Field-driven scalar-to-axial Higgs mode transition in charge-density wave materials

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Emergent order is related to the breaking of symmetries - a paradigm that dictates physics across all length- and energy scales. In condensed matter physics, emergent order (e.g., of magnetic or electronic nature) is commonly ruled by Neumann's principle, which states that the underlying crystal symmetry governs the symmetry elements of the newly ordered phase. An interesting case arises when multiple continuous symmetries break simultaneously, which can endow the newly formed order parameter with unusual properties that are distinct from that of the underlying crystal symmetries, i.e., order beyond Neumann's principle.

Raman spectroscopy is a polarization-resolved technique and as such capable of capturing the symmetries of various order parameters. We present results on the charge-density wave phase in the rare-earth tritelluride $GdTe_3$, which constitutes an exotic case where the amplitudon (the fundamental excitation of the charge-density wave) can be described as an axial Higgs mode. Such excitation can be stabilized through the simultaneous breaking of multiple continuous symmetries [1]. By employing a magnetic field to the charge-density wave, we tune the axial Higgs-type amplitude modes [2]. This indicates that the axial character is directly related to magnetic degrees of freedom. Our approach opens up an in-situ control over the axial character of emergent Higgs modes, which can be directly accessed through polarization-resolved Raman spectroscopy.

References

[1] Y. Wang, et al., Nature **606**, 896 (2022).
[2] D. Wulferding, et al., Nat. Commun. **16**, 114 (2025).