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EDITORIAL

Special Issue
Quantum dynamics of nano-structured systems

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Systems of reduced dimensions not only allow studies of genuine quantum mechanical effects in complex many particle systems, but also offer possibilities for new device designs and functionalities. The articles collected in this special issue cover recent advances of the physics of nanostructured systems, ranging from the search for new materials for microelectronics and spintronics, via the physics of quantum transport and superconductivity, to properties of cold atom systems and molecules.

Today's microelectronics is mostly built on silicon technology; however, other materials are explored for future applications. The reduction of the dimension of devices to a few nanometers requires full control of the placement of dopants in the substrates. The article by Chroneos et al. is motivated by these developments and reviews recent studies on impurity diffusion, point defect engineering, and interface passivation in germanium.

The spin-orbit interaction in suitable geometries offers the possibility to achieve all-electrical control of the electron spin. Raimondi et al. report on the surprises arising in the description of a two-dimensional electron gas, and work out a $SU(2)$ description of the spin-orbit interaction that considerably simplifies the theoretical approach. Spin dynamics is also of interest in other classes of materials. Garg considers molecular nanomagnets, for which he proposes a new mechanism for the magnetization reversal. Olivos et al. study the spin excitations in the Heusler compound Co_2NiGa as a function of pressure. Generally speaking, Heusler alloys are of interest in the field of actuation, sensing and spintronics.

Recently it has been shown that the irradiation of graphene flakes by electromagnetic waves leads to higher harmonic generation and frequency mixing. Motivated by these findings, Mikhailov studies the nonlinear electromagnetic response of a three-dimensional electron gas and analyzes the best conditions for the second-harmonic generation. Meng et al. investigate correlated electrons on the honeycomb lattice, i.e., the structure of graphene, applying quantum Monte Carlo simulations. They discover that a spin-liquid emerges between a state described by massless Dirac fermions and an antiferromagnetically ordered Mott insulator.

About twenty years ago Ralph and Buhrmann found a scaling behavior in the conductance of copper quantum point contacts, as it is expected for a two-channel Kondo system. However, to find a realistic microscopic model which generically exhibits a two-channel Kondo fixed point turned out to be difficult. In their article, Ballmann and Kroha analyze the robustness of the two-channel Kondo fixed point in a model of a dynamical impurity with a rotational degree of freedom, and discuss how this may explain the spectra measured by Ralph and Buhrmann. Open questions exist also in the theory of quantum dots. Treiber et al. apply the theory of diffusion in graphs to study transport and dephasing in a quantum dot. They present results for the temperature dependence of the weak localization correction and discuss the possibility to observe the zero-dimensional regime of dephasing. For systems consisting of a large number of particles, average values of physical quantities are sufficient. Nanostructures, on the other hand, may exhibit large fluctuations in their physical properties, such that more detailed information has to be extracted from the many-body wave function of the system. In their contribution, Rammer and Shelankov present a method based on tagging particles, using special gauge transformations for coping with such situations.

The theoretical description of strongly correlated electrons remains a difficult task, and new methods to tackle the interaction problem have to be devised. A standard technique is the Green's function method. The retarded Green's function and the spectral function can be obtained by an analytic continuation of a function of discrete Matsubara frequencies to a continuous function on the real-frequency axis. Numerically, however, this analytical contin-

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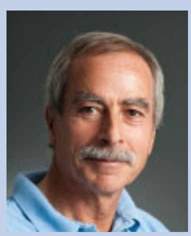
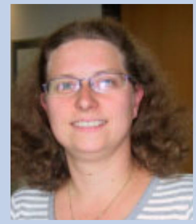
uation proved to be ill-conditioned. In this context, Granath et al. suggest a new scheme to work with discrete-time Matsubara Green's functions. In this new scheme the analytic continuation of the Matsubara Green's function to real frequencies can be performed numerically with a high precision. Another high-precision numerical technique, the DMRG, is used by Schmitteckert and Evers to study the charge susceptibility of a Kondo system. They aim not only at a better understanding of the Kondo effect in complex molecular systems, but also attempt to find improved exchange-correlation potentials for density functional theory. The DMRG is also employed by Bohr and Schmitteckert in order to determine the conductance through a benzene-like ring structure. An alternative approach to strongly correlated system, the radial representation of the Kotliar-Ruckenstein slave bosons, is investigated by Frésard and Kopp; exact results are presented for a two-site model. On the other hand, special models allow for exact solutions via the Bethe *ansatz*. For example, Amico and Osterloh study superconducting pairing correlations in the canonical ensemble with this technique, in particular, the finite-size scaling of the pairing.

Experimental studies of quantum phase transitions in systems of cold atoms in traps have led to a revival of interest in lattice models of interacting bosons. Kurdestany et al. develop an inhomogeneous mean-field theory for the extended Bose-Hubbard model with a confining potential, and explore the implications for experiments. Dynamical features of a Bose-Einstein condensate confined to a double-well potential are investigated by Lu and Li.Understanding the static and dynamical properties of vortices is essential in studies of superfluids and superconductors. An important step was the observation by Eckern and Schmid that vortices behave – under certain conditions – like massive particles subject to dissipation. Fazio and Schön review the quantum vortex dynamics in two-dimensional Josephson junction arrays or optical lattices.

The *quantum dynamics of nano-structured systems* has been a main focus of the scientific work of Ulrich Eckern; this special issue has been prepared on the occasion of his 60th birthday. We and many of the authors of this issue had the pleasure to collaborate with him on related topics for many years. We congratulate him on this occasion, and wish him many more years of fruitful activities.



Gerd Schön received his PhD in physics from the University of Dortmund in 1976. After periods as postdoc, Heisenberg fellow and visiting Assistant Professor in Karlsruhe, Cornell University, UC Berkeley, UC Santa Barbara, and Jülich he was appointed full professor at TU Delft in 1988. Since 1991 he holds the chair for Theoretical Solid State Physics at University of Karlsruhe, now KIT. He received the Walter Schottky prize of the DPG (shared with U. Eckern and W. Zwerger), the A. v. Humboldt award of the Academy of Finland, the Miller Visiting Professor award of UC Berkeley, and in 2011 the Fritz London Memorial Prize.



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