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2D Materials Conference

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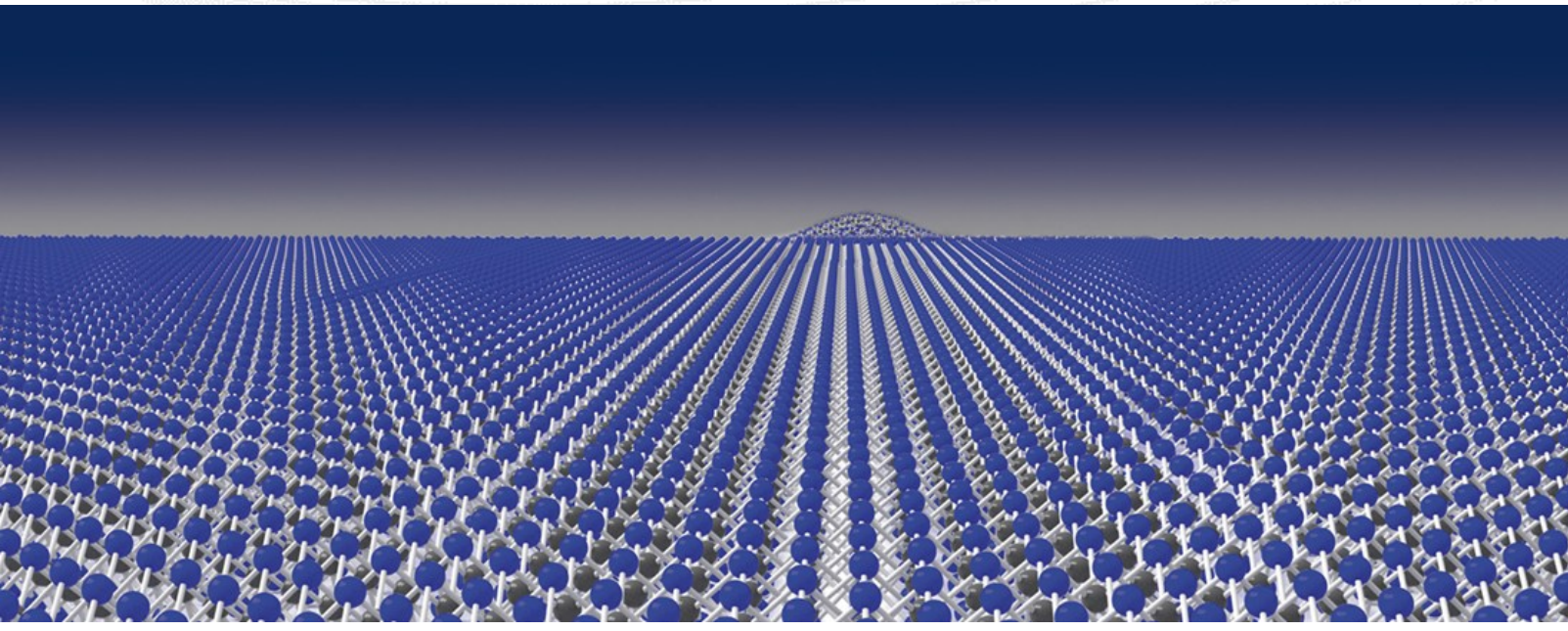
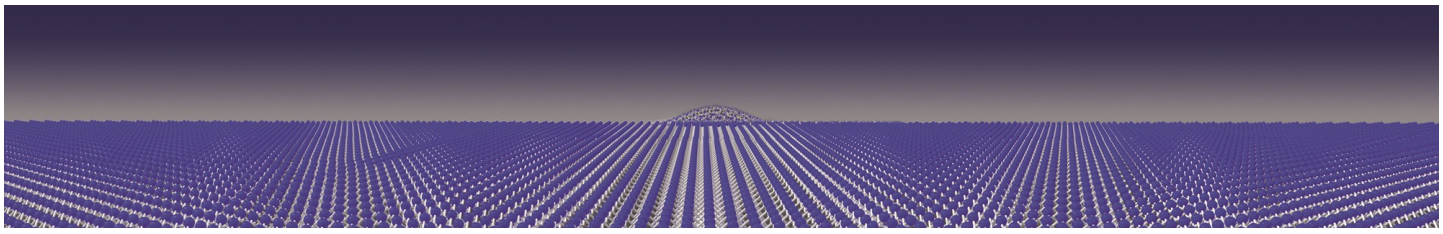


