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A mean field model of the magnetic structure in hematite-ilmenite solid solutions and exsolved nanostructures of ilmenite and hematite

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We present a class of mean field models of lamellar compounds which make it possible to understand and predict the temperature dependence of M_s in nanoscale layer stacks. Nanostructured compounds, like some of the observed exsolution lamellae in natural hemo-ilmenite and ilmenohematite have magnetic material properties, which are considerably different from those of their bulk constituents. Whenever a hematite lamella has an uneven number of octahedral layers this leads to an uncompensated net magnetic moment. The all these lamellar moments together create a macroscopic magnetization. In our mean field model this is described as one-dimensional sequence of exchange coupled layers. The magnetization M_i of the i-th plane is described by a Brillouin function, the argument of which includes the effective magnetic field generated by the exchange interactions with the adjacent layers. After solving the resulting system of nonlinear equations, the net magnetic moment $M_s(T)$ is obtained as the sum over all M_i. To model bulk solid solutions between ilmenite and hematite, we modify the mean field model by taking into account statistical distributions of Fe^{3+} in the ilmenite Fe^{2+} and Ti^{4+} layers. At 0 K we also minimize the free energy of these systems to find metastable states and possible metamagnetic transitions.