DEPTH–MOTION INTEGRATION: THE PULFRICH PHENOMENON

Perception of motion and stereoscopic depth are fundamental features of human visual functions; they seem to be closely related and perhaps jointly encoded in the brain. To assess such a neuronal integration, we have recorded MEG signals while the subject perceive the Pulfrich phenomenon. When a swinging pendulum or a dynamic random dot pattern is viewed with a light-attenuating filter before one eye, the pendulum bob or the dots on the pattern are perceived to move in an elliptical path in depth. The perceived motion in depth depends on the density of the filter used and the eye covered with the filter: If the right eye is covered, the motion appears counterclockwise and if the left eye is covered the motion appears to be clockwise. Similarly, if we observe binocularly a dynamic random noise pattern (e.g. TV’s black and white noise) while having a light-attenuating filter on one eye, we perceive an illusion of crisp depth and coherent motion of all randomly distributed dots even though the stimulus pattern does not contain any coherently moving elements. In both of these cases, the light-attenuating filter in front of one eye causes a delay in the retinal signal processing and in the transmission of neuronal signals from the affected eye. This results in different arrival times of the neuronal signals from the two eyes to the different processing stages of the visual cortex.

We have recorded MEG signals while the subjects perceive the Pulfrich effect with random-dot stimuli. Compared with the same stimuli viewed without the filter, we observed activation in all occipital cortical regions that are known to be involved in extracting three-dimensional structure from motion. Our preliminary results suggest that stereoscopic depth and motion are jointly encoded in areas V1, V2, V3A, hMT/V-5+ and in the dorsal parietal cortex.

ACTION VIEWING

S. Avikainen, N. Forss, **R. Hari**, J. Järveläinen, S. Liuhanen, and M. Schürmann

Collaboration with: N. Nishitani (Tokorozawa, Japan) and A. Wohlschläger (Münich, Germany)

As social creatures, we humans spend a considerable part of our waking time in predicting the intentions and feelings of our cocitizens. This largely unconscious cerebral computing is based on sensory cues derived from other persons' behavior, gestures, and vocalizations. Recent studies indicate that this socially very important “reading of other persons’ minds” is based on a “mirror-neuron system” (MNS). The monkey frontal cortex has been shown to contain 'mirror neurons' that discharge both when the monkey performs hand actions and when it observes another individual to make similar actions. Human functional imaging studies, including our previous MEG studies, have demonstrated a similar MNS system in the human brain, comprising at least the Broca's region, the primary motor cortices, and the superior temporal sulcus.

PROBLEM OF AGENCY AND SOMATOSENSORY ACTIVATION

The existence of the MNS means that overlapping brain areas may be activated when persons view and perform motor acts. Thus we cannot avoid the problem of agency, meaning that how do I know that “I” made a certain motor act and not only saw it, if the corresponding brain activation patterns are very similar? This might sound like a trivial question but it is not because misattribution of one’s own acts is possible and occurs in some psychiatric patients may address their own actions to some external agents and experience that they are under ”alien control”.

In the healthy human brain, the problem of agency might be solved by two main mechanisms. One is the efferent copy that is sent to other brain areas to inform them of the forthcoming movements — the same mechanism is used to explain why you cannot easily tickle yourself — that is because you already know what your fingers are going to do.´The other important mechanism could be the feedback provided by proprioceptive and other somatosensory afferents during our own movements. We therefore recorded somatosensory evoked fields to median nerve stimulation from 9 healthy subjects during (i) rest, (ii) manipulation of a small object, and (iii) observation of the same action, to find out to what extent the somatosensory cortices display behavior similar to the human mirror-neuron system. SI signals were enhanced and SII signals suppressed during both manipulation and observation, except when the right manipulating hand was stimulated. Our results suggest that the SI and SII cortices contribute to the human mirror-neuron system, possibly providing information necessary for preserving the sense of self during action observation.

VIEWING ABNORMAL HAND POSTURES

Humans recognize various hand and finger postures, own and of other individuals, rapidly and without effort, and any abnormalities typically catch immediate attention. In studying the brain mechanisms of such recognition performance, we first attempted to find out whether activations of visual cortical areas would differ while subjects view natural vs. unnatural finger postures.

MEG signals were recorded from 8 healthy subjects, while they were observing still images of natural and unnatural finger postures. Subjects were asked either to respond with a finger lift when the image matched the previous one (*observation*) or to imitate the previous natural hand posture whenever an imperative stimulus (a ball) appeared (*imitation*). Brain activity was quantified in two large regions of interest comprising the bulk of the occipital cortex of each hemisphere, excluding the striatal and parieto-occipital regions. During observation the mean occipital activity was 32% stronger and during imitation 42% stronger for unnatural than natural finger postures. The difference started 150–200 ms after stimulus onset and the effect was seen in 7 out of 8 subjects. Viewing unnatural finger postures thus seems to automatically enhance activation of the extrastriate cortices, possibly via top-down influences that facilitate further processing of unusual hand shapes.

DEFICIENT IMITATION IN AUTISM

Autism is associated with impairment in attribution of mental states and imitation and we were interested, in collaboration with colleagues in Munich, in finding out to what extent on-line imitation of goal-directed movements would be deficient in adult high-functioning autistic and Asperger subjects.

Five adult subjects, 3 with autistic disorder and 2 with Asperger syndrome and 8 healthy controls were asked to imitate a set of hand movements, made by the experimenter sitting opposite to them. Both the subjects and the experimenter had one pen and a blue and a green cup placed on the table in front of them. The task was to imitate the movements on-line as if looking in a mirror (*mirror*) or in a crossed-over fashion (*crossed*). In both conditions, the hand movements consisted of a sequence of 80 movements (putting the pen with left or right hand into the green or the blue cup with two different-type of hand grips). In both groups and conditions, most errors were made in the hand grip, and altogether there were significantly more errors in the *crossed* than in the *mirror* condition. In general, the autistic subjects made more errors than the controls. The autistic group differed significantly from the controls in the *mirror* condition and the difference was largest for the hand grip (62% vs. 90% correct; cup 98% vs. 98%; hand 84% vs. 96%). There were no significant group differences in the *crossed* condition. Our results show that adult high-functioning autistic and Asperger subjects are deficient in on-line imitation of goal-directed hand movements. This deficit seems to depend on the strategy used for imitation. People usually prefer mirror-image movements in imitation but the autistic subjects did not benefit as much as the controls from using the mirror-image movements.

VIDEO VS. LIVE PRESENTATION

In our previous action viewing studies we used live performers within the magnetically shielded room, with good results. We now asked whether similar effects would be obtained by video presentation of similar stimuli. We recorded neuromagnetic oscillatory activity from the primary motor cortex of 10 healthy subjects when they observed “live” and videotaped finger movements. The left and right median nerves were stimulated alternatingly and the poststimulus level of the ~20 Hz rhythm was quantified. Compared with the rest condition, the ~20 Hz rhythm was dampened 15-19% more when the subjects observed live than videotaped hand movements, indicating stronger activation of the primary motor cortex. These results suggest that the human mirror neuron system differentiates natural and artificially presented movements.

LANGUAGE PERCEPTION AND PRODUCTION - FUNCTION AND DYSFUNCTION

P. Helenius, M. Husberg, K. Kiviniemi, J. Kujala, **R. Salmelin**, A. Tarkiainen, M. Vihla, and T. Vuorinen

The successive and largely overlapping stages in language processing, from sensory analysis to linguistic assessment, memory search, and motor function, can only be satisfactorily characterized and understood using combined spatial and temporal information. Comparison of persons with normal language function and subjects who have a functional developmental disorder, with no obvious structural correlates, in a specific aspect of language such as reading (dyslexia) or speaking (stuttering) provides us with estimates of brain areas and time windows which are potentially critical to normal function, and which can then be subjected to detailed experimentation.

PERCEPTION OF SPEECH AND NON-SPEECH SOUNDS

We have previously found differences in the hemispheric balance of auditory activation to pure tones (1 kHz) between Finnish- and German-speaking males. To further investigate the effects of linguistic background on auditory processing, we compared responses to pure tones (120 Hz, 1 kHz, 4 kHz) and to the vowel /u/ and a complex tone corresponding to its formant frequencies (F1-F3), presented in separate sequences, in Finnish- and Swedish-speaking Finnish males. A stronger response at 100 ms after stimulus onset (N100m) was detected in the right than left hemisphere, as is usual in Finns, similarly for all stimuli and in both subject groups. However, at around 200 ms after stimulus onset, Swedish-speaking subjects had larger interhemispheric differences and different signal morphology than the Finnish-speaking subjects, supporting the notion that linguistic background influences basic auditory processes. Possibly, Swedish-speaking subjects had retained a juvenile response component due to their bilingual surrounding after early childhood.

Effect of attention to speech vs. non-speech sounds on hemispheric balance was investigated by presenting to the subjects vowels /a/ and /i/ spoken by two female speakers and two complex tones corresponding to the formant frequencies of the vowels spoken by speaker 1. N100m responses to the frequent (non-target) stimuli, the vowel /i/ spoken by speaker 1 and the corresponding complex tone, were recorded during passive and active listening conditions. There were three active listening conditions: phoneme detection (/a/ of either speaker), speaker detection (speaker 2), and complex tone identification (formants of /a/). Complex tones evoked stronger N100m in the right hemisphere than vowels. The hemispheric balance was not affected by task. The reduction of right-hemisphere activation for vowels indicates relative increase of left-hemisphere involvement, possibly reflecting a shift towards more language-specific processing.

In the third study, the stimuli were synthetic Finnish vowels (/a/, /u/), consonant-vowel syllables (/pa/, /ka/), complex sounds composed of the formant frequencies (F1-F3) of the speech stimuli, and simple sine-wave tones corresponding to the F2 formant of the speech stimuli, presented monaurally in a randomized order. The N100m response in the left hemisphere was stronger for speech sounds than for complex and simple non-speech sounds, similarly for vowels and syllables and independent of the stimulated ear. No such modulation was seen in the right hemisphere. The left-hemisphere effect may reflect access to phonological representation.

FUNTIONAL NEUROANATOMY OF READING

Using MEG, we have shown that in fluent reading, activation proceeds via visual feature processing in the occipital cortex at about 100 ms to letter-string specific analysis in the left inferior occipitotemporal cortex about 150 ms after the word onset and, after 200 ms, to the left superior temporal cortex for processing the meaning (semantics) of single words and context.

Research into the functional neuroanatomy of reading was continued by two studies. The first one investigated the role of the occipito-temporal cortex in processing letter-strings with varying length, lexicality, and letter position (vertical dimension). Neither the occipital midline responses at about 100 ms nor the bilateral inferior occipito-temporal responses at about 150 ms after stimulus onset were particularly sensitive to the lexicality or length of the letter-strings. However, it appeared that the right-hemisphere occipito-temporal responses were more sensitive than the left-hemisphere responses to vertical shifts of letter position. Successful reading requires knowledge of both the identity of single letters and their positions within the string. The present results suggest that the left-hemisphere occipito-temporal areas deal more with the identity of the letters whereas the corresponding right-hemisphere structures are more involved with processing of their relative positions.

The neuroanatomical basis of faster reaction times in reading short than long letter-strings was studied by passive viewing of long (8-letter) and short (4-letter) Finnish words and pronounceable non-words. The cortical areas involved were the same for words and nonwords. A pure length effect in activation strength was detected in the midline occipital cortex at about 100 ms after stimulus onset, likely reflecting low-level visual analysis common to all stimuli. At 200 to 600 ms, a combined length and lexicality effect was evident in the left superior temporal cortex. The activation lasted longer for long than short letter-strings, with a clearly reduced effect for words as compared with nonwords. The activation was more pronounced and lasted longer for nonwords than words. These spatially and temporally overlapping lexicality and length effects apparently reflect converging lexico-semantic and phonological influences, and emphasize further the important role of the left superior temporal cortex in language processing.

DYSLEXIA

In continuation of our studies on the cortical basis of dyslexia, we have recently investigated the functional capacity of occipito-temporal cortex in dyslexic individuals. We have previously shown that visually presented letter-strings activate the left inferior occipito-temporal cortex less efficiently in dyslexic than non-reading-impaired individuals at about 150 ms after stimulus onset. This functional deficiency could be specific to letter-strings or it could also reflect a more general dysfunction in this cortical area and time window. In a recent study on non-reading-impaired individuals, we demonstrated that faces activate the bilateral occipito-temporal cortices, in the near vicinity of the areas activated by letter-strings and in the very same time window. We now tested face and object processing in dyslexic individuals, several of whom had participated in our previous study of letter-string processing. The early (< 200 ms) bilateral occipito-temporal responses to faces did not differ between dyslexic and non-reading-impaired subjects. The functional deficit in the left occipito-temporal cortex thus appears to be specific to letter-strings. However, behavioural tests showed that the dyslexic individuals had difficulties in judging the similarity of faces and geometrical shapes, possibly related to a difference between the subject groups in activation of the right parieto-temporal cortex at about 250 ms after stimulus onset.

SPEECH PRODUCTION

In speech production, motor cortex involvement during different types of verbal and non-verbal mouth and tongue movements was investigated by evaluating the task-related modulation of 20-Hz activity, known to be largely generated in the motor cortex. The modulation concentrated to two sites along the central sulcus, identified as the face and hand representations. The 20-Hz suppression was relatively similar during all tasks, but the post-movement rebound was left-lateralized in word production. The latencies of suppression in the left and right hemispheres were correlated during verbal tasks. The 20-Hz activity in the hand areas showed clear suppression but not rebound. The suppression was pronounced in the non-verbal tasks but was diminished for the verbal tasks. Increasing linguistic content of lip and tongue movements was thus associated with spatially more focal motor cortex involvement, left-hemisphere lateralization of face area activation, and correlated timing across hemispheres.