Poster Session

Overview



Poster Session

P1. Intrinsic plasmon canalization in the natural biaxial van der Waals material $MoOCl_2$ 9

Farid Aghashirinov[1*], Andrea Manchini[2], Lin Nan[2], Giacomo Venturi[2], Nicola Melchioni[2], Florian Mangold[1], Bettina Frank[1], Antonio Ambrosiol[2] & Harald Giessen[1]

P2. High-Performance Ultrathin MoS_2 Nanoribbon Phototransistors 10

Abhay Vivek Agrawal, Timur Shegai

P3. Scanning Near-Field Optical Microscopy in Liquid with Graphene 10

Rutuja Ainapure[1*], Kevin George Alex[1], Enrico Baù[1], Andreas Tittl[1]

P4. Controlling the spin-polarized light emission of an antiferromagnetic 2D material 11

Gabriel Albuquerque Dias Souza[1*], Frederico Barros de Sousa[1], Ana Paula Moreira Barboza[2], Ingrid David Barcelos[3], Bernardo Ruegger Almeida Neves[2], Marcio Daldin Teodoro[1]

P5. Mem-emitting capabilities in a device based on Clinochlore/$MoSe_2$ 11

Alessandra Ames[1*], Frederico B. Sousa[1], Gabriel A. D. Souza[1], Raphaela de Oliveira[2], Igor R. F. Silva[1], Gabriel L. Rodrigues[2], Kenji Watanabe[3], Takashi Taniguchi[3], Gilmar E. Marques[1], Ingrid D. Barcelos[2], Alisson R. Cadore[2], Victor Lopez-Richard[1], Marcio D. Teodoro[1]

P6. Rotational AFM/CFM for quantum optical twisting microscopy 12

Dieter Andres[1], Rajarshi Bhattacharyya[1], Emre Yazici[2], Takahiro Uto[2], Ignacio Baldoni[1], Clemens Schäfermeier[1], Nahid Hosseini[4], Georg Fantner[4],

P7. TBA 13

Muhammad Asif

P8. Importance of pure dephasing in the optical response of excitons in high-quality van der Waals heterostructures 13

Anabel Atash Kahlon[1*], Matan Meshulam[1], Tomer Eini[1], Thomas Poirier, James H. Edgar, Seth Ariel Tongay and Itai Epstein[1]

P9. Phase Modulation in the Visible Spectrum Using Nanocube Resonators 14

Inbar Ayalon, Itai Epstein

P10. Visualizing Stray Field Distributions in Ni Micromagnets and CoRuCrSi Polycrystals via Low-Temperature Quantum Diamond Microscopy 14

Swapnil R. Bait[1*], Somak Basistha[1], Barnabha Bandyopadhyay[2], K. G. Suresh[2], Sindhunil Barman Roy[2,3,4], Kasturi Saha[1]

P11. Self-hybridized non-Hermitian exciton-polaritons in triclinic rhenium diselenide 15

Ramachandra Bangari[1*], Siddharth Nandanwar [1,2], Thomas Folland[1]

P12. Investigating strain effects on the far-infrared optical response of $SrTiO_3$ membranes 16

Domitille Baux-Remini[1], Konnor Koons[2], Yin Liu[2], Ruijuan Xu[2], Alexey B.Kuzmenko[1]

P13. Engineering strong bosonic correlations in 2D materials 17

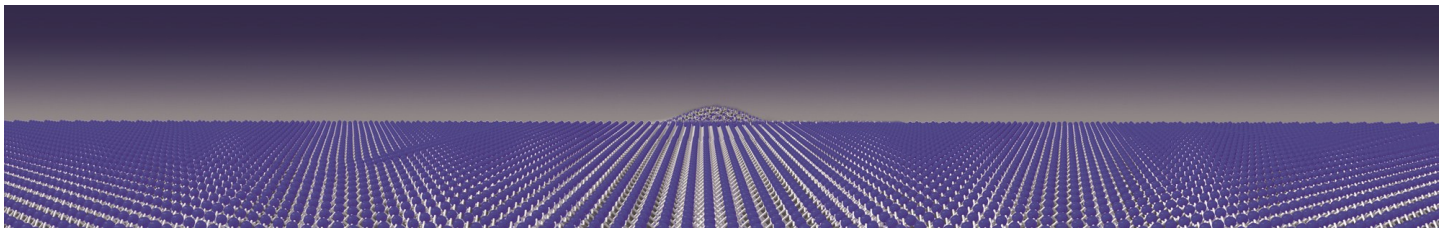
Amine Ben Mhenni

P14. Towards Experimental Realization of M-Point Moiré Systems 17

Leon R. Benoist[1], Jules Lefeuvre[1], Soumyajit Samal[1], Sushmita Chandra[4], Claudia Felser[4], B. Andrei Bernevig[2], Dmitri Efetov[1,3]

