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Magneto-orbital helices as a route to coupling magnetism and ferroelectricity in multiferroic CaMn7O12

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In compounds with long-range ferromagnetic or antiferromagnetic ordering, the magnetic and structural degrees of freedom may couple through orbital ordering. It has long been hoped that this type of coupling could be exploited to create high-temperature multiferroics - materials in which both ferroelectricity and long-range magnetism coexist in a single phase, and may couple to give rise to spontaneous magneto-electric functionality. In this talk I will report a detailed experimental study of the multiferroic oxide CaMn7O12. Our complementary data from pyroelectric current, magnetometry, single crystal x-ray diffraction, and powder neutron diffraction experiments show that CaMn7O12 supports an unprecedented incommensurate magneto-orbital texture below the Neel temperature of 90 K. Furthermore, this magneto-orbital helix was found to give rise to a giant, magnetically induced, ferroelectric polarisation. I will discuss a phenomenological coupling model between orbital, antiferromagnetic, and ferroelectric degrees of freedom in this multiferroic compound. Importantly, our model is consistent with the presence of an experimentally observed second magnetic phase transition at 48 K to a ground state magnetic structure that appears to decouple from the orbital modulation, and at the time of writing, is yet to be fully solved.