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Electronic Correlations and Semi-Dirac Points in Nodal-line Semimetals

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Dirac fermions with highly-dispersive linear bands are usually considered weakly correlated, due to relatively large bandwidths (W) compared to Coulomb interactions (U). With the discovery of nodal-line semimetals, the notion of Dirac point has been extended to lines and loops in the momentum space [1]. The anisotropy associated with nodal-line structure gives rise to greatly reduced kinetic energy along the line. However, experimental evidence for anticipated enhanced correlations in nodal-line semimetals is sparse. Here we report on prominent correlation effects in a nodal-line semimetal compound ZrSiSe [2] through a combination of optical spectroscopy and density-functional-theory calculations. We observed two fundamental spectroscopic hallmarks of electronic correlations: strong reduction (1/3) of the free carrier Drude weight and of the Fermi velocity compared to predictions of density functional band theory. The renormalization of Fermi velocity can be further controlled with external magnetic field. Finally, I will discuss the discovery of gapless semi-Dirac points in a closely related compound ZrSiS [3]. The hybrid massless and massive dispersions of the elusive semi-Dirac points entail characteristic Landau levels that scale with the magnetic field as $B^{2/3}$. This unique power-law was observed in ZrSiS and the origin and implications of these semi-Dirac points will be discussed. [1] Y. Shao, Z. Sun et al, PNAS 116, 1168 (2019) [2] Y. Shao et al, Nat. Phys. 16, 6 (2020) [3] Y. Shao, S. Moon et al, (in preparation)