

# THz Electrodynamics in 2D Correlated Topological Semimetals: from high-performance sensing to programmable chiral charge order

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Two-dimensional correlated topological semimetals provide a unique platform in which strong electron correlations, nontrivial band topology, and broken symmetries converge to generate exceptionally strong nonlinear electrodynamics in THz regime. In the first part of the talk, I will introduce our recent experimental effort to study the unique interplay among the quantum geometrical properties, gate-tunable electron correlation and THz electrodynamics in 2D correlated topological semimetals TaIrTe<sub>4</sub>. Building upon the nonlinear Hall effect as a new mechanism for THz rectification, we have observed a large zero-bias responsivity ( $\sim 0.3$  A/W), ultralow NEP ( $\sim \text{pW/Hz}^{1/2}$ ), broadband THz response (0.1 to 10 THz) and ultrafast intrinsic speed ( $\sim \text{ps}$ ) at room temperature. The THz sensing performance can be further enhanced by introducing gate-tunable electron correlations [1].

Building on this strong THz light-matter interaction, we explore whether light can move beyond probing electronic order to actively program it. We will discuss how helical optical and THz fields provide a route to reshape this delicate energy landscape, stabilize chiral charge order, and on demand control its handedness [2]. The observed light-induced chiral charge order intertwined with electron correlation and topology establishes the necessary symmetry-breaking conditions to access more exotic phases, such as fractional quantum anomalous Hall states and chiral superconductivity. Together, these results establish THz electrodynamics in 2D correlated topological semimetals as a pathway from high-performance sensing to the programmable creation and control of chiral quantum order.

[1] T. Xi et al., Nature Electronics **8**, 578 (2025).

[2] T. Xi et al., submitted (2026).

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