Monday Afternoon, January 26, 2026

PCSI
Room Ballroom South - Session PCSI-MoA1
Layered Magnetism

Moderator: Christopher Palmstrøm, University of California, Santa Barbara

2:00pm **PCSI-MoA1-1 Dielectric Tensor, Magnetic Anisotropies and Coupled Excitations in Layered Magnetic Semiconductors CrSBr*, Ursula Wurstbauer,*** University of Münster, Germany **INVITED**

Two-dimensional materials exhibit unique properties due to their atomically thin structure and weak van der Waals (vdW) coupling between layers resulting in layer dependent properties. As in the case of the layered magnetic semiconductor CrSBr, individual layers are ferromagnetically ordered below the Neel temperature (T_N»132K), while adjacent layers are coupled antiferromagnetically. Due to the highly anisotropic electronic bands in CrSBr, electronic and excitonic states at the fundamental band-gap behave quasi-one-dimensional [1]. Moreover, the resulting excitonic transitions are highly sensitive to the collective spin order. Below the critical temperature, an external magnetic field applied along the magnetic hard directions drives the system from the antiferromagnetic into a ferromagnetically ordered state causing a quadratic red-shift of the exciton energies theoretically explained by spin-allowed charge transfer changing the composition and nature of excitons [2]. By a combination of magneto-reflectance, magneto-photoluminescence and magneto resonant inelastic light scattering (RILS) experiments, we study strong coupling between charge, lattice and spin degrees of freedom as well as their changes when interfaced to other 2D magnetic semiconductors from the transition metal phosphor trisulfide group with different magnetic anisotropies.

The strong light matter interaction in thin CrSBr film is highly tunable by layer number and magnetic polarization. To develop a better understanding, we access the materials dielectric tensor in the paramagnetic and ferromagnetic phase by variable-temperature spectroscopic imaging ellipsometry. In agreement with theory, we extract highly anisotropic dielectric functions along the crystallographic main axes with strong excitonic resonances particularly in the plane [4].

We acknowledge the fruitful collaboration with Florian Dirnberger, Julian Klein, Zdeněk Sofer, Marie-Christin Heißenbüttel, Thorsten Deilmann and Michael Rohlfing.

[1] J. Klein et al. ACS Nano, 17, 6, 5316–5328 [tel:5316–5328] (2023).

[2] M.-C. Heißenbüttel et al. 111, 075107 (2025).

[3] F. Dirnberger et al. Nature 620, 533–537 (2023).

[4] P.M. Piel, S. Schaper, et al (2025).

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2:40pm **PCSI-MoA1-9 Magneto-Optical Studies of Layered Antiferromagnet $CrPS_4$*, Jongchan Kim,*** Seoul National University, South Korea*; Kenji Watanabe, Takashi Taniguchi,* NIMS (National Institute for Materials Science), Japan*; Je-Geun Park, Jieun Lee,* Seoul National University, South Korea

Two-dimensional magnetic materials have recently attracted significant attention as promising platforms for studying spin-based devices such as spin filters or valves and investigating exotic spin-dependent phenomena such as the realization of magnetic skyrmions. However, micrometer-scale dimensions of these materials make their direct magnetic characterization challenging. Conventional bulk measurement techniques are often insufficient, therefore, approaches through transport measurements or optical probes must be employed. In this work, we investigate thin-layers of antiferromagnetic semiconductor $CrPS_4$, which is an A-type antiferromagnet in its bulk form, and explore its spin properties through magneto-optical effects and polarization-resolved photoluminescence (PL) measurements.

The few-layer flakes of $CrPS_4$ investigated in our work are obtained by mechanical exfoliation from bulk crystals which are subsequently capped with hBN. For probing the spin polarization, we measured the degree of circular polarization of PL emission from $CrPS_4$ in Faraday geometry and confirm the out-of-plane spin orientation which is further supported by the magnetic circular dichroism (MCD) measurements. We further extend our study to the Voigt geometry, performing both MCD and circularly polarized PL measurements to track the evolution of spin orientation under in-plane magnetic fields. Taken together, these optical spectroscopic results demonstrate the potential of two-dimensional antiferromagnets as versatile platforms for exploring spin physics in van der Waals platforms and advancing next-generation spin-based technologies.

2:45pm **PCSI-MoA1-10 UPGRADED: Van der Waals Antiferromagnets $Co_{1/3}NbS_2$ and $Co_{1/3}TaS_2$: Topological Magneto-Optics & Tunable Chiral/Nematic Phases*, Scott Crooker,*** National High Magnetic Field Laboratory

The family of intercalated niobium and tantalum dichalcogenides, $M_{1/3}NbS_2$ and $M_{1/3}TaS_2$ (where M= V, Cr, Mn, Fe, Co, Ni), are van der Waals materials hosting layers of spins on 2D triangular lattices -- an archetypal frustrated network that can lead to a rich variety of complex magnetic states.$Co_{1/3}NbS_2$ and $Co_{1/3}TaS_2$ are antiferromagnets (AFMs) that exhibit giant spontaneous Hall conductivity despite vanishing net magnetization [1], suggesting nontrivial AFM order and potential for AFM spintronics. Recent neutron diffraction studies point to a non-coplanar "tetrahedral" triple-**Q** AFM order with scalar spin chirality [1]. In contrast to conventional collinear AFM order, this (and certain other) complex AFM spin configurations can allow for off-diagonal Hall conductivity, σ_{xy}, which in turn generates anomalous and topological Hall effects in transport studies.

