Fermion-parity duality and energy relaxation in interacting open systems

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Abstract

Energy decay due to heat currents is of key importance in the continued downscaling of electronic devices. Progress in controlling and detecting heat transfer has been achieved using various approaches, including few-electron heat currents through molecular-scale devices with electro-statical gating. Now also time-dependent measurement and control of heat are within experimental reach and have incited theoretical studies. An important open question is how a generic, small electron system with strong level-quantization and Coulomb interaction dissipates in time the stored energy into a coupled electronic bath. In this presentation, I will show that the time-dependent heat current out of a confined, interacting fermionic system is dictated by a many-particle parity mode with large amplitude due to a duality relation between decay-modes and amplitudes [1]. The duality holds generally for fermionic open quantum systems with arbitrarily strong wide-band coupling to noninteracting reservoirs and is derived from the fermion-parity superselection (univalence) postulate of quantum mechanics. In the weak-coupling, Markovian limit it relates the decay-amplitude of the parity mode in a surprisingly simple way to the stationary state of a dual system with attractive interactions – we call this the inverted stationary state. We find that, in order to experimentally see the interaction-dominated heat current one needs to apply a sudden gate-voltage switch, which prepares an initial state that most closely resembles this inverted stationary state. The role of the parity mode clarifies the breakdown of the tight-coupling picture of time-resolved energy transport. [1] Jens Schulenborg, Roman B. Saptsov, Federica Haupt, Janine Splettstoesser, and Maarten R. Wegewijs, to be submitted.

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