DEPARTMENT OF PHYSICS AND ASTRONOMY
and
DEPARTMENT OF MATHEMATICS

Topology-Physics Seminar Series

Is the Earth's Atmosphere a Topological Insulator?

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No, of course not. However, there are aspects of global atmospheric circulation—the Kelvin and Rossby-gravity (or Yanai) waves localized near the equator—that exhibit topological features [1] analogous to condensed matter systems such as the quantum Hall effect [2] and the quantum spin Hall effect [3]. Indeed, one can determine Berry connections, curvatures, and phases for the gravity waves, which have a Chern number of 2, and the Kelvin and Yanai waves emerge as a consequence of the bulk-edge correspondence. This provides a modern perspective on the propagating coastal waves that were first calculated by Lord Kelvin in the late nineteenth century.

I will start from the rotating shallow water equations (on a flat Earth!) and show how the linearized version of these equations becomes equivalent to a spin-one quantum particle in a magnetic field. After lots of hand-waving, I will calculate the Chern number, derive the Kelvin and Yanai waves, and discuss (and invoke) the bulk-edge correspondence. The Coriolis force plays a starring role—it changes sign at the equator and thus serves as a waveguide for the topological waves.

[1] P. Delplace, J.B. Marston, and A. Venaille, Topological origin of equatorial waves, Science 358, 1075 (2017).
[2] D. J. Thouless, M. Kohmoto, M. P. Nightingale, and M. den Nijs, Quantized Hall Conductance in a 2D Periodic Potential, Phys. Rev. Lett. 49, 405 (1982).
[3] M. Z. Hasan and C. L. Kane, Topological insulators, Rev. Mod. Phys. 82, 3045 (2010).

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CSP Conference Room 322, Physics Building

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