Magnetic microscopy of ordering in mesoscopic magnetic systems

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Modern nanofabrication techniques have enabled the design and fabrication of mesoscopic spin systems composed of large numbers of interacting nanoscopic magnetic islands. Using the shape of the magnetic islands an anisotropy can be defined by the aspect ratio of the islands creating preferred magnetization directions and rendering the island to resemble Ising like macrospins. In the case of arrays of magnetic islands their arrangement can be used to investigate the effect of dipolar interactions between elements. Through such means it is possible to create magnetic model systems of artificial spins into different geometries. These systems include classical spin systems such as one- and two-dimensional Ising systems [2, 4] and artificial spin ices [5] with square [1] and kagome geometries as well as more novel arrangements such as shakti spin ice [3]. The lateral dimension of these islands allow microscopy techniques to be utilized to directly observe and quantify the magnetic ordering of the magnetism in the arrays. For this, magnetic microscopy techniques, such as magnetic force microscopy (MFM) and photoemission electron microscopy utilizing X-ray magnetic circular dichroism (XMCD-PEEM), have proven to be a vital tool and a wealth of results have been gathered using such methods. MFM enables observations of the static arrangements of the magnetization in large arrays of artificial spin system [4] and XMCD-PEEM additionally allows dynamical effects to be observed and quantified [1, 2, 3]. Results obtained using such methods will be presented and discussed including investigations on the magnetic ordering in artificial analogues of the two dimensional Ising model and how the energy landscape in artificial spin ice systems can be controlled affecting their ordering and dynamics.

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