Pressure induced multiferrocity in $PrMn_2O_5$

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Multiferroics which exhibit coupled electric polarization and magnetization, are exceptional multifunctional materials. They can respond to the application of both electric and magnetic fields, and thus can allow a much greater degree of control for electronic device.

The RMn_2O_5 series of multiferroic is extensively studied for its strong magneto-electric coupling (MEC). The microscopic mechanism of the MEC has been nearly clarified and is associated with the exchange-striction model. Since small variations of the interatomic distances directly modify the superexchange integrals, one can expect the multiferroic properties to be strongly affected by the external pressure. In contrast with the other members of the RMn_2O_5 family, $PrMn_2O_5$ is paraelectric at ambient pressure. This makes it the best candidate for a pressure induced multiferroicity, never encountered before.

We report here the first accurate determination of the magnetic structure under pressure in the $PrMn_2O_5$ by powder neutron diffraction. A new magnetic phase is revealed. It presents at low pressure (2 GPa) and becomes completely exclusive at 8 GPa. This pressure induced phase seems to have a universal character because it has been observed already in YMn_2O_5. In $PrMn_2O_5$, the magnetic direction developing under pressure has a new behaviour. While the spins are perpendicular to each other at ambient pressure in $PrMn_2O_5$, leading to the absence of electric polarization. The spins become collinear under pressure, which is exactly what expected within the framework of the exchange- striction model.

This presages a pressure induced multiferroic transition in the non-ferroelectric $PrMn_2O_5$ and paves the way to the conception of new multiferroic materials with tunable properties.