DEVELOPMENT OF CLINICAL APPLICATIONS OF MEG IN COLLABORATION WITH HUCH

N. Forss, **R. Hari**, M. Hämäläinen, M. Illman, K. Juottonen, E. Kirveskari, **J. Mäkelä**, S. Salenius, R. Salmelin, and M. Seppä

A 'CliniMEG' team was assembled in 1997 to develop clinical applications of MEG to routine use in collaboration with the Department of Clinical Neurosciences at the Helsinki University Central Hospital. The focus has been on preoperative evaluation of patients with brain tumors and epilepsy. We have developed routine methods to provide the neurosurgeon with 3-dimensional visualization of the functional anatomy of the rolandic cortex, to facilitate tumor resection without damaging functionally irretrievable areas in the somatomotor strip. In our routines, the central sulcus is identified by functional and morphological criteria; the functional landmarks are based on somatosensory responses to hand, foot, and occasionally also to lip stimulation, and motor cortex identification on cortex-muscle coherence.

The functional locations are displayed on 3-D reconstructions of the individual brains, with the blood vessels, derived from MR angiography, shown on the exposed brain surface; this was achieved with software developed at the BRU specifically for this purpose. During surgery, the preoperative localizations have been confirmed with cortical stimulations and recordings, and at least one member of the CliniMEG team has been present in the operation room. The preoperative visualization of the functional anatomy has greatly facilitated navigation during the neurosurgical operation.

In early 2001, most of the routines and softeware developed in BRU for CliniMEG's studies of patients with brain tumors and epilepsy for presurgical purposes were transferred to the Department of Clinical Neurophysiology, Helsinki University Central Hospital. The BRU has still contributed to development of the routines at the hospital, and a couple of patients with more complex localization problems have been studied in the BRU.

METHODOLOGICAL DEVELOPMENT

J. Gross, S. Hakala, M. Husberg, **R. Hari**, **M. Hämäläinen**, **O. Jensen**, **V. Jousmäki**, J. Kujala, J. Numminen, L. Parkkonen, **R. Salmelin**, M. Seppä, L. Stenbacka, A. Tarkiainen and K. Uutela

INSTRUMENTATION AND ACQUISITION SOFTWARE

The collaboration with VTT Automation to study the noise performance of the new magnetically shielded room and to adjust the active compensation system to reject external noise has continued. The system controlling the active compensation and the software were upgraded resulting in improvements in the performance of the magnetically shielded room. The Vectorview MEG system has been maintained in close collaboration with Neuromag Ltd.

Methods for measuring the head position during MEG data acquisition and algorithms for correcting the field maps using the measured movements were developed further. The head position estimation was made faster and more accurate with the use of a Kalman filter. Software tools for head movement estimation were developed.

MEG ANALYSIS OF PHASE-LOCKED EVOKED RESPONSES

The software for calculating minimum current estimates (MCEs) was improved: possibility for using boundary element models in MEG forward calculations was implemented and head movement correction algorithm was added. Software tools for using fMRI measurements as a priori information for MEG analysis were developed.

MEG data are typically interpreted using source models because of the nonunique inverse problem. Although single current dipoles, adequately representing local active areas, can be identified accurately, multiple and overlapping sources form a challenge for MEG modelling. We tested multidipole modelling and minimum current estimates (MCEs) with complicated source configurations. Simulated current sources were placed to physiologically meaningful areas of the human visual cortices. Ten volunteers from the laboratory staff analysed four different simulations with both dipole modelling and MCE without prior information of the sources. In general the same sources were found using both modelling methods. Subjects tended to select more false positive sources with MCE than with dipole model, most likely in part due to their inexperience with the method. Dipole model was more accurate than MCE both in time and space for nonsimultaneous sources, but both methods performed similarly when sources overlapped in time. For all source configurations, considerably smaller source amplitudes were reported with MCE than with the dipole models.

A comparison of different versions of the Independent Component Analysis (ICA) for extracting evoked MEG responses was carried out in collaboration with the Neural Networks Institute, Helsinki University of Technology. Attempts have been started to develop ICA-based artefact removal from MEG records for routine use.

The advantages and disadvantages of realistically shaped three-dimensional boundary-element models in MEG source localization were studied using computer simulations.

MEG ANALYSIS OF CORTICAL RHYTHMS AND CONNECTIVITY

Identifying the sources of oscillatory activity in the human brain is a challenging problem. The fluctuations in phase and amplitude of cortical oscillations preclude signal averaging over successive sections of the data without a priori assumptions. The previous approaches of identifying sources of oscillatory activity by dipole modelling of bandpass filtered data are quite laborious and requires that multiple criteria are defined by an experienced user. We have introduced a convenient method for source localization using minimum current estimates (MCE) in the frequency domain. The algorithm has been tested on simulated and measured MEG data and compared with conventional dipole modelling.

We have continued the development of our analysis method for identification of brain areas with correlated time series of activation, Dynamic Imaging of Coherent Sources (DICS). The method was successfully applied to elucidate the neural basis of intermittent motor control. In this case, starting from a peripheral signal, 6-9 Hz pulsatile velocity changes of slow finger movements, it was possible to show that the timing of the finger movements was directly correlated with oscillatory activity in the motor cortex, which again was sustained by cerebellar drive via thalamus and premotor cortex. We are currently developing techniques for identifying cortical networks in experiments where oscillatory peripheral signals are not available. We are also developing methods to detect functionally coupled areas which are consistent (and thus comparable) across tasks and subjects, a critical issue in complex cognitive paradigms.

DICS also allows localization of sources of rhythmic activity. We are currently comparing the performance of DICS, frequency-domain MCE, and sequential dipole modelling in analysis of measured and simulated data.

VISUALIZATION OF MEG DATA ON MRI

Our new visualization method based on texture mapped triangle meshes was improved by making the preprocessing phase faster and more robust. This method allows fast and realistic-looking visualizations of human brain from MRI data using standard OpenGL-based graphics hardware. Texture-mapped cutting planes were used for visualizing inner structures with MCE data showing the activation areas. New research was started to create brain surface tesselations going into sulci facilitating visualization of 3D geometry and activity at these locations of cortex.

DEPTH OF ANESTHESIA: COLLABORATION WITH DATEX-OHMEDA

We have studied various measures of signal entropy and complexity in MEG and EEG signals recorded from sleeping subjects. A fairly good correlation between the depth of sleep and some of the measures was observed. The results were similar to those obtained from anesthetic depth assessment studies using comparable methods. The research was done in collaboration with Datex-Ohmeda.

FUNCTIONAL MAGNETIC RESONANCE IMAGING

R. Hari, V. Jousmäki, **J. Numminen**, S. Salenius, **R. Salmelin**, **M. Schürmann** and T. Tanskanen

ADVANCED MAGNETIC IMAGING (AMI) CENTER

The scientists of BRU and LTL have taken active part in the preparation of the Advanced Magnetic Imaging (AMI) Center that will be opened in February 2002. The center, designed and built by a HUT based concortium and financed among others by TEKES and Wihuri Foundation, houses a 3-Tesla magnet by General Electric that will be used by BRU for brain imaging studies.

Experimental setups and commercial equipments for the stimulation environment of the 3-T fMRI have been tested in Töölö Hospital with a 1.5-T magnet. Visual, auditory and tactile stimulators have been tested and purchased. Trigger system for the fMRI was selected and feedthroughs of the electrically shielded room were designed. The BRU members have also started to learn the fMRI methodology by collaborating with several laboratories in which fMRI is already part of the research routine.

FMRI AT TÖÖLÖ HOSPITAL

Basics of functional magnetic resonance imaging have been investigated at the Department of Radiology in Töölö hospital. The MRI unit in Töölö hospital was equipped with a control system for stimulus presentation and timing. This system is similar to that in the BRU, and it is based on fiber optic technique. In collaboration with Raimo Joensuu from the Electrical Engineering Department at Helsinki University of Technology and Jaana Hiltunen from the National Institute of Occupational Health a new sequence called “epibold” was installed to the 1.5 T GE Signal scanner of the MRI unit. With this sequence we were able scan the whole brain (rather than a small number of slices) in our fMRI experiments. The data transfer from Töölö to the BRU was optimized as well as the conversion of raw data to a format suitable for further analysis. Several analysis programs were tested.

fMRI was applied to the study of tactile memory in humans. Short trains of three tactile stimuli were presented to fingers II-IV of the subject´s left hand, followed after 600-1200 ms by a second train of stimuli. The subject’s task was to memorize the order in which the fingers were stimulated. If the two trains were identical, the subjects were asked to lift their right hand index finger during the time interval before the next train pair (1700-2200 ms). The stimuli were presented in 30-s blocks, between which were 30 s rest blocks with no task. This memory session was followed by a control session with the same stimuli but without the memory task. In this control session the subject was asked to react to infrequent stimuli presented to the left V finger. Altogether 10 subjects have been investigated. The results are currently being analyzed.

FMRI IN COLLABORATION WITH THE AIVI NMR GROUP (KUOPIO)

We have started comparison of fMRI and MEG activation patterns in response to vibrotactile somatosensory stimulation, using an identical experimental setup in both modalities. The 1-s vibratory stimuli were presented at intervals of 1, 3, and 5 seconds. The aims of the study are three-fold: First, we wish to compare the locations of the activated sites using standard fMRI BOLD technique. Second, we hope to develop fMRI sequences which would give stronger emphasis to parenchymal (rather than venous) signals. Third, we hope to compare the effect of interstimulus interval on synchrony (MEG) and amount (fMRI) of activation in the primary somatosensory cortex and in other activated areas, possibly including the second somatosensory cortex.

FMRI AT NIH

In collaboration with colleagues at NIH, Bethesda, Maryland USA, we have carried out combined MEG-fMRI studies. fMRI has been used previously to show that visually presented categories of objects elicit distinct spatial patterns of response in ventral extrastriate cortex, and that these category-related responses can be modulated by attention. Event-related potentials and fields, which have a finer temporal resolution than fMRI, have demonstrated temporally specific neural responses to object categories in ventral extrastriate cortex, including an early face-specific response with a latency of 170 ms (N170) as well as later face-specific responses. The effect of attention on the temporal components of neural responses to object categories is unknown.

Nine subjects performed a one-back recognition task during 4 different stimulus conditions: faces (F), houses (H), and double exposure images of superimposed faces and houses with selective attention to faces (Dblx-F) or houses (Dblx-H). Subjects were instructed to respond when a stimulus matched the previously presented stimulus. In MEG, the N170m was clearly evident in the F condition. N170m was clearly evident also in both Dblx conditions regardless of whether the subject was attending to the face or the house, suggesting that the processing of the face in the double-exposure stimulus occurs prior to the influence of attention. At about 200-250 ms after stimulus onset the signals started to be modulated by attention. The behaviour now followed that seen in the pure H and F conditions, depending on which aspect of the image (house or face) was attended. In fMRI, on the other hand, attention to houses resulted in activation of the area as was activated by houses presented alone and therefore separate scan the face area. The brief detour of activation to the 'face area' in the Dblx-H condition, revealed by MEG, was thus not visible in fMRI. The MEG results identify the time point at which attention modulates processing of information regarding object categories.

FMRI AT THE FUNCTIONAL IMAGING LABORATORY (LONDON)

Under normal circumstances information from a number of sources is combined to compute a unitary percept of the body, but after pathology these influences may be perceived simultaneously, resulting in multiple dissociated conscious representations. We have previously described subject E.P., a right-handed female stroke patient with a right frontomesial lesion who sporadically experiences a supernumerary 'ghost' left arm that occupies the previous position of the real left arm after a delay of 60–90 s. We now used a delayed response paradigm in fMRI to examine, in collaboration with colleagues at FIL, London and in Jyväskylä, the neurovascular correlates of E.P.'s illusion. Comparison of periods of time during scanning when the ghost arm was present against when it was not revealed a single cluster located on the right medial wall in the supplementary motor area ('SMA proper'). Our results suggest that areas traditionally classified as part of the motor system can influence the conscious perception of the body. We propose that, as a consequence of her injury, E.P. is aware of the position of the phantom limb in this 'action space' while also continuing to be aware of the true position of her real limb based on afferent somatosensory information.

TEACHING ACTIVITIES

COURSES

Martin Schürmann, lecturer, *Non-invasive measurement of human brain function: Basic signal processing for electrophysiological studies with hands-on MATLAB exercises*, course for graduate students at HUT 11/2001-02/2002.

Juha Tuoriniemi, lecturer, **Kirsi Juntunen**, teaching assistant, *Matalien lämpötilojen fysiikan menetelmät (Methods for Low Temperature Physics) (Kyl-0.102).*

Janne Viljas, teaching assistant, *Secondary Macroscopic Quantum Effects (Tfy-44.147).*

SUPERVISION OF SPECIAL PROJECTS

Harry Alles supervised **Vesa Vaskelainen's** special project *Gas operating system.*

Harry Alles supervised **Heikki Junes'** special project *A cold valve.*

Antti Tarkiainen supervised **Maria Husberg's** special project *The use of a three-layer boundary-element model in localization of brain activity.*

Erkki Thuneberg supervised **Noora Kovalainen's** special project *Surface texture of 3He-A in rf field.*

Grigori Volovik supervised **Pekka Huhtala's** special project *Fermions in extended objects.*

ACADEMIC DEGREES

DIPLOMA THESES

Jan Kujala graduated as M.Sc.Tech. from the Department of Engineering Physics and Mathematics on June 12. His diploma thesis *Dynamic imaging of coherent sources: Development of a method and software* was done in the LTL. Supervisor: Professor Toivo Katila. Instructors: Docent Riitta Salmelin and Dr. Joachim Gross.

