One dimensional systems 1

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Quasi-one-dimensional systems in solid state physics show an amazing variety of interesting phenomena. The goal of the first talk in a series about one-dimensional systems is the characterization of the low-energy physics of gapless one-dimensional systems of interacting spin-1/2 fermions.

Three-dimensional metals in the *normal state* are described by Landau's *Fermi liquid theory*. The single-particle excitations are the so-called *quasi-particles*. They are derived from the particles of the free electron gas by adiabatically switching on the interactions, and one can think of them as single charged particles (formally interaction-free) which are surrounded by a distorted charge distribution. The quasi-particles have the same quantum numbers as the original free particles and also obey Fermi-Dirac statistics. The electron-electron interactions lead to a renormalization of the kinetic parameters, like the effective mass, and to finite lifetime of the single-particle excitations.

The Fermi liquid picture which applies for the three-dimensional system is not valid in one dimension. It is well known that for interacting one-dimensional electron systems the breakdown of the Fermi liquid theory is expected.

The proper model for describing an interacting 1D system of spin-1/2 fermions without a gap in the spin or charge excitation channel is the *Luttinger model*. An exact solution by *bosonization* is presented i.e. we will find a representation of the underlying *Tomonaga-Luttinger Hamiltonian* in terms of boson operators which can be diagonalized by a Bogoliubov transformation. This particular technique to solve the problem can only be applied in one dimension. As a result we find that the elementary excitations are (bosonic) *collective* spin and charge fluctuations. These charge and spin density fluctuations propagate with different velocities and therefore charge and spin of an electron entering the system will have separated completely after some time (*spin-charge separation*).

It is widely believed that the Luttinger model describes the generic behavior of *any* gapless 1D system of interacting spin-1/2 fermions and F.M. Haldane introduced the name *Luttinger liquids* for such systems in analogy to the Fermi liquid.