

**Subject:** MATERIALS SCIENCE COLLOQUIUM, George Christou, University of Florida, "Single-Molecule Magnets and Their Supramolecular Aggregates: A Molecular Approach to Nanomagnetism", Thursday, February 14, 2008, 11:00 a.m., Building 212, Room A-157, John Schlueter

**From:** Marlene Metz <metz@anl.gov>

**Date:** Tue, 22 Jan 2008 11:03:56 -0600

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MATERIALS SCIENCE COLLOQUIUM

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**SPEAKER:** George Christou  
University of Florida

**TITLE:** "Single-Molecule Magnets and Their Supramolecular Aggregates: A Molecular Approach to Nanomagnetism"

**DATE:** Thursday, February 14, 2008

**TIME:** 11:00 a.m.

**PLACE:** Building 212, Room A-157

**HOST:** John Schlueter

Refreshments will be available at 10:45 a.m

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**Abstract:** Many specialized applications of magnets require monodisperse, nanoscale magnetic particles, and the discovery that individual molecules can function as nanoscale magnets was therefore a significant development. Each molecule functions as a nanoscale, single-domain magnetic particle that below its blocking temperature (TB) exhibits the classical macroscale property of a magnet, namely magnetization hysteresis. SMMs owe their properties to a combination of a large ground state spin (S) value and easy-axis (Ising) type anisotropy, which give a significant barrier (vs kT) to magnetization relaxation. SMMs thus represent a molecular (or bottom up) approach to new nanoscale magnetic materials, offering all the advantages of molecular chemistry, as well as displaying the superparamagnetism of a much larger, classical magnetic particle. SMMs are also true mesoscale materials, straddling the interface between classical and quantum behavior by also exhibiting quantum tunneling of magnetization (QTM). As such, they have also proven to be excellent test subjects for new experiments and discoveries in condensed matter physics, such as the quantum exchange-bias effect described below. SMMs have been proposed for potential applications such as information storage at the molecular level and their use as qubits in quantum computing, but these require that their properties be both well understood and better controlled, particularly the QTM. The  $[\text{Mn}_{12}\text{O}_{12}(\text{O}_2\text{CR})_{16}(\text{H}_2\text{O})_4]$  and  $[\text{Mn}_4\text{O}_3\text{Cl}_4(\text{O}_2\text{CR})_3(\text{py})_3]$  (R = various) compounds (or simply Mn<sub>12</sub> and Mn<sub>4</sub>) with spin ground states of S = 10 and 9/2, respectively, are among the best currently understood, and it has been discovered that the magnetic properties (including QTM) of these and others can be significantly altered in a controllable manner using standard chemistry techniques. This is accomplished, for example, by varying the

peripheral organic groups (which can affect the inter-molecule separations and the local molecular symmetry within the crystal), or by the addition of one or more extra electrons to each molecule. For Mn<sub>4</sub> SMMs with  $S = 9/2$ , modifications have also included their crystallization as [Mn<sub>4</sub>]<sub>2</sub> supramolecular dimers within the crystal (shown). These display fascinating exchange-biased QTM properties due to exchange interactions between the two halves of each dimer, establishing the feasibility of tuning the QTM in SMMs. The talk will overview this area, emphasizing the effect of various targeted and controllable modifications, as well as efforts to synthesize and study larger size and/or larger spin SMMs.

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