Finite-Temperature Magnetism

R. Skomski[1]

[1] *University of Nebraska*

Many magnetic materials are used at and above room temperature, but the temperature dependence of intrinsic and extrinsic magnetic properties is only partially understood. Several aspects of finite-temperature magnetism will be discussed. Nanostructuring has a far-reaching impact on the magnetism at nonzero temperatures, as exemplified by the well-known fact that the Curie temperature of zero-dimensional magnets (nanoparticles) and one-dimensional magnets (nanowires) is exactly zero. There are no true finite-size corrections in zero and one dimensions, so the interpretation of experimental data is a nontrivial consideration. The complexity of the problem is enhanced by electronic transitions as the size or diameter of the structure increases. One example is the occurrence of very weak itinerant ferromagnetism in Co2Si nanoparticles, which causes quantum-mechanical effects to be strong over several interatomic distances. From the viewpoint of first-principle theory, density-functional calculations are now able to accurately describe the motion of itinerant electrons in spin-dependent potentials, including potentials with varying spin direction, as encountered near the Curie temperature. However, this approach does not solve the underlying many-body problem, as epitomized by the strongly correlated Heisenberg model. The reason is that density-functional calculations imply well-defined local spin directions, that is, the wave functions are eigenfunctions of the Pauli matrices. Such eigenfunctions are contradictory to the Heisenberg limit, as we will elaborate by explicitly solving a simple many-body model. An even more complicated situation is encountered in the area of finite-temperature magnetocrystalline anisotropy, which will be illustrated by a few examples. Finite-temperature micromagnetism has remained a controversial issue, in spite of decades of research. We will briefly summarize the state of the art and direct attention to some questions that are only partially solved at present, such as the interference between magnons and nanoscale structural features.