MS16-1-6 Spin- and charge-density wave coupling in chromium studied through the spin-flip transition: statics and ultrafast dynamics
#MS16-1-6

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Abstract
Chromium is a very peculiar system in condensed matter, as it develops both a spin-density-wave (SDW) and a charge-density-wave (CDW) despite its 3D cubic structure [1]. They appear concomitantly below the Néel transition temperature TN=311K with a large-period modulation (>50 nm for the SDW) and are found to be linked by a harmonic relationship, the CDW period being half the SDW period. Their orientation is also similar, and as the three <100> directions of the crystal are equivalent, they are found to be oriented along one of them in different domains called Q-domains. The description of the SDW requires going a step further: the magnetic moments are modulated with a linear polarization along the SDW, and their orientation abruptly flips from transverse to longitudinal with respect to the direction of the modulation, at the so-called spin-flip transition (SFT) that takes place at TSF=123K.
Although this description has been known for many years, a question remains concerning the mechanism that accounts for the CDW formation. The origin of the SDW is clearly attributed to a magnetic instability resulting from the pairing of a large number of electron and hole states at the Fermi level, favored by a peculiar Fermi surface geometry that allows good nesting between electron and hole pockets. The origin of the CDW is less clear, and two main scenarii are found in the literature. The first one relies on magnetostritive coupling that would lead to a periodic lattice distortion and hence to a CDW with half the SDW period due to the interaction between the SDW and the lattice [2]. The other scenario involves a second nesting of unnested bands remaining after the SDW formation, that would lead to a CDW instability [3]. Those two scenarii have a fundamental difference: the first one involves the lattice, while the other one only involves electronic states.
In order to clarify the link between SDW, CDW and atomic lattice, we performed several experiments through the SFT. Indeed, at this transition, the magnetic domains merge to form magnetic domains with a single orientation, while the CDW and lattice should be unaffected. We first probed the local structure of SDW, CDW and lattice using coherent X-ray diffraction (CXRD) that is particularly sensitive to local phase defects of these modulations, and show that the CDW 'feels' the SFT, the correlation lengths becoming smaller at the transition [4]. We then use time-resolved X-ray diffraction (TR-XRD) in synchrotron and XFEL, with time resolutions down to 50fs, to probe the apparition dynamics of the CDW after laser excitation that destroys the density waves [5]. After showing that there is a threshold effect for the excitation, we will present a comparison of the CDW dynamics above and below the SFT. We will then discuss the relevance of the different scenarii found in the literature, in the light of our results.

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