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Controlling Magnetism in Spin-Orbit-Driven Oxides with Epitaxial Strain

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The layered perovskite iridates Sr_2IrO_4 and Ba_2IrO_4 are the prototypical spin-orbital Mott insulators, displaying a novel $j_{eff} = 1/2$ ground state driven by strong 5d spin-orbit coupling effects. Efforts to understand, and ultimately control, this spin-orbit-induced ground state have led to a surge of interest in thin film iridates, which offer unique opportunities for the tuning of electronic and magnetic properties via epitaxial strain. We have performed complementary resonant magnetic x-ray scattering (RMXS) and resonant inelastic x-ray scattering (RIXS) measurements on epitaxial thin film samples of Sr_2IrO_4 and Ba_2IrO_4. By measuring 13 to 50 nm films grown on a variety of different substrates (PSO, GSO, STO, LSAT), we are able to investigate the impact of applied tensile and compressive strain on the magnetic structure, correlation lengths, and characteristic excitations of these materials. We find that the dispersion of the low-lying magnetic and orbital excitations is strongly affected by strain-induced structural changes, and show that epitaxial strain provides an effective method for tuning three distinct energy scales: the magnetic ordering temperature (T_N), the magnetic exchange interactions (J), and the non-cubic crystal field splitting (Δ_{CEF}). Perhaps most strikingly, we demonstrate that hard x-ray RIXS can be used to perform detailed magnetic dispersion measurements on thin film samples of 13 nm ($\sim$5 unit cells) or less.

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[1] A. Lupascu et al, Phys. Rev. Lett. 112, 147201 (2014).