Mean field theory of magnetic ordering

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In a next step, we will discuss on a phenomenological level the interactions between magnetic moments in the solid that lead to a magnetic phase transition. These interaction include the magnetic dipole interaction, the exchange and some higher order interactions. At high temperatures, the thermal fluctuations will drive the system to a magnetically disordered state, i.e. the paramagnetic state. Below a critical temperature, magnetic order can be formed. Depending on the microscopic details, ferromagnetic, ferrimagnetic, antiferromagnetic or helical order can be found. We will briefly discuss the predictions of the classical theory on some of the observables as the transition temperature, the magnetization, the susceptibility and the specific heat and illustrate, how these quantities can be measured. This lecture will also discuss some general aspects of phase transition including the thermodynamic relations between some of the observables, the fluctuation dissipation theorem, the Krames-Kronig relation and the correlation length and time. The focus will be on the experimental implications of these aspects.

Finally, we will risk a short d-turn to quantum systems to show the limit of mean field theories especially for the case of antiferromagnetic systems and frustrated magnets and prepare the stage for models of localized versus itinerant systems.

The lecture requires some prior knowledge on statistical mechanics and thermodynamics. As an introduction to this lecture, the following textbooks are an excellent choice:

- J. M. D. Coey, Magnetism and Magnetic Materials, Cambridge University Press (2010)
- S. Blundell, Magnetism in Condensed Matter, Oxford University Press (2001)
- C. Kittel, Introduction to Solid State Physics, Wiley (2005)