P15. Development of a Cryogenic Quantum Twisting Microscope: System Buildup, Conducted Measurements and Fabrication of Clean, Gated Twisted Devices 18

M. Bhatt[1*], J. Williams[1], M. Daschner[1], M. Chen[1], A. Vadlamani[1], J. Li[1], C. Obermayer[1], A. Heindl[1], P. Altpeter[1], K. Watanabe[2], T. Taniguchi[2], D. K. Efetov[1]



P16. Scanning-Probe and Magneto-Optical Studies of Integer and Fractional Moiré Chern Insulators 19
R. Bhattacharyya[1] , M. Bacani[1] and E. Redekop[2]

P17. Ferroelectric interlayer excitons with electrically switchable dipole moments in bilayer WSe_2.....20
Fabian Buchner[2], Yao Lu[1], Chao-Peng Shen[1], Yu-Han Bao[1], Xinyue Zhang[3], Jueting Zheng[1], Zhen-Zhou Gao[1], Zi-Feng Guo[1], Bo Yi[1], Kenji Watanabe[4], Takashi Taniguchi[5], Chuan Liu[1], Xiang Wang[1], Qiucheng Li[1], Bin Ren[1], Long Zhang[3], Paulo E. Faria Junior[6,7], Sebastian Bange[2], Kai-Qiang Lin[1,3], John M. Lupton[2]

P18. Role of photonic interference in exciton-mediated magneto-optic responses 21
Güven Budak[1,2,3]*, Christian Riedel[1,2], Akashdeep Kamra[4], Patrick Rinke[2,5,6], Christian Back[1,2,3], Matthias Stosiek[2,5,6], Florian Dirnberger[1,2,3]

P19. Engineering strong correlations in 2D materials 22
Elif Cetiner*[1,2,3,4], Amine Ben Mhenni[1,2], Jonathan J. Finley[1,2], Nathan P. Wilson[1,2], Nadine Leisgang[3,4]

P20. Electrical current control of anomalous Hall effect in WTe_2/Fe_3GeTe_2 bilayers 23
L. Chen, J. P. Guo, T. N. G. Meier, and C. H. Back

P21. Resolving Symmetry-broken States with Quantum Twisting Microscope in Rhombohedral Graphene ..23
Moyu Chen

P22. Characterizing carbon doping in hBN utilizing near-field hyperbolic phonon-polariton propagation 23
Timothy Chester-Parsons[1]*, Alexander Knight[1], Kenji Watanabe[2], Takashi Taniguchi[3], Alexander I. Tartakovskii[1]

P23. Dynamic Engineering of Two-Dimensional Materials and Their vdW heterostructures via Rectified Femtosecond Laser Shock Peening.....25
Tsegaye Bojago Dado

P24. Toward a Quantum Twisting Microscope for cryogenic applications.....25
Maximilian Daschner[1]*, Mudit Bhatt[1], Joshua Williams[1], Moyu Chen[1], Ashwin Vadlamani[1], Jiazhou Li[1], Philipp Zitzler[1], Philipp Altpeter[1], Christian Obermayer[1], Anton Heindl[1], Dmitri Efetov[1]

P25. Enhanced Phonon-Assisted Tunneling in Metal-Twisted Bilayer Graphene Junctions.....26
Suvronil Datta[1]*, Radhika Soni[1], Robin Bajaj[2], Saisab Bhowmik[1], Shinjan Mandal[2], K. Watanabe[3], T. Taniguchi[4], Manish Jain[2], and U. Chandni.[1]

P26. Segregation channels in V-doped monolayer WS2 revealed by X-ray nanoprobes and Raman spectroscopy 27
Frederico B. Sousa[1], Raphaela de Oliveira[2], Matheus J. S. Matos[3], Elizabeth Grace Houser[4], Gilmar Eugenio Marques[1], Leandro M. Malard[5], Mauricio Terrones[4], Bruno R. Carvalho[6], Helio Chacham[5], Marcio D. Teodoro[1]

