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Spin wave description of ultracold 2D paramagnetic crystal

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The spin wave approach is used to describe the paramagnetic with pair dipole interaction of magnetic moments. It is based on the Holstein–Primakoff transformation of spin operators. Lattice Hamiltonian includes Zeeman energy and full dipolar energy with secular and non-secular terms, while the exchange energy is assumed to be negligible. The model describes the nuclear subsystem of paramagnetic insulator, e.g. solid H and O, 13C-enriched materials and electron shell system of rare earth salts where the exchange interaction vanishes due to the large distance between magnetic atoms. The 2D paramagnetic crystal is considered. It is placed into the uniform constant magnetic field which is orthogonal to the lattice plane. The magnetic saturation is considered as the ground state. All spins orient along field at the saturation and disorder occur because of thermodynamic fluctuations. The dipolar interaction causes the collective spin deviation at ultracold limit; the temperature must be <0.001 K for typical paramagnetics. In the current study, the thermal dependence of magnetization and specific heat were found taking into account the spin wave elastic scattering. The specific heat curve differs from the well-established Schottky law which realizes in the ideal paramagnetics without particle interaction. Nevertheless, the Schottky curve is confirmed for the temperatures >0.01 K and it may change in the ultracold region. Also, the spin wave approximation becomes applicable under the high magnetic fields. It requires the additional numerical or experimental studies.

Biography

Kirill Tsiberkin has completed his PhD from Perm State University (PSU). He is the Teaching Assistant of Theoretical Physics Department of PSU, Technician at the electronic manufacturer “Control Systems”, Perm, Russia and Executive Secretary of the PSU Physical Faculty Bulletin. He has published 12 papers in peer-reviewed journals (8 of them are indexed in WoS/Scopus) in areas of fluid dynamics, signal processing and magnetism.

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