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Ultrafast photoinduced electron dynamics in strontium iridate

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Since the discovery of high-Tc superconductors, understanding Mott insulating phases and their insulator to metal transitions has become increasingly important [1]. As opposed to the Mott-insulating ground state found in 3d-electron compounds, a metallic ground state is expected to be found in strontium iridates, due to the extended 5d electronic orbitals of the Ir ions. However Sr_2IrO_4, shows a non metallic behavior[2]. Its insulating ground state arises mainly from the cooperative action of the onsite Coulomb interaction and strong spin orbit coupling, leading to a novel Jeff=1/2 Mott-insulating ground state [3]. While the insulating ground state of Sr_2IrO_4 below T_N = 240K is stabilized by a Mott-Slatter mecanism, the origin of the high temperature insulating ground state remains under controversy. The presence of magnetic fluctuations may also give rise to a possibly Mott-Slatter hybrid scenario in which pseudo-spins long range correlations may cooperate with spin-orbit and onsite Coulomb interaction[5-6].

A possible way to disentangle magnetic fluctuations effects from Mott physics signatures is realized by photo-exciting strontium iridate single crystals with femtosecond light pulses. Following this approach, earlier pump-probe studies [7,8] have pointed out strong similarities between iridates and cuprates electron dynamics such as two distinct time scale dynamics along with the formation of in-gap states.

In order to uncover short time electron dynamics, we present a high harmonic generation (HHG) based time resolved photo-emission of Sr_2IrO_4. This study has been performed at Attolab, a novel XUV based HHG beamline facility opened to external users, delivering photons from 19 to 100 eV with < 30 fs pulse duration at 10 kHz repetition rate [9]. Using a 1.55 eV pump (fluence 2 mJ/cm2) with a 31.65 eV probe, we reveal for the first time the short time dynamics of the entire valence band of Sr_2IrO_4 at room temperature. Our data reveal crucial informations about the time and energy resolved dynamics of the short lived in-gap states forming in the first 50fs after the photo-excitation. The origin of these in-gap states seems to be consistent with the framework of photo-doping of Mott insulators[10] in which a photo-induced Mott gap renormalization occurs. This renormalization is observed via a light-induced shift of the valence band whose dynamics appears to be k-dependent. This might be a consequence of the k-dependence of the orbital character of Sr_2IrO_4 band structure as reported in [11].

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