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Femtosecond snapshots of the electron-boson coupling in copper oxides and other correlated materials

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One of the pivotal questions in the physics of unconventional superconductors is whether the low-energy dynamics of the charge carriers is mediated by bosons with a characteristic timescale. This issue has remained elusive as electronic correlations are expected to greatly accelerate the electron–boson scattering processes, confining them to the very femtosecond timescale. Recent advances in ultrafast spectroscopy allowed us to simultaneously push the time resolution and frequency range of transient reflectivity measurements, up to the point of direct observing the effective electron–boson interaction in doped copper oxides. The extremely fast timescale ($\sim$15 fs) is in agreement with numerical calculations based on the $t-J$ model and the repulsive Hubbard model, in which the relaxation of the photo-excited charges is achieved via inelastic scattering with short-range antiferromagnetic excitations with an energy spectrum extending up to $\sim$300 meV. Our results support a scenario in which the strong local magnetic correlations provide a dissipative channel that is effective on the 10 fs timescale. Secondly, we will present very recent results on the model system Na_2IrO_3, in which the interplay of the spin-orbit coupling, the onsite Coulomb repulsion and the hopping within the Ir hexagons gives rise to a complex magnetic ground state, characterized by strong antiferromagnetic correlations below 100 K and the emergence of a zig-zag magnetic phase at T=12 K. The energy exchange between the photoexcited charge carriers and the antiferromagnetic background is observed by monitoring a specific high-energy quasi-molecular orbital, which turns out to be sensitive to the magnetization of the system.