Q 30: Quantum effects

Time: Tuesday 14:00–16:00 Location: F 128

Group Report Q 30.1 Tue 14:00 F 128

Coherent delocalisation and transport efficiency in disordered, noisy networks — •Federico Levi, Björn Witt, and Florian Mintert — Freiburg Institute for Advanced Studies (FRIAS), Albert-Ludwigs-Universität Freiburg, Alberstr.19, 79104 Freiburg

We investigate the role of quantum coherence in excitation transport across noisy, disordered networks. Our goal is to understand the impact of constructive multi-path interference on the transport efficiency. Necessary condition for multi-path interference is the coherent delocalisation of the excitation over multiple network sites; to characterise the spatial extent of this delocalisation we introduce a notion of coherence length for discrete systems and present techniques to characterise it for mixed states. More specifically we construct a hierarchy of criteria which provide a sufficient condition for coherent delocalisation of an excitation over a given number of sites. With these tools we consider in particular the case of networks driven incoherently by a thermal light field, for which we quantify the excitation flux in a stationary state. Although those states are strongly mixed we can verify enhanced coherent delocalisation in networks that yield highly efficient transport.

Q 30.2 Tue 14:30 F 128

Enhancing the sensitivity of chemical magnetometers — •Markus Tiersch[1,2], Gian Giacomo Guerreschi[1,2], Ulrich E. Steiner[3], and Hans J. Briegel[1,2] — [1]University of Innsbruck, Austria — [2]Institute for Quantum Optics and Quantum Information, Innsbruck, Austria — [3]Fachbereich Chemie, University of Konstanz, Germany

Magnetic field effects of chemical reactions that are explained by the radical pair mechanism can be used for chemical magnetometry and constitute the basis of a primary hypothesis for animal magnetoreception. We propose a new experimental approach based on molecular photoswitches to achieve additional control of these chemical reactions at the level of the recombination dynamics, and thus to allow for short-time resolution of the spin dynamics. This proposal enables experiments to test some of the standard assumptions of the radical pair model, and it improves the sensitivity of a model system for a chemical magnetometer by two orders of magnitude. For the experimentally well-studied model system, where the radical pair is formed by pyrene (Py) with N,N-dimethylaniline (DMA), we discuss how signatures of entanglement can be used to measure magnetic fields.

Q 30.3 Tue 14:45 F 128

Decoherence-assisted transport in quantum critical systems — •Gian Luca Giorgi[1] and Thomas Busch[2] — [1]AG Theoretische Quantenphysik, Theoretische Physik, Universität des Saarlandes, D-66123 Saarbrücken, Germany and Department of Physics, University College Cork, Cork, Republic of Ireland — [2]Quantum Systems Unit, Okinawa Institute of Science and Technology, Okinawa 904-0411, Japan

A two-level system interacting with an external bath is unavoidably subject to coherence loss. On the other hand, decoherence can be used to enhance the transport properties between the two levels of the systems. The bath is modelled as an XY spin chain in the presence of an external magnetic field, and is subject to a quantum phase transition by changing the intensity of the external field itself.

Driving the bath from the paramagnetic towards the ferromagnetic region, the dynamics of the qubit is studied. The transition probability from the lower level to the upper level is enhanced by the bath, and this noise-assisted phenomenon is sensitive to the change of the quantum phase of the environment.

First, we discuss the case of an isotropic chain. In the zero-temperature case, the bath renormalizes the system Hamiltonian, making it possible to improve the transition probability. Even if the mechanism is more complicated, the same qualitative enhancement can be observed for finite temperatures regime and by releasing the isotropic assumption.

