Abstract Dominque Givord:

Thirty years of material science applied to magnetism: discoveries and new applications

In 1980, soft magnetic materials serving as guides or concentrators of magnetic flux in electromagnetic machines dominated the field of technical magnetism; permanent magnets were essentially hard ferrites, used in loudspeakers and simple motors; Fe2O3 magnetic particles were used in data recording tapes; hard disk drives were an expensive optional component of a new device, the personal computer; spin-dependent transport was a physical phenomenon of secondary importance.

The discovery of NdFeB hard magnets in 1983 led to a transformation in the design of electrical motors and generators and the discovery of Giant Magnetoresistance in 1988 marked the birth of spintronics, one of today's most active domains of condensed matter physics research. During this same period, society was transformed by the development of information technology while the challenges posed by global warming and resource limitations were progressively recognised.

The advent of high-performance magnets and spintronics led to the extraordinary development in magnetic studies needed to unravel the mechanisms governing magnetization processes and spin-dependent transport phenomena. Magnetism had essentially been understood in terms of exchange interactions and anisotropy; other effects resulting from spin-orbit interactions, the role of disorder, or the possible existence of competing magnetic interactions, were essentially unrecognized. The fact that magnetization reversal may be driven by a (spin) current, was yet to be discovered.

Today, further progress in the understanding of magnetism and magnetic materials is crucial for solving new challenges, from achieving incremental improvements in existing materials to discovering fundamentally new types of magnetic materials. The study of magnetic materials is greatly benefiting from impressive developments in characterisation techniques (e.g. aberration corrected TEM, 3D-atom probe tomography, X-ray magnetic circular dichroism, near-field microscopies) as well as ever more powerful computers, needed for DFT calculations and micromagnetic modelling. Electronic structure calculations combined with data mining are being used to successfully guide the development of new magnetic materials such as magnetic seminconductors, half-metals or magnetocaloric materials. Advanced micro and nanofabrication techniques serve to fabricate new nanoobjects, often based on multilayer stacks of different materials. Magnetic nanoparticles have a growing number of bio-medical applications.

In this talk I will give an overview of recent and on-going developments, focussing on some examples, which illustrate the impressive vitality of the field of material science applied to magnetism.