Ultrafast dimensionality-dependent dynamics of magnetic correlations in photo-doped Sr_2IrO_4

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Magnetic correlations are intimately related to some of the most iconic phenomena in doped Mott insulators including the pseudogap, non-Fermi liquids and high T_C superconductivity. Advances in ultrafast optics provide numerous opportunities for driving materials into exotic states, but a controlled targeting of particular states requires a detailed understanding of the nature of magnetism in photo-excited materials. This talk will describe the first implementation of magnetic resonant elastic and inelastic X-ray scattering at a free electron laser in order to characterize the behavior of the magnetic correlations in photo-doped Mott insulator Sr_2IrO_4. Example data are plotted in Figure 1. We find that the transient state 2$\sim$ps after the excitation has strongly suppressed long-range magnetic order, but hosts photo-carriers that induce strong, non-thermal magnetic correlations. The magnetism recovers its two-dimensional (2d) in-plane Néel correlations on a timescale of a few ps, much faster than the three-dimensional (3d), long-range magnetic order, which recovers over a much longer timescale of a few 100 ps.

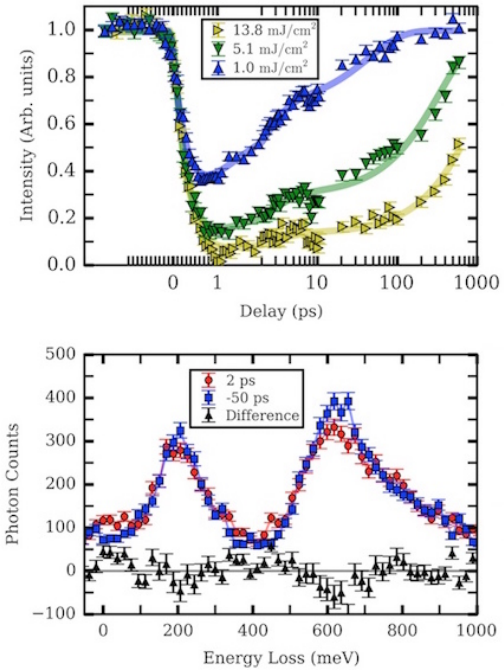

Figure 1: Top: the intensity of the magnetic Bragg peak in Sr_2IrO_4 as a function of time delay and fluence showing the suppression of long range magnetic order above $\sim$5 mJ/cm^2. Bottom: a RIXS spectrum at (p, 0) with a 6 mJ/cm^2 fluence at -50 ps (before the pump pulse) and 2 ps (after the pump pulse) showing minimal changes in the short range magnetic correlations under a fluence that strongly suppresses magnetic order.

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