

**MAGNETOELECTRIC COUPLING VIA SPIN STATE TRANSITIONS****Shalinee Chikara<sup>1</sup>, John Singleton<sup>1</sup>, Shizeng Lin<sup>2</sup>, Cristian Batista<sup>2</sup>, Nathan Smythe<sup>3</sup>, Vivien Zapf<sup>1</sup>**<sup>1</sup>*National High Magnetic Field Laboratory, Los Alamos National Laboratory, Los Alamos, NM, USA*<sup>2</sup>*Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM, USA*<sup>3</sup>*Chemical Division, Los Alamos National Laboratory, Los Alamos, NM, USA*

Multiferroics (MFs) are a class of multifunctional materials in which different ferroic orders, usually – ferromagnetism and ferroelectricity are strongly coupled. MFs are characterized by strong and controllable coupling of magnetic and electric orders and magnetic field switching of electric dipoles and vice versa. Traditionally, multiferroic behavior is studied in inorganic oxides, thin films and heterostructures. Since new classes of materials are accompanied by different functionalities, we chose to look beyond the traditional multiferroic candidates to metal organics with their inherent functionalities. Metal organics are crystalline compounds with a magnetic metal ion and organic molecules. Thermally and magnetically induced spin state transitions (SSTs) are dominant magnetic functionality in metal organics and have been observed up to room temperatures. Multiferroics behavior is usually achieved by coupling of different long-range orders, such as ferromagnetic and ferroelectric ordering. Here we use a *spin state transition* instead of long-range magnetic order to achieve multiferroic coupling. For example, the  $S = 1$  to  $S = 2$  transition in  $Mn(3+)$  is a spin-state transition. The spin-state transition can become cooperative due to structural coupling between molecules. SSTs are accompanied by change in the orbital occupation, ionic size and bonding and hence, intrinsically strongly coupled to the lattice and charge degrees of freedom. Moreover, the relevant energy scales and structure symmetries in metal organics are extremely tunable by simply replacing the metal ion and/or the attached organic entity. Therefore, metal organics provide a flexible framework to design materials with optimal energy scales most conducive to coupled ferromagnetism and ferroelectricity. We demonstrate for the first time magneto-electric coupling due to spin-state transitions. We use high magnetic fields at the pulsed magnetic field facility at LANL and DC facility at NHMFL, Tallahassee. Such high magnetic fields allow access to all or most of the phase space of this material giving a good handle on various energies that needs to be optimized for designing next generation multiferroics.

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