G. L. Giorgi and Th. Busch, Physical Review A 86, 052112 (2012)

Q 30.4 Tue 15:00 F 128

Centro-symmetric Hamiltonians foster quantum transport — •Mattia Walschaers[1,2], Roberto Mulet[1,3], and Andreas Buchleitner[1] — [1]Physikalisches Institut, Albert-Ludwigs-Universitat Freiburg, Freiburg, Germany — [2]Instituut voor theoretische fysica, KU Leuven, Leuven, Belgium — [3]Complex System Group, University of Havana, Havana, Cuba

We propose a model for fast and highly efficient quantum transport of excitations, through finite, disordered systems. The presented mechanism is statistically robust against configurational changes which alter the realization of disorder. We furthermore discuss the potential relevance of our findings for excitation transport in photosynthetic light harvesting complexes.

Q 30.5 Tue 15:15 F 128

Revisiting the spin in relativistic quantum mechanics — •Heiko Bauke[1], Sven Ahrens[1], Christoph H. Keitel[1], and Rainer Grobe[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Intense Laser Physics Theory Unit and Department of Physics, Illinois State University, Normal, IL 61790-4560 USA

Recently, renewed interest in the fundamental aspects of the electron spin arose from the growing field of relativistic quantum information [1] and high precision measurements of the electron's magnetic dipole moment [2]. According to the formalism of quantum mechanics, some Hermitian operator corresponds to each measurable quantity, e. g. the spin. Though the spin is regarded as a fundamental property of the electron there is no universally accepted spin operator within the Dirac theory. We investigate the properties of different proposals for such an operator. It is demonstrated that most candidates are lacking some features which one might naturally expect for a spin angular momentum operator. We will argue that some operator suggested by Pryce [3], however, is an ideal candidate for a relativistic spin operator.

[1] A. Peres and D. R. Terno, Rev. Mod. Phys. **76**, 93 (2004); P. L. Saldanha and V. Vedral, N. J. Phys. **14**, 023041 (2012).
[2] D. Hanneke *et al.*, Phys. Rev. Lett. **100**, 120801 (2008); S. Sturm *et al.*, Phys. Rev. Lett. **107**, 023002 (2011).
[3] M. H. L. Pryce, Proceedings of the Royal Society A **150**, 166 (1935).

Q 30.6 Tue 15:30 F 128

Coherent coupling of a single molecule to a plasmonic nanoantenna — •Benjamin A. Gmeiner, Andreas Maser, Tobias Utikal, Stephan Götzinger, and Vahid Sandoghdar — Max Planck Institute for the Science of Light and Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), D-91058 Erlangen, Germany

We report on a new experiment investigating the coherent coupling of single molecules to plasmonic antennas. So far, all experiments in the field of plasmonics have been limited to the study of the enhancement of the excitation, the modification of the spontaneous emission rate, or changes in the angular radiation pattern accessed via the red-shifted fluorescence detection. Theoretical reports [1] predict that striking effects such as transparency (cloaking) or ultrastrong absorption can take place if a light beam interacts coherently with the coupled system of a quantum emitter and a plasmonic structure. We combine cryogenic high-resolution spectroscopy with localization microscopy to identify and study single molecules coupled to gold nanospheres. We report on our latest findings and their interpretation as Fano resonances, which are expected to result from the interference between the broad particle plasmon resonance of the gold nanoparticle and the narrow resonance of the molecule.

[1] X-W. Chen, V. Sandoghdar, M. Agio, Coherent interaction of a metallic structure with a single quantum emitter: from super absorption to cloaking, submitted (arXiv:1211.2152v2)

Q 30.7 Tue 15:45 F 128

Observing the quantum Zeno effect of a single state spin — •Max Strauss, Janik Wolters, Niko Nikolay, Simon Schönfeld, and Oliver Benson — Nanooptik, Institut für Physik, Humboldt Universität zu Berlin, Newtonstraße 15,D-12489 Berlin, Germany

Nitrogen vacancy (NV) centres in diamond exhibit remarkable features, comparable to those of a trapped atom albeit being a genuine solid-state system. Intense research in recent years has sought to exploit these exceptional attributes for various applications ranging from quantum information to neurosciences. We report the experimental observation of the quantum Zeno effect in the radio frequency transition between two NV^- ground state spin levels (a spin 1 system) in nanodiamond using optical read-out techniques.