PH.D. DISSERTATIONS

Jaakko Ruohio defended his Ph.D. thesis *Doubly quantized vorticity and other NMR experiments on rotating 3He superfluids* on April 6. The opponent was Professor Jeevak Parpia from Cornell University, Ithaca, NY, USA. The work, carried out in the LTL, was supervised by **Matti Krusius**.

Jari Penttilä defended his Ph.D. thesis *Influence of electromagnetic environment in single tunnel junctions* on April 7. The opponent was Professor David Haviland from The Royal Institute of Technology in Stockholm, Sweden. The work, carried out in the LTL, was supervised by **Pertti Hakonen**.

Viktor Tsepelin defended his Ph.D. thesis *Investigations of solid-liquid interfaces in helium at ultralow temperatures* on June 6. The opponent was Professor Sébastien Balibar, Laboratoire de Physique Statistique, France. The work, carried out in the LTL, was supervised by **Harry Alles** and **Alexei Babkin.**

Juha Kopu defended his Ph.D. thesis *Numerical calculations on vortex phenomena in helium superfluids* on June 9. The opponent was Professor Vladimir Mineev from CEA-Grenoble, France. The work, carried out in the LTL, was supervised by **Erkki Thuneberg.**

Kimmo Uutela defended his Ph.D. thesis *Estimating neural currents from neuromagnetic measurements* on December 18. The opponent was Professor Livio Narici from University of Rome "Tor Vergata", Italy. The work, carried out in the LTL, was supervised by **Matti Hämäläinen**.

SYMPOSIA

ULTI III USERS' MEETING

Symposium on Ultra Low Energy Physics: Methods and Phenomenology, was held in Pohja, in January 10 - 14, 2001. It was organized by LTL and attracted 85 scientists from 11 countries. It was the third symposium in a series of meetings sponsored by ULTI I, II and III, the three consecutive European Union visitor programs of the Low Temperature Laboratory. The previous symposia were organized in 1994 and 1998.

The object of the symposium was to review the progress of the ongoing ULTI III projects (EU grant number HPRI-1999-CT-00050 in the Transnational Access to major Research Infrastructures program, 2000 - 03) and explore the possibilities for future experiments within this program. The scientific program of the symposium consisted of 39 oral contributions and 22 posters in the following five areas:

Cosmology and Condensed Matter Physics
Quantum Phases of ^{3}He and ^{4}He
Superconductivity and Magnetism
Mesoscopics
Low Temperature Techniques.

The Symposium Proceedings, edited by Harry Alles, Pertti Hakonen, Matti Krusius, Mikko Paalanen, Erkki Thuneberg, Juha Tuoriniemi and Grigory Volovik appeared in Journal of Low Temperature Physics, Vol 124.

NEURO-BIRCH III USERS´ MEETING

The Brain Research Unit arranged a Neuro-BIRCH III users´ meeting in Majvik, Kirkkonummi 14.-16.9. 2001. Altogether 64 scientists participated, 35 of them from Finland. There were scientists from the following countries: France, Italy, Germany, Portugal, UK, Denmark, Japan, Greece, USA, and the Czech Republic.

The program, which was focussed on the present and future of MEG, aroused a lot of interest and discussion. Altogether 22 presentations were given during this stimulating weekend.

Not to forget the recreational side in the meeting, the Finnish Olympic Games (including Throwing the Mobile) took place on Saturday and were successfully finished by sauna and a dip into the ice-cold sea.

SYMPOSIUM IN HONOR OF GRIGORY VOLOVIK AND HIS SEMINAL CONTRIBUTIONS IN PHYSICS

Year 2001 marked a triple anniversary in Grigory Volovik's scientific career. He celebrated his 55th birthday and the 25th anniversary of his first publication on topological defects. Exactly 20 years ago, in August of 1981, he also played a significant role when the vortices of superfluid ^{3}He were first observed in our laboratory.

The LTL wanted to recognize the contributions of Grigory Volovik by organizing in his honor a public symposium on Quantum Field Theory in Condensed Matter Physics. In this one-day meeting, held on September 10, 2001, many friends and colleagues shared their memories about Grigory Volovik. The list of speakers included Olli Lounasmaa, Nikolai Kopnin, Pertti Hakonen, Matti Krusius, and Erkki Thuneberg with short contributions. Professor Thomas Kibble (Topological defects in cosmology and condensed matter) from Imperial College, London, Professor Vladimir Mineev (Paraconductivity near normal metal-superconductor quantum critical point) from CEA, Grenoble, and Academicians Vladimir Dmitriev (Pulsed NMR experiments on ^{3}He in aerogel), Igor Fomin (Symmetry of the superconducting phase in the itinerant ferromagnet UGe_2) and Alexander Parshin (Kinematic multiplication of steps and the nature of burst-like growth of helium crystals) from Kapitza Institute, Moscow gave also short reviews of their latest scientific endeavors. Finally Grigory Volovik responded by telling, how it all really happened.

LTL SEMINAR SERIES

RESEARCH SEMINARS ON LOW TEMPERATURE PHYSICS

Organized by **Matti Krusius** and **Pertti Hakonen**

Dr. Jaakko Koivuniemi, CERN, Geneve, Switzerland: *The present status of the COMPASS experiment at CERN* (Jan 5)

Prof. Jarmo Hietaranta, University of Turku*: Faddeev-Skyrme vortices and knots* (Jan 23)

Dr. Julien Delahaye, LTL: *Some aspects of the electronic properties of quasicrystals* (Feb 21)

Prof. Jeevak Parpia, Cornell University, Ithaca, New York, USA: *Dynamic mechanical properties of nanoscale materials* (Apr 4)

Prof. Jeevak Parpia, Cornell University, Ithaca, New York, USA: *3He in Aerogel - Introducing disorder into a superfluid* (Apr 5)

Dr. Andrei Zaikin, Forschungszentrum Karlsruhe, Institut für Nanotechnologie, Germany: *Coulomb blockade and quantum transport through coherent conductors* (Apr 19)

Prof. Frank Hekking, Magistere-CNRS, Grenoble, France: *Entangled states in a Josephson charge qubit coupled to a superconducting resonator* (Apr 20)

Dr. Ladislav Skrbek, Institute of Physics ASCR and Charles University, Prague, Czech Republic: *Is He II turbulence classical?* (May 9)

Prof. Satoshi Tanda, Department of Applied Physics, Hokkaido University, Sapporo, Japan: *Topological matter of chain and layer compounds* (Jun 12)

Prof. Nikolai Kopnin, LTL: *Impurity band in superfluid point contacts* (Jun 11)

Prof. Boris Spivak, Physics Department, Washington University, Seattle, Washington, USA: *Properties of strongly correlated electron gas in Si-MOSFET's* (Jun 15)

Prof. Philip Adams, Lousiana State University, Baton Rouge, Lousiana, USA: *Bridging the gap: Quantum metallicity in a 2D insulator* (Aug 6)

Dr. Mikael Fogelström, Institute for Theoretical Physics, Chalmers and Göteborg University, Gothenburg, Sweden: *Transport through superconductor / magnetic dot / superconductor* (Aug 10)

Dr. Juha Tuoriniemi, LTL: *Ultraherkkiä mittauksia erittäin kylmissä heliumseoksissa, (Ultrasensitive measurements on extremely cold helium mixtures)* (Aug 21)

Prof. Maurice Chapellier, École Normale Supérieure, Paris, France: *The search for dark matter: Experiments with the Edelweiss detector* (Aug 28)

Prof. Tanmay Vachaspati, Case Western Reserve University, Cleveland, Ohio, USA: *Interaction of magnetic monopoles and domain walls* (Aug 29)

Dr. Kurt Gloos, University of Jyväskylä, Finland: *Point-contact experiments with heavy-fermion superconductors* (Sep 4)

Prof. Noriyuki Hatakenaka, NTT Basic Research Laboratories, Atsugi, Japan: *Solitonic surfing* (Sep 7)

Dr. Frank Wilhelm, Ludwig-Maximilians-Universität, München, Germany: *An asymptotical von-Neumann measurement strategy for solid-state qubits* (Sep 11)

Prof. Hiroumi Ishii, Osaka City University, Japan: *Magnetism of Pr compounds with two non-equivalent lattice sites* (Sep 27)

Prof. Edouard Sonin, LTL: *Interplay of ferromagnetism and superconductivity in a ferromagnet-superconductor bilayer* (Sep 28)

Dr. Vadim Gurevich, Ioffe Institute, Zelenogorsk, Russia: *Theory of shot noise of coulomb drag current* (Oct 19)

Dr. Boris Zakharchenya, Ioffe Institute, Zelenogorsk, Russia: *Optical cooling of nuclear spins in semiconductors* (Oct 31)

Prof. Dr. Wilfried Schoepe, University of Regensburg, Germany: *Turbulence in superfluid helium-4 at mK temperatures* (Nov 16)

RESEARCH SEMINARS OF THE BRAIN RESEARCH UNIT

Organized by **Päivi Helenius** and **Ole Jensen**

Dr. Kenneth Pugh, Yale University School of Medicine, New Haven, Connecticutt, USA: *Methodological issues in neuroimaging studies of skilled reading and reading disability: establishing brain/behavior links* (Feb 5)

Dr. Nobuya Fujiki, LTL: *Frequency tagging of auditory input* (Feb 12)

Dr. James Haxby, NIMH, Bethesda, Maryland, USA: *Distributed and overlapping representations of faces and objects in ventral temporal cortex* (Feb 15)

Ms. Maria Husberg, LTL: *The use of a three-layer boundary-element model on localization of brain activity* (Feb 26)

Dr. Fumiya Takeuchi, Hokkaido University, Research Institute for Electronic Science, Kita-ku, Japan: *How should we use the magnetometer data?*(Feb 26)

Ms. Tiina Vuorinen, LTL: *Paper: Clustering of perinhinal neurons with similar properties following visual experience in adult monkeys,* Nature Neurosci (2000) 3:1143-1148 (Mar 5)

Dr. Ole Jensen, LTL: *Paper: Rapid feature selective neuronal synchronization through correlated latency shifting,* Nature Neurosci (2001) 4:194-200 (Mar 5)

Dr. Hidehisa Yanashita, Hiroshima, Japan: *Neuroimaging studies in Hiroshima University* (Mar 12)

Prof. John Lisman, Braanders University, Waltham, Massachusetts, USA and Prof. Wolf Singer, Max-Planck Institut für Hirnforschung, Germany: *Binfing and gamma extravaganza* (Mar 19)

Ms. Cristina Simões, LTL: *Paper: Long-range cortical synchronization without concominant oscillations in the somatosensory system of anestesized cats*, J. Neurosci (2001) 21:1795-1808 (Mar 26)

Mr. Mika Seppä, LTL: *Paper: Mathematical/computational challenges in creating deformable and probabilistic atlases of the human brain*, Human Brain Mapping (2000) 69:167-171. (Mar 26)

Dr. Markku Sainio, LTL: *Occupational solvent induced psycho-organic syndrome* (Apr 2)

Dr. Flamine Alary, LTL: *Paper: Regenerating the damaged central nervous system,* Nature (2000) 407:963-970 (Apr 9)

Dr. Juha Päällysaho, LTL: *Cerebellum - a vision review* (Apr 23)

Ms. Katri Kiviniemi, LTL: *Paper: Activation of the left amygdala to a representation to fear,* Nat. Neurosci (2001) 4: 437-441 (May 7)

Dr. Juha Järveläinen, LTL: *Paper: Looking for the agent: an investigation into conciousness of action and self-consiousness in schizphrenic patients,* Cognition (1997) 65:71-86 (May 14)

Dr. Martin Schürmann, LTL: *Minds ear in musician* (May 14)

Mr. Jan Kujala, LTL: *Paper: Hearing the sound of silence: a magnetoencephalographic study,* Neuroreport (2001) 12 (May 21)

Dr. Minna Vihla, LTL: *Paper: A fMRI study with written Chinese,* Neuroreport (2001) 12:83-88 (May 21)

Dr. Marjatta Pohja, LTL: *Paper: Functional changes of the primary somatosensory cortex in patients with unilateral lesions,* Brain (2001) 124: 757-768 (May 28)

Mr. Kimmo Uutela, LTL: *Detecting and correcting head movements in neuromagnetic measurements* (Jun 4)

Ac. Prof. Riitta Hari, LTL: *Mirror neurons* (Jun 18)

Dr. Ryusuke Kakigi, Department of Integrative Physiology, National Institute for Physiological Sciences, Okazaki, Japan: *Neurophysiologic assesment of pain* (Aug 10)

Mr. Lauri Parkkonen, LTL: *Review: stochastic resonance in neural systems* (Sep 10)

Mr. Topi Tanskanen, LTL: *Paper: Neurophysiological investigation of the basis of the fMRI signal,* Nature 2001 Jul 12;412 (6843):150-157 (Sep 10)

Dr. Sylvain Baillet, Cognitive Neuroscience & Brain Imaging Laboratory, Hopital de la Salpêtriére, Paris, France: *The Brain Storm toolbox* (Sep 19)

Mr. Antti Tarkiainen, LTL: *My latest results concerning fluent readers, dyslexic readers and face processing* (Sep 24)

Ms. Sari Avikainen, LTL: *Journal papers*: *The functional neuroanatomy of social behavior,* Critchley et al. Brain (2000) 123:2203-2212; *Abnormal ventral temporal cortical activity during face discrimination among individuals with autism and Asperger syndrome,* Schultz et al. Arch. Gen. Psychiatry (2000) 57:331-340 (Sep 24)

