Unique two-dimensional spin ordering in Mn-substituted $Sr_3Ru_2O_7$

On May 25, 2012, the LSU members of the condensed matter physics group published a Rapid Communication in Physical Review B Journal on a unique spin structure observed in layered compound $Sr_3(Ru_{0.84}Mn_{0.16})_2O_7$ *[PRB 85, 180410(R) (2012)]*. This work was done in collaboration with scientists at Oak Ridge National Laboratory (ORNL).

While layer ruthenate materials are well known to display an array of exciting phenomena such as metal-insulator transitions (MIT), spin-orbital ordering, exotic superconductivity, and quantum criticality, this neutron scattering work has revealed an unusual *E*-type antiferromagnetic (AFM) structure in Mn-substituted $Sr_3Ru_2O_7$ (x = 0.16) [See Fig. 1]. They found that this layered ruthenate behaves as a quasi-two-dimensional (2D) antiferromagnet with in-plane (*ab)* long-range ordering but only single bilayer (5-6Å) ferromagnetic correlations along the *c* direction bellow T_N = 78 K. Such Mn-induced magnetic structure is unusual because the critical behavior of the staggered magnetization (i.e. the AFM order parameter) does not reflect the expected behavior of a 2D magnetic phase transition.

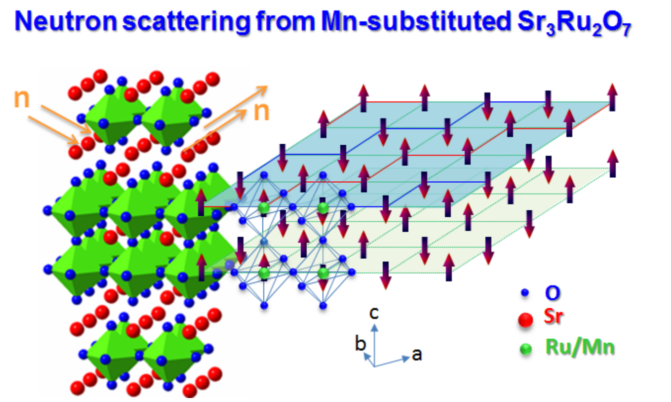

FIG. 1 Left: The neutron scattering process on a single crystal. Right: Schematic diagram revealing the spin texture of the $Sr_3(Ru_{0.84}Mn_{0.16})_2O_7$ single crystal resulting from magnetic refinement of neutron scattering data. The magnetic unit cell is delimited by the octahedra (more than one unit cell is shown in order to make evident the zigzag chains of the *E-type* AFM structure).

The material synthesis group led by Dr. Rongying Jin at LSU provided high quality single crystals, whose magnetic properties were characterized by elastic neutron scattering at the High Flux Isotope Reactor at ORNL, a national facility under the Department of Energy. Due to the unique properties of neutrons, neutron scattering is a powerful probe of the structure and dynamics of materials. Their lack of electric charge allows them not only to penetrate deeply into the target, but also to be at a close proximity to the nuclei, thus making neutrons ideal for the study of the bulk crystal structure of materials. In addition, the neutron has a magnetic moment, which allows it to interact with spins of unpaired electrons through magnetic dipole interaction, providing important information about magnetic ordering in solids.

LSU graduate student Dalgis Mesa, the first author of the paper, has said: “We are very happy with our findings, and will continue investigations in order to uncover the physics behind such an unusual magnetic structure.”

LSU Professor Dr. Jiandi Zhang, the leader of the investigation and who collaborates with both Prof. Jin’s and Prof. Ward Plummer’s group, has said: “The accurate description of the magnetic structure is an important step towards a more global understanding of the competing interactions present in this type of materials, which results in the emergence of exotic phenomena and functionality.”