Single-particle emission from the Andreev's level

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Abstract

Recently, high-speed quantum-coherent electron sources injecting one- to few-particle excitations into the Fermi Sea have been experimentally realized.[1]-[3] The main obstacle to using these excitations as flying qubits [4] for quantum-information processing purposes is decoherence due to the long-range Coulomb interaction [5]. An obvious way to get around this difficulty is to employ electrically neutral excitations, for instance electron-hole pairs from the composite source.[6] Here we discuss how such excitations can be generated on-demand using the same injection principles as in existing electron sources. Namely, with the help of a voltage pulse of a certain shape applied to the Fermi Sea, or using a driven quantum dot with superconducting correlations. In the former case a two-particle state (per spin) is excited, an electron-hole pair. While in the latter case a single-particle state with a variable charge is excited, an electron-hole superposition (EHS). Using a time-resolved electric current, in Fig.1 we show how the EHS composition varies with magnetic field from symmetric (electrically neutral) to asymmetric (charged). As shown in Fig.2, heat carried by EHS is proportional to charge, not noise, as in the case of the electron-hole pair state.

References

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Figures

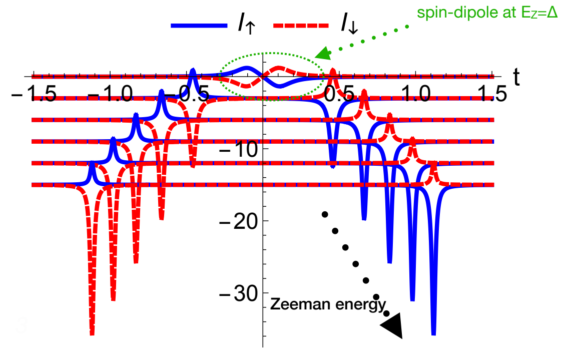

Figure 1: A time- and spin-resolved electric current injected into a normal lead from the Andreev's level, driven by a gate potential linear in time, U ~ t. Graphs at different Zeeman energies, E_z/Δ= 1;1.1;1.2;1.3;1.4; and 1.5, are shifted for clarity. Δ is the superconducting gap

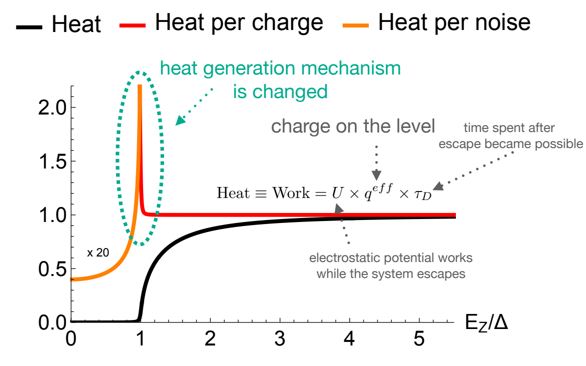

Figure 2: Electrical and thermal quantities are smooth functions of Zeeman energy. In contrast, their ratios clearly demonstrate a phase transition at E_z=Δ, from the phase when the Andreev's level crosses the Fermi energy and changes its population as the gate potential U(t) is varied, to the phase when the population does not change with varying U(t).