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First high energy and temporal resolution pump-probe RIXS at the EuXFEL

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High-resolution Resonant Inelastic X-ray scattering (RIXS) and ultrafast pump-probe techniques using optical or THz radiation have nowadays reached a prominent role for the investigation of strongly correlated materials.
At the intersection of the two worlds, the development of a high energy and high temporal resolution RIXS instrument at the SCS beamline of the European XFEL is a cornerstone in the field of x-ray techniques. After the successful commissioning of the User Consortium Heisenberg RIXS (hRIXS) spectrometer in May 2021, we have recently carried out first pump-probe (pp) RIXS experiments. As a test case, we selected the prototypical cuprate parent compound La_2CuO_4 (LCO) and NiO, pumped with an optical laser above the Mott gap. The pp-RIXS measurements at the Cu L_3 and Ni L_3 edges were performed with a 113 kHz pulse repetition rate, reaching a temporal resolution of ≈100 fs and an energy resolution of ≈ 93 meV and ≈ 80 meV for the Cu and Ni L3 edges, respectively. Exploiting full control over laser power and delay between optical and x-ray pulses, we acquired spectra changing the pump delay between 0.1 ps and 5 ps, and the laser fluence on the sample from 1 mJ/cm^2 up to 35 mJ/cm^2.
We observed strong changes in the orbital and charge-transfer excitations driven by the optical pumping in both samples, clearly scaling with the laser fluence and with a sub-ps dynamics. The results of this first high-resolution ppRIXS commissioning represent a major success and opens the route to ppRIXS studies on strongly correlated materials at the European XFEL.

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