**Electron Holography of Dipolar Magnetism in Fine Particle Assemblies**

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Nanoparticle magnets are a novel class of materials, in which a lattice of magnetic ions is replaced by a meta-lattice of magnetic nanoparticles. Inter-particle exchange interactions are absent, while dipolar interactions dominate. As a result, nanoparticle magnets behave differently from conventional magnets and their properties may be controlled and tuned by selecting the spacing and compositions of the constituent nanoparticles. We have studied dipolar interactions in self-assembled Cobalt nanoparticle magnets using off-axis electron holography in the transmission electron microscope (TEM). The technique enables the orientation and magnitude of the magnetic moment of each nanoparticle in an array to be determined and correlated with the structural properties of the meta-lattice, including the degree of order of the particles and their size distribution. Our study reveals that dipolar interactions are sufficiently strong to support long-range ferromagnetic order, even when the lattice of nanoparticles is highly disordered. This observation supports the possibility of creating amorphous dipolar magnets, in contrast to the expectation that a disordered dipolar system necessarily implies spin-glass behavior [1].

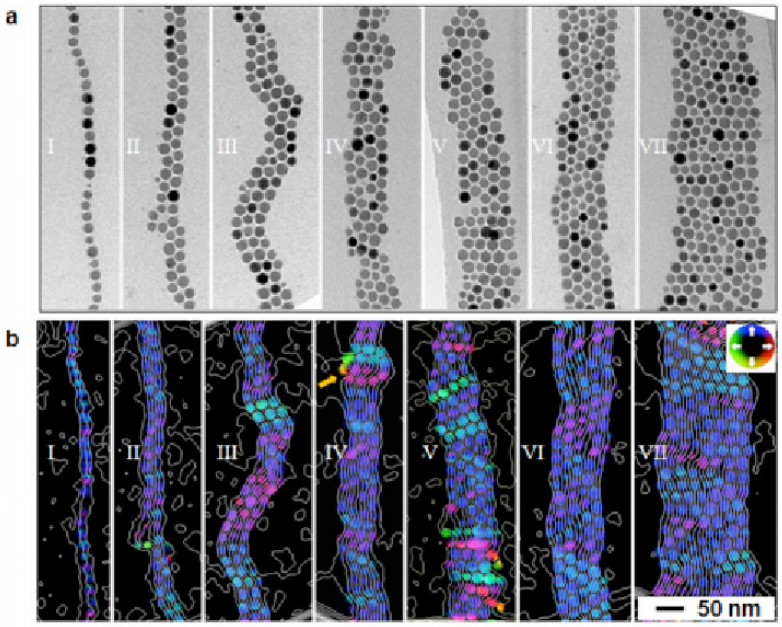


Fig. 1: (a) Bright-field TEM images and (b) electron holographic maps obtained from chains of 15 nm Co particles recorded at remanence after saturation. The white contours and colors in (b) provide a measure of the magnitude and direction of the in-plane moments. Figure from Ref. [1].

[1] M. Varon, Sci. Rep. 3, 1234 (2013)