Q 63: Quantum Effects: Entanglement and Decoherence III

Time: Friday 14:00–16:00 Location: A 310

Group Report Q 63.1 Fr 14:00 A 310

Multipartite entanglement: Creation with identical particles and general classification — •Malte Tichy, Benno Salwey, Klaus Mayer, Florian Mintert, and Andreas Buchleitner — Albert-Ludwigs-Universität Freiburg

We study the classification of entanglement in high-dimensional multipartite systems and processes to generate states of distinct entanglement properties by means of linear optics. Two states are said to contain a different kind of entanglement if they cannot be obtained from each other with finite probability just by means of local manipulation. We derive a general framework to discriminate inequivalent entanglement properties in high dimensional multi-partite systems via permutation symmetries of multiple tensor products of the quantum states. Having identified distinct classes of entanglement, we investigate which of those can emerge in multidimensional many-particle quantum walks with bosons and fermions and point out the differences to analogous situations with distinguishable particles. In particular we focus on the generalized n-port beam splitter, easily realizable for photons with linear optics elements only, and the fourpartite qubit case.

Q 63.2 Fr 14:30 A 310

Optimal dynamical control of many-body entanglement — •Felix Platzer, Florian Mintert, and Andreas Buchleitner — Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

We derive time-dependent control fields, which are suitably tailored to maximize a multipartite entanglement measure and thus steer a given system towards highly entangled states. The usage of an entanglement measure as target functional naturally leads to an optimization over the multitude of states with equivalent entanglement properties, and results in the creation of the most suitable highly entangled state, i.e. the state which is most rapidly produced and most robust against the predominant type of decoherence. This rather general framework is then readily applied to nitrogen vacancy centers in diamond, whose permanent and uncontrollable interaction strengths impede the creation of high entanglement. Not only does our control scheme achieve and maintain strong entanglement through local driving only, but it is also intrinsically robust to possible experimental imperfections, e.g. imperfectly estimated coupling constants or imperfect control sequences.

Q 63.3 Fr 14:45 A 310

Entanglement-enhanced energy transport — •Torsten Scholak[1], Fernando de Melo[1,2], Thomas Wellens[1], Florian Mintert[1], and Andreas Buchleitner[1] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, D-79104 Freiburg, Germany — [2]Instituut voor Theoretische Fysica, Katholieke Universiteit Leuven, Celestijnenlaan 200D, B-3001 Heverlee, Belgium

In many areas of physics we witness dramatic differences between classical and quantum transport. In general, we expect quantum features to fade away on large scales, due to the ever more unavoidable – and detrimental – influence of the environment which scrambles relative phases and damps quantum amplitudes. Recent experimental evidence suggests, however, that the functional efficiency of large biomolecular units may stem from quantum coherence phenomena, despite strong environment coupling. We explain such efficiency, under the assumption that evolution is able to steer finite size three dimensional systems into molecular conformations with optimal coherent transport properties. It turns out that such optimal conformations are characterized by specific, optimal entanglement properties between different sites of the molecular complex.

Q 63.4 Fr 15:00 A 310

Dissipation induced Tonks-Girardeau gas of polaritons — •Martin Kiffner and Michael Hartmann — Technische Universität München, Physik-Department I, James-Franck-Straße, 85748 Garching, Germany

In one-dimensional systems, bosons can behave with respect to many observables as if they were fermions. This strongly correlated regime of a Tonks-Girardeau (TG) gas regime can be reached for strong repulsive interactions between the particles. Recently, an experiment [1] with cold molecules showed that not only elastic interactions, but even two-particle losses alone are able to create a TG gas.

Here we derive a scheme for the generation of a Tonks-Girardeau (TG) gas of polaritons with purely dissipative interaction [2]. We put forward a master equation approach for the description of stationary light in atomic four-level media and show that, under suitable conditions, two-particle decays are the dominant photon loss mechanism. These dissipative two-photon processes increase the interaction strength by at least one order of magnitude as compared to their dispersive counterparts and can drive the polaritons into the TG regime. Our scheme allows to measure local and non-local correlations of the TG gas via quantum optical techniques.

