Incommensurate charge-density-waves as seen by time-resolved x-ray diffraction

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Spin- (SDW) and Charge-density wave (CDW) states are ubiquitous in solid state physics. They both correspond to a modulation of the spin or the charge density with twice the Fermi wave vector of the electron gas. Frequently, this wave vector is not commensurate with the reciprocal lattice, which makes these density waves (DW) aperiodic and their order parameters 2D. As both states are gapped, they are sensitive to impulsive absorption of laser infrared pulses, which induces phase transformations. Interestingly enough, CDW are generally coupled to the lattice, which make them easy to observe by X-ray diffraction.

In this work, we compare the *dynamical behavior* of CDW after an infrared laser pulse in three different incommensurate DW systems: Chromium [1], $K_{0.3}MoO_3$ (so-called blue bronze) [2], and 1T-TaS_2 [3-4]. We use pump-probe diffraction techniques to follow the incommensurate reflections (position, width and intensity) as a function of the delay between the infrared pulse and the X-ray pulse. In all three cases, the CDW is strongly depressed after the pulse in an ultrafast way, which could lead either to a melting of the state [1-2], or to a photo-induced phase transition towards another CDW state [3]. In the blue bronze, the melting of the incommensurate phase, which is second order, is driven by a *coherent phonon*: the amplitude mode of the incommensurate state. In the IT-TaS2 case, where the transition is first order, we give evidence that the photo-induced incommensurate phase develops by a fast sub-ns *nucleation-growth-coarsening process* never observed before [3-4].

At longer delays, the recovery of the initial CDW state follows different mechanisms which depend on the compound. In chromium [1], we show that the CDW wave vector tilts in an asymmetrical way before recovering its initial value, indicating a complex change of periodicity of the CDW driven by CDW-dislocations nucleation.

Thanks to these time-resolved techniques, new information on the temporal evolution of a 2D order parameter, along with the mechanisms of variation of incommensurate wave vectors can be obtained.

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