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Multiple magnetic interactions in ordered perovskite-structure oxides

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Cation ordering in transition-metal oxides often drastically modifies their properties. We focus on A-and-B-site-ordered quadruple perovskite-structure oxides $AA'_3B_2B'_2O_{12}$, in which transition-metal ions are included at the A', B, and B' sites in an ordered manner. In such compounds A'-A', A'-B, A'-B', and B-B' interactions compete with each other and play important role in giving rise to unusual properties. The A-and-B-site-ordered quadruple perovskite $CaCu_3Fe_2Sb_2O_{12}$ with magnetic Fe^{3+} at the B site and nonmagnetic Sb^{5+} at the B' site was successfully synthesized under a high-pressure and high-temperature condition. The B-site Fe^{3+} spin sublattice adapts a tetrahedral framework and the Fe^{3+}-Fe^{3+} antiferromagnetic interaction causes geometrical spin frustration as seen in the double perovskite Ca_2FeSbO_6. With the introduction of Cu^{2+} into the A' site, the frustration is relieved by strong antiferromagnetic A'(Cu^{2+})-B(Fe^{3+}) interaction, leading to a ferrimagnetic ordering below 160 K. When B'-site Sb^{5+} was replaced with Re^{5+}, another A-and-B-site-ordered quadruple perovskite $CaCu_3Fe_2Re_2O_{12}$ was synthesized by a high-pressure technique. The compound contains magnetic Fe^{3+} at the B site and Re^{5+} at the B' sites, and strong antiferromagnetic A'(Cu^{2+})-B'(Re^{5+}) interaction overcomes the A'(Cu^{2+})-B(Fe^{3+}) interaction, leading to a ferrimagnetism with the ferromagnetic A'(Cu^{2+})-B(Fe^{3+}) spin arrangement below 550 K. More importantly, the electronic structure of $CaCu_3Fe_2Re_2O_{12}$is half metallic and the compound shows large magnetoresistance by the spin-dependent transport.

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