Low temperature thermodynamics of one-dimensional exactly solvable spin models with impurities

E. Ezerskaya and O. Dzhenzherov

V.N.Karazin Kharkiv National University, Faculty of Physics, 8 Svoboda Sqr., 61022 Kharkiv, Ukraina, E–mail: yezerska@karazin.ua

This work is devoted to the theoretical treatment of low temperature thermodynamics of some exactly solvable quantum models based on spin-1/2 XX-chain. We study analytically and numerically the finite spin-1/2 XX chains with defects of different nature: finite linear XX-chain with one distorted XX bond, finite linear XX-chain with one ZZ (or XX) impurity spin at one of the intermediate lattice site and two finite XX-chains, connected through an additional ZZ spin.

Real quasi-one-dimensional magnetic structures are characterized by different types of structure defects. The theoretical study of the influence of these defects on the energy spectrum and the thermodynamics of spin chains is of interest.

All above models can be reduced to the finite XX-chain with impurities. For these models we derived the analytical formulas for some principal and local thermodynamic characteristics and studied numerically their field and temperature dependence on the model parameters. In particular, we found a complex dependence of the heat capacity on applied magnetic field with numerous minima and maxima.

We found, that the field dependence of the magnetization at rather low temperatures has the finite jumps associated with impurity levels. In addition, the field dependence of average value of the ZZ impurity spin in the case of antiferromagnetic interaction with the main XX chain may have an oscillating behavior in a weak magnetic field and a jump in the critical field. We associate this jump with an impurity spin-flip along the direction of the magnetic field. So, the localized levels may effect noticeably on local thermodynamic characteristics.

E. Ezerskaya acknowledge the support from the VolkswagenStiftung, Germany (via grant 151110), and O. Dzhenzherov acknowledge the support from the State Fund of fundamental research of Modern Physics (via grant 33683).