Mr. Andrea Brovelli, Cognitive Neuroscience Center, SISSA, Trieste, Italy: *Medium-range oscillatory network and the 20-Hz sensorimotor induced potential (20-Hz SIP)* (Oct 1)

Dr. Tuukka Raij, LTL: *Journal paper: Functional imaging of brain responses to pain: a review and metanalysis,* Peyron et al., Neurophysiol. Clin. (2000) 30:263 (Oct 8)

Dr. Päivi Helenius, LTL: *Cortical organization of semantic and syntactic processing during reading* (Oct 8)

Ms. Tiina Vuorinen, LTL: *Processing of speech and nonspeech sounds in the left auditory cortex* (Oct 15)

Ms. Reetta Lehtonen, LTL*: Journal paper*: *Dyslexia, development and the cerebellum,* Trends Neurosci. 2001 Sep; 24(9):515-6 (Oct 15)

Mr. Nuutti Vartiainen, LTL: *Journal paper: Cortical reorganization in motor cortex after graft of both hands,* Nature Neuroscience. 2001 July; 4(7):691-692 (Oct 22)

Mr. Mika Seppä, LTL: *Visualizing human brain from T1 weighted MR images using texture mapped triangle mesh* (Oct 22)

Dr. Joseph Classen, Neurologische Klinik der Universität Rostock, Germany: *Induction of plasticity in the human motor cortex* (Oct 29)

Ms. Cristina Simões, LTL: *Journal paper: Hierarchical equivalence of somatosensory areas I and II for tactile processing in the cerebral cortex of the marmoset monkey,* Zhang et al., J. Neurophysiol. (2001) 85: 1823-1835 (Nov 5)

Dr. Ole Jensen, LTL: *The physiological basis of cortical gamma and beta oscillations: A review and recent findings* (Nov 5)

Mr. Antti Tarkiainen, LTL: *Graphic formats* (Nov 19)

Ms. Cristina Simões, Mr. Topi Tanskanen, and Dr. Ole Jensen, LTL: *SFN summary* (Nov 26)

Dr. Marja Laasonen, Department of Psychology, University of Helsinki: *Temporal processing in developmental dyslexia* (Dec 3)

Dr. Juha Järveläinen, LTL: *SFN summary* (Dec 3)

Mr. Alexander Fingelkurts, Laboratory of Computational Engineering, Helsinki University of Technology: *The probability-classification analysis of single-trial spectral EEG/MEG changes* (Dec 10)

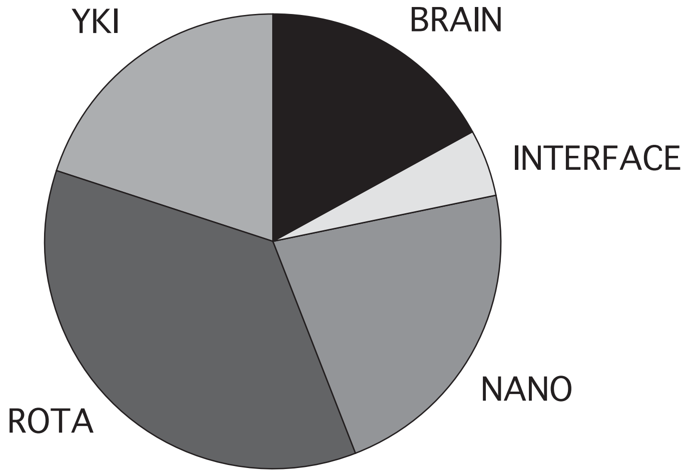
Mr. Andrey Fingelkurts, Laboratory of Computational Engineering, Helsinki University of Technology: *Analysis of the operational structure of electromagnetic brain field* (Dec 10)

Ms. Tiina Vuorinen, LTL: *SFN summary* (Dec 10)

TECHNICAL SERVICES

MACHINE SHOP

A. Huvila, **J. Kaasinen**, M. Korhonen, M. Lehtovuori, and K. Rauhanen.



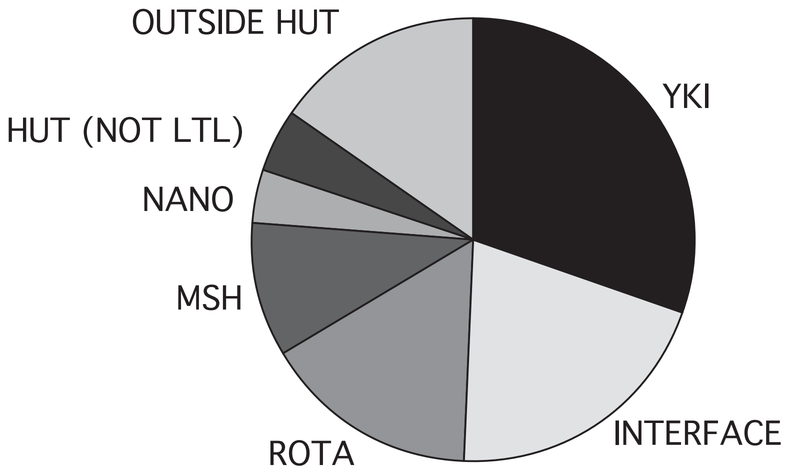
Distribution of the workload for different users' groups.

The LTL workload on the workshop was 1177 machine hours. The total workload 3091 machine hours include also work for Institute of Biomedical Engineering and Materials Physics Laboratory as well as Advanced Energy Systems.

CRYOGENIC LIQUIDS

A. Isomäki and A. Salminen

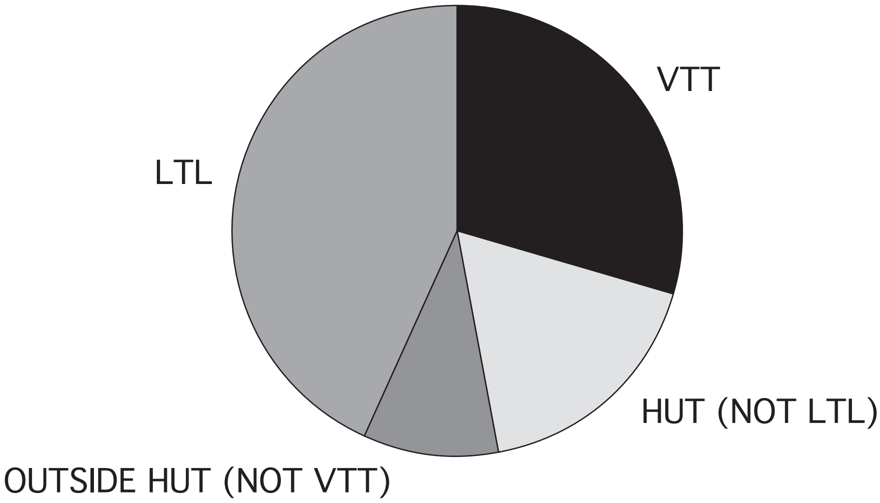
Helium



The total amount of liquid helium delivered to the users was about 44 000 liters.

The helium liquefaction equipment (Linde TCF-20) has been in use for over 13 years and its renewal will become necessary within the next 4 years. Our helium gas storage capacity is 12.5 cubic meters at high pressure (150 bars) which corresponds to about 2500 liquid liters. The liquid storage capacity is at present about 3500 liters of liquid helium in various cryogenic containers.

Nitrogen



Our nitrogen liquefier (Linde - LINIT 25) was installed in 1996 and more than half of its production goes outside the LTL. The total amount produced this year was 46 500 liters. The distribution of the users is shown above.

ACTIVITIES OF THE PERSONNEL

PERSONNEL WORKING ABROAD

Berglund, CERN, Switzerland, 25.1. - 2.2., 28.3. - 1.4., 30.8. - 15.9.

Hakonen, CRTBT, Grenoble, France, 15. - 21.9.

Hämäläinen, Massachusetts General Hospital, Nuclear Magnetic Resonance Center, Massachusetts, USA, starting from 1.2.

Jousmäki, Veterans General Hospital, Taipei, Taiwan, 4.4. - 13.4.

Koivuniemi, CERN, Switzerland.

Roschier, Yale University, New Haven, Connecticut, USA, 9.5. - 10.6.

Tsepelin, University of New Mexico, Albuquerque, New Mexico, USA, 16. - 23.1.

CONFERENCE PARTICIPATION AND LABORATORY VISITS

Ahlskog	Poster, *Multiwalled carbon nanotubes as nanoscale electronic devices,* ULTI III Users' Meeting, Ultra Low Energy Physics : Methods and Phenomenology, Pohja, Finland, 10.1

Poster, *Multiwalled carbon nanotubes as nanoscale electronic devices,* Nanotube-2001: International Workshop on the Science and Applications of Nanotubes, Potsdam, Germany, 22.7.

Alles — Invited talk, *Optical experiments at ultra low temperatures - new facets on helium-3 crystals (in Estonian),* Annual Meeting of Estonian Physical Society, Tartu, Estonia, 12.2.

Oral presentation, *The Low Temperature Laboratory of Helsinki University of Technology through the eyes of an insider (in estonian),* seminar, Tartu University, Institute of Physics, Tartu, Estonia, 23.11.

Avikainen — Invited talk, *Brain mechanisms of action observation,* Second Nordic Conference of Research on Autism/Asperger Syndrome, Oulu, Finland, 22.2.

Invited talk, *Ihmisen Peilisolujärjestelmä, (Human Mirror Neuron System),* Yle, Prisma-ohjelma (TV program), Helsinki, Finland, 24.2.

Participation, Neuro-BIRCH III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Poster, *Enhanced exstrastriatal activation during observation of unnatural finger postures,* Society for Neuroscience 31st Annual Meeting, San Diego, California, USA, 10.11.

Blaauwgeers — Poster, *The A-B boundary experiment in rotating superfluid 3He*, ULTI III Users´ Meeting, Ultra Low Energy Physics: Methods and Phenomenology, Pohja, Finland, 10.1.

Forss — Session chairman, Oppivat aivot (Learning Brains*)*, Tieteen Päivät (Science Days 2001), University of Helsinki, Helsinki, Finland, 10.1.

Invited talk, *Timing in cortical sensorimotor network*, Neuroscience for Dummies II: Timing in Brain Function, Helsinki University of Technology, Espoo, Finland, 6.4.

Fujiki — Poster, *Binaural interaction revealed using frequency-tagged amplitude-modulated tones,* The 7th Annual Meeting of the Organization for Human Brain Mapping, Brighton, United Kingdom, 10.6.

Hakonen — Session chairman and Organizer of the Kevo Spring School on Mesoscopic Physics for Graduate Students of Nordic Countries , Kevo Subarctic Research Institute, Kevo, Finland, 22.4.

Invited talk, *Energy spectroscopy in a Josephson junction,* Superconducting Devices in Nanoelectronics, Naples, Italy, 28.5.

Session chairman, Superconducting Devices in Nanoelectronics, Naples, Italy, 28.5.

Poster, *Multiwalled carbon nanotube: Luttinger liquid or not,* Nanotube-2001: International Workshop on the Science and Applications of Nanotubes, Potsdam, Germany, 22.7.

Lecture, *Energy spectroscopy on a Josephson junction,* Max-Planck Institute, Dresden, Germany, 26.7

Consultation, *Superconductor-Insulator transition,* Max-Planck Institute, Dresden, Germany, 26.7.

Oral presentation, *1) Energy spectroscopy on a Josephson junction, 2) Zero point anomaly in diffusive multiwalled carbon nanotubes,* Review of the program of the NorFA network, Copenhagen, Denmark,1.9.

Consultation, *Collaboration within EU-program*, CRTBT, Grenoble, France, 15.9.

Poster, *Manufacture of single electron transistors using AFM-manipulation on multiwalled carbon nanotubes,* Micro and Nanoengineering Conference 2001, Grenoble, France, 16.9.

Lecture, *Energy level spectroscopy in a single Josephson junction,* CRTBT seminar, CRTBT, Grenoble, France, 18.9.

Hari

Invited plenary talk, *Magnetoenkefalografia aivotutkijan työvälineenä* -- *Äyräpää-luento(MEG as a tool of a brain scientist* -- *Äyräpää lecture),* Lääkäripäivät 2001, Helsinki, Finland, 7.1.

Invited talk, *Peilisolujärjestelmä: miten aivomme reagoivat kanssaihmisten liikkeisiin (The mirror neuron system: how our brains react to movements of cocitizens),* Suomalaisen tutkimuksen eturintamassa. Duodecim-seuran 120-vuotisjuhlasymposium, Helsinki, Finland, 9.1.

Participation, Neuroscience Finland 2001, Saariselkä, Finland, 15.3.

Participation, Artic Symposium on Mechanisms of Memory and Memory Disorders, Saariselkä, Finland, 17.3.

Invited talk, *Introduction to timing issues in human brain imaging*, Neuroscience for Dummies II: Timing in Brain Function, Helsinki University of Technology, Espoo, Finland, 6.4.

Session chairperson, Neuroscience for Dummies II: Timing in Brain Function, Helsinki University of Technology, Espoo, Finland, 6.4.

Conference chairperson, Neurosciece for Dummies II: Timing in Brain Function, Helsinki University of Technology, Espoo, Finland, 6.4.

Invited talk, *Minineglect in dyslexic adults*, The Neglect Day, Helsinki University of Technology, Espoo, Finland, 26.4.

Conference and session chairperson, The Neglect Day, Helsinki University of Technology, Espoo, Finland, 26.4.

Invited talk, *Neuromagnetic studies of the human mirror neuron system,* XV International Congress of Clinical Neurophysiology, Buenos Aires, Argentina, 16.5.

Invited talk, *Current dipoles as models of brain activity*, XV International Congress of Clinical Neurophysiology, Buenos Aires, Argentina, 16.5.

