Condensed Matter Physics Seminar Series

Optical control of topological memory in Chern insulators

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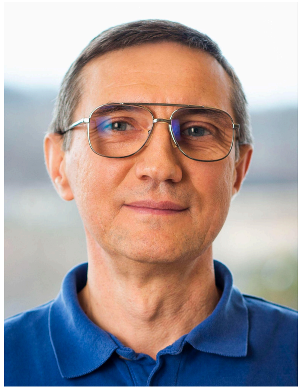

Under suitable conditions, some twisted graphene multilayers and transition-metal dichalcogenides become Chern insulators, exhibiting the anomalous quantum Hall effect and orbital magnetization. Our theory [1] describes the interaction of a Chern insulator with circularly polarized light. We show that the interaction energy couples the helicity of incident light to the Berry curvature of the electrons. Taking advantage of this interaction, we describe optical switching of the sign of the Chern number, representing topological memory, by circularly polarized light. Moreover, two laser beams of the opposite circular polarizations can nucleate domains with the opposite Chern numbers and thus produce an optically configurable domain wall carrying chiral edge modes [1].

One experimental setup uses quasi-equilibrium cooling of a material through a phase transition in the presence of non-resonant circular light [1]. This setup was realized experimentally for gyrotropic order in 1T-TiSe2 [2], antiferromagnetic order in the topological axion insulator MnBi2Te4 [3], and ferromagnetic order in the 2D spin ferromagnet Fe3GeTe2 [4]. Another setup uses non-equilibrium optical pumping by resonant circular light. It was realized experimentally in the 2D spin ferromagnet CrI3 [5] and for Chern orbital ferromagnets in twisted MoTe2 bilayers [6-8].

Using a similar theory, we also show that circular stirring of an optical lattice can induce a controlled direct current [9], which is similar to the circular photogalvanic effect in solid-state physics. This effect can be used to transport neutral bosonic atoms in an optical lattice over a given distance in a specified direction.

[1] S. S. Pershoguba and V. M. Yakovenko, “Optical control of topological memory based on orbital magnetization,” PRB 105, 064423 (2022); Erratum: PRB 108, 059904(E) (2023).

[2] S.-Y. Xu et al., “Spontaneous gyrotropic electronic order in a transition-metal dichalcogenide,” Nature 578, 545 (2020).

[3] J.-X. Qiu et al., “Axion optical induction of antiferromagnetic order,” Nature Materials 22, 583 (2023).

[4] Ti Xie et al., "High-efficiency optical training of itinerant two-dimensional magnets", Nature Physics 21, 1118 (2025).

[5] P. Zhang et al., “All-optical switching of magnetization in atomically thin CrI3,” Nature

Victor Yakovenko is a Professor of Physics at the University of Maryland. He is a Fellow of the American Physical Society and was a recipient of the Sloan Research Fellowship and the Packard Fellowship in Science and Engineering. He is a theoretical physicist, studying electronic properties of various materials for more than 40 years. He is also well known for his work in econophysics, applying methods of statistical physics to economics and finance. Victor Yakovenko was born in Donetsk and studied in the Ukraine-wide physical-mathematical boarding high school in Kyiv. He graduated from Moscow Physical-Technical Institute with M.S. in 1984 and completed his Ph.D. at the Landau Institute for Theoretical Physics in 1987, where he was subsequently employed as a Research Scientist. In 1991 he became a Postdoc at the Department of Physics, Rutgers University. In 1993 he joined the University of Maryland, College Park as Assistant Professor and became Associate Professor in 1999 and Full Professor in 2004. More info at https://physics.umd.edu/~yakovenk/

Friday, April 10th at 11am
4-330 PAB

Hosted by Yaroslav Tserkovnyak