[1] N. Syassen, D. M. Bauer, M. Lettner, T. Volz, D. Dietze, J. J. Garcia-Ripoll, J. I. Cirac, G. Rempe, S. Dürr, Science **320**, 1329 (2009).

[2] M. Kiffner and M. J. Hartmann, arXiv:0908.2055.

Q 63.5 Fr 15:15 A 310

Optimal quantum many-body dynamics — •Felix Platzer[1], Torsten Scholak[1], Fernando de Melo[2], Florian Mintert[1], and Andreas Buchleitner[1] — [1]Albert-Ludwigs-Universität Freiburg — [2]Katholieke Universiteit Leuven

We investigate the evolution of quantum many-body systems with permanent inter-particle interactions and their ability to evolve into highly entangled states. We are following a statistical approach in which we test the dynamics of coupled spins, a random spatial arrangement of which induces randomly distributed coupling elements. Correlating entanglement properties and transport efficiency over many realizations reveal that high multi-partite entanglement is an indispensable catalyst for energy transport. Whereas optimality is of extreme statistical unlikeliness, we argue that evolution could have found exactly such untypical geometries resulting in the astonishing transport efficiency of biological compounds. In the generic case where the natural coupling mechanism does not result in the evolution to high entanglement we can use suitably tailored time-dependent control fields to steer the system towards a desired class of highly entangled states. In our approach to coherent control this is achieved with the help of a multipartite entanglement measure as target functional, what leaves the freedom to find those states with given entanglement properties that have advantageous dynamical properties. Applying our framework to NV-centers, we find rapid evolution into those highly entangled states that are robust to against the prevailing decoherence mechanism.

Q 63.6 Fr 15:30 A 310

Assymptotic multipartite entanglement at finite temperature — •Simeon Sauer, Florian Mintert, and Andreas Buchleitner — Physikalisches Institut Albert-Ludwigs-Universität Freiburg

When a many-body system is coupled to a noisy, thermal environment, it rapidly loses its coherences. Multipartite entanglement relies on such coherences, and therefore decays accordingly; and it does so, the faster, the larger the system and the hotter the environment is. However, external coherent driving is likely to slow down such decay, and it might even stabilize entanglement at a finite level.

Here, we study the entanglement dynamics in a periodically driven many-body system, embedded in a thermal environment. With the help of the Floquet formalism, we identify steady states and characterize their entanglement properties. With this approach, we look for conditions (such as strength and frequency of the driving, and environmental temperature) that maintain a finite amount of multipartite entanglement for asymptotically large times.

Q 63.7 Fr 15:45 A 310

Attosecond neutron scattering from open quantum systems — •C. Aris C.-Dreismann — Institute of Chemistry, Technical University of Berlin, D-10623 Berlin, Germany

Neutron Compton scattering (NCS) from single nuclei of atoms in molecules, e.g. H2 (and/or single atoms, e.g. He) is effectuated in the attosecond timescale. The related "scattering time" is considered in detail, in relation with the Uncertainty Relations. It is shown that the entity "scattering time" gives a statistical measure of the length of the time interval during which an elementary neutron-nucleus collision may occur, in the same way that the spatial extent of a particle wavefunction (or wavepacket) gives a statistical measure of the extent of the region in which the particle may be found. Consequently, the elementary neutron-nucleus scattering process represents a time-interference phenomenon over the sub-femtosecond ”scattering time” window. Moreover, the very short-range strong interaction of the neutron-nucleus collision implies that the scattering system (e.g. a proton partically ”dressed” with electrons) must be considered as an open quantum system. Experimental results from H2, D2 and HD are mentioned and their ”anomalous” scattering property [1] in the attosecond timescale is qualitatively discussed, also in connention with the Schulman-Gaveau effect [2].

[1] G. Cooper, A. P. Hitchcock, C. A. Chatzidimitriou-Dreismann, PRL 100, 043204 (2008); and references therein. [2] L. S. Schulman, B. Gaveau, PRL 97, 240405 (2006).