Light induced metastable spin-orbital order in Ca_2RuO_4

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There is growing interest recently to achieve novel far-from-equilibrium orders in quantum matter driven by dynamical controlling parameters. Experimentally, impulsive laser excitation of quantum solids has been identified as a promising strategy for achieving macroscopic quantum states that are otherwise inaccessible or hidden in thermal equilibrium; examples include light-induced superconductivity, dynamical ferroelectricity, and unconventional charge orders. In this talk, I will show our recent demonstration of a light-induced spin-orbital order in Ca_2RuO_4 single crystals, a type of correlated antiferromagnetic insulator featuring strong charge-lattice and spin-orbital couplings. Upon photodoping the crystal with laser pulses, we observed an ultrafast melting of the native antiferromagnetic order on picosecond timescales and its recovery when laser pulses were removed for long enough time. However, we identified an intermediate time window within which the crystal develops a long-range spin-orbital entangled order that is distinct from any known phase of the same material along any static tuning knob. The new order is metastable in nature and results from trapping of the system in a local minimum in the free energy landscape. Our results pave the way for steering correlated materials into hidden states by providing laser-induced directional control of the system's trajectory in the phase space.