Amsterdam Summer Workshop on Low-D Quantum Condensed Matter 2007

Summary

The 2007 Amsterdam Summer Workshop on Low-D Quantum Condensed Matter was held in Amsterdam July 2-7, 2007. The activity was in part organized within the framework of the ESF program on Interdisciplinary Statistical and Field Theory Approaches to Nanophysics and Low Dimensional Systems (INSTANS). The organizing committee consisted of K. Schoutens, J.-S. Caux and A.M.M. Pruisken.

The main focus of the workshop was on low-dimensional and nano-scale condensed matter systems and quantum statistical mechanics. This subject matter is central in the scientific agenda of the INSTANS program. The main themes and topics have been: correlated electrons, spin systems and quantum liquids, cold atomic gases, quantum Hall physics, topological phases.

The workshop has been attended by 55 scientists. Of these, 31 were directly associated with the ESF program; 24 came from non-European countries.

The scientific program has consisted of 1-hour review lectures (5, the majority given by leading experimentalists), 30-minute lectures (19), and scheduled discussion sessions (4). In addition, there has been ample time for informal discussions among participants.

Scientific content and discussion at the event

The themes and topics addressed at the meeting have been: correlated electrons, spin systems and quantum liquids, cold atomic gases, quantum Hall physics, topological phases. In the scientific program, the lectures have been grouped around the various themes.

At the meeting, there has been extensive discussion on nanoscale interferometers, in particular those operating in a system where electrons form a fractional quantum Hall liquid (lectures by Heiblum, Stern, Gefen). These interferometers are used to observe the so-called fractional statistics of the fundamental quasi-particles in these systems. It is foreseen that interferometers can be used to provide experimental proof of the existence of so-called non-abelian statistics in quantum Hall systems (Haldane, Slingerland). There is a fascinating proposal for using these systems for the purpose of fault tolerant quantum computation. The results reported and discussed at the workshop help pave the way towards this possible application.

At the workshop there has been ample discussion of graphene, the incarnation of carbon where the atoms are placed in a two-dimensional chicken-wire configuration (Katsnelson, Beenakker, Evers, Mirlin). In this material, electrons satisfy a relativistic Dirac equation rather than the Schrödinger equation and this leads to fascinating new phenomena. The many ideas for applications of graphene based devices strongly stimulate the research on this topic.

Ever since the first realization of Bose-Einstein condensation in atomic gases, the fantastic possibilities for cooling and manipulating atomic gases give rise to fascinating experiments. There are many parallels to the more traditional field of quantum electrons,

but at the same time many features are entire new and unprecedented, due to important differences in the relevant parameter regimes (such as time scales) and experimental accessibility. At the workshop, there were experimental (van Druten) and theoretical (Demler, Stern) contributions on this topic.

Low-dimensional electron systems with strong correlations remain at the center stage of condensed matter physics. At the workshop Nagler presented the state of the art in imaging these systems with the help of neutron scattering, indicating future experimental directions. There were many talks on theoretical approaches for analysing these systems (Fisher, Egger, Affleck, Essler, Glazman, Pasquier) and there was a scheduled afternoon discussion on the use of supersymmetry as a novel tool for understanding particular phases with strong quantum charge frustration.

A highly topical development is the study of entanglement in quantum mechanical many particle systems. At the workshop, break-through results on this were presented by some of the best experts in the field (Haque, Korepin, Moore). The study of entanglement is a highly promising direction, with important implication for the fields of quantum information and quantum computation.

Results and impact on future directions

The way these Workshops work is not so much that new results are produced on the spot, but that the reporting of progress and the exchanging of new ideas leads to progress further down the road. The future directions take shape from progress in the field, from interaction with other fields and from possibilities to contribute to innovation in industry. In the above we already mentioned some of these directions. Prominent among them is the study and development of novel materials and devices (electronics, atomics and anyonics); graphene and atomic matter in optical lattices are prime examples. A second major direction is that of quantum information, with such applications as quantum cryptography, quantum communication and quantum computation.

Final program

1-hour review lectures

- The one-dimensional Bose gas on a chip – *N. J. van Druten, Universiteit van Amsterdam*
- Properties of fractionally charged quasiparticles determined by shot noise measurements – *M. Heiblum, Weizmann institute*
- Graphene: a new bridge between condensed matter physics and QED – *M. I. Katsnelson, Radboud Universiteit Nijmegen*
- Proposed experiments to detect non-Abelian quasiparticles – *A. Stern, Weizmann Institute*
- Inelastic neutron scattering in zero and 1D quantum spin systems – *S. E. Nagler, Oak Ridge National Laboratory*

30-minute invited lectures

- From interference experiments with low-dimensional condensates to quantum sine-Gordon models – *E. Demler, Harvard University*
- 2D spin liquids and itinerant non-Fermi liquids – *M. P. A. Fisher, KITP at UC Santa Barbara*
- Demonstration of one-parameter scaling at the Dirac point of graphene – *C.W.J. Beenakker, Instituut-Lorentz, Leiden University*
- Interaction effects in quantum point contacts – *R. Egger, Dsseldorf*
- Branch-cut singularities in the thermodynamics of Fermi liquid systems – *A. Finkelstein, Weizmann Institute*
- Tunnelling exponent of electrons into fractional quantum Hall edges in the presence of soft boundaries – *D.C. Cabra, Strasbourg*
- Multifractality of wavefunctions near surfaces – *F. Evers, Karlsruhe*
- Electron transport and quantum criticality in disordered graphene – *A.D. Mirlin, Karlsruhe*
- Dephasing from electron-electron interactions in ballistic conductors – *P. W. Brouwer, Cornell University*
- Mach-Zehnder detector of fractional statistics quasiparticles: transport and noise – *Y. Gefen, Weizmann*
- Abelian and non-Abelian FQHE wavefunctions, generalized Fock space, and Jack polynomials – *F.D.M. Haldane, Princeton*
- Anyon models: from fusion rules to observable parameters – *J. K. Slingerland, UC Riverside/Caltech*
- Spin-1/2 chains: beyond the Luttinger liquid approximation – *I. Affleck, UBC Vancouver*
- Temperature effects on spin correlations in Haldane-gap magnets – *F.H.L. Essler, Oxford*
- Response functions of 1D interacting fermions with nonlinear dispersion – *L. Glazman, Minneapolis*
- Quantum information concepts for many-particle physics – *M. Haque, Dresden*
- Entanglement in spin chains – *V. Korepin, YITP Stony Brook*
- Entanglement entropy at quantum critical points – *J. E. Moore, UC Berkeley*
- Emerging $O(3)$ symmetry in a 3D classical dimer model – *V. Pasquier, Saclay*

scheduled discussions

- Discussion on Mach-Zehnder interferometer based on edge states transport in qHe
- Discussion on frustration and criticality in 2D (supersymmetric) lattice models.
- Discussion on entanglement entropy/black hole entropy.
- Discussion on correlations in 1D: theory and experiment.