Session chairperson, *Magnetoencephalography, Poster session,* XV International Congress of Clinical Neurophysiology, Buenos Aires, Argentina, 16.5.

Invited talk, *Impaired processing of rapid stimulus sequences as a result of sluggish attention shifting in dyslexic adults: A new interpretation,* Sensory Bases of Reading and Language Disorders, University of Essex, Essex, England, 27.5.

Session chairperson, Sensory Bases of Reading and Language Disorders, University of Essex, Essex, England, 27.5.

Invited talk, *Reading other minds: The human mirror neuron system*, Nokia Summit on Cognition and Artificial Intelligence, Helsinki, Finland, 8.6.

Discussant, *Panel Discussion: Neuroscience, Machine Cognition, Artificial Intelligence; Towards Great Inventions,* Nokia Summit on Cognition and Artificial Intelligence, Helsinki, Finland, 8.6.

Invited comment, *The European computerized human brain database,* The First National Symposium on Neuroinformatics, Helsinki, Finland, 18.6.

Invited talk, *The human mirror neuron system,* ESPR2001, European Society for Pediatric Research, Annual Meeting, Helsinki, Finland, 8.8.

Session chairperson, *New methods of assessing brain function,* ESPR2001, European Society for Paediatric Research, Annual Meeting, Helsinki, Finland, 8.8.

Session chairperson and Workshop Organizer, The 1st NeuroHUT seminar, Helsinki University of Technology, Espoo, Finland. 31.8.

Invited talk, *Brain Research Unit, Low Temperature Laboratory (presentation of activities),* The 1st NeuroHUT Seminar, Helsinki University of Technology, Espoo, Finland, 31.8.

Conference chairperson, The 1st NeuroHUT Seminar, Helsinki University of Technology, Espoo, Finland, 31.8.

Participation, Brains, Genes, Chips: Information Processing in Biological and Manmade Systems, Stockholm, Sweden, 10.9.

Session chairperson, Neuro-BIRCH III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Invited plenary talk, *The human mirror neuron system,* 1st Taiwan-Finland Bilateral MEG Symposion, Taipei, Taiwan, 5.10.

Invited talk, *Yläraajan toiminnan säätely ja aivot, (Brain control of upper limb functions),* Käpylä-seminaari 2001. Keskushermoston tapaturmainen vaurio ja yläraajan toiminta. (Käpylä Seminar 2001. Traumatic Lesions of the Central Nervous System and Function of the Upper Limb), Helsinki, Finland, 10.10.

Invited plenary talk, *Does the new brave brain research help us to understand human behavior?,* Neuroscience2001, Helsinki, Finland, 23.11.

Invited plenary talk, *The human mirror-neuron system,* Nobel Jubilee Symposium "Beyond Genes", Stockholm, Sweden, 6.12.

Participation, Nobel Centennial and Nobel Prize 2001 Festivities, Stockholm, Sweden 9.12.,

Helenius

Invited talk, *Lukihäiriö ja aivot - Miksei lukeminen luista? (Dyslexia and brain activation - Why is reading so difficult?),* Tieteen Päivät: Mitä päässä tapahtuu? (Science Days 2001, What is happening in our heads?), University of Helsinki, Helsinki, Finland, 15.1.

Participation, Optimising the Functional Magnetic Resonance Imaging Experiments, Helsinki University of Technology, Espoo, Finland 8.3.

Participation, The Neglect Day, Low Temperature Laboratory, Helsinki University of Technology, Espoo, Finland, 26.4.

Participation, Neuro-BIRCH III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Hänninen — Poster, *NMRF frequencies of single splay soliton in 3He*, ULTI III Users' Meeting, Ultra Low Energy Physics: Methods and Phenomenology, Pohja, Finland 10.1.

Oral presentation, *NMR spectrum of a soliton in 3He-A*, International Symposium on Quantum Fluids and Solids 2001, University of Konstanz, Konstanz, Germany 22.7.

Illman — Participation, Neuro-BIRCH III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Järveläinen — Oral presentation, *Characterization of human mirror neuron system with MEG*, HFSP Workshop on Mirror Neurons, University of Southern California, Los Angeles, USA, 7.11.

Jensen — Invited talk, *Frontal theta activity in humans increases parametrically with memory load in a working memory task*, Max Planck Institute of Cognitive Neuroscience, Leipzig, Germany, 28.2.

Poster, *Information transfer between rhythmically coupled networks: Reading the hippocampal phase code*, Arctic Symposium on Mechanisms of Memory and Memory Disorders, Saariselkä, Finland, 17.3.

Invited talk, *Frontal theta activity in humans increases parametrically with memory load in a working memory task*, Cognitive Neuroscience and Brain Imaging Laboratory, Hopital de la Salpêtrière, Paris, France, 4.4.

Invited talk, *Temporal coding in hippocampus*, Neuroscience for Dummies II: Timing in Brain Function, Helsinki University of Technology, Espoo, Finland, 6.4.

Invited talk, *The somatosensory mu rhythm: New insights on physiology and cortico-muscle synchrony*, Massachusetts General Hospital Nuclear Magnetic Resonance Center, Boston, Massachusetts, USA, 7.6.

Invited talk, *The somatosensory mu rhythm: New insights on physiology and cortico-muscle synchrony*, Neuroscience and Center for BioDynamics, Boston University, Boston, Massachusetts, USA, 12.6.

Invited talk, *The somatosensory mu rhythm: New insights on physiology and cortico-muscle synchrony*, Department of Neurosurgery, Children's Hospital, Boston, Massachusetts, USA, 13.6.

Invited talk, *Frontal theta activity (6-8 Hz) increases with load in a short-term memorytask: a parametric MEG study*, National Institute of Mental Health, National Institutes of Health, Bethesda, Maryland, USA, 20.6.

Invited talk, *The somatosensory mu rhythm: New insights on physiology and cortico-muscle synchrony*, National Institute of Neurological Disorders and Stroke, National Institutes of Health, Bethesda, Maryland, USA, 21.6.

Poster, *Increased cortical 15-25 Hz mu rhythm with GABAergic transmission is not associated with increased cortico-muscle coherence in the same frequency band*, Dynamical Neuroscience IX, San Diego, California, USA, 9.11.

Poster, *Increased cortical 15-25 Hz mu rhythm with GABAergic transmission is not associated with increased cortico-muscle coherence in the same frequency band*, The Society for Neuroscience 31st Annual Meeting, San Diego, California, USA, 10.11.

Invited talk, *The functional significance of theta and alpha oscillations in working memory*, F.C. Donders Centre, Nijmegen, Holland, 22.11.

Jousmäki

Consultation, *Stimulus environment at Veterans' General Hospital in Taipei*, Veterans General Hospital, Taipei, Taiwan, 4.4.

Participation, Neuro-Birch III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Invited talk, *Magnetoencephalographic (MEG) studies of somatosensation and audiotactile interaction,* 1st Taiwan-Finland Symposium on Magnetoencephalography: Clinical Research and Applications, Veterans' General Hospital, Taipei, Taiwan, 5.10.

Consultation, Barco Simulation Products, Barco Factory, Kuurne, Belgium, 9.11.

Juntunen

Poster, *Exact diagonalization of the Rh nuclear spin system compared to high temperature expansion results*, XXXV Annual Conference of The Finnish Physical Society, Jyväskylä, Finland, 22.3.

Kiviniemi

Participation, Human Brain Mapping Conference 2001, Brighton, UK, 10.6.

Lecture, *Sanojen tuotto ja aivot (Word production and brain),* Fonetiikan tutkijaseminaari, Turku, Finland, 10.10.

Oral presentation, *Neuromagnetic activity preceding success and failure in aphasic naming*, Society for Neuroscience 2001 Annual Meeting, San Diego, California, USA, 11.10.

Krusius

Lecture, *The phase boundary between the A and B phases of superfluid 3He in rotation,* Seminaire Fluides et Solides Quantiques, Centre de Recherches sur les Tres Basses Temperatures (CRTBT-CNRS), Grenoble, France, 12.6.

Invited talk, *Vortex physics in 3He-A,* European Science Foundation Programme on Vortex Matter, Conference on Critical Properties of Vortex Matter, Loen, Norway, 21.6.

Invited talk, *Quantized vortex lines and vortex sheets in superfluid 3He-A*, European Science Foundation Programme on Cosmology in the Laboratory, First COSLAB Workshop, Imperial College, University of London, London, UK, 7.7.

Interview in radio programme*: The Nobel Prize in Physics in 2001: Bose-Einstein Condensation*, Interview by Jaana Kanninen for the news hour at 22:00 in Yleisradio, Yleisradio, Helsinki, Finland, 9.9.

Invited talk, *Quantized vorticity in p-wave order-parameter fields: The case of the 3He superfluids,* II European Conference on Vortex Matter in Superconductors, European Science Foundation Programme on Vortex Matter, Crete, Greece 15.9.

Lecture, *Quantized vortex lines or sheets: What is formed in dynamical drives in anisotropic superfluid 3He-A,* Seminaires des Institutes de Physique des Matiéres Condensés, Grenoble, France, 5.10.

Interview in radio programme*: The Nobel Prize in Physics in 2001: Bose-Einstein Condensation*, Interview by Maija Typpi in radio Yle 1, Radiaattori, Helsinki, Finland, 17.10.

Invited talk, *Quantized vorticity in 3He superfluids,* Nobel Jubilee Symposium: Condensation and Coherence in Condensed Systems, Gothenburg, Sweden, 4.12.

Kujala

Participation, Optimising the Functional Magnetic Resonance Imaging Experiments, Helsinki University of Technology, Espoo, Finland, 8.3.

Participation, Workshop on Coherence Analysis, Cognitive Neuroscience and Brain Imaging Laboratory, Hopital de la Salpêtrière, Paris, France, 24.3.

Consultation, Development Session on Dynamic Imaging of Coherent Sources, Heinrich-Heine University, Düsseldorf, Germany, 4.4.

Participation, The Neglect Day, Helsinki University of Technology, Espoo, Finland, 26.4.

Participation, Neuro-BIRCH III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Mäkelä — Oral presentation, *MEG, minimal invasive surgery, electric stimulation and functional imaging of the brain*, Turku University Central Hospital, Turku, Finland, 19.1.

Poster, *Dorsal penile nerve stimulation elicits strong activation in the second somatosensory cortex,* XV International Congress of Clinical Neurophysiology, Buenos Aires, Argentina,16.5.

Session chairman, Neuro-Birch III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Oral presentation, *Toiminnallinen MEG-paikannus neurologisilla potilailla (Functional MEG localization in neurological patients),* OYKS Neurologian klinikan jatkokoulutustilaisuus (Occation for Further Education, Neurological Clinic, Oulu University Hospital), OYKS, Oulu, Finland, 25.10.

Martikainen — Poster, *SQUID amplifier for vibrating wire viscometers* , ULTI III Users' Meeting, Ultra Low Energy Physics: Methods and Phenomenology, Pohja, Finland, 10.1.

Poster, *Vibrating wire measurements in 3He-4He mixtures in the ballistic quasiparticle regime,* International Symposium on Quantum Fluids and Solids (QFS 2001), Konstanz, Germany, 22.7.

Numminen — Participation, 7th Annual Meeting of the Organization for Human Brain Mapping, Brighton, United Kingdom, 10.6.

Paalanen — Oral presentation, *Pieni on kaunista, vielä pienempi näkymätöntä (Small is beatiful, smaller invisible),* Tieteen Päivät (Science Days), Helsinki, Finland 11.1.

Invited talk, *Multiwalled carbon nanotube as a transmission line*, 36th Rencontres de Moriond, Electronic Correlations: from Meso - to Nano - Physics, Le Moriond, France, 26.1.

Lecture, *Nanotechnology - Past, Present and Future,* Winter School of Ioffe Institute, Zelenogorsk, Russia, 2.3.

Lecture, *Multiwalled nanotubes as transmission lines,* Winter School of Ioffe Institute, Zelenogorsk, Russia, 2.3.

Lecture, *Multiwalled nanotubes: Luttinger liquid or not?,* Princeton Physics seminar, NEC Laboratories in Princeton, New Jersey, USA, 6.3.

Lecture, *Multiwalled nanotube: Luttinger liquid or not?,* Bell Laboratories of Lucent Technologies, Murray Hill, New Jersey, USA. 8.3.

Oral presentation, *Multiwalled carbon nanotube: Luttinger liquid or not?,* APS March Meeting, Seattle, Washington, USA. 12.3.

Oral presentation, *Energy level spectroscopy in periodic potential of macroscopic quantum variable,* APS March Meeting, Seattle, Washington, USA, 12.3.

Lecture, *How to organize an LT conference?*, Ohio State University, Columbus, Ohio, USA, 19.3.

Lecture, *Multiwalled carbon nanotube: Luttinger liquid or not?*, Ohio State University, Columbus, Ohio, USA, 19.3.

Lecture, *Electron transport in multiwalled nanotubes,* University of Turku, Physics Department, Turku, Finland, 4.6.

Participation, *Brains, Genes & Chips: Information processing in biological and man-made systems,* Symposium of The Peter Wallenberg Foundation, Stockholm, Sweden, 10.9.

Lecture, *Nanotekniikan tulevaisuus (The future of nanotechnology),* Varkauden tiedeklubi, Varkaus, Finland, 5.11.

Lecture, *Tieteellisen julkaisemisen tavoitteet ja normit, (The goals and norms of scientific publications),* TKK:n Kalliotekniikan tutkijakoulu, (Department of Metallurgy, Helsinki University of Technology), Espoo, Finland, 21.11.

Session chairman, Nobel Jubilee Symposium, Condensation and Coherence in Condensed Systems, Gothenburg, Sweden, 4.12.

