Klein tunneling and electron optics of Dirac Weyl fermions with tilted energy dispersion

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The outstanding electronic and transport properties of relativistic-like fermions have been extensively studied in solid state systems with isotropic linear dispersions such as graphene [1]. Among many interesting phenomena discovered, the Klein tunneling is a direct evidence and concurrently provides a playground for implementing tests of relativistic quantum dynamics of quasiparticles in simple experiments [2]. In addition, the Dirac fermions in graphene exhibit several behaviors analogous to light rays in optical media [3] such as refraction, reflection, and Fabry-Pérot interferences, making it an ideal platform for electron optics demonstration and novel quantum device development.

Beyond graphene, several (both 2D and 3D) Dirac-Weyl materials have been recently explored [4]. In contrast to graphene, many of them however exhibit tilted (and also anisotropic) energy dispersions around the Dirac-Weyl cones, leading to novel electrical and optical phenomena.

In this talk, we present novel transport properties of Dirac-Weyl fermions in hetero-doped structures [5] induced by the effects of tilted energy dispersion. In particular, we find that instead of being observed in a unique direction (i.e., normal incidence) as in the non-tilted case, the Klein tunneling of tilted Dirac-Weyl fermions of opposite chiralities is achieved in two separated oblique directions. In addition, interesting phenomena such as anisotropic Fabry-Pérot resonances, valley filtering and beam splitting effects, and novel electron optics behaviors in Dirac-Weyl p-n junctions are also predicted. Besides being crucial to fully understand the relativistic-like phenomena of Dirac-Weyl fermions, our findings could be the basis for novel applications of the host materials in electron optics and valleytronics.

References

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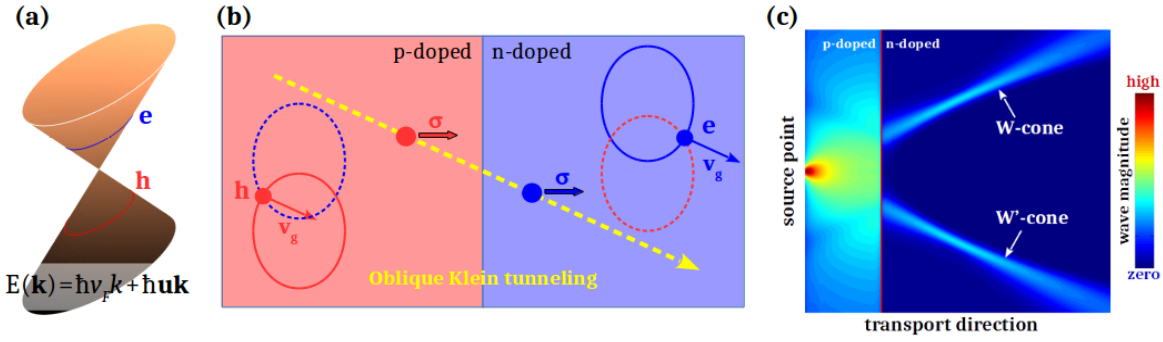

Fig.1: Transport properties of Dirac-Weyl fermions with tilted energy dispersion in hetero-doped systems. (a) Tilted Dirac-Weyl energy dispersion. (b) A diagram illustrating the observed oblique Klein tunneling: **σ** pseudospin and $\mathbf{v_g}$ group velocity. (c) Dirac-Weyl fermion wave propagating though a p-n doped interface.