Electronic, magnetic and topological properties of semi-Dirac dispersion with strongly broken particle-hole symmetry

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ABSTRACT: The recently discovered semi-Dirac (semi-Weyl) point in TiO_2/VO_2 with massless dispersion along the diagonal of the Brillouin zone and massive dispersion in the perpendicular direction is an important development towards achieving highly anisotropic topologically non-trivial states by engineering complex electronic structures from easily available materials. This model is extended from previous studies on a two-dimensional square lattice to a three orbital model. The electronic, magnetic and topological aspects of the system are explored by varying experimentally tunable parameters, viz. on-site energies, hopping amplitudes, and inter-orbital coupling strengths. With moderate inter-orbital interactions, the middle band has a flat contour and touches the lower band at four semi-Dirac points. When subject to an external magnetic field perpendicular to the lattice, the energy spectrum exhibits fractal structure with respect to the fractional part of the number of magnetic flux quanta per unit cell (Hofstadter spectrum) and each subband has a well defined Chern number which we have calculated numerically.