TT 33: Correlated Magnetism – Dynamics and Spectroscopy

Time: Tuesday 11:00–12:30 Location: HSZ/0105

TT 33.1 Tue 11:00 HSZ/0105

Nonlinear spectroscopy of spiral magnets — •Wolfram Brenig — Institute for Theoretical Physics, Technical University Braunschweig, D-38106 Braunschweig, Germany

Spin systems with noncollinear long range order (NCLRO) allow for light-matter coupling via effective dipole moments which stem from the inverse Dzyaloshinskii-Moriya interaction. This permits to explore spin excitations of quantum magnets using time-dependent electric fields, which is of particular interest in the nonlinear regime, where second harmonic generation and two-dimensional spectroscopy may provide insight into the dynamics beyond linear probes. Here, we present results for such nonlinear response functions, using spin-wave theory and considering quasi two-dimensional magnets with NCLRO arising from frustration.

TT 33.2 Tue 11:15 HSZ/0105

Third-Order Nonlinear Response in Frustrated Magnets: Efficient Calculation in the Frequency Domain — •Marius Möller, Roser Valentí, and David A.S. Kaib — Institut für Theoretische Physik, Goethe-Universität Frankfurt, Max-von-Laue-Strasse 1, 60438 Frankfurt am Main, Germany

Techniques measuring higher-order response functions, such as two-dimensional coherent spectroscopy (2DCS) were proposed as powerful tools to provide deeper insights into the excitations of a system. However, calculating nonlinear response functions can be computationally intensive. Recently, we proposed an efficient Lanczos-based approach to calculate the second order susceptibility $\chi^2(\omega_t, \omega_\tau)$ [1]. Here, we present different approaches and approximations to compute the more commonly probed third-order susceptibilities $\chi^3(\omega_t, \omega_\tau)$ directly in the frequency domain. We compare them in terms of convergence, numerical stability and computational cost. Finally, we apply these techniques to frustrated magnets.

M.M., D.K. and R.V. gratefully acknowledge funding by the DFG (German Research Foundation): TRR 288-422213477.

[1] D.A.S. Kaib, M. Möller, R. Valentí, arXiv:2502.01746 (2025.

TT 33.3 Tue 11:30 HSZ/0105

Terahertz Time-Domain Spectroscopy of Coupled Spin and Low-Energy Excitations in $CeCoGe_3$ — •Debankit Priyadarshi[1], Zekai Chen[1], Erik W. de Vos[1], Geetha Balakrishnan[2], and Manfred Fiebig[1] — [1]ETH Zurich, Switzerland — [2]University of Warwick, United Kingdom

We present a direct observation of the interaction between a low-frequency excitation and a spin-wave resonance [1] in the intermetallic heavy-fermion compound $CeCoGe_3$ using terahertz time-domain spectroscopy. $CeCoGe_3$ exhibits three low-temperature magnetic transitions at 21 K, 12 K and 8 K [2]. In addition to the observation of a magnon mode below the Nèel temperature at 1.04 THz, we find a temperature-independent low-frequency excitation at 0.4 THz. The absorption intensities of the low-frequency mode and the magnon mode suggest an inverse coupling effect which becomes strongest below the second magnetic transition at 12 K. This hints at strong magnon-phonon coupling emerging at low-temperatures. These results can therefore shed light on how lattice vibrations influence heavy-fermion magnetism. Additionally, optical-pump THz-probe measurements are performed to investigate the role of electronic excitations in order to understand the cross-talk between these three different fundamental degrees of freedom in inter-metallic systems.

[1] M. Smidman et al., *PRB* 88, 134416 (2013).
[2] A. Thamizhavel et al., *J. Phys. Soc. Jpn.* 74, 1858 (2005).

TT 33.4 Tue 11:45 HSZ/0105

Exploring the Nonlinear Magnetic Response of FeI_2 via Two-Dimensional Coherent Spectroscopy — •Sagar Ramchandani[1], Yoshito Watanabe[1], Simon Trebst[1], and Ciarán Hickey[2] — [1]Institute for Theoretical Physics, University of Cologne, Cologne, Germany — [2]School of Physics, University College Dublin, Belfield, Dublin 4, Ireland

Nonlinear THz spectroscopy has emerged as a powerful method to extract new information beyond conventional linear response. In this work, we employ a semi-classical approach to 2-dimensional coherent spectroscopy (2DCS), implemented in the context of the Sunny Julia package for modelling atomic-scale magnetism. We apply this framework to explore the nonlinear response of FeI_2, a 2D spin-1 antiferromagnet with hybridized dipolar-quadrupolar fluctuations, to reveal its rich nonlinear dynamics.

TT 33.5 Tue 12:00 HSZ/0105

Measuring Anyonic Exchange Phases Using Two-Dimensional Coherent Spectroscopy — •Nico Kirchner[1], Wonjune Choi[2], and Frank Pollmann[1] — [1]Technical University of Munich, TUM School of Natural Sciences — [2]Theoretical Division, T-4 and Center for Nonlinear Studies, Los Alamos National Laboratory

Identifying experimental signatures of anyons, which exhibit fractional exchange statistics, remains a central challenge in the study of two-dimensional topologically ordered systems. Previous theoretical work has shown that the threshold behavior in linear response spectroscopy can reveal the fractional exchange statistics between an anyon and its antiparticle. In this work, we extend this framework to nonlinear, two-dimensional coherent spectroscopy. We demonstrate by analyzing time-ordered four-point correlation functions that the threshold behavior of nonlinear response functions encodes the fractional statistics between general pairs of anyons that can combine to any composite topological charge. This feature in particular provides a powerful probe for unambiguously distinguishing non-Abelian anyons, which can form multiple composite charges with distinct nontrivial braid statistics. Our approach is validated using numerical simulations that are consistent with the correct fractional exchange statistics for both the Abelian anyons in the toric code and non-Abelian Ising anyons.

TT 33.6 Tue 12:15 HSZ/0105

Control of chiral topological phases: Dynamics of a chiral spin liquid — •Ruben Burkard and Urban Friedrich Peter Seifert — Institut für Theoretische Physik, Universität Köln, Zülpicher Straße 77a, 50937 Köln, Germany

As recent advances in experiment make it increasingly feasible to realize and control unconventional quantum many-body states, we investigate the out-of-equilibrium dynamics of a chiral spin liquid, with the aim of drawing lessons for the control of topologically ordered phases. In particular, we consider the Hubbard model on the triangular lattice near the Mott transition, which can be described by an effective spin model with higher-order interaction terms and is believed to host a CSL phase. In order to drive the system out of equilibrium, we apply ultrafast optical pulses, which couple to the spins in the system via magnetoelectric couplings and induce nonthermal, reversible modifications to the system's effective spin Hamiltonian. These can be derived from an appropriate Hubbard model in a Floquet approach. We then formulate a time-dependent parton mean-field theory to study the light-induced dynamics of the magnetic degrees of freedom. From this study, one might also infer lessons for other systems with chiral topological order, such as fractional quantum anomalous Hall (FQAH) states recently observed (and optically controlled) in twisted $MoTe_2$, or chiral pseudospin liquids in Moiré heterostructures.