d^0 ferromagnetism

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Spin electronics will develop in new directions if a ferromagnetic semiconductor can be developed with high spin polarization and a Curie temperature in excess of 500 K. It should be p- or n- dopable, and possess a respectable mobility. We are far from achieving this goal, but thin films of dilute ferromagnetic oxides and nitrides such as Co-substituted ZnO or Mn-substituted SnO_2 are high-temperature ferromagnets, whose properties challenge our understanding of magnetism in nonmetals. A model of exchange mediated by an n-type, donor impurity band goes some way towards explaining the ferromagnetism, but it fails to account for two characteristic features of the systems, i) a moment per 3d cation which is exceptionally large, and may exceed the spin-only value and ii) unusual anisotropy of the spontaneous magnetization.
More remarkable, is room-temperature ferromagnetism in materials such as HfO_2 or CaB_6, which contain no *d*-electrons. These materials are incompatible with the ***m***-*J* paradigm for solid-state magnetism. The likely origin of the magnetism is extended defects at the film/substrate interface. The moment appears to be largely orbital in character. Other possible d^0 magnetic systems such as thiol-coated gold nanaoparticles and defective graphite will be discussed, and some speculations given regarding a new paradigm of orbital magnetic order.

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