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Artificial Ferroic Systems: from hybrid systems to magnetic metamaterials

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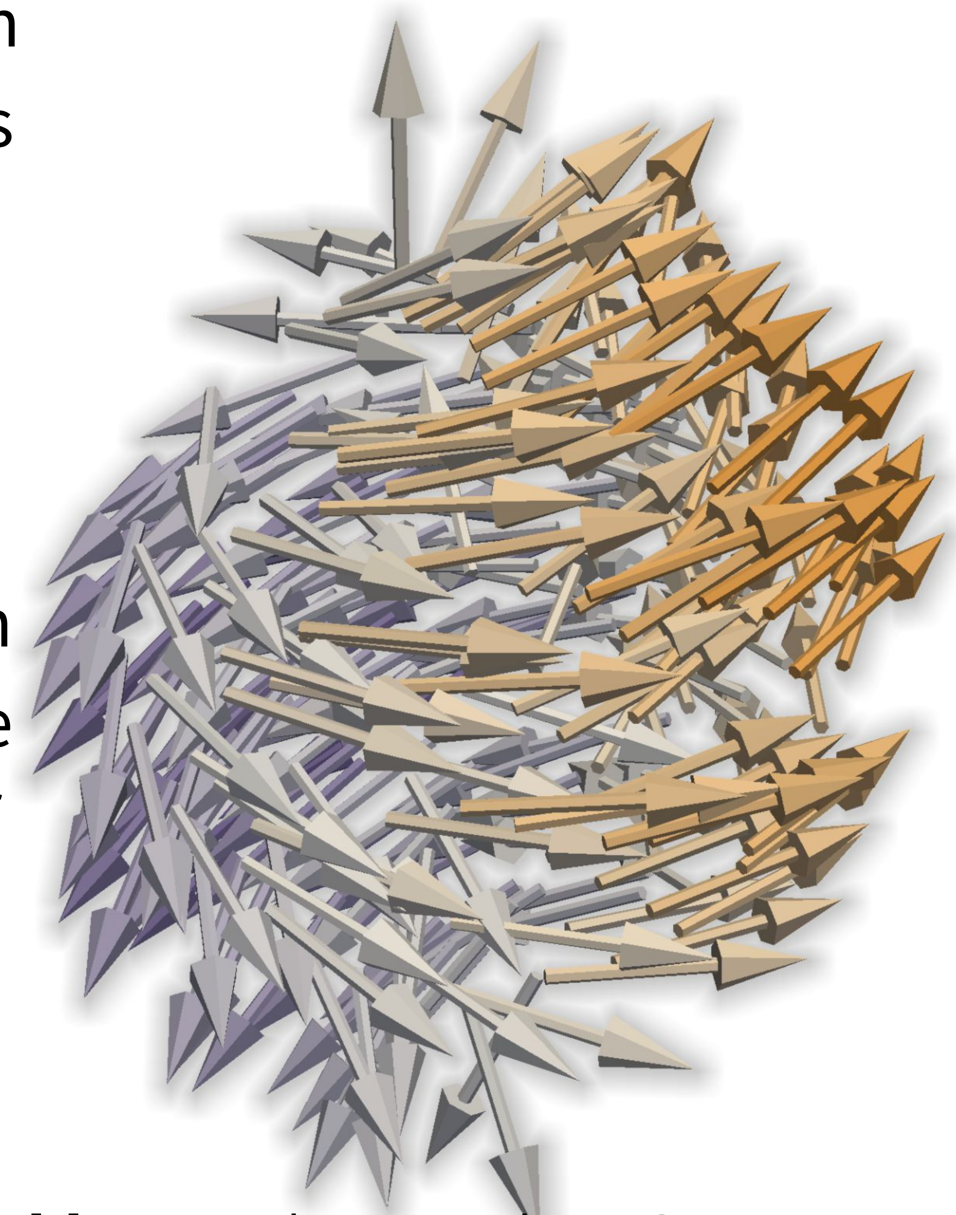
Abstract: In artificial ferroic systems [1], novel functionality is engineered through the combination of structured ferroic materials and the control of the interactions between the different components. I will present two classes of these systems, beginning with hybrid structures. In a mesoscopic system incorporating two different ferromagnetic layers, the static and dynamic behaviour result from the mutual imprint of the magnetic domain configurations, which can be exploited to create a nanoscale switch for the magnetisation [2]. I will also discuss our work on complex oxide composites, in particular multiferroic composites for control of the state of the magnetic components with an electric field [3, 4], as well as the use of strain engineering to enhance magnetic properties [5].

The second class is artificial spin ice, which consists of ordered arrays of dipolar-coupled nanomagnets. These systems display emergent magnetic monopoles, which nucleate in pairs and separate a magnetic field [6]. In systems with superparamagnetic elements, we observe the zero-field evolution of magnetic configurations in to the lowest-energy states [7, 8], and we have demonstrated that these thermally-active systems are magnetic metamaterials that can support thermodynamic phase transitions equivalent to those found in microscopic spin systems [9]. It is also possible to engineer an artificial spin ice that displays dynamic chirality where the average magnetization rotates in unique sense during thermal relaxation [10]. From simulations, it can be seen that this emergent chiral behaviour is driven by the topology of the magnetostatic field at the edges of the nanomagnet array, resulting in an asymmetric energy landscape. Finally we have developed synchrotron x-ray methods to obtain chemical, structural and magnetic information in 3D [11], as well as to study magnetic correlations in smaller nanomagnets at faster timescales [12].



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