Abstract Submitted
for the MAR16 Meeting of
The American Physical Society

Disorder and metal-insulator transitions in Weyl semimetals HUA JIANG, College of Physics, Optoelectronics and Energy, Soochow University, Suzhou 215006, China, CHUI-ZHEN CHEN, International Center for Quantum Materials, School of Physics, Peking University, Beijing 100871, China, JUNTAO SONG, Department of Physics, Hebei Normal University, Hebei 050024, China, QING-FENG SUN, International Center for Quantum Materials, School of Physics, Peking University, Beijing 100871, China, ZIQIANG WANG, Department of Physics, Boston College, Chestnut Hill, Massachusetts 02167, USA, X. C. XIE, International Center for Quantum Materials, School of Physics, Peking University, Beijing 100871, China
— The Weyl semimetal (WSM) is a newly proposed quantum state of matter. It has Weyl nodes in bulk excitations and Fermi arcs surface states. We study the effects of disorder and localization in WSMs and find three novel phase transitions.(I) Two Weyl nodes near the Brillouin zone boundary can be annihilated pairwise by disorder scattering, resulting in the opening of a topologically nontrivial gap and a transition from a WSM to a three-dimensional (3D) quantum anomalous Hall state. (II) When the two Weyl nodes are well separated in momentum space, the emergent bulk extended states can give rise to a direct transition from a WSM to a 3D diffusive anomalous Hall metal. (III) Two Weyl nodes can emerge near the zone center when an insulating gap closes with increasing disorder, enabling a direct transition from a normal band insulator to a WSM. We determine the phase diagram by numerically computing the localization length and the Hall conductivity, and propose that the novel phase transitions can be realized on a photonic lattice.

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Date submitted: 06 Nov 2015 Electronic form version 1.4