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Dirac Materials

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Discoveries of superfluid phases in 3He, high Tc superconductors, graphene and topological insulators have brought into focus materials where quasiparticles are described by same Dirac and Weyl equation that governs behavior of relativistic particles. This class of materials, called Dirac materials [1], exhibits unusual universal features: Klein tunneling, chirality and impurity resonances. I will explore these similarities and discuss the unique role of symmetries that protect the Dirac spectrum. As an example of universal behavior of Dirac-Weyl materials I will consider impurity resonances, filling of the gap and gapless spectra in the magnetically doped topological insulators [2]. I will also discuss Dirac materials quantum imaging and how the ripples in the Dirac sea produced by defects can induce fascinating features in local magnetism and Kondo effect. At the end I will outline future opportunities to design Dirac materials that host bosonic Dirac excitations, something that would not be possible in particle physics [3]. Work supported by US DOE E304. [1] T.O. Wehling, A.M. Black-Schaffer, A.V. Balatsky (2014) Dirac materials,Advances in Physics, 63:1, 1-76. [2] A. M. Black-Schaffer, A. V. Balatsky, and J. Fransson, Phys. Rev. B 91, 201411(R) (2015). [3] S. Banerjee, A. M. Black-Schaffer, J. Fransson, H. Agren, A.V. Balatsky, Bosonic Dirac Materials in 2 Dimensions, preprint [2015], J. Fransson et.al, Dirac Magnons, preprint [2015].