

Magnetism: Special issue overview

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Since the early days of our civilization, magnetic phenomena were observed due to the existence of natural magnets, the "loadstone". The use of magnetic needles for compasses made navigation one of the most profitable areas of application. An aura of mystery and magic has always surrounded magnetic phenomena. Sir W. Gilbert at the beginning of the XVII century wrote the first scientific compendium "De Magnete, Magneticisque Corporibus, et de Magno magnete tellure; Physiologia nova, plurimisque & argumentis, & experimentis demonstrata. Londra, Pietro Short, 1600"

Since then and with relevant historic milestones such as the experimental genius of Michael Faraday and the theoretical compendium of J. Clerk Maxwell, magnetism nowadays is one of the scientific pillars of human knowledge. The theoretical advances and the strong involvement of magnetism in all branches of technological development make this discipline one of the most relevant areas of current research. The present monograph is a consequence of the large activity in this exciting field. The capabilities for materials fabrication with control at the nanoscopic level and the development of new instruments are the basis of an everyday emerging and interdisciplinary magnetism.

In this issue, we have tried to cover the most exciting topics in magnetism with articles by relevant specialists in this field.

New advances in the application of magnetic properties in life sciences are of great interest due to the strong social implications related to health problems. The impact of magnetism in diagnosis and therapy constitutes a rapidly developing field, summarized in the A. Curtis and P. Freitas contributions. Other interdisciplinary examples are the contributions from J.M.D. Coey and D. Gatteschi in which the close connection of Magnetism with Chemistry has opened new research fields such as the electrochemical growth of new materials under the influence of an applied magnetic field and research

on mesoscopic magnetism based on the spectacular development of molecular chemistry techniques. With regard to the development of new experimental techniques, the emergence imaging possibilities based on the use of magnetic force microscopy opens a new area that will allow a better understanding of magnetism at a micro- and nanoscopic level. The G. Guntherodt and colleagues contribution reports the state of the art in this field. D. Givord describes the wide range of application of magnetic materials in which the control of the change in the coercive field by more than six orders of magnitude allows the design of materials with adequate magnetic properties going from the very soft to the extremely hard. A. Hernando reviews magnetism in nanocrystalline materials showing relevant examples of how nanoscale influences the magnetic properties.

Several contributions are devoted to one of the currently most expanding areas of magnetism: "spintronics". This field, lying at the interface between Magnetism and Electronics is of considerable interest given the large demand for novel electronic devices, in which a magnetic field acting on the spin of the electrons can control the electrical current. The description of several phenomena based on the control of the spin in heterostructures such as magnetoresistive magnetic multilayers, magnetic tunnel junctions, and hybrid ferromagnetic-semiconductor are nicely summarized in the A. Fert contribution. The spin injection phenomena at these interfaces are described in the J.A.C. Bland contribution showing a highly efficient spin transport from a semiconductor to a ferromagnet at room temperature, whose origin could be spin-polarized Schottky barriers. Within the former context the deep knowledge of magnetic interactions in diluted magnetic semiconductors supports the existence of ferromagnetism well above room temperature, a subject that is summarized in the T. Dietl contribution. Half-metal ferromagnets are of great interest within the context of spin-polarized transport and many magnetic oxides fall within this category. Among them, an exciting renewal of interest in manganites has been opened up with the discovery of colossal magnetoresistance; B. Raveau and A. Maignan report on these extraordinary properties that are found and expected in magnetic oxides. Also related to possible applications of magnetoresistance in electronic devices, N. Garcia has found huge ballistic magnetoresistance at nanocontacts; this discovery is proposed as the basis for extremely sensitive sensors needed for reading heads in the compacted new Terabit/inch² technology. Magnetostriction effects observed by means of atomic force microscopy are also reported; A. del Moral summarizes the effect and the new theoretical aspects and applications based on magnetostriction phenomena. Finally, F. Steglich reports on the strong electronic correlations and describes how they are at the origin of the formation of extremely heavy quasiparticles composed of a local spin part and delocalized charge-carrier contributions. They may form Cooper pairs that are an essential ingredient to explain the coexistence of magnetism and superconductivity.

These selected contributions offer a broad description of relevant aspects of magnetism in the scientific and technological development of today and demonstrate that this old discipline constitutes the background for technological innovation at the beginning of this new century.

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Sir William Gilbert.