Two-Dimensional Spectroscopy of Bosonic Collective Excitations in Disordered Many-Body Systems

I Morera Navarro[1], A Gomez Salvador[1], and E Demler[1]

[1]*Department of Physics, ETH Zurich, Zürich, Switzerland*
Contact Email: imorera@ethz.ch

Traditional probes in condensed matter physics typically rely on linear response techniques, which excel at measuring two-point correlation functions. However, these methods often fail to istinguish between different microscopic mechanisms underlying spectral broadening, especially when similar spectral lineshapes arise from different mechanisms.

Two-dimensional (2D) spectroscopy, a well-established technique in nuclear magnetic resonance and optical spectroscopy, is now emerging as a powerful complement to these linear-response methods in condensed matter systems. By extending measurements into the nonlinear regime, 2D spectroscopy offers access to higher-order correlations and serves as a unique tool to disentangle distinct broadening mechanisms.

Recent developments in terahertz technology have facilitated the development of 2D terahertz spectroscopy, enabling the study of low-energy excitations in systems such as superconductors, magnons, and topological materials. In this talk, I will explore the application of 2D spectroscopy to probe collective bosonic excitations in quantum many-body systems, with a focus on its exceptional ability to distinguish and analyze the underlying broadening processes.

From a theoretical perspective, I will highlight the strengths of the Keldysh formalism, combined with the Baym-Kadanoff approach, to construct conserving approximations for nonlinear response functions in disordered systems.