First Experimental Observation of Weyl Points

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Weyl particles – massless particles linearly dispersing in all three dimensions (3D) -- were first theorized by Hermann Weyl in 1929, who found such a solution to the Dirac equation proposed by Paul Dirac in 1928. A material hosting Weyl particles features singular points in its dispersion relations – the Weyl points. Weyl points are 3D upgrades of the 2D Dirac points in graphene, the proposal of which led to a Nobel prize in Physics in 2010. However, there has been no observation of the Weyl points (particles) until 2015.

In 2015, MIT MRSEC researchers have experimentally observed that photons propagating inside a specially-designed 3D photonic crystal behave the same way as the long-sought Weyl particles. This realization is based on their own theoretical work two years ago, proposing Weyl points in the band structure of a gyroid photonic crystal. With the help from MIT Central Machine Shop, the team fabricated an inversion-breaking double-gyroid photonic crystal at the microwave frequency (Figure A). They then characterized the bulk photon dispersions of the crystal using angle-resolved transmission, working with their collaborators in Zhejiang University in China. The transmission results reveal the Weyl dispersions matching the theoretical results (Figure B). Since Weyl points are unique topological monopoles in the momentum space, this work also paves the way to a variety of opportunities of topological photonics in three dimensions.

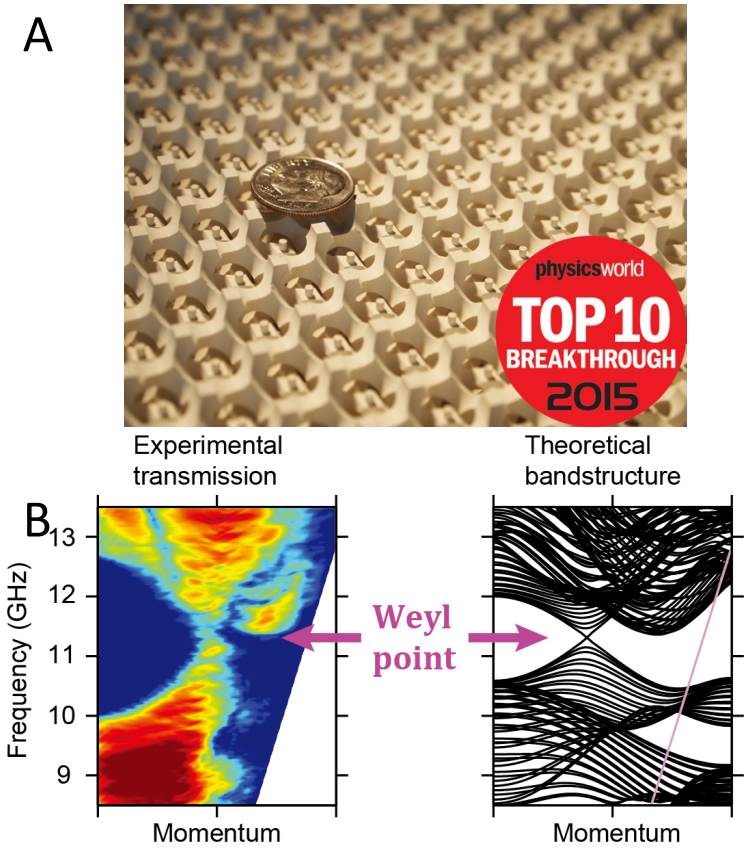

Figure: (A) The surface of the double-gyroid sample, with a dime on top, hosting Weyl quasiparticles in the form of microwave electromagnetic waves.
(B) Comparison between the experimental and theoretical results. The bulk transmission data matches the predicted Weyl dispersions.
This work was named Top-10 Breakthroughs of the year in 2015 by physicsworld.com, and one of 8 Highlights by the APS.

Ling Lu, Zhiyu Wang, Dexin Ye, Lixin Ran, Liang Fu, John D. Joannopoulos and Marin Soljačić. "Experimental observation of Weyl points" *Science*, 349, 622-624 (2015)
Ling Lu, Liang Fu, John D. Joannopoulos and Marin Soljačić. "Weyl points and line nodes in gyroid photonic crystals" *Nature Photonics*, 7, 294-299 (2013)

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