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Spin Wave Theory for Magnetic Insulators

Since the formulation of the Heisenberg Model more than 80 years ago this approach was quite successful to describe magnetic phenomena in magnetic insulators. It is an effective model which emerges from the interplay of the Coulomb interaction between electrons and the Pauli principle. Nevertheless the model is still used in recent works. A lot of them focus on spin-wave theory which is an approximation technique to solve the Heisenberg model.

In the Heisenberg Antiferromagnet quantum fluctuations are quite strong which render this system interesting to study quantum effects. Using the mapping to spin-waves (magnons) one can identify characteristics of the interacting Bose gas in the symmetry broken phase that are related to infra-red singularities in the perturbation theory of the Bose gas. With the help of transversal and longitudinal modes this is even visible in physical observables.

A quite different systems are thin films of the ferrimagnetic insulator yttrium-iron garnet (YIG) where spin-waves have been excited via microwave pulses and detected by means of optical Brillouin light scattering. Using the fact that the spin-wave dispersion has a minimum at finite wave-vectors, Demokritov et al. (2006) showed that magnons can condense into a strongly correlated coherent state even at room temperature. The existence of a minimum in the magnon spectrum of YIG is the result of a subtle interplay between finite-size effects of the thin film, the short range exchange and the long range dipole-dipole interactions. We combine the 1/S-expansion with Ewald summation techniques to calculate the magnon-spectrum of thin YIG films. Our approach provides a straightforward method to determine the interactions between magnons which is a starting point for further investigations on the non-equilibrium behaviour of the magnon gas in YIG.