Magnetic information in the Light Diffracted by Arrays of Nanometer-scale Magnets

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A key issue in fundamental physics and data storage technology is to understand and control magnetic phenomena, which appear when systems are confined to the nano-scale. The magnetic properties of nano-scale magnetic materials are continuously investigated using a variety of experimental techniques and the ever-increasing efforts devoted to their study are leading to the development of novel systems.

Magneto-optical measurement techniques, especially the Magneto-Optical Kerr effect (MOKE), are established and widely used characterization techniques for the study of fundamental magnetism issues in thin and ultrathin film/multilayered samples. The basic observation in magneto-optics is that the optical properties of a magnetic material change with an alteration of the magnetization state.

So far the vast amount of work done using MOKE has been in a simple reflection geometry, which limits its applicability to planar structures and physical geometries. Only recently, several successful attempts have been made to extend MOKE to diffraction techniques (see Fig. 1), in order to exploit the interference effects of light being diffracted by arrays of nano-structures. This technique, called diffracted magneto optic Kerr effect (D-MOKE), in conjunction with micromagnetic simulations, demonstrated to be a powerful and non-destructive technique for investigating the spatial correlation of the magnetic spin distribution at the nano-scale in a periodic matrix of nano-structures [1].

D-MOKE has been applied to the study of broad variety of magnetic phenomena occurring in arrays of nano-particles as, e.g.,: correlation of the magnetic spins distribution to effects of magnetostatic self energy and dipolar interactions [2]; magnetization reversal path and magnetic configurations in arrays subjected to competing interactions (magnetic frustration) [3].

In this talk, the experimental and theoretical aspects of obtaining the magnetic information carried by laser beams diffracted from an array of nanosized magnetic objects are reviewed. Experimentally it will be shown that MOKE hysteresis loops recorded from diffracted beams (see Fig. 2) are proportional to the magnetic form factor or, equivalently, to the Fourier component of the magnetization corresponding to the reciprocal lattice vector of the diffracted beam. It is finally shown a particular experimental implementation of D-MOKE based on magneto-optical ellipsometry techniques, which allow for the extraction of the unit cell magnetic configuration directly from D-MOKE loops without the aid of micromagnetic simulations. Evidence is given that this recent extension of D-MOKE capabilities provides a vastly improved far-field optical characterization method of the microscopic collective magnetic behavior of arrays of nano-magnets.

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References

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[3] R. F. Wang et al., Nature **439**, 303 (2006).

Figures

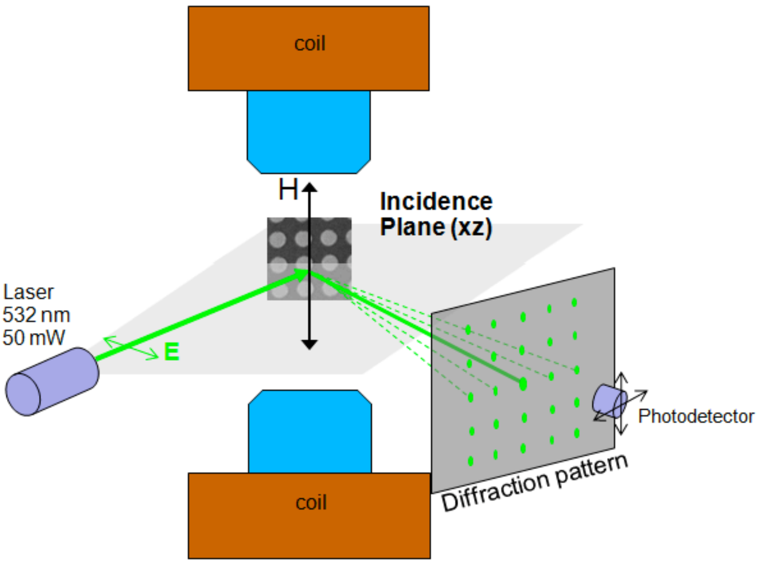

Fig.1: Schematic drawing showing the transverse MOKE configuration for recording magnetization loops at specularly reflected and diffracted beams

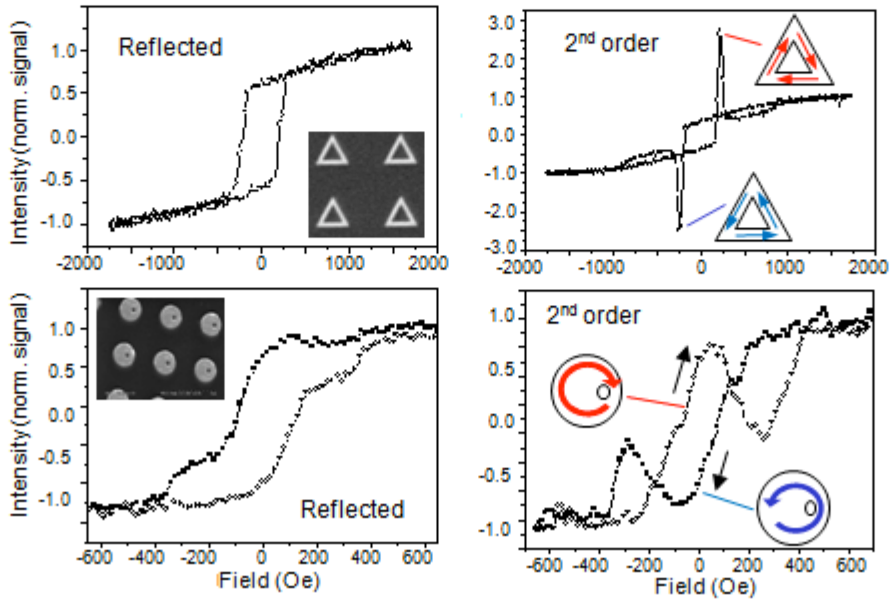

Fig.2: Examples of hysteresis loops from arrays of dots shown in the scanning electron microscopy images in the insets, showing the unusual shapes of D-MOKE with respect to conventional MOKE loops measured from the reflected beam. In the specific cases shown, the unusual shape of D-MOKE loops is related to the nucleation of magnetic vortex states of well defined chirality.