

Diagnosing a strong topological insulator by quantum oscillations

in collaboration with
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Nordita 02.09.2014



...Why pose the question at all?

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11:10-11:35
IAE-2

Mo-IS04-2

ARPES studies of the possible topological Kondo insulator SmB_6
Emmanouil Frantzeskakis, Nick De Jong, Berend Zwartsenberg, Yingkai Huang, Shyama V. Ramankutty, Tran V. Bay, Erik Van Heumen, Pieter Pronk, Yu Pan, Anne de Visser, Xin Zhang, Jiuxing Zhang, Fanxing Zhang, Lihong Bao, Ojiyed Tegus, Freek Masseur, Andrei Varykhalov, Milan Radovic, Mark S. Golden

Van der Waals - Zeeman Institute, University of Amsterdam

Abstract book page 156

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Abstract book page 156

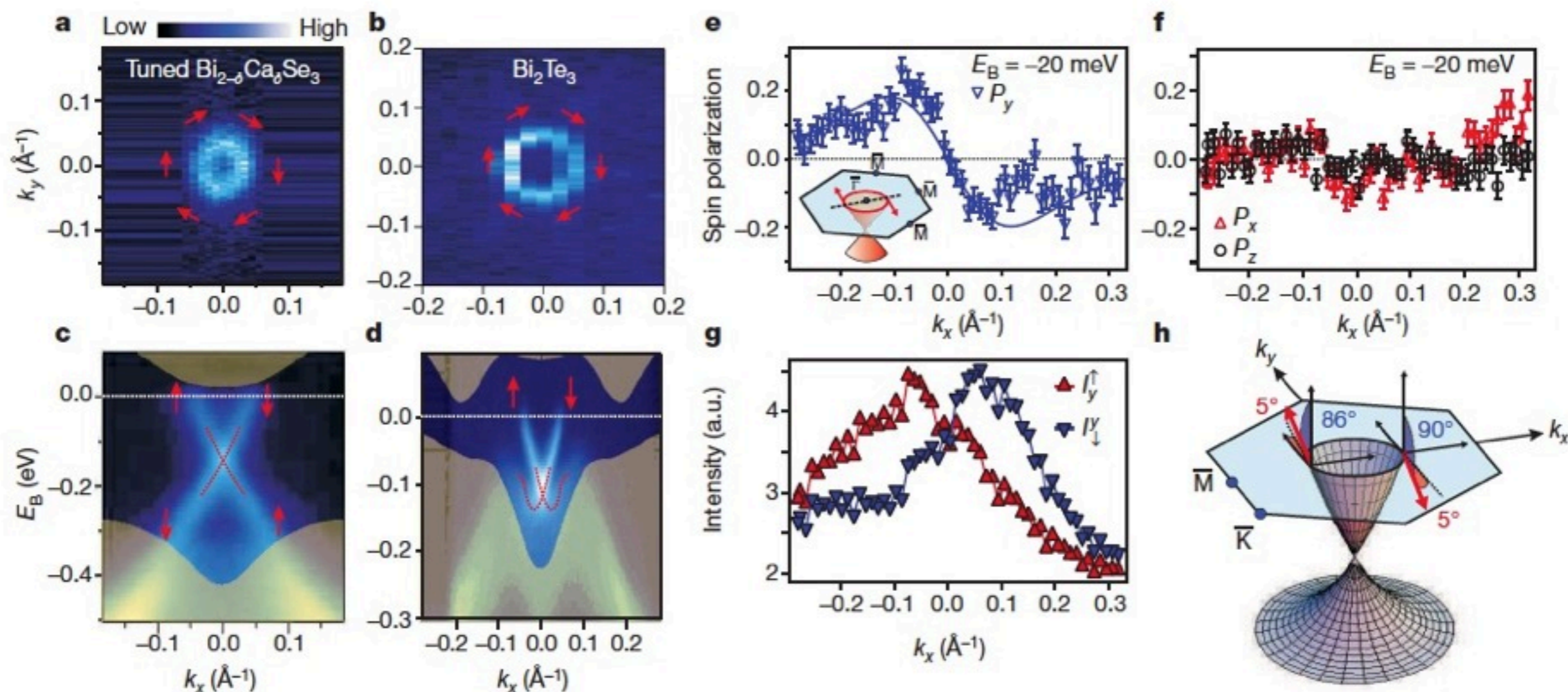
- I. E. Tamm (1932). "On the possible bound states of electrons on a crystal surface".
- W. Shockley (1939). "On the Surface States Associated with a Periodic Potential".

