Stuttgarter Physikalisches Kolloquium

Max-Planck-Institut für Intelligente Systeme
Max-Planck-Institut für Festkörperforschung
Fachbereich Physik, Universität Stuttgart

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Magnetism - Understanding the rules of attraction and its complexity

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Abstract

Magnets are key components of energy-related technologies, such as direct drive wind turbines, e-mobility and magnetic refrigeration. They are also important in robotics and automatisation, sensors, actuators, and information technology. Additive manufacturing (AM) as well as controlled phase-decomposition of complex alloys are promising pathways to design magnetic materials with properties tailored to specific applications. Such novel approaches require the use of functionalized nanomagnets at length scales between few nanometers and several micrometers and a fundamental understanding of the microscopic interactions governing macroscopic magnetism, i.e. understanding the rules of attraction.

Starting with a discussion of basic concepts of magnetic properties with a focus on how to tune parameters in a nanomagnet, I will highlight selected state-of-the-art experimental approaches that allow us to experimentally analyze multifunctional particles with single particle or even atomic precision. The apparently complex behavior of hybrid metal/metal, metal/oxide, or oxide/oxide interface materials – core-shell materials – can be understood from the three fundamental interactions in magnetism: magnetic exchange due to orbital overlap, spin-orbit interaction due to inner- and intra-atomic relativistic effects (e.g., crystal field effects) and the long-range magnetic dipolar interaction. Several examples will be presented, including the formation of above-room-temperature ferromagnetic interfaces between antiferromagnetic core/shell layers, the design of a macroscopic magnet with a monopole-like magnetic response and non-collinear spin-structures in magnetic MAX phases.