Overdamped by Design: Quasicrystal Dynamics and Their Thermodynamic and Transport Signatures

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Quasicrystals—often described as “impossible materials of the second kind”—exhibit microscopic and collective dynamics that fundamentally depart from the textbook picture of periodic crystals. The absence of translational periodicity places their atomistic behavior in an intermediate regime between ordered crystals and disordered solids such as glasses. At the collective level, this manifests in the emergence of an additional, unconventional excitation: the phason. Unlike standard phonons, phasons display a nontrivial crossover from an overdamped, diffusive regime at long wavelengths to a propagating, sound-like regime at shorter scales. In this talk, I will present a unified view of quasicrystal dynamics, connecting microscopic rearrangements to effective long-wavelength descriptions. Within this framework, the nature of phasons is clarified in terms of symmetry principles and effective field theory. I will then discuss how these overdamped bosonic modes impact thermodynamic and transport properties, leading to distinctive signatures beyond conventional crystalline behavior. Finally, I will place these results in a broader context, highlighting connections to complex crystals and twisted two-dimensional materials, and outlining a more general framework for dynamics in aperiodic and emergent solids.