A tunable topological insulator in the spin helical Dirac transport regime

D. Hsieh¹, Y. Xia¹, D. Qian^{1,5}, L. Wray¹, J. H. Dil^{6,7}, F. Meier^{6,7}, J. Osterwalder⁷, L. Patthey⁶, J. G. Checkelsky¹, N. P. Ong¹, A. V. Fedorov⁸, H. Lin⁹, A. Bansil⁹, D. Grauer², Y. S. Hor², R. J. Cava² & M. Z. Hasan^{1,3,4}

LETTERS

NATURE | Vol 460 | 27 August 2009



Q: Do non-degenerate spin-helical states alone prove that you are dealing with a topological insulator?

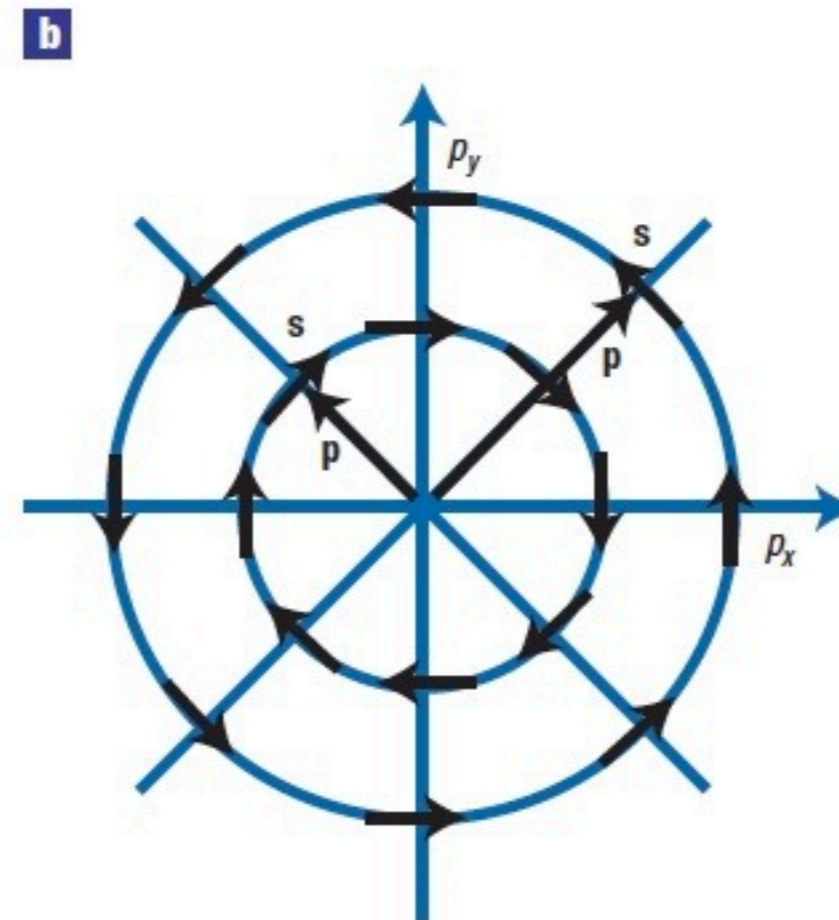
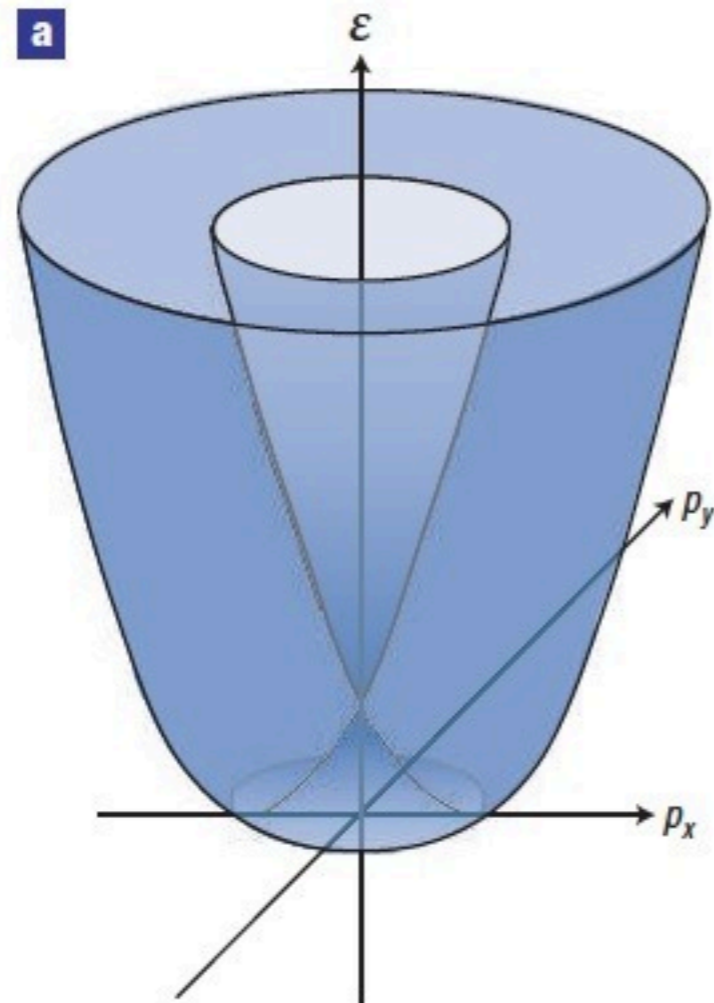
Q: Do non-degenerate spin-helical states alone prove that you are dealing with a topological insulator?

