Introduction to the Theory of Magnetism in Solids

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While the subject of 'Magnetism' has had a long history, the 'Theory of Magnetism in Solids' developed only after the advent of quantum mechanics. The initial understanding of the exchange interaction and the formulation of the Heisenberg Hamiltonian are foundations that underlie the vocabulary and concepts being used today. The local spin density approximation (LSDA) of density functional theory is another cornerstone that has proven surprisingly accurate and useful for itinerant electron materials. It is nearly always the first computational approach adapted when trying to predict or understand a new magnetic system. It is when the LSDA is inadequate that new methods have been developed. Indeed, many modern theoretical methods for studying magnetic materials are using LSDA 'failures' as the prototype systems to explore the effects of strong electron correlations, finite temperature effects, excited state properties, and magnetic anisotropy. There are also issues concerning optimal computational methods, and how to combine methods applicable for different length scales to accurately simulate magnetic phenomena at the nanometer and micron regions. Obviously this talk can not cover or even mention all the relevant topics, but will instead focus a few examples to illustrate the basic ideas and challenges in this highly active field of research. Time permitting, topics mentioned will include LSDA, RKKY, LSDA+U, Rare Earths, Non-collinear Magnetism, Magneto Optics, Spin Dynamics, Statistical Coarse Graining, Oxides, and DMFT.