# Supermagnetic states of nanoparticles

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Ensembles of single domained ferromagnetic (FM) nanoparticles, in which magnetic interparticle interactions are sufficiently weak, show *superparamagnetic* (SPM) behavior. However, at increased interactions the system eventually shows collective behavior, which overcomes the individual anisotropy properties of the particles. Different collective states of magnetism were first recognized [1] on so-called *discontinuous magnetic metal-insulator multilayers* (DMIM) consisting of focused ion-beam grown $Co_{80}Fe_{20}$ nanoparticles on glassy $Al_2O_3$ (Fig. 1). At sufficiently small interparticle distances as controlled by the nominal $Co_{80}Fe_{20}$ film thickness, 0.5 nm < $t_n$ < 1.1 nm, dipolar interaction enables *superspin glass* (SSG) properties. Similar to atomic spin glasses they reveal chaotic *SSG* ground states as corroborated by aging properties such as memory and rejuvenation. At increased concentration, but still below physical percolation, 1.1 nm < $t_n$ < 1.4 nm, stronger interactions give rise to *superferromagnetic* (SFM) states with domain formation (Fig. 2) similar to that in conventional FM films [2]. At $t_n$ > 1.4 nm the *metal-insulator multilayers* (MIM) become continuous owing to physical interparticle percolation. Owing to inherent layer roughness competing ANNNI-type dipolar interactions give rise to modulated magnetization profiles as evidenced by polarized neutron reflectivity and MOKE microscopy [3].

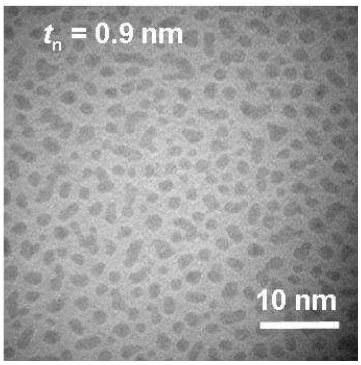


Fig.1 TEM image of $Co_{80}Fe_{20}$ nanoparticles making up a SSG.

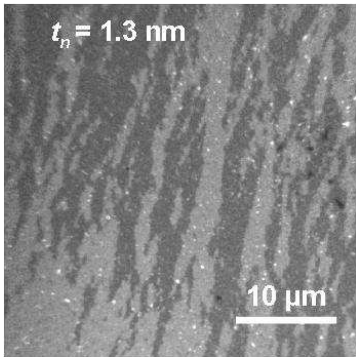


Fig.2 SFM domains in a DMIM $[Co_{80}Fe_{20}(1.3nm)/Al_2O_3(3nm)]_{10}$ imaged by XPEEM [2].

The talk will highlight the most important developments in the field of '*supermagnetism*' [4] comprising *superparamagnetism*, *superspin glass*, *super-* and *percolated ferromagnetism.*

References

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