A: Not quite.

Q: Why?

A: Because, e.g., in inversion layers, such states appear due to Rashba spin-orbit coupling, simply because of structural inversion asymmetry.

E. I. Rashba (~1960) :



Q: Do the Landau level spectroscopy and the Berry phase analysis alone prove that you are dealing with a topological insulator?

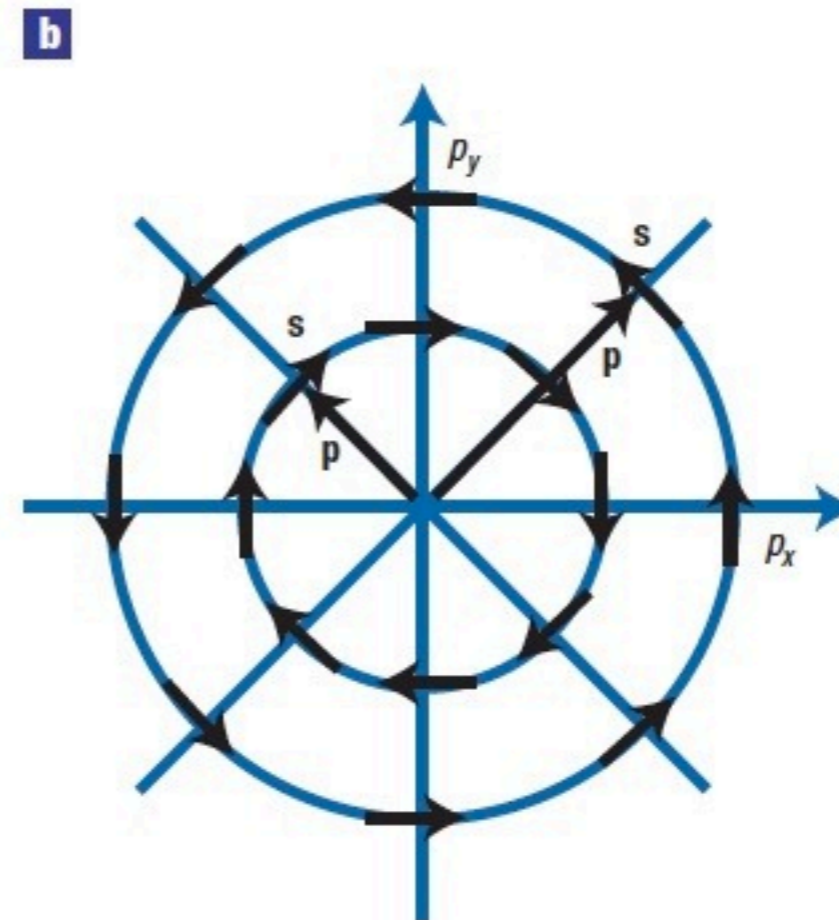
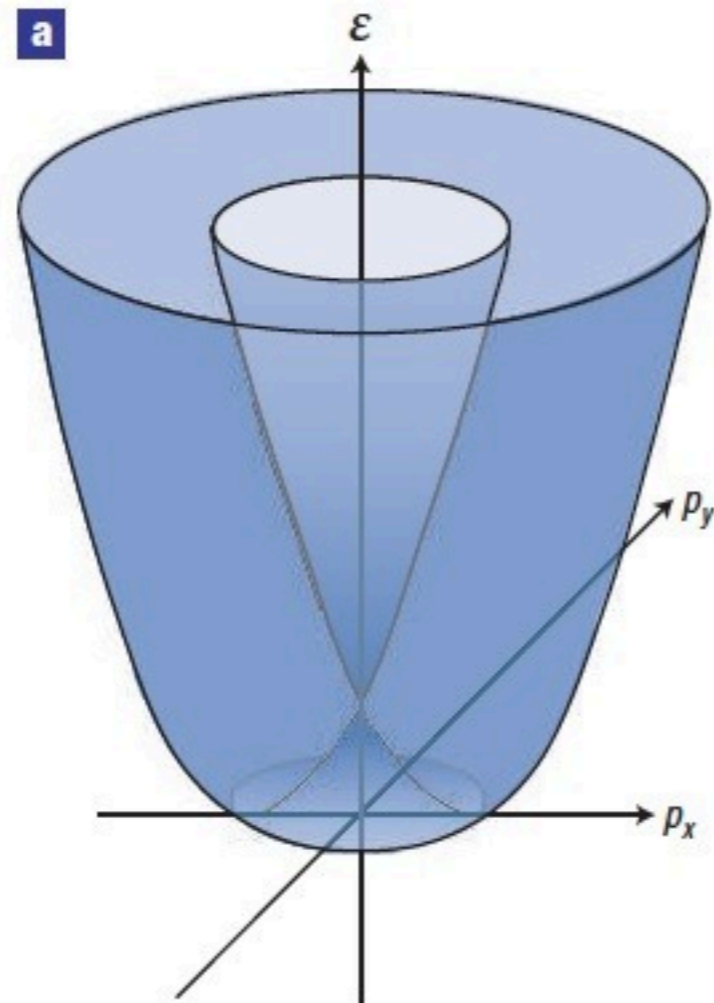
$$I = \cos \left[2\pi \frac{F}{H} + \pi + \gamma \right]$$

