The Growing Charge-Density-Wave Order in CuTe Lightens and Speeds up Electrons

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Charge density waves (CDWs) are pervasive orders in solids that usually enhance the effective mass (m*) and reduce the Fermi velocity (v_F) of carriers. Here, we report on the inverse — a reduced m* and an enhanced v_F correlated with the growth of the CDW order in CuTe with gapped, practically linearly dispersing bands — reminiscent of emergent CDW-gapped topological semimetals. Using momentum-dependent electron energy-loss spectroscopy (q-EELS, Fig. 1), we simultaneously capture m* and v_F of the CDW-related, practically linearly dispersing electrons by plasmon dispersions across the transition (335 K, T_{CDW}), with m* of 0.28 m_0 (m_0, the electron rest mass) and of ~0.005*c* (*c*, the speed of light) at 300 K [1]. With the growth of the CDW order-parameter strength toward 100 K, the electrons become lighter and move faster by ~20%. Thorough inspections below T_{CDW} unveil the essential underlining factor of the decreasing light-electron density by the increasing opening of the CDW gap. The quantum analogy of the reducing electron density in graphene diminishes electronic screening, yielding renormalized conical-linear bands with lighter, faster electrons and hinting on our discoveries. CuTe urges explorations on the CDW-correlation notion across versatile CDW-gapped quantum matters with q-EELS as a prominent probe for the subject.

Keywords: effective mass, Fermi velocity, topological quantum matters, plasmons, electron energy-loss spectroscopy.

[1]I.-T. Wang, T.-L. Chou, C.-E. Hsu, Z. Lei, L.-M. Wang, P.-H. Lin, C.-W. Luo, C.-W. Chen, C.-N. Kuo, C. S. Lue, C.-H. Chen, H.-C. Hsueh, M.-W. Chu, "*The Growing Charge-Density-Wave Order in CuTe Lightens and Speeds up Electrons*", Nature Communications (15) 9345 (2024).