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Ultrafast dynamics of energy relaxation in CsI single crystals measured by TRXEOL with sub-picosecond time resolution

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We report on the first to our knowledge measurements of TRXEOL (time-resolved X-ray excited optical luminescence) with sub-picosecond time resolution. The up-conversion gating technique applied to luminescence in CsI single crystals excited by XUV pulses from FLASH allowed monitoring the energy relaxation during thermalization, self-trapping of charge carriers and formation of luminescence centers followed by their de-excitation. Two types of intrinsic luminescence, corresponding to the two components seen in time evolution of 340 nm luminescence after 125 eV excitation, have been identified. In particular interesting is the fast contribution which rises and decays within the first picosecond. We assign it to the hot intraband luminescence (IBL) corresponding to electron radiative transitions within the conduction band during thermalization. Although discovered in the early eighties, the present work is the first time that the intraband luminescence has been temporally resolved and unambiguously identified. We would like to emphasize that intrinsically fast intraband luminescence is presently considered to be a promising candidate for improving time resolution of scintillator based detectors (coincidence time resolution in this case) down to the ten-picosecond level which is of demand for such applications as time-of-flight positron emission tomography, positron annihilation lifetime spectroscopy and high energy physics.

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