Crucially, $\sigma_{xy}(\omega)$ is frequency-dependent, and at optical frequencies it generates Kerr rotation and magnetic circular dichroism (MCD).Thus, the full power of optics, including imaging and spectroscopy, can be applied to study complex AFM orders in $Co_{1/3}NbS_2$ and $Co_{1/3}TaS_2$.Here we show [2,3], using light spanning infrared-ultraviolet (1-3 eV), that MCD is a powerful and incisive probe of chiral triple-**Q** AFM order. Measurements at different photon energies are compared with DFT calculations. Scanning MCD microscopy is used to directly image (and also write) chiral 3**Q** domains. In $Co_{1/3}TaS_2$, linear dichroism studies also reveal three-state (Z_3) nematicity arising from a single-**Q** stripe phase, as well as phases where chirality *and* nematicity coexist [3]. A theoretical analysis based on a *continuous multi-**Q** manifold* captures the emergence of these distinct magnetic phases, resulting from the interplay between four-spin interactions and weak magnetic anisotropy. Our findings establish $Co_{1/3}TaS_2$ as a rare platform hosting diverse multi-**Q** states with distinct combinations of spin chirality and nematicity).

[1] N.J. Ghimire *et al*, Nat. Comm. **9**, 3280 (2018); H. Takagi *et al*, Nat. Phys. **19**, 961 (2023).

[2] E. Kirstein *et al*, *arXiv:2507.18829 (in press, Phys Rev. Lett.);* E. Kirstein, *arXiv:2507.08148*

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3:10pm **PCSI-MoA1-15 Highly Efficient Interlayer Exciton Microcavity Laser in Free-standing 2D Heterostructures*, Yeeun Cho,*** Seoul National University, South Korea*; Kenji Watanabe,* Research Center for Electronic and Optical Materials, National Institute for Materials Science, Japan*; Takashi Taniguchi,* Research Center for Materials Nanoarchitectonics, National Institute for Materials Science, Japan*; Jieun Lee,* Seoul National University, South Korea

Monolayer transition metal dichalcogenides (TMDs) and their heterostructures offer a versatile platform for photonics owing to their atomic thickness and strong excitonic interactions. Interlayer excitons (IXs) in heterobilayers possess long lifetimes and tunable emission energiesleading to various interesting phenomena, yet their weak oscillator strength limits emission intensities and lasing behaviors.In this work, we report efficient IX lasing from a $MoSe_2/WSe_2$ heterobilayer through integrationwith a free-standing silica microsphere cavity. The suspended geometry enhances IX emission by more than an order of magnitude relative to supported regions and enables efficientcoupling to high-Q cavity(Q ~2600). A lasing threshold as low as 75 nW is observed, as confirmed by the superlinear emissionkinkand linewidth narrowingin the power dependence measurements.The lasing threshold of the suspended sample is reduced by more than ten times compared to thesupported samples, consistent with the measuredIX lifetimes.These findings establish free-standing van der Waals heterostructures integrated with microcavities as compact and low-powerconsumptioncoherent light sources for quantum photonicsapplications.

3:15pm **PCSI-MoA1-16 Strain-Programmable Exciton Diffusion in Moiré Heterostructures*, Chiho Song,*** Seoul National University, South Korea*; Chiranjit Mondal,* Seoul National University, South Korea, India*; Jaebin Lee,* Seoul National University, South Korea*; Kenji Watanabe, Takashi Taniguchi,* NIMS (National Institute for Materials Science), Japan*; Bohm Jung Yang, Jieun Lee,* Seoul National University, South Korea

Moiré superlattices in van der Waals heterostructures based on two-dimensional materials have recently gained significant attention as an intriguing platform for exploring strongly correlated electronic states and engineering novel excitonic properties. Such superlattices have been generally created and tuned either by lattice constant mismatch or layer twisting. However, strain is also a powerful tool for tuning the moiré superlattices, which yields fascinating features distinct from the twisted cases due to the C_3 rotational symmetry breaking. Herein, we experimentally and theoretically investigate the optical properties of interlayer excitons (IXs) generated in strain-induced $MoSe_2$-WSe_2 heterobilayers.

In our experiment, we fabricated vertically stacked MoSe2-WSe2 heterobilayers in which uniaxial strain is applied to a single constituent layer. Due to the type-II band alignment, the heterobilayer exhibits long-lived IXs with electrons and holes spatially separated in opposite layers. We probe the strain effect on the IX emission polarization and diffusion over the stacked region which shows peculiar coupling of the excitonic behavior with the strain-induced moiré potentials. Firstly, we found the linearly polarized IX emission resulting from the C3 rotational symmetry breaking of the moiré potential over a wide spatial area. Secondly, through spatially resolved IX diffusion measurements, we found that IXs diffuse preferentially along the applied strain direction over several micron scales. Our experimental observations are also consistent with the density functional theory (DFT) calculation results of the strain-induced moiré potential landscapes.

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