Q: Do the Landau level spectroscopy and the Berry phase analysis alone prove that you are dealing with a topological insulator?

$$I = \cos \left[2\pi \frac{F}{H} + \pi + \gamma \right]$$

A: Not quite...

E. I. Rashba (~1960) :



Look at one dimension :

PHYSICAL REVIEW B 74, 195312 (2006)

Time reversal polarization and a Z_2 adiabatic spin pump

Liang Fu and C. L. Kane

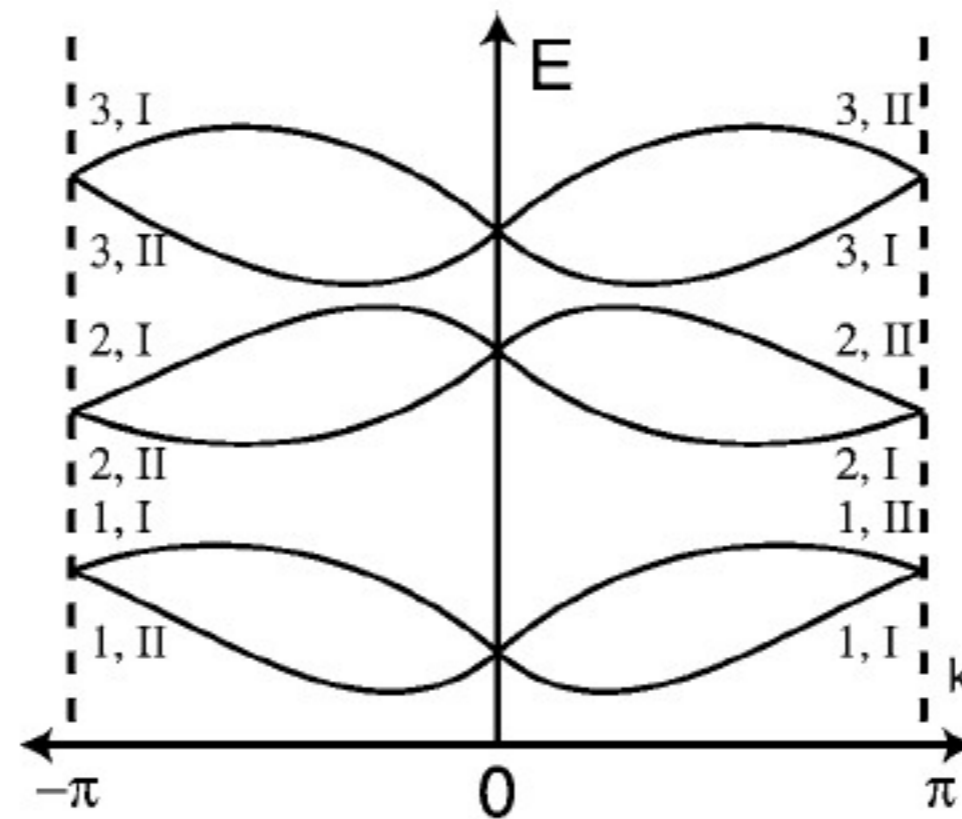


FIG. 2. Schematic one-dimensional band structure with spin-orbit interactions. The energy bands come in time reversed pairs which are degenerate at $k=0$ and π .

Look at one dimension :

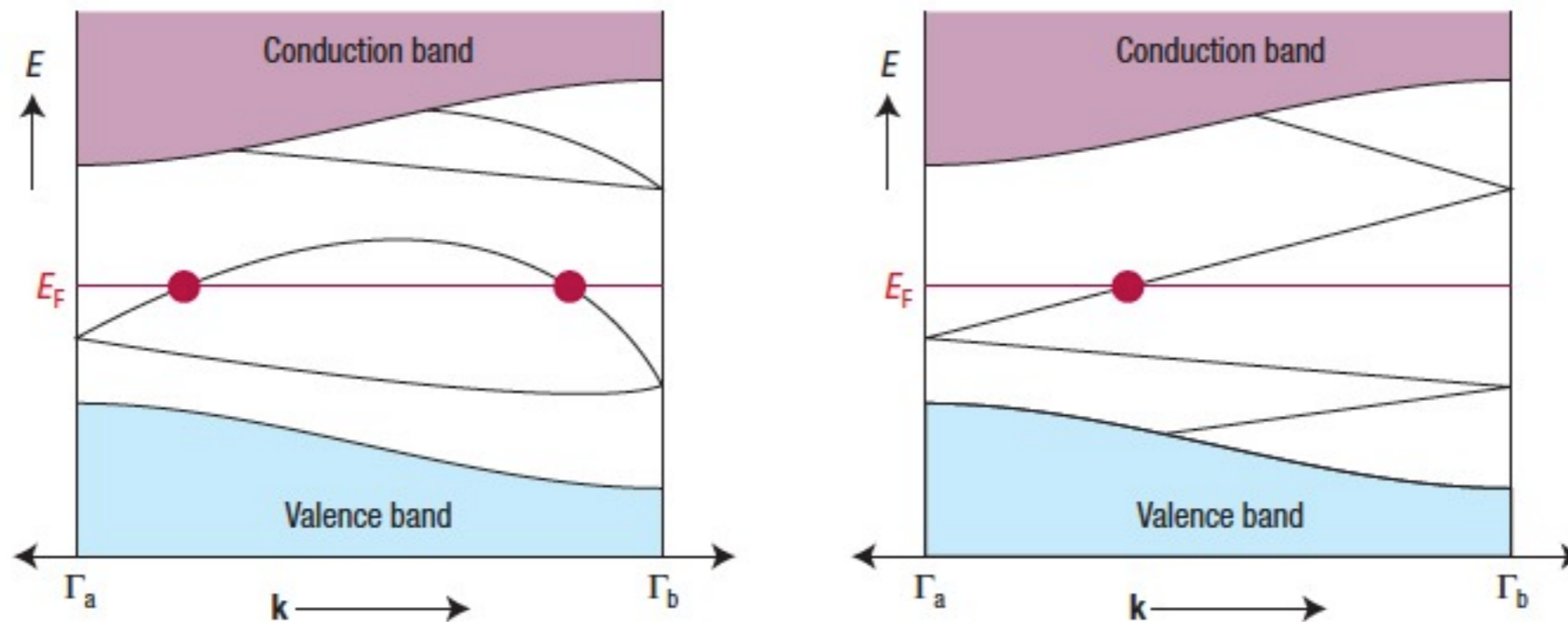
nature physics | VOL 4 | MAY 2008 | www.nature.com/naturephysics