P27. Quantum Imaging of Nanoscale Electronic Transport in Graphene with Scanning Diamond Magnetometry 28
Chaoxin Ding[1]*, Marius Palm[1], Kevin Kohli[1],
Jorge Estrada-Álvarez[2], Maya Klang[1], Debang Shi[1], Sofie Kölling[1],
Takashi Taniguchi[3], Kenji Watanabe[4], Christian Degen[1]

P28. Thermoelectric Studies of Heavy Fermion Physics in Magic-Angle Twisted Bilayer Graphene 29
Ranit Dutta[1,2], Yuxiao Wu[1,2], Carl Hudeczek[1], Egor M. Agapov[1], Giorgio Di Battista[1,2], and Dmitri K. Efetov[1,2]

P29. TBA 29
Giuliano Esposito

P30. Enhanced exciton interaction in semiconducting MoS2/WSe2 moiré superlattices.....29
Hanlin Fang[1,2*], Qiaoling Lin[1,2], Xingyu Huang[1], Martijin Wubs[1,2], Sanshui Xiao[1,2]

P31. In-Liquid Scattering Scanning Near-Field Optical Microscopy using Thin Polaritonic Membranes 30
Kevin George Alex*, Rutuja Ainapure, Enrico Baù , Andreas Tittl

P32. Exciton Polaritons vs Plasmons Polaritons: Nonlocal corrections, confinement and loss 30
Yonatan Gershuni [1,2,3,4,*] , Itai Epstein[1,3,4]

P33. TBD 31
Tobias Gokus, Korbinian Kaltenecker

P34. Imaging of Complexity in vdW Magnets: From Spin Glass State to Stacking Fault-Induced Subsystems .31
Sergey Grebenchuk[1]*, Makars Šiškins[1], Maciej Koperski[1,2], K. S. Novoselov[1,2]

P35. Imaging electron-phonon coupling in graphene moiré superlattice 32
Ziqi Han[1], Yuyang Wu[1], Xiao Lin[1], Hong-Jun Gao[1,2], Lili Jiang[1]

P36. Silicon On-Chip Light Sources Based on MoS_2/WSe_2 Heterobilayers.....32
Xingyu Huang[1]*, Hanlin Fang[1], Martijn Wubs[1], Sanshui Xiao[1]

P37. Observation of spin chirality with nonlinear optics 33
Youqiang Huang[1]*, Tiago V. C. Antão[2], Adolfo O. Fumega[2], Mikko Turunen[1], Yi Zhang[1], Hanlin Fang[3], Nianze Shang[1], Juan C. Arias-Muñoz[1], Fedor Nigmatulin[1], Hao Hong[4], Andrew S. Kim[5], Faisal Ahmed[1], Hyunyong Choi[5], Sanshui Xiao[3], Kaihui Liu[4], Jose L. Lado[2], Zhipei Sun[1]

P38. Magnetoabsorption as a source for spin polarization in 2D systems 33
Gabriel M. Jacobsen[1,2]*, Vinicius A. de Oliveira[1], Baolai Liang[3], Morgan E. Ware[2],
Gregory J. Salamo[2], Yuriy I. Mazur[2], Gilmar E. Marques[1], Victor Lopez-Richard[1],
and Marcio D. Teodoro[1]

P39. Probing Theoretical Limit of Polaritonic Loss in Isotopically Engineered hBN 34
Minsoo Jang and Min Seok Jang

P40. SQUID-on-Lever, the hybrid scanning probe with sub-100 nm spatial resolution 36
Daniel Jetter, Timur Weber, Jan Ullmann, Simon A. Koch, Simon F. Pfander, Katharina Kress, Andriani Vervelaki, Boris Gross, Oliver Kieler, Ute Drechsler, Priya R. Baral, Arnaud Magrez, Reinhold Kleiner, Armin W. Knoll, Martino Poggio, and Dieter Koelle

P41. Hyperbolic Metasurfaces as Platforms for Purcell Enhancement of Quantum Emitters in 2D Materials 37
Manobina Karmakar

P42. Imaging of plasmon-phonon polaritons in wide bandgap semiconductors 37
Irmantas Kasalynas

P43. Facile Van der Waals hBN Encapsulation and Stabilization of Perovskite Quantum Dots Emission 37
Jiyun Kim[1,2*], Karin Yamamura[1,2], Jake Horder[1,2], Igor Aharonovich[1,2]

P44. Nanometer-Scale Cavities For Mid-Infrared Radiation via Image Phonon Polariton Resonators 38
Michael Klein[1]*, Yonathan Gershuni[1], Alisa Perutski[1] , Jean-Paul Hugonin[2], Itai Epstein[1,3,4]