Paetau — Invited talk, *MEG and epilepsy in diagnosis and surgical evaluation,* Swedish Epilepsy Society autumn course, EEG-diagnostik av epilepsi, Tekniska Högskolan, Lund, Sweden, 19.10.

Parkkonen — Poster, *High-resolution magnetometer and gradiometer recordings of spike-like (600 Hz) SEF bursts,* Neuroscience Finland 2001, Saariselkä, Finland, 15.3.

Participation, Arctic Symposium on Mechanisms of Memory and Memory Disorders, Saariselkä, Finland, 17.3.

Participation, Neuro-BIRCH III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Participation, Autumn School, Oxford Centre for Cognitive Neuroscience, Oxford, UK, 25.9.

Lecture, *MEG tutorial*, MEG Tutorial Course for the Users of the MGH MEG Facility, Athinoula A. Martinos Center, Massachusetts General Hospital, Harvard University, Massachusetts, USA, 3.12.

Pohja — Participation, Neuropaattinen Kipu (Neuropathic Pain), Oulu, Finland, 13.9.

Participation, Neuro-BIRCH Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Raij Tommi — Invited talk, *Neuromagnetic characterization of dynamic cortical networks supporting human cognition*, Neuroscience Finland 2001: Novartis-Exelon Prize Winner, Saariselkä, Finland, 15.3.

Participation, Arctic Symposium on Mechanisms of Memory and Memory Disorders, Saariselkä, Finland, 17.3.

Raij Tuukka — Participation, Neuropathic Pain, Oulu, Finland, 13.9.

Renvall — Participation, The Neglect Day, HUT, Espoo, Finland, 26.4.

Poster, *Diminished auditory mismatch fields in dyslexic adults* , Sensory Bases of Reading and Language Disorders, University of Essex, England, 27.5.

Participation, Imaging Neuronal Function, Cognitive Neurobiology Laboratory, A. I. Virtanen Institute, University of Kuopio, Finland, 27.8.

Participation, Neuro-BIRCH III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Invited talk, *Magnetoencephalography in studies of human brain function,* Helsinki Biograduate School: Cell Biology Seminars, Biomedicum, Helsinki, Finland, 28.11.

Roschier — Poster, *Ultrasensitive carbon nanotube single-electron transistor,* 36th Recontres de Moriond Electronic Correlations: From Meso- to Nano-Physics, Le Moriond, France, 20.1.

Poster, *Ultrasensitive carbon nanotube single-electron-transistor,* Kevo Spring School on Mesoscopic Physics for Graduate Students of Nordic Countries, Kevo, Finland, 22.4.

Visit to Leiden University, Leiden, The Netherlands, 29.9.

Invited talk, *Sensitivity of the rf-SET,* SQUBIT/QDNS/TMR Meeting at Chalmers, Gothenburg, Sweden 25.11.

Salenius — Invited talk, *Interactions between muscle activity and cortical rhythms,* Movement and Sensation International Symposium (IUPS satellite), Cairns, Australia, 3. - 6.9.

Invited talk, *Interactions between muscle activity and cortical rhythms,* 1st Taiwan - Finland Symposium on Magnetoencephalography, Taipei, Taiwan, 5.10.

Salmelin — Consultation, *Discussion of approaches to estimating cortico-cortical coherence from MEG data,* Cognitive Neuroscience and Brain Imaging Laboratory, Hopital de la Salpêtrière, Paris, France, 24.3.

Invited talk, *Cortical dynamics of word production in stutteres,* Neuroscience for Dummies II: Timing in Brain Function, Helsinki University of Technology, Espoo, Finland, 6.4.

Invited talk, *Cortical dynamics of language function and dysfunction,* Maryland Mayfest 2001 Cognitive Neuroscience of Language, Washington DC, Maryland, USA, 18.5.

Consultation, Universitäts-Krankenhaus Eppendorf, Hamburg, Germany, 31.5.

Session chairperson, *Oral session: Language,* 7th International Conference on Human Brain Mapping (HBM2001), Brighton, UK, 10.6.

Lecture, *Kielellisen toiminnan ja sen häiriöiden reaaliaikainen kuvantaminen ihmisaivoissa (Real-time imaging of language function and dysfunction in the human brain),* Helsingin yliopiston kurssi, Psykologian vapaa puoliarvosana (Pps500, 10 ov)(Course in the Helsinki University), Helsinki, Finland, 2.8.

Invited talk, *Conceptual issues in merging MEG/EEG and fMRI in neuroscience,* Optimising the Functional Magnetic Resonance Imaging Experiments, Helsinki University of Technology, Espoo, Finland, 3.8.

Invited plenary talk, *MEG and language,* MEG/EEG Spring School, Paris, France, 5.8.

Invited talk, *Cortical dynamics of silent and overt reading,* Helsinki Summer School of Cognitive Neuroscience HSCN 2001, Lammi, Finland, 2.9.

Invited talk, *Real-time functional anatomy of language processing,* Helsinki Summer School of Cognitive Neuroscience HSCN 2001, Lammi, Finland, 2.9.

Session chairperson, *Session: Language and cognition,* Neuro-BIRCH III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Invited talk, *MEG studies of language processing,* 1st Taiwan-Finland Symposium on Magnetoencephalography, Taipei, Taiwan, 5.10.

Invited talk, *Cortical dynamics of language function and dysfunction,* A.I. Virtanen Institute Research Seminar, Kuopio, Finland, 10.12.

Schürmann — Lecture, *EEG- und MEG-Korrelate der Assoziation zwischen Sinnesempfindungen verschiedener Modalitäten (EEG and MEG correlates of association between sensations in different modalities),* Lecture to 2nd year students of medicine (course of physiology), Medizinische Universität zu Lübeck (Medical University Lübeck), Germany, 19.11.

Oral presentation, *The human mirror-neuron system: MEG studies and suggested fMRI experiment,* Visit to Institute of Medicine, Forschungszentrum Jülich, Jülich, Germany, 21.11.

Silén — Invited talk, *MEG in pain research,* Orton Hospital, Helsinki, Finland, 19.4.

Participation, 24th International Epilepsy Congress, Buenos Aires, Argentina, 13.5.

Oral presentation, *Cortical control of muscle contraction in ULD type PME,* XV International Congress of Clinical Neurophysiology, Buenos Aires, Argentina, 17.5.

Invited talk, *Activation of the sensorimotor cortex in PME,* Neuroscience for Dummies II, Helsinki University of Technology, Espoo, Finland, 31.5.

Invited talk, *Hermoston ikääntyminen (Aging of the central nervous system),* Geriatrisen hoidon seminaari, University of Helsinki, Helsinki, Finland, 7.11.

Invited talk, *Aivojen ikääntyminen ja dementia (Aging of the brain and dementia),* Geriatrisen hoidon seminaari, Korpilampi, Espoo, Finland, 29.11.

Sillanpää — Oral presentation, *Titanium single electron transistor fabricated by electron beam lithography,* NIST, Boulder, Colorado, USA, 11.6.

Simões — Oral presentation, *Left-hemisphere dominant human SII activation after bilateral median nerve stimulation,* 31st Annual Meeting of Society for Neurosciences, San Diego, California, USA, 10.11.

Tanskanen — Invited talk, *Means to transiently cancel neglect,* The Neglect Day, Helsinki University of Technoplogy, Espoo, Finland, 26.4.

Consultation, Getting started with visual MEG experiments, Integrated Brain Research Unit, Veterans' General Hospital, Taipei, Taiwan, 2.5.

Visit, Department of Psychology, Taiwan National University, Taipei, Taiwan, 21.5.

Poster, *Temporal characteristics of celective attention to faces and houses: A MEG Study,* Seventh Annual Meeting of the Organization for Human Brain Mapping, Brighton, UK, 10.7.

Participation, Imaging Neuronal Function, Cognitive Neurobiology Laboratory, A. I. Virtanen Institute, University of Kuopio, Finland, 27.8.

Participation, Neuro-BIRCH III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Participation, Dynamical Neuroscience IX: Timing, Persistence and Feedback Control, San Diego, California, USA, 9.11.

Poster, *Timing of contour integration in human visual cortex: MEG recordings ,* Society for Neuroscience 31st Annual Meeting, San Diego, California, USA, 10.11.

Poster, *Perceptual selectivity is diminished after shifting selective attention between object categories,* Society for Neuroscience 31st Annual Meeting, San Diego, California, USA, 10.11.

Tarkiainen Antti

Participation, Optimising the Functional Magnetic Resonance Imaging Experiments, Helsinki University of Technoplogy, Espoo, Finland, 8.3.

Oral presentation, *Dynamics of face perception in the occipito-temporal cortex,* Neuroscience Finland 2001, Saariselkä, Finland, 15.3.

Invited talk, *Early cortical processing of faces and letter strings,* Neuroscience for Dummies II: Timing in Brain Function, Helsinki University of Technology, Espoo, Finland, 6.4.

Participation, Neuro-BIRCH III Users' Meeting, Majvik, Kirkkonummi, Finland, 14.9.

Tarkiainen Reeta

Poster, *1/f noise in carbon nanotubes,* ULTI III Users' Meeting, Ultra Low Energy Physics: Methods and Phenomenology, Pohja, Finland, 10.1.

Poster, *1/f noise in carbon nanotubes,* Materiaalifysiikan tutkijakoulun talviseminaari, Jyväskylä, Finland, 11.1.

Thuneberg

Poster, *Hydrostatic parameters of superfluid 3He-B,* ULTI III Users' Meeting, Ultra Low Energy Physics: Methods and Phenomenology, Pohja, Finland, 10.1.

Participation, XXXV Annual Conference of the Finnish Physical Society, Jyväskylä, Finland, 22.3.

Tsepelin

Poster, *Morphology and growth kinetics of 3He crystals,* ULTI III Users' Meeting, Ultra Low Energy Physics: Methods and Phenomenology, Pohja, Finland, 10.1.

Oral presentation, *Morphology and growth anisotropy of 3He crystals,* University of New Mexico, Albuquerque, New Mexico, USA, 16.1.

Oral presentation, *Morphology and growth anisotropy of 3He crystals,* University of California, Santa Barbara, California, USA, 23.1.

Oral presentation, *Morphology and growth anisotropy of 3He crystals,* Stanford University, California, USA, 25.1.

Tuoriniemi

Session chairman, Session on superconductivity, ULTI III Users' Meeting, Ultra Low Energy Physics: Methods and Phenomenology, Pohja, Finland 10.1.

Uutela	Invited talk, *MEG modeling and fMRI*, Optimising the Functional Magnetic Resonance Imaging Experiments, Helsinki University of Technology, Espoo, Finland, 8.3.
	Poster, *Combined analysis of MEG and fMRI using minimum l1-norm estimates*, Neuroscience Finland 2001, Saariselkä, Finland, 15.3.
Viljas	Poster, *Pinhole models for Josephson pi states in 3He-B*, ULTI III Users' Meeting, Ultra Low Energy Physics: Methods and Phenomenology, Pohja, Finland 10.1.
	Oral presentation, *Pi states in 3He-B Josephson junction arrays*, International Symposium on Quantum Fluids and Solids 2001 , University of Konstanz, Konstanz, Germany, 22.7.
Volovik	Invited talk, *Superfluid analogies of cosmological phenomena,* Seminar de Physique Theorique, University of Lausanne, Switzerland, 19.1.
	Invited plenary talk, *Sakharov gravity in superfluids and the cosmological constant problem,* V International Conference on Cosmoparticle Physics, COSMION-2001, Moscow-St.Petersburg, Russia, 21.5.
	Invited talk, *What can we learn from condensed matter analogs of gravity?,* Third Conference 'Landau Days', Landau Institute for Theoretical Physics, Chernogolovka, Russia, 26.6.
	Session chairman, Third Conference 'Landau Days', Landau Institute for Theoretical Physics, Chernogolovka, Russia, 26.6.
	Invited talk, *Vacuum in quantum liquids and in high energy physics and cosmology,* Workshop of ESF programme COSLAB (Cosmology in the Laboratory), Imperial College, London, UK, 7.7.
	Session chairman, Workshop of ESF programme COSLAB (Cosmology in the Laboratory), Imperial College, London, UK, 7.7.
Vuorinen	Participation, Dynamical Neuroscience IX, San Diego, California, USA, 9.11.

