Superparamagnetism of individual $SrRuO_3$ nanostructures – a direct confirmation of the century-old Langevin equation

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The magnetization of a magnet is only stable when the energy barrier for its reversal is large compared to the thermal energy. As the volume of a magnet is decreased, this stability is eventually lost, and the magnet enters what is known as a superparamagnetic state. This behavior limits the size of grains that can be used in magnetic data storage, but is useful, for instance, for medical imaging and treatment techniques. The fundamental equation describing the effect of an applied magnetic field on superparamagnetic particles was first proposed by Paul Langevin about a century ago. The Langevin equation has been widely used to analyze experiments performed on ensembles of magnetic nanoparticles without the ability to observe the underlying dynamics of specific nanoparticle. Here, we demonstrate for the first time the applicability of the Langevin equation to individual superparamagnetic fluctuations, by monitoring the time dependence of the magnetization of a patterned nanostructure of the itinerant ferromagnet $SrRuO_3$ [1].

References:

[1] O. Sinwani, J. W. Reiner, and L. Klein, Phys. Rev. B **89**, 020404(R) (2014).