How wavefunction geometry helps explain the electromagnetic responses of solids

Joel E. Moore[1,2]
[1]*Department of Physics, University of California, Berkeley*
[2]*Materials Sciences Division, Lawrence Berkeley National Laboratory*

The first examples of topological phases were discovered via their ability to support quantized, dissipationless electrical transport, as in the quantum Hall effect. In the picture introduced by Thouless and collaborators, quantization results because a geometrical property of wavefunctions, the Berry curvature, gets integrated over a closed manifold, the Brillouin zone. Later work clarified that many other ground-state or adiabatic properties depend on similar geometrical objects, as in the modern theory of polarization. However, it only became clear relatively recently that wavefunction geometry also controls many properties that are far from the ground state, such as certain optical properties at low frequency, and can even lead to unexpected quantization. Two examples to be discussed are low-frequency optical rotation in linear optics and the chiral photocurrent or circular photogalvanic effect in nonlinear optics, which behaves remarkably in certain Weyl semimetals: (equation to be explained in talk, or see [1-3] below)

$$\frac{1}{2}\left[\frac{dj_{\circlearrowright}}{dt} - \frac{dj_{\circlearrowleft}}{dt}\right] = \frac{2\pi e^3}{h^2 c \epsilon_0} I C_n. \tag{1}$$

The talk closes with brief remarks on an emerging frontier: new out-of-equilibrium measurements and quantum simulators are forcing us to confront a new challenge: how to find signatures of topological order when systems are far from their ground state.

1. F. de Juan, A. Grushin, T. Morimoto, J. E. Moore, Nat. Comm. 2017.
2. D. Rees et al. (Felser, Torchinsky, Orenstein), Science Advances 2020.
3. A. Avdoshkin, V. Kozii, J. E. Moore, PRL 2020.