Topological semimetal: a probable new state of quantum optical lattice gases protected by D$_4$ symmetry

KAI SUN, JQI and CMTC, University Of Maryland, W. VINCENT LIU, University of Pittsburgh and KITP UCSB, S. DAS SARMA, JQI and CMTC, University of Maryland — We demonstrate that a novel topological semimetal emerges as a parity-protected critical theory for fermionic atoms loaded in the $p$ and $d$ orbital bands of a two-dimensional optical lattice. The new quantum state is characterized by a parabolic band-degeneracy point with Berry flux $2\pi$, in sharp contrast to the $\pi$ flux of Dirac points as in graphene. We prove that this topological liquid is a universal property for all lattices of D$_4$ point group symmetry and the band degeneracy is protected by odd parity. Turning on interparticle repulsive interaction, the system undergoes a phase transition to a topological insulator, whose experimental signature includes chiral gapless domain-wall modes, reminiscent of quantum Hall edge states.

$^1$KS and SDS acknowledge the support of JQI-NSF-PFC, AFOSR-MURI, ARO-DARPA-OLE and ARO-MURI. W.V.L. is supported by ARO and ARO-DARPA-OLE. We thank the KITP at UCSB for its hospitality where this research is supported in part by NSF Grant No. PHY05-51164.

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Date submitted: 18 Nov 2010

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