

Abstract Submitted  
for the MAR14 Meeting of  
The American Physical Society

**Hopf insulators and their topologically protected surface states<sup>1</sup>**

SHENG-TAO WANG, DONG-LING DENG, CHAO SHEN, LU-MING DUAN, Department of Physics, University of Michigan, Ann Arbor, Michigan 48109, USA — Three-dimensional (3D) topological insulators in general need to be protected by certain kinds of symmetries other than the presumed  $U(1)$  charge conservation. A peculiar exception is the Hopf insulators which are 3D topological insulators characterized by an integer Hopf index. To demonstrate the existence and physical relevance of the Hopf insulators, we construct a class of tight-binding model Hamiltonians which realize all kinds of Hopf insulators with arbitrary integer Hopf index. These Hopf insulator phases have topologically protected surface states and we numerically demonstrate the robustness of these topologically protected states under general random perturbations without any symmetry other than the  $U(1)$  charge conservation that is implicit in all kinds of topological insulators.

<sup>1</sup>NBR- PC (973 Program) 2011CBA00300 (2011CBA00302), the DARPA OLE program, the IARPA MUSIQC program, the ARO and the AFOSR MURI program

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Date submitted: 15 Nov 2013

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