P45. Optically Addressable Molecular Spins at 2D surfaces 38
XuanKai Zhou, Yan Tung Kong, Cheuk Kit Cheung, Ruoming Peng, Jörg Wrachtrup

P46. Emergence of Chiral Polaritons in CrSbr via In Situ Twisting.....39
S. Kovalchuk[1]*, A. Dewambrechies[1], N. S. Mueller[1], O. Yücel[1], Y. Yu[1],
G. Lopez-Polin[2], I. Horcas[2], S. Manas Valero[3], E. Coronado[3], K. I. Bolotin[1]

P47. KPFM on Molecular 2D TMDC Heterostructures 39
Mira Kreßler*, Marleen Hußmann, Qing Cao, Fabian Grote, Siegfried Eigler, Patryk Kusch

P48. 40
P49. Photophysical Properties of Yellow Quantum Emitters in Electron-Irradiated Hexagonal Boron Nitride 41
Sonya Kukulina[1,2]*, Julien Chénedé[1,2], Mouli Hazra[1,2], Tobias Vogl[1,2]

P50. Ultrafast dnamics in strain-engineered 2D semiconductors 41
Abhijeet Kumart1*, Douglas J. Bock, Denis Yagodkin, Edith Wietek, Bianca Höfer, Max Sinner, Adrián Dewambrechies, Pablo Hernández López, Sviatoslav Kovalchuk, Raghav Dhingra, Sebastian Heeg, Cornelius Gahl, Florian Libisch, Alexey Chernikov, Ermin Malic, Roberto Rosati, Kirill I. Bolotin

P51. Spatially resolved current-induced phenomena in $tMoTe_2$ 42
M. Labendik[1],†, T. Xiao[1],† , F. Xu[2],† , W. Zhi[1], H. Zhou[1,2], T. Li[2,3] and E. Zeldov[1]

P52. Wideband superresolution covariance magnetometry: from techniques to probing spin dynamics in the van der Waals magnet $Cr_2Ge_2Te_6$ 43
Xuan Hoang Le[1,2]*, Morgan Thinel[1,2,3], Yunfeng Shui[2], Chengfeng Zhu[2], Pavel Dolgirev[1], Piotr Put[1,2], Arjun Pillai[2], Alex Cui[1,3], Eugene Demler[4], Nikola Maksimovic[5], Philip Kim[1,3], Hongkun Park[1,2], Mikhail Lukin[1]

P53. Tunable Many-Body Effects in Multilayer Graphene Probed by Quantum Twisting Microscopy 44
Jiazhuo Li[1,2], Moyu Chen[1,2], Maximilian Daschner[1,2], Mudit Bhatt[1,2], Ashwin Vadlamani[1,2], Joshua Williams[1,2], Philipp Altpeter[1,2], Christian Obermayer[1,2], Kenji Watanabe[3], Takashi Taniguchi[3], Dmitri K. Efetov[1,2†]

P54. Spin Orbit Interactions of Light for Resonance Fluorescence Measurements 45
Anton Lögl[1]*, Wenze Lan[1], Meryem Benelajla[2], Clemens Schäfermeier[3], Khaled Karrai[3], and Bernhard Urbaszek[1]

P55. Interaction Between Vibrational, Electronic, and Magnetic Degrees of Freedom in CrSBr....46
Daria Markina[1]*, Priyanka Mondal[1], Lukas Krelle[1], Sai Shradha[1], Mikhail M. Glazov[2], Regine von Klitzing[1], Kseniia Mosina[3], Zdenek Sofer[3], and Bernhard Urbaszek[1]

P56. Local Tuning and Reversible Lateral Nanofocusing of Hyperbolic Phonon Polaritons 46
Jacob T. Heiden[1], Haozhe Tong[2,3], Yongjun Lim[4], Heerin Noh[5],

Pablo Alonso-González[6,7], Alexey. Y. Nikitin[2,8], Seungwoo Lee4[,5],

Sergey G. Menabde[1]∗, and Min Seok Jang[1]*

P57. Spectroscopy of Wigner crystal polarons in an atomically thin semiconductor 47
F. Menzel[‡1]*, L.Wang[‡1], F. Pichler[‡2,3], P. Knüppel[1], K. Watanabe[4], T. Taniguchi[5],

M. Knap[2,3], T. Smoleński[1]

P58. Temperature-Dependent Optical and Polaritonic Properties of Excitons in hBN-Encapsulated Monolayer TMDs 48
Matan Meshulam[1,2], Anabel Atash Kahlon[1], Yonatan Gershuni[1,2], Thomas Poirier[3],