EXPERTISE AND REFEREE ASSIGNMENTS

Ahlskog	Referee, Journal of Applied Physics
Alles	Referee, Journal of Low Temperature Physics
Berglund	Advisory Editor, Cryogenics
	Member, Finnish Academy of Technical Sciences
	Member, International Cryogenics Engineering Committee, ICEC
	Member, Svenska tekniska vetenskapsakademien i Finland
	Referee, US National Science Foundation
Forss	Referee, Stroke
Hakonen	Fellow, American Physical Society
	Member, Finnish Academy of Sciences and Letters
	Referee, Europhysics Letters

	Referee, Journal of Low Temperature Physics
	Referee, Physical Review B
	Referee, Physical Review Letters
	Referee, National Science Foundation, USA
Hari	Associate Editor, Human Brain Mapping
	Consultant, Department of Clinical Neurophysiology, Helsinki University Central Hospital (part-time)
	Coordinator, EU Large-Scale Installation Neuro-BIRCH III, Espoo, Finland
	Coordinator, Functional Brain Mapping, Finland-Taiwan Scientific Cooperation
	Member, Academia Europaea, UK
	Member, American Physiological Society
	Member, Editorial Board of Brain Topography
	Member, Editorial Board of Clinical Neurophysiology
	Member, Editorial Board of Human Brain Mapping
	Member, Editorial Board of inScight (web journal)
	Member, Editorial Board of Neuroimage
	Member, Editorial Board of Neuroscience Research
	Member, European Dana Alliance for the Brain
	Member, Finnish Academy of Sciences and Letters
	Member, Review Committee Meeting for The Cognitive Brain Science Research Group, RIKEN BSI, Tokyo, Japan
	Member, Scientific Advisory Board of the National PET Center, Turku
	Member, Scientific Board, 10th European Congress of Clinical Neurophysiology, Lyon, France
	Member, Selection Panel for the Wiley Young Investigator’s Award
	Member, Society for Neuroscience, USA
	Member, Steering Committee of the Helsinki Graduate School of Neurobiology
	Partner, Human Frontier Science Research Grant RG 39-98 on Action Viewing
	Referee for Associate Professor, Massachusetts General Hospital, USA
	Referee for grants, Ministere de la Recherche, France
	Referee for Chair of Neuroscience, University of Manchester
	Referee, Audiology & Neuro-Otology
	Referee, Brain

	Referee, Brain Topography
	Referee, Cerebral Cortex
	Referee, Clinical Neurophysiology
	Referee, Cognitive Brain Research
	Referee, Journal of Neuroscience
	Referee, Nature Neuroscience
	Referee, NeuroImage
	Referee, Proceedings of the Royal Society of London. Series B
	Referee, Stroke
Helenius	Referee, Brain
	Referee, Human Brain Mapping
Jensen	Referee, Journal of Neurophysiology
Kopnin	Referee, JETP Letters
	Referee, Journal of Experimental and Theoretical Physics (JETP)
	Referee, Physical Review B
	Referee, Physical Review Letters
	Referee, Superconductor Science and Technology
Krusius	Adjunct member of Selection Committee for the International Fritz London Award in Low Temperature Physics
	Advisory Editor, Physica B: Condensed Matter
	Fellow of the American Physical Society
	Member of the Board, Low Temperature Section, Condensed Matter Division, European Physical Society
	Member of International Advisory Board, International Conference on Low Temperature Physics, Hiroshima, Japan, 20. - 27.08. 2002
	Member of International Advisory Board, International Symposium on Ultra-Low Temperature Physics, Kanazawa, Japan, 28. - 31.08.2002
	Member of examination committee of Sebastien Triqueneaux, Université Paul Sabatier de Toulouse, in CRTBT - CNRS Grenoble, 10.07.2001
	Member, Academia Europaea
	Member, European Physical Society
	Member, Finnish Academy of Sciences and Letters
	Member, Finnish Physical Society

	Member of the Organizing Committee, International Conference on Quantum Fluids and Solids - QFS 2001, Konstanz, Germany, 21.-27.07.
	Member, Steering Group, European Science Foundation Network on Topological Defects – Non-equilibrium Field Theory in Particle Physics, Condensed Matter, and Cosmology
	Member of the Steering Committee, European Science Foundation Programme on Cosmology in the Laboratory (COSLAB)
	Referee, Physical Review B
	Referee, Physical Review Letters
	Referee, Physica Scripta
	Referee statements, Engineering and Physical Sciences Research Council, UK
	Referee statements, INTAS, EU
	Referee statements, National Science Foundation, USA
	Promotion statement, Georgia Institute of Technology, USA
	Secretary, Physics Group of Finnish Academy of Sciences and Letters
Lounasmaa	Advisory Editor, Europhysics Letters
	Fellow, American Physical Society
	Foreign Member, National Academy of Sciences of the USA
	Foreign Member, Royal Swedish Academy of Sciences
	Honorary Fellow, Indian Cryogenics Council
	Honorary Member, Finnish Physical Society
	Member, Academia Europaea, UK
	Member, Board of the Center for Ultra-Low Temperature Research, University of Florida
	Member, Commission A1/2, International Institute of Refrigeration
	Member, European Physical Society
	Member, Finnish Academy of Sciences and Letters
	Member, Finnish Academy of Technical Sciences
	Member, LUMA-panel set up by the Ministry of Education
	Member, Research Council of HUT 01.09.1999 – 31.07.2003
	Member, Societas Scientiarum Fennica
Mäkelä	Referee, Human Brain Mapping
	Referee, Journal of Neurology

Referee, NeuroImage

Referee, Neurosurgery and Psychiatry

Secretary, Working Group for Defining a Research Program for the Military Health Care in the Near Future (2000–2005)

Opponent for Doctoral Dissertation of Leena Lauronen at Helsinki University on 30.08.2001

Paalanen Chairman, Selection Committee of Magnus Ehrnrooth Prize in Physics

Coordinator of Low Temperature Physics Research, Finland-Taiwan Scientific Cooperation

Coordinator of ULTI III (Ultra Low Temperature Installation) Large Scale Installation in EU-funded IHP program 1.4.2000 - 31.3.2003

Fellow, American Physical Society

Member, Academia Europaea, UK

Member, Advisory Committee of 19th Nordic Semiconductor Meeting, Copenhagen, 21. - 23.5.2001

Member, Board of Arkhimedes (Finnish Physical Journal)

Member, Board of High Speed Electronics Photonics, Nanoscience, and Quantum Devices Consortium in Chalmers University of Technology, Gothenburg, Sweden

Member, Board of Uudenmaan Rahasto of Finnish Cultural Foundation

Member, Comission C5 Low Temperature Physics, International Union of Pure and Applied Physics (IUPAP)

Member, Editorial Board of Journal of Low Temperature Physics

Member, Evalution team of the Natural Science Departments of University of Kuopio, Finland

Member, Finnish Academy of Sciences and Letters

Member, Finnish Academy of Technical Sciences

Member, International Advisory Committee of an American TV program on low temperature physics (Chairman Professor Russel Donnelly, University of Oregon, USA)

Member, International Advisory Committee of LT23, Japan

Member, International Advisory Committee, International Conference on Quantum Transport and Quantum Coherence, Tokyo, Japan

Member, Resource Review Board of ATLAS experiment at CERN

Member, Steering Board of CARAMEL, a nanotube research consortium in Chalmers, Sweden

Member, Steering Committee of ESF-sponsored PiShift Network

Pre-examineer of licentiate thesis of Lasse Lensu, Lappeenranta University of

Technology

Referee for appointment of a full professor in University of Cincinnati, Ohio, USA

Referee, Applied Physics Letters

Referee, EU Science Programs

Referee, The Israel Science Foundation

Referee, Journal of Low Temperature Physics

Referee, National Science Foundation, USA

Referee, Physical Review B

Referee, Physical Review Letters

Referee, Swedish Research Council for Engineering Sciences

Salmelin — Member, Organizing Committee, Eurosco Conference: The Science of Aphasia, Italy

Member, Organizing Commitee, Symposium on Optimising fMRI Experiments, Finland

Referee, Brain

Referee, Behavioural Brain Research

Referee, Cerebral Cortex

Referee, Clinical Neurophysiology

Referee, Cognitive Brain Research

Referee, European Journal of Neuroscience

Referee, Experimental Brain Research

Referee, Human Brain Mapping

Referee, IEEE Transactions on Biomedical Engineering

Referee, Journal of Clinical Neurophysiology

Referee, Journal of Neuroimaging

Referee, Journal of Speech, Language, and Hearing Research

Referee, Neuroimage

Referee, Neuroscience Letters

Referee, Proceedings of the National Academy of Sciences, USA

Referee, Psychophysiology

Reviewer for grant applications, Human Frontier Science Program

Reviewer for grant applications, National Science Foundation (USA)

Reviewer for grant applications, The Wellcome Trust (UK)

Thuneberg	Referee, Physical Review A
	Referee, Physical Review B
	Referee, Physical Review Letters
Tuoriniemi	Referee, Physical Review Letters
	Organizer, ULTI III Users' Meeting, Ultra Low Energy Physics: Methods and Phenomenology, Pohja, Finland 10.1.
	Member, Program committee of the 36th Physics Days of the Finnish Physical Society
Uutela	Referee, IEEE Transactions on Biomedical Engineering
	Referee, Medical & Biological Engineering & Computing
Volovik	Member, Finnish Academy of Sciences
	Associate Editor, JETP Letters, Russia
	Editor, Vortices in Unconventional Superconductors and Superfluids, Springer, 2002
	Member of International Advisory Board, International Symposium on Ultralow-Temperature Physics, Kanazawa, Japan, 28. - 31.08.2002
	Organizer, Workshop on Quantum Vacuum Properties in Condensed Matter and Cosmology Tours, France, 17. - 20.5.
	Co-chairman, ESF Scientific programme 'Cosmology in the laboratory' (COSLAB), 2001-2005
	Opponent for Ph.D. Thesis of Pavel Krotkov in Landau Institute, Chernogolovka, Russia, 29.6.
	Referee, EPSRC, UK

AWARDS

Pertti Hakonen and **Grigory Volovik** were elected to the Finnish Academy of Sciences and Letters, Pertti as an ordinary member and Grigory as a foreign member.

Riitta Hari was awarded the Matti Äyräpää Prize for medical excellence by the Finnish Medical Society Duodecim on Jan 7.

Riitta Hari was also granted the Alvar Prize for significant contribution to scientific study of dyslexia by the Finnish dyslexia societies on Sep 7.

Mikko Paalanen was granted the Knight, First Class, of the Order of White Rose of Finland by the President of the Republic of Finland on Dec 6.

Tommi Raij got the Novartis-Exelon award for the best scientific thesis in neurosciences in 2000 of The Finnish Brain Research Society Jan 1.

Erkki Thuneberg was elected from eleven applicants to the theoretical physics professorship in University of Oulu. After his promotion to the professorship, Erkki also received the annual Väisälä Prize in Physics, largely on the work done in our laboratory.

Juha Tuoriniemi became a docent of magnetism in the Department of Engineering Physics and Mathematics of HUT.

PUBLICATIONS

LOW TEMPERATURE PHYSICS PUBLICATIONS

JOURNAL ARTICLES

Ahlskog, M., Hakonen, P., Paalanen, M., Roschier, L., and Tarkiainen, R., Multiwalled carbon nanotubes as building blocks in nanoelectronics, Journal of Low Temperature Physics **124** (2001) 1/2, 335-352, (2001048)

Alles, H., Tsepelin, V., Babkin, A., Jochemsen, R., Parshin, A.Y., and Todoschenko, I., *Observations on faceting of ^{3}He crystals at T = 0.55 mK,* Journal of Low Temperature Physics **124** (2001) 1/2, 189-196, (2001045)

Aranson, I.S., Kopnin, N.B., and Vinokur, M., *Dynamics of vortex nucleation by rapid thermal quench,* Physical Review B **63** (2001) 184501-1/11, (2001035)

Eltsov, V.B., Blaauwgeers, R., Krusius, M., Ruohio, J.J., and Schanen, R., *NMR spectroscopy of the douple-quantum vortex in superfluid ^{3}He-A,* Journal of Low Temperature Physics **124** (2001) 1/2, 123-146, (2001043)

Finne, A., Grönberg, L., Blaauwgeers, R., Eltsov, V.B., Eska, G., Krusius, M., Ruohio, J.J., Schanen, R., and Suni, I., *Superconducting Nb-film LC resonator,* Review of Scientific Instruments **72** (2001) 9, 3682-3686, (2001067)

Fischer, U.R. and Volovik, G.E., *Thermal quasi-equilibrium states across Landau horizons in the effective gravity of superfluids*, International Journal of Modern Physics D **10** (2001) 1, 57-88, (2001033)

Juntunen, K.I., Lefmann, K., Knuuttila, T.A., and Tuoriniemi, J.T., *High temperature expansion and exact diagonalization of the rhodium nuclear spin system compared to experimental results,* Journal of Low Temperature Physics **124** (2001) 1/2, 271-289, (2001024)

Knuuttila, T.A., Tuoriniemi, J.T., Lefmann, K., Juntunen, K.I., Rasmussen, F.B., and Nummila, K.K., *Polarized nuclei in normal and superconducting rhodium*, Journal of Low Temperature Physics **123** (2001) 65-102, (2001022)

Kopnin, N.B., *Boltzmann kinetic equation for excitations outside vortex cores,* Journal of Low Temperature Physics **124** (2001) 1/2, 209-222, (2001046)

Kopnin, N.B. and Vinokur, V.M., *Superconducting vortices in ac fields: Does the Kohn theorem work?* Physical Review Letters **87** (2001) 1, 017003-1/4, (2001030)

Kopu, J. and Krusius, M., *Spin-mass vortex in ^{3}He-B: Order-parameter texture and NMR signature*, Physical Review B **64** (2001) 094504-1/6, (2001034)

Kopu, J. and Thuneberg, E.V., *Soliton-limited superflow in ^{3}He-A between parallel plates*, Journal of Low Temperature Physics **124** (2001) 1/2, 147-162, (2001044)

Lefmann, K., Knuuttila, T.A., Martikainen, J.E., Kuhn, L.T., and Nummila, K.K., *Effect of heat treatment of pure and carbon-polluted rhodium samples on the low-temperature resistivity*, Journal of Materials Science **36** (2001) 839-844, (2001011)

Lütke-Entrup, N., Blaauwgeers, R., Plaçais, B., Huxley, A., Kambe, S., Krusius, M., Mathieu, P., and Simon, Y., *Flux-flow resistivity in UPt_3: Evidence for nonsingular vortex-core structure*, Physical Review B **64** (2001) 020510-1/4, (2001049)

Martikainen, J. and Tuoriniemi, J.T., *SQUID amplifier system for vibrating wire resonators*, Journal of Low Temperature Physics **124** (2001) 1/2, 367-382, (2001023)

Niemetz, M., Schoepe, W., and Krusius, M., *Comment on "Repetitive single vortex-loop creation by a vibrating wire in superfluid ^{3}He-B"*, Physical Review Letters **87** (2001) 5, 059601-1, (2001036)

