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Binding of spinon and holon in the anisotropic 1D $t-J$ model[1]
JURIJ SMAKOV, ALEXANDER CHERNYSHEV, STEVEN WHITE, University of California Irvine — In the 1D $t-J$ and Hubbard models spin and charge dynamics are independent, leading to the well-known spin-charge separation: splitting of the physical electron (hole) into free spinon and holon excitations. Considerably less is known about the interaction between such excitations. To address this problem, we have performed a detailed theoretical and numerical study of anisotropic XXZ-version of the t-J model using Bethe-Salpeter equation and exact diagonalization and DMRG methods on systems of up to 128 sites. We find that holon and spinon form a bound state for any value of anisotropy $\alpha = J_\perp/J_z$ smaller than one. A remarkable agreement between the theory and numerical results has been demonstrated. We argue that the binding is largely controlled by the spinon energy spectrum. Qualitatively, the bound state near the Ising limit $\alpha \ll 1$ corresponds to the confinement of a free holon in the vicinity of an essentially immobile, impurity-like spinon with binding energy $\Delta \sim J_z^2/t$. However, already for $\alpha \gtrsim 0.5$ an almost relativistic spinon is only weakly bound to the holon. Such a change in the character of pairing results in a dramatic evolution of Δ as a function of α: binding energy goes from a finite value at $\alpha = 0$ to the exponential drop-off close to the isotropic case.

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