CONDENSED MATTER SCIENCES SEMINAR

Professor Fariborz Kargar

Auburn University

Host

Dr Naipeng Zhang

Title

Brillouin–Mandelstam Spectroscopy of Low-Energy Excitations: Acoustic Phonons, Magnons, and Spin–Lattice Coupling

Friday, October 23rd, 2026

1st Floor – B333

15:00-16:00

Abstract

Acoustic phonons and magnons are fundamental low-energy excitations that govern the thermal, elastic, and magnetic properties of crystalline materials. Their dispersion and interactions can be substantially modified by dimensional confinement, artificial periodicity, structural disorder, external stimuli, and coupling between lattice and spin degrees of freedom. Understanding these effects is essential for investigating collective excitations and developing approaches to control phonon and spin-wave propagation in advanced nanostructures and quantum materials. Experimentally probing these low-energy excitations, however, remains challenging, particularly in low-dimensional materials and micron-scale structures where conventional techniques, such as neutron and ultrasound techniques, face significant limitations. Brillouin–Mandelstam spectroscopy (BMS) provides a powerful, noncontact optical approach for probing low-energy acoustic phonons and magnons [1].

In this talk, I will introduce the fundamentals of BMS and briefly highlight our previous studies of acoustic phonon dispersion in nanostructures and disordered crystals [2–6], as well as confined spin waves in magnetic materials [7,8]. The main focus of the talk will be on the phonon excitations and spin–lattice coupling in low-dimensional antiferromagnetic materials, particularly the MPX_3 family of van der Waals magnets [9,10]. While conventional Raman spectroscopy has been widely employed to investigate spin–phonon interactions through optical phonons, long-wavelength acoustic phonons provide a complementary probe of the elastic response associated with magnetic ordering. I will present our recent BMS investigation of the antiferromagnetic semiconductor $NiPS_3$, where we observe pronounced softening of surface acoustic Rayleigh waves near the Néel temperature of ~155 K, corresponding to a 6–7% reduction in phase velocity [10]. Combined with first-principles calculations and continuum elastic modeling, these results reveal substantial magnetoelastic coupling and demonstrate how magnetic ordering modifies long-wavelength lattice dynamics in low-dimensional antiferromagnets. These studies highlight the versatility of BMS for investigating low-energy lattice and spin excitations and establish new opportunities for understanding spin–lattice interactions in low-dimensional magnetic and quantum materials.

Acknowledgments

F.K. acknowledges support from NSF DMR Award No. 2436557, "Controlling Electron, Magnon, and Phonon States in Quasi-2D Antiferromagnetic Semiconductors for Enabling Novel Device Functionalities," and NSF MRI Award No. 2019056, "Development of a Cryogenic Integrated Micro-Raman-Brillouin-Mandelstam Spectrometer."

References

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BIO

Dr. Fariborz Kargar is an Assistant Professor in the Materials Engineering Program at Auburn University. He received his Ph.D. in Electrical Engineering from the University of California, Riverside (UCR), in 2016. Before joining Auburn, he served as Manager of the Phonon Optimized Engineered Materials (POEM) Center and Assistant Adjunct Professor at UCR, followed by a Visiting Research Scientist appointment at UCLA. His research focuses on Brillouin–Mandelstam and Raman spectroscopies for investigating phonons, magnons, and spin–lattice interactions in low-dimensional and quantum materials. His research is supported by multiple National Science Foundation (NSF) grants, including awards for developing advanced cryogenic micro-Raman–Brillouin–Mandelstam instrumentation and investigating low-energy excitations in two-dimensional antiferromagnetic semiconductors.