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# Clusters and holes: Exchange networks in hematite-ilmenite solid solutions

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Holes and clusters of exchange networks dominate the low-temperature, metastable phase diagram of the system

$$(1-x)\,\mathrm{Fe_2O_3}\;x\,\mathrm{FeTiO_3}\;\;(\mathrm{Ilm}x).$$

By our measurements we have probed and extended the phase diagram of Ishikawa *et al.* (1985) in the light of magnetic influences of the random exchange links, which originate either by replacing random pairs of $Fe^{2+}$ and $Ti^{4+}$ ions in the ordered ilmenite lattice by two $Fe^{3+}$ions (ordered Ilm$x$ phase), or by randomly replacing two $Fe^{3+}$ ions in the hematite lattice by a pair of $Fe^{2+}$ and $Ti^{4+}$ ions (disordered Ilm$x$ phase). Now a large dataset is available from these measurements, and we propose several new ideas to interpret the sometimes unexpected results. By refining a method of Ishikawa (1967), we analyze the PM' region of the phase diagram in terms of a mean field theory of interacting clusters. This allows to determine cluster sizes and interaction field distribution by inverting hysteresis measurements of Ilm92 and Ilm97. To understand the relation between ordered and disordered phases we design a mean field theory to determine Neel and Curie temperatures of both. An especially interesting finding is that the experimentally observed intersection of PM-PM' crossover with the AF phase boundary close to Ilm97 can be explained by analyzing average exchange interaction strengths.