Discovery of new colossal magnetoresistance mechanism

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A NIMS research group has discovered a new material, $NaCr_2O_4$, which displays a novel type of colossal magnetoresistance effect. The new material was developed by ultra-high pressure synthesis.

Materials in which electrical resistance changes by an order of magnitude when a magnetic field is applied are called colossal magnetoresistance (CMR) materials. Virtually all known CMR materials are oxides of manganese, and their CMR mechanism also depends on a special ferromagnetic-metallic phase of manganese ions. However, new CMR mechanisms and material search guidelines which do not rely on manganese oxides have been demanded.

In this research, a new material, $NaCr_2O_4$, was developed by ultra-high pressure synthesis, focusing on the following two points: (1) Calcium ferrite structures have both a 1-dimensional crystal structure and a structure which displays magnetic frustration, and (2) oxides with tetravalent ions of Cr have a special electronic state.

It was found that a CMR effect occurs in $NaCr_2O_4$, which is not a ferromagnetic metal, but rather, is an antiferromagnetic semiconductor. Although the CMR effect appears over a wide temperature range, i.e., the entire temperature range below the magnetic transition temperature, this is a CMR effect with a new mechanism, which has the novel feature of not displaying history effects with respect to temperature or the magnetic field.

This result has important implications for the search for CMR materials, as it is also necessary to consider the antiferromagnetic semiconductors, which had seemed unrelated to the CMR effect until now. The new mechanism proposed as a result of this research has the potential to become a new material search guideline, as the CMR effect can be considered to occur in the diverse structures of various transition metal compounds.

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