Condensed matter dark states in a quantum system with two pairs of sublattices

Yoonah Chung[1], Minsu Kim[1], Yeryn Kim[1], Keun Su Kim[1]

[1] *Department of Physics, Yonsei University, Seoul, Republic of Korea*

In nature, there are quantum states that do not interact with photons and thus cannot be detected by spectroscopic means; there are referred to as dark states [1–4]. By extending this concept to condensed matter systems, we identify a novel concept of condensed matter dark states that are not observable by angle-resolved photoemission spectroscopy (ARPES), regardless of experimental conditions such as light polarization and scattering geometry. Our model, based on the tight-binding approximation, demonstrates that these dark states result from double destructive interference of the initial-state wavefunctions between two sublattice pairs [5, 6]. We demonstrate this mechanism in palladium diselenide ($PdSe_2$) as a model system. The unit cell of $PdSe_2$ contains four palladium sublattices connected by multiple glide-mirror symmetries [7]. In this system, the ARPES signal from the valence band is absent in the whole specific Brillouin zones. This absence is due to the relative phases between the sublattices, which become fully polarized to one of four phase types in each Brillouin zone, forming a checkerboard pattern that alternates zone by zone. We generalize this dark state mechanism to other materials with similar structural features, such as cuprate superconductors [8].

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