Penttilä, J.S., Hakonen, P.J., Sonin, E.B., and Paalanen, M.A., *Experiments on dissipative dynamics of single Josephson junctions*, Journal of Low Temperature Physics **125** (2001) 89-114, (2001069)

Roschier, L., Tarkiainen, R., Ahlskog, M., Paalanen, M., and Hakonen, P., *Multiwalled carbon nanotubes as ultrasensitive electrometers*, Applied Physics Letters **78** (2001) 21, 3295-3297, (2001027)

Schakel, A.M.J., *Percolation, Bose-Einstein condensation, and string proliferation*, Physical Review E **63** (2001) 026115-1/11, (2001005)

Schakel, A.M.J., *Vortices, hedgehogs & other topological beasts*, Foton (Polish) **73** (2001) 15-21, (2001054)

Sillanpää, M.A., Heikkilä, T.T., Lindell, R.K., and Hakonen, P.J., *Inverse proximity effect in superconductors near ferromagnetic material*, Europhysics Letters **56** (2001) 4, 590-595, (2001060)

Sonin, E.B., *Tunneling into 1D and quasi-1D conductors and Luttinger-liquid behavior*, Journal of Low Temperature Physics **124** (2001) 1/2, 321-334, (2001047)

Tarkiainen, R., Ahlskog, M., Penttilä, J., Roschier, L., Hakonen, P., Paalanen, M., and Sonin, E., *Multiwalled carbon nanotube: Luttinger versus Fermi liquid*, Physical Review B **64** (2001) 195412-1(-4), (2001062)

Thuneberg, E.V., *Hydrostatic theory of superfluid ^{3}He-B(1)*, Journal of Low Temperature Physics **122** (2001) 5/6, 657-682, (2001017)

Tsepelin, V., Alles, H., Babkin, A., Härme, J.P.H., Jochemsen, R., Parshin, A.Y., and Tvalashvili, G., *Observation of higher order facets on ^{3}He crystals*, Physical Review Letters **86** (2001) 6, 1042-1045, (2001004)

Volovik, G.E., *Reentrant violation of special relativity in the low-energy corner*, Pis´ma v Zhurnal Eksperimental´noi i Teoreticheskoi Fiziki **73** (2001) 4, 182-185, (2001013D)

Volovik, G.E., *Reentrant violation of special relativity in the low-energy corner*, JETP Letters **73** (2001) 4, 162-165, (2001013D)

Volovik, G.E., *Mesoscopic Casimir forces in quantum vacuum*, Pis´ma v Zhurnal Eksperimental´noi i Teoreticheskoi Fiziki **73** (2001) 8, 419-423, (2001021D)

Volovik, G.E., *Mesoscopic Casimir forces in quantum vacuum*, JETP Letters **73** (2001) 8, 375-379, (2001021D)

Volovik, G.E., *Fermion zero modes in Painlevé-Gullstrand black hole*, Pis´ma v Zhurnal Eksperimental´noi i Teoreticheskoi Fiziki **73** (2001) 12, 721-725, (2001039D)

Volovik, G.E., *Fermion zero modes in Painlevé-Gullstrand black hole*, JETP Letters **73** (2001) 12, 637-641, (2001039D)

Volovik, G.E., *Superfluid analogies of cosmological phenomena*, Physics Reports **351** (2001) 4, 195-348, (2001040)

Volovik, G.E., *Vacuum energy and cosmological constant: View from condensed matter*, Journal of Low Temperature Physics **124** (2001) 1/2, 25-39, (2001042)

BOOK SECTIONS

Blaauwgeers, R., Eltsov, V.B., Krusius, M., Ruohio, J., and Schanen, R., *Quantized vorticity in superfluid ^{3}He-A: Structure and dynamics*, Quantized Vortex Dynamics and Superfluid Turbulence (2001) 399-420, (B2001065)

Kopnin, N.B., *Theory of nonequilibrium superconductivity*, International Series of Nanographics on Physics 110 (2001) 1-319, (B2001020)

CONFERENCE PROCEEDINGS

Ahlskog, M., Tarkiainen, R., Roschier, L., Paalanen, M., and Hakonen, P., *Multiwalled carbon nanotubes as single electron transistors*, Proc. of AIP-Conference “Nanonetwork Materials: Fullerenes, Nonotubes, and Related Systems” **590** (2001) 141-144, (C2001068)

Roschier, L., Tarkiainen, A., Ahlskog, M., and Hakonen, P., *Low-noise electrometer made of multiwalled carbon nanotube*, Proc. of XXXVIth Rencontres de Moriond “Electronic Correlations: From Meso-to Nano-Physics”, Series: Moriond Workshops (2001) 459-462, (C2001071)

Tarkiainen, R., Ahlskog, M., Roschier, L., Hakonen, P., and Paalanen, M., *Tunneling into resistive multiwalled carbon nanotubes*, Proc. of XXXVIth Rencontres de Moriond “Electronic Correlations: From Meso-to Nano-Physics”, Series: Moriond Workshops (2001) 437-442, (C2001070)

Volovik, G.E., *Interplay of real space and momentum space topologies in strongly correlated fermionic systems*, Proc. of The XVIII Lisbon Autumn School “Topology of Strongly Correlated Systems”, (2001) 30-49, (C2001051)

REPORTS

Kopu, J. and Krusius, M., *Spin-mass vortex in ^{3}He-B: Order-parameter texture and NMR signature*, TKK-KYL-005 (2001) 12, (R2001009)

Penttilä, J.S., Hakonen, P.J., Sonin, E.B., and Paalanen, M.A., *Experiments on dissipative dynamics of single Josephson junctions*, TKK-KYL-003 (2001) 26, (R2001001)

Tarkiainen, R., Ahlskog, M., Penttilä, J., Roschier, L., Paalanen, M., Sonin, E., and Hakonen, P., *Multiwalled carbon nanotubes as high impedance transmission lines*, TKK-KYL-004 (2001) 11, (R2001002)

Tsepelin, V., Alles, H., Babkin, A., Jochemsen, R., Parshin, A.Y., Todoschenko, I., and Tvalashvili, G., *Morphology and growth kinetics of ^{3}He crystals below 1 mK*, TKK-KYL-006 (2001) 31, (R2001018)

THESES

Kopu, J., *Numerical calculations on vortex phenomena in helium superfluids*, (2001) 108, (T2001029)

Penttilä, J., *Influence of electromagnetic environment in single tunnel junctions*, (2001) 114, (T2001015)

Ruohio, J., *Doubly quantized vorticity and other NMR experiments on rotating ^{3}He superfluids*, (2001) 126, (T2001014)

Tsepelin, V., *Investigations of solid-liquid interfaces in helium at ultralow temperatures*, (2001) 98, (T2001028)

BRAIN RESEARCH PUBLICATIONS

JOURNAL ARTICLES

Barros, A.K., Vigario, R., Jousmäki, V., and Ohnishi, N., *Extraction of event-related signals from multichannel bioelectrical measurements*, IEEE Transactions on Biomedical Engineering **47** (2001) 5, 583-588, (2001063)

Bräutigam, S., Bailey, A.J., and Swithenby, S.J., *Task-dependent early latency (30-60 ms) visual processing of human faces and other objects*, NeuroReport **12** (2001) 7, 1531-1536, (2001025)

Forss, N., Narici, L., and Hari, R., *Sustained activation of the human SII cortices by stimulus trains*, NeuroImage **13** (2001) 497-501, (2001006)

Forss, N. and Silén, T., *Temporal organization of cerebral events: Neuromagnetic studies of the sensorimotor system*, Rev Neurolog (Paris) **157** (2001) 8-9, 816-821, (2001055)

Forss, N., Silén, T., and Karjalainen, T., *Lack of activation of human secondary somatosensory cortex in Unverricht-Lundborg type of progressive myoclonus epilepsy*, Annals of Neurology **49** (2001) 1, 90-97, (2001003)

Gross, J., Kujala, J., Hämäläinen, M., Timmermann, L., Schnitzler, A., and Salmelin, R., *Dynamic imaging of coherent sources: Studying neural interactions in the human brain*, Proceedings of the National Academy of Sciences of the United States of America (PNAS) **98** (2001) 2, 694-699, (2001007)

Hari, R. and Renvall, H., *Impaired processing of rapid stimulus sequences in dyslexia*, Trends in Cognitive Sciences **5** (2001) 12, 525-532, (2001057)

Hari, R., Renvall, H., and Tanskanen, T., *Left minineglect in dyslexic adults*, Brain **124** (2001) 1373-1380, (2001031)

Heikman, P., Salmelin, R., Mäkelä, J., Hari, R., Katila, T., and Kuoppasalmi, K., *Relation between the frontal 3-7 Hz MEG activity and efficacy of ECT in major depression*, The Journal of ECT **17** (2001) 2, 136-140, (2001032)

Järveläinen, J., Schürmann, M., Avikainen, S., and Hari, R., *Stronger reactivity of the human primary motor cortex during observation of live rather than video acts*, NeuroReport **12** (2001) 16, 3493-3495, (2001052)

Jensen, O., *Information transfer between rhythmically coupled networks: Reading the hippocampal phase code*, Neural Computation **13** (2001) 2743-2761, (2001056)

Levänen, S. and Hamdorf, D., *Feeling vibrations: enhanced tactile sensitivity in congenitally deaf humans*, Neuroscience Letters **301** (2001) 75-77, (2001019)

Levänen, S., Uutela, K., Salenius, S., and Hari, R., *Cortical representation of sign language: Comparison of deaf signers and hearing non-signers*, Cerebral Cortex **11** (2001) 506-512, (2001026)

Marsden, J., Brown, P., and Salenius, S., *Involvement of the sensorimotor cortex in physiological force and action tremor*, NeuroReport **12** (2001) 9, 19371941, (2001072)

Mäkelä, J., Kotila, M., and Henriksson, M., *Thalamic alternations in schizophrenia (Letters to the editor)*, American Journal of Psychiatry **158** (2001) 2, 323-324, (2001066)

Mäkelä, J.P., Kirveskari, E., Seppä, M., Hämäläinen, M., Forss, N., Avikainen, S., Salonen, O., Salenius, S., Kovala, T., Randell, T., Jääskeläinen, J., and Hari, R., *Three-dimensional integration of brain anatomy and function to facilitate intraoperative navigation around the sensorimotor strip*, Human Brain Mapping **12** (2001) 180-192, (2001008)

Murayama, N., Lin, Y.-Y., Salenius, S., and Hari, R., *Oscillatory interaction between human motor cortex and trunk muscles during isometric contraction*, NeuroImage **14** (2001) 1206-1213, (2001053)

Narici, L., Forss, N., Jousmäki, V., Peresson, M., and Hari, R., *Evidence for a 7- to 9-Hz "sigma" rhythm in the human SII cortex*, NeuroImage **13** (2001) 4, 662-668, (2001016)

Ohara, S., Mima, T., Baba, K., Ikeda, A., Kunieda, T., Matsumoto, R., Yamamoto, J., Matsuhashi, M., Nagamine, T., Hirasawa, K., Hori, T., Mihara, T., Hashimoto, N., Salenius, S., and Shibasaki, H., *Increased syncronization of cortical oscillatory activities between human supplementary motor and primary sensorimotor areas during voluntary movements*, The Journal of Neuroscience **21** (2001) 9377-9386, (2001073)

Simões, C., Mertens, M., Forss, N., Jousmäki, V., Lütkenhöner, B., and Hari, R., *Functional overlap of finger representations in human SI and SII cortices*, The Journal of Neurophysiology **86** (2001) 4, 1661-1665, (2001050)

Uutela, K., Taulu, S., and Hämäläinen, M., *Detecting and correcting for head movements in neuromagnetic measurements*, NeuroImage **14** (2001) 1424-1431, (2001058)

Vanni, S., Raninen, A., Näsänen, R., Tanskanen, T., and Hyvärinen, L., *Dynamics of cortical activation in a hemianopic patient*, NeuroReport **12** (2001) 4, 861-865, (2001012)

Vanni, S., Tanskanen, T., Seppä, M., Uutela, K., and Hari, R., *Coinciding early activation of the human primary visual cortex and anteromedial cuneus*, Proceedings of the National Academy of Sciences of the United States of America (PNAS) **98** (2001) 5, 2776-2780, (2001010)

BOOK SECTIONS

Hämäläinen, M.S. and Nenonen, J.T., *Magnetic source imaging*, Engineering Superconductivity (2001) 464-479, (B2001064)

Hari, R., *Ihmisaivojen kuvantamisesta*, Kodin Terveystieto, Aivot ja hermosto, Valitut Palat (2001) 90-91 (B2001037)

CONFERENCE PROCEEDINGS

Lammertmann, C., Fujiki N., Lutkenhöner, B., and Hari, R., *Short-term decrement of the auditory N1m response*, Proc. of 12th Int. Conf. on Biomagnetism, (2001) 50-53, (C200188)

Nishitani, N. and Hari, R., *Temporal dynamics of cortical representation for action*, Proc. of 12th Int. Conf. on Biomagnetism, (2001) 331-334, (C2001061)

Uutela, K. and Hämäläinen, M., *Correcting for head movements in MEG inverse problem*, Proc. of 12th Int. Conf. on Biomagnetism, (2001) 809-812, (C2001061)

MAGAZINE ARTICLE

Hari, R., *Magnetoenkefalografia aivotutkijan työkaluna*, Äyräpää-luento, Duodecim 2001, Volume **117** (2001) 681-688, (M2001041)

THESIS

Uutela, K., *Estimating neural currents from neuromagnetic measurements*, (2001) 125, (T2001059)