THE t-J MODEL IN ONE DIMENSION : EXACT SOLUTION AT |t| =J .

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Abstract

By means of the Bethe ansatz technique, we have diagonalized exactly the one dimensional t-J Hamiltonian for $|t|=J$.[1]
We emphasize that the model we have solved can not be obtained as the large-U limit of the repulsive Hubbard model, for which the exchange constant $J=4t^2/U \ll t$, the hopping strength .
The ground state properties and the low-lying excitation spectrum are discussed for the case $t=J>0$,[2] where the model becomes supersymmetric [3]. For all values of the band filling, the ground state can be pictured as a liquid of singlet bound pairs. From a formal point of view , the structure of the ground state is similar to that of the attractive Hubbard model[4]. However, the physics is more like that of the repulsive Hubbard model[5,6]. In particular, the ground state involves pairs of electrons of arbitrarily weak binding energies, resulting in a gapless spectrum.
The low-lying part of the spectrum is composed of two types of excitations:
i) Charge excitations occurring only away from half-filling. This mode is gapless and carries no spin. In Anderson's terminology [7], it corresponds to a holon-antiholon branch. It is the analogue of the particle-hole excitation in a Fermi liquid. The holons have an effective Fermi surface at $2k_F$ ($k_F=\pi N/2N_a$).

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ii) Spin excitations which, at half-filling, reduce to the two-parametric family of states of Faddeev and Takhtajan [8]. The excitation consists in breaking a pair with (triplet) or without (singlet) spin-flip and carries no charge. The spectrum is gapless : this is due to the presence of a continuum of asymptotically unbound pairs . Near half-filling , this mode can be identified as a double-spinon branch. The effective Fermi surface for spinons is at k_F.

In conclusion, we have determined the ground state and the elementary excitation spectrum of the t-J model at $|t|=J$ for arbitrary band filling. We believe that the model for $t=J$ belongs to the same universality class as the repulsive Hubbard model and do not expect a phase transition in the interval $0<J/t\leq 1$.[9]

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