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Energy dependent spatial texturing of the charge order in 1T-Cu_xTiSe_2

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The competition between electronic ground states is a central topic in modern condensed matter physics. 1T-Cu_xTiSe_2 hosts a charge density wave (CDW) and becomes superconducting for x>0.04, which makes it a prototypical system to investigate the interplay between superconductivity and charge order. Superconductivity in 1T-Cu_xTiSe_2 seems to follow a BCS s-wave behaviour with possible multi-gap features. The onset of superconductivity has been linked to the formation of incommensurate CDW domains in the literature. Conversely, the CDW phase still lacks a clear understanding from a microscopic point of view. In order to address these issues, we performed a detailed scanning tunneling microscopy and spectroscopy study of the impact of Cu intercalation on the CDW in 1T-Cu_xTiSe_2 [1, 2].
Density functional theory modelling allowed us to identify Cu atoms, which are found to intercalate randomly on the octahedral site in the van der Waals gap and to inhomogeneously band-dope the material. Upon Cu doping, the CDW modulation develops a complicated energy-dependent domain structure with the formation of π-domain walls, and striking electron-hole complementary CDW patches. The former could be a source of incommensuration in the CDW, but the domains are too small to confine superconductivity. The latter can be explained in terms of a local band shift induced by Cu intercalation as confirmed by tunneling spectroscopy. Interestingly, these findings imply that the CDW gap is not pinned to the Fermi level in this system.
A finite CDW amplitude is detected in all crystals investigated, including the superconducting ones, invalidating both Fermi surface nesting and a purely excitonic mechanism for the CDW formation and suggesting a possible coexistence of SC and CDW order in 1T-Cu_xTiSe_2.

References

[1] A.M. Novello et al. Phys. Rev. Lett. 118, 017002
[2] M. Spera et al, arXiv:1710.04096