MAR16-2015-004767

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Weyl semimetals and topological phase transitions

SHUICHI MURAKAMI, Tokyo Inst of Tech - Tokyo

Weyl semimetals are semimetals with nondegenerate 3D Dirac cones in the bulk. We showed that in a transition between different Z_2 topological phases, i.e. between the normal insulator (NI) and topological insulator (TI), the Weyl semimetal phase necessarily appears when inversion symmetry is broken. In the presentation we show that this scenario holds for materials with any space groups without inversion symmetry. Namely, let us take any band insulator without inversion symmetry, and assume that the gap is closed by a change of an external parameter. In such cases we found that the system runs either into (i) a Weyl semimetal or (ii) a nodal-line semimetal, but no insulator-to-insulator transition happens. This is confirmed by classifying the gap closing in terms of the space groups and the wavevector. In the case (i), the number of Weyl nodes produced at the gap closing ranges from 2 to 12 depending on the symmetry. In (ii) the nodal line is protected by mirror symmetry. In the presentation, we explain some Weyl semimetal and nodal-line semimetals which we find by using this classification. As an example, we explain our result on ab initio calculation on tellurium (Te). Tellurium consists of helical chains, and therefore lacks inversion and mirror symmetries. At high pressure the band gap of Te decreases and finally it runs into a Weyl semimetal phase, as confirmed by our ab initio calculation. In such chiral systems as tellurium, we also theoretically propose chiral transport in systems with such helical structures; namely, an orbital magnetization is induced by a current along the chiral axis, in analogy with a solenoid. [1] S. Murakami, New J. Phys. 9, 356 (2007). [2] S. Murakami and S. Kuga, Phys. Rev. B 78, 165313 (2008). [3] R. Okugawa, and S. Murakami, Phys. Rev. B 89, 235315 (2014). [4] M. Hirayama, R. Okugawa, S. Ishibashi, S. Murakami, and T. Miyake, Phys. Rev. Lett. 114, 206401 (2015). [5] T. Yoda, T. Yokoyama, S. Murakami, Sci. Rep. 5, 12024 (2015).