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Charge-controlled magnetism in colloidal doped semiconductor nanocrystals

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Electrical control over the magnetic states of doped semiconductor nanostructures could enable new spin-based information processing technologies, but the relatively weak interactions between dopants and charge carriers have so far suggested that such gated magnetism will be limited to cryogenic temperatures. This talk will describe the observation of a large, reversible, room-temperature magnetic response to charge injection in free-standing colloidal ZnO nanocrystals doped with Mn(II) ions. Injected electrons are found to delocalize throughout the entire nanocrystal, and to activate new ferromagnetic Mn(II)-Mn(II) exchange interactions that are strong enough to overcome antiferromagnetic coupling between nearest-neighbor Mn(II) ions, making the full magnetic moments of all dopants observable upon charging. Removal of the electron causes the system to revert to its original form, allowing reversible charge-controlled manipulation of room-temperature nanocrystal magnetism. The physical properties of these charged, doped nanocrystals are directly analogous to those of bound magnetic poltroons (BMPs) postulated to underlie high-temperature ferromagnetic ordering in the bulk forms of this and related diluted magnetic oxides. This discovery of charge-controlled magnetism in free-standing colloidal nanocrystals that is large, reversible, and stable at room temperature presents new opportunities for fundamental studies and raises interesting possibilities for the development of spin-based information processing technologies from solution-processable semiconductor nanostructures.
Related references: Ochsenbein, S. T.; Feng, Y.; Whitaker, K. M.; Badaeva, E.; Liu, W. K.; Li, X.; Gamelin, D. R., *Nature Nanotechnology*, 4, 681 **(2009)**; Liu, W. K.; Whitaker, K. M.; Kittilstved, K. R.; Gamelin, D. R., *J. Am. Chem. Soc.*, 128, 3910 **(2006)**.