SYQF 1: Interacting Degrees of Freedom in Ultrathin Quantum Films

Time: Friday 9:30–12:15 Location: HSZ/AUDI

Invited Talk SYQF 1.1 Fri 9:30 HSZ/AUDI

Exciton dressing by extreme nonlinear magnons in a layered semiconductor — •Geoffrey M. Diederich — University of Maryland Baltimore County, 1000 Hilltop Circle, Baltimore MD, USA

Collective excitations presenting nonlinear dynamics are fundamental phenomena with broad applications. A prime example is nonlinear optics, where diverse frequency-mixing processes are central to communication and attosecond science, and extreme (>sixth-order) harmonic generation provides broad wavelength conversion. Leveraging recent progress in van der Waals magnetic semiconductors, we demonstrate nonlinear optomagnonic coupling. In the layered antiferromagnetic semiconductor CrSBr, we observe exciton states dressed by up to 20 harmonics of magnons, resulting from their extreme nonlinearities. We also create tunable optical sidebands via sum- and difference-frequency generation between two optically bright magnon modes under symmetry-breaking magnetic fields. Moreover, we can tune the observed difference-frequency generation mode into resonance with one of the fundamental magnons, which results in parametric amplification of magnons. Our findings realize the modulation of the optical-frequency exciton with the extreme nonlinearity of magnons at microwave frequencies, which could find applications in magnonics and hybrid quantum systems, and provide a method for optomagnonic neuromorphic computing devices.

Invited Talk SYQF 1.2 Fri 10:00 HSZ/AUDI

A tale of demons and decay in two-dimensional (alter)magnets — •Alexander Mook — Universität Münster

Altermagnets are a newly discovered class of magnetic materials that combine broken time-reversal symmetry with zero net magnetization, offering promising opportunities for spintronics. I will introduce the basic principles of altermagnetism and discuss two recent advances in understanding their collective excitations. First, electron-electron interactions create a new type of low-energy mode: spin-polarized acoustic plasmons ("spin demons"). Second, I will show how the splitting of magnon bands enables spontaneous magnon decay driven purely by quantum many-body fluctuations, setting an intrinsic limit on magnon lifetimes. These findings highlight the unconventional excitation physics of altermagnets and their potential for future functional materials.

Invited Talk SYQF 1.3 Fri 10:30 HSZ/AUDI

Magnetism, light and matter - Role of excitons in two-dimensional magnets — •Florian Dirnberger — Zentrum für QuantumEngineering (ZQE), Technical University of Munich, Garching, Germany — Department of Physics, TUM School of Natural Sciences, Technical University of Munich, Munich, Germany

Studies on van der Waals magnetic materials have recently unveiled a rare type of optical quasiparticle formed by spin-polarized electronic states in magnets. With properties that have no analogue among excitons in conventional semiconductors, these so-called magnetic excitons offer a compelling playground to explore the interplay between magnetism, light and matter.

In this talk, I will review the magneto-optical properties of excitonic van der Waals magnets, with a particular focus on recent work on the antiferromagnetic insulator CrSBr. This archetypal layered magnet provides key insights into how magnetic order alters excitonic responses, and how excitons in turn influence magnetic dynamics. It further enables experiments to probe magnetic excitons in the regime of strong light-matter coupling, bringing concepts from photonics into the picture. Optical spectroscopy reveals pronounced exciton responses to applied magnetic fields, dynamic coupling between excitons and both coherent and incoherent magnons, and magnon-induced excitonic correlations. Together, these results open new directions for magneto-optics and highlight opportunities to control magnetically correlated quantum materials through strong light-matter interactions.

15 min. break

Invited Talk SYQF 1.4 Fri 11:15 HSZ/AUDI

Advantages and challanges of resonance Raman scattering with infrared excitation energy — •Leonetta Baldassarre — Department of Physics, Sapienza University of Rome, I-00185 Rome Italy

Resonance Raman scattering is a valuable spectroscopic technique, providing a probe into the intertwined electronic and vibrational properties of materials. The main strength of resonance Raman lies in its ability to selectively map distinct regions of the electron and phonon dispersion simply by tuning the excitation laser energy.

I will introduce our experimental approach of performing resonance Raman by lowering the excitation energy deep into the Near-Infrared. This frequency shift is strategic, enabling us to probe scattering processes resonant with the bottom of the conduction band in narrow-band semiconductors or close to the Dirac points. I will provide an overview of the custom-built experimental setup and present the results from its application to diverse materials such as layered semiconductors like $MoSe_2$ and $MoTe_2$ or graphene.

Our measurements are compared to *ab-initio* calculations so to identify the phonons involved in the resonant processes and, in the case of graphene, introduce the existence of a momentum-dependent electron-phonon coupling between low-energy carriers and zone-boundary optical phonons. Resonance Raman scattering with infrared excitation can be thus viewed as an indispensable tool for exploring and understanding the essential, often-hidden, charge-carrier and lattice dynamics that define the physics of low-dimensional quantum matter.

Invited Talk SYQF 1.5 Fri 11:45 HSZ/AUDI

Shining light on 2D antiferromagnets — •Dmytro Afanasiev — Radboud University

Ultrafast optical control of antiferromagnetic order is a key goal in spintronics and magnonics. Resonant excitation of local orbital degrees of freedom, such as dd transitions in transition-metal ions, offers a direct route to modify magnetic exchange and anisotropy on femtosecond timescales. However, orbitally driven photomagnetism has been demonstrated in only a few materials, and the factors governing its efficiency remain unclear.

Here, we study ultrafast spin dynamics induced by resonant pumping of dd transitions in layered antiferromagnetic thiophosphates XPS3. We first establish the photomagnetic response in single magnetic-ion compounds, where local orbital excitation triggers coherent spin precession via ultrafast anisotropy modulation. We then extend this approach to binary compounds containing two distinct transition-metal ions, demonstrating that selective excitation of specific orbital resonances strongly enhances the efficiency and controllability of magnon generation.

These results identify general design principles for orbitally driven photomagnetism in collinear antiferromagnets and establish transition-metal substitution as a powerful strategy for achieving efficient ultrafast control of antiferromagnetic spin dynamics.