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The role of duality in one-dimensional transport of interacting particles through a constriction

Abstract:

We study the effect of an embedded constriction, like a weak scatterer (WS) or a weak link (WL), on transport of a Luttinger liquid (LL) made of two sorts of interacting particles (e.g., electrons coupled to acoustic phonons in a quantum wire/nanotube or Fermi-Bose mixtures of cold atoms). We find that a duality relation between scaling dimensions of the electron backscattering in the WS and WL limits, well-known for the standard LL, holds in the presence of the additional coupling for any uncorrelated strengths of boson and fermion scattering from the constriction. This means that at low temperatures such a system remains either an ideal insulator or an ideal conductor, regardless of the scattering strength. In particular, this leads to "sympathetic superflow" of fermions through the constriction provided that bosons are superfluid, i.e. in a quasi-condensate. On the other hand, when fermion and boson scatterings from the impurity are correlated, the system has a rich phase diagram that includes a conductor-insulator transition at some intermediate value of the scattering strength.