Absence of spontaneous persistent current for interacting fermions in a one-dimensional mesoscopic ring

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We address the issue of whether a system of interacting electrons confined to a one-dimensional ring can sustain a spontaneous persistent current in the absence of an externally applied flux. The current-current coupling between electrons, describing radiative back-action effects, is exactly treated in the formalism of quantum electrodynamics, where the electrons interact via the exchange of virtual photons. In addition, the instantaneous screened Coulomb potential is taken into account using the Luttinger liquid model including finite-size parity effects. The partition function is calculated exactly, with the result that the system does not possess a spontaneous persistent current. We show that, in the presence of an external flux, the amplitude of the (conventional) persistent current is reduced by quantum fluctuations of the internal transverse electromagnetic field. These corrections can be expressed in terms of the self-induction of the ring and are shown to be of first and higher order in the small dimensionless parameter alphaupsilon(F)*/c, where alpha is the fine-structure constant and upsilon(F)* the Fermi velocity renormalized through Coulomb interactions.

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