Charles L. Kane

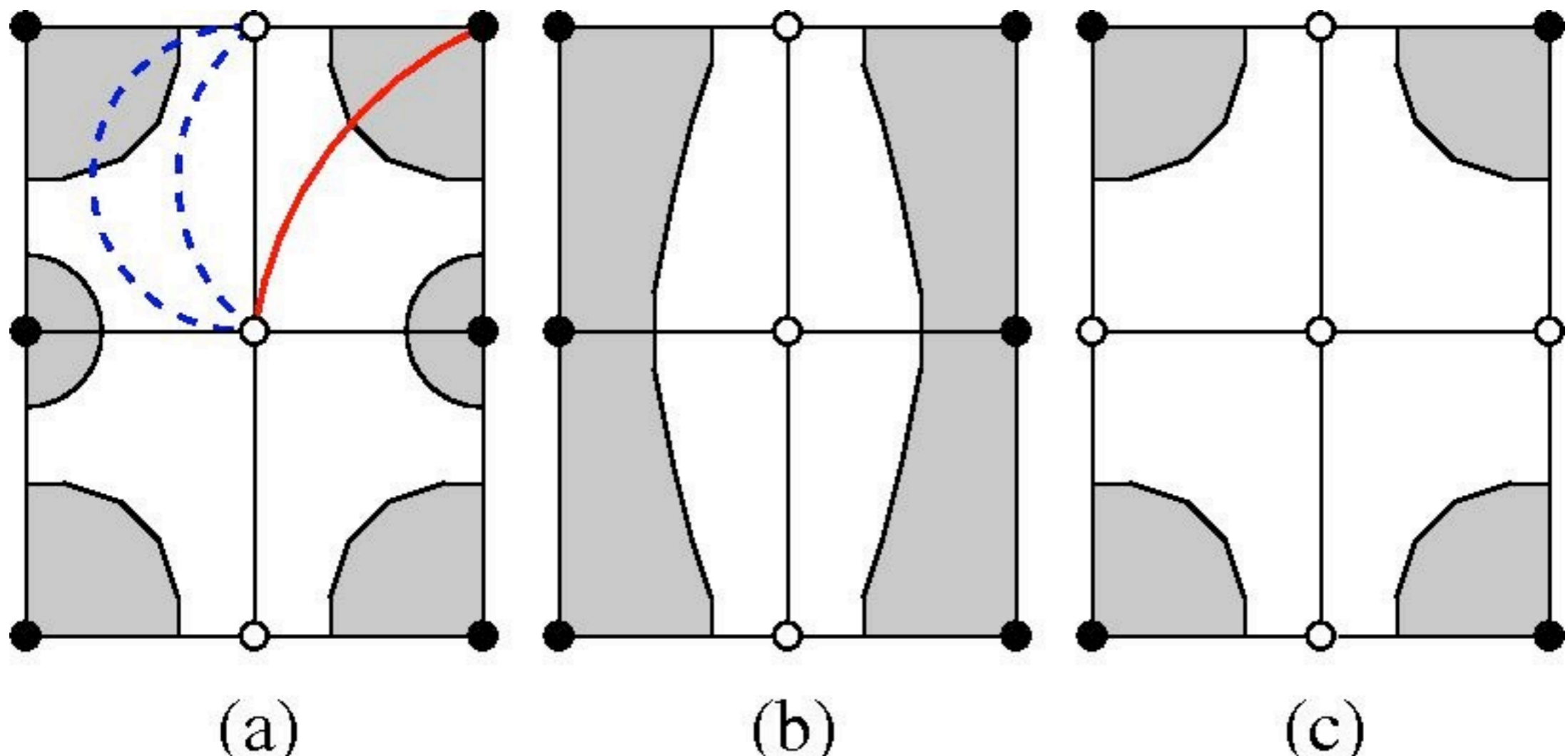
NEWS & VIEWS

CONDENSED MATTER

An insulator with a twist



Diagnosing a strong topological insulator by quantum oscillations:



Conclusion:

- An odd number of fundamental frequencies of quantum oscillations mean a strong topological insulator.
- An even number of fundamental frequencies mean a weak or a topologically trivial insulator.

...Thank you!

([arXiv:1401.6228](https://arxiv.org/abs/1401.6228))