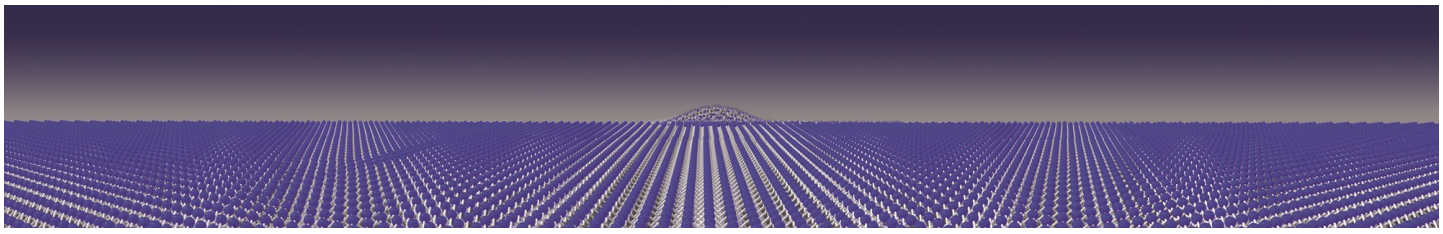
James H. Edgar[3], Seth Ariel Tongay[4], Itai Epstein[1,5,6,*]

P59. Ultrafast and ultracold nanoscopy of 2D materials 49
Lars Mester

P60. Quantum Electrodynamics of excitons in Bilayer Graphene 49
Abraham Nava-Mireles*, Lorenzo Orsini, Frank HL Koppens

P61. Rabi oscillations of a monolayer quantum emitter driven through its excited state 50
Victor N. Mitryakhin[1]*, Ivan A. Solovev[1], Alexander Steinhoff[1], Jaewon Lee[2], Martin Esmann[1], Ana Predojević[2], Christopher Gies[1] and Christian Schneider[1]

P62. Twist-tuned exchange and hysteresis in a bilayer van der Waals magnet....50
Priyanka Mondal [1]*, Sonu Verma [2], Wenze Lan [1], Lukas Krelle [1], Ryan Tan [1], Regine von Klitzing [1], Kenji Watanabe [3], Takashi Taniguchi [3], Kseniia Mosina [4], Zdenek Sofer [4], Akashdeep Kamra [2], Bernhard Urbaszek [1]



P63. General purpose magnetometer – Comparison of scanning NV, MFM and MOKE.....51
Andrea Morales,

P64. Charge density wave phase transition in 1T-TaS_2.....53
Zixuan Ning*, Yi Zhang, Zhipei Sun

P65. An ultrastable open cavity platform for closed-cycle cryostats and high magnetic fields.....53
Jonathan Noé

P66. THz Nanoscopy and Sum-Frequency Microscopy of Structural Domains in van der Waals Quaternary Oxides 53
Dorothée S. Mader[1], Gonzalo Alvarez-Perez[2], Niels Bruby[3], Xiaosheng Yang[4], Richarda Niemann[1], Maximilian Obst[5], Nele Stetzuhn[3], Eduardo Ortega[1], Elena Gelzinyte[1], Sabrina Juergensen[3], J. Michael Klopf[6], Sebastian F. Maehrlein[1,5,6], Martin Wolf[1], Lukas Eng[5], Susanne Kehr[5], Christian Carbogno[1], Stephanie Reich[3], Kirill Bollotin[3], Peining Li[4], Niclas S. Mueller[1,3], and Alexander Paarmann[1],*

P67. Polariton Jackiw Rebbi Edge States in hBN/WSe2 Double Grating Heterostructures 54
Oscar Palma Chaundler

P68. Programmable phonon-assisted resonant energy transfer between moiré cells in charge-tunable $MoSe_2$-WS_2 moiré superlattices 54
P. Parzefall[1]*, N. Paulik[1], C. Serati de Brito[2], J. Göser[3], J. Trapp[3], K. Watanabe[4], T. Taniguchi[5], D. Erkensten[6], G. Meneghini[6], Y. Galvão Gobato[2], E. Malic[6], A. Högele[3], C. Schüller[1]

P69. Time-resolved near-field spectroscopy of III-V semiconductor core-shell nanowires.....55
Andrei Luferau[1,2], Maximilian Obst[2], Stephan Winnerl[1], Alexej Pashkin[1]*, Susanne C. Kehr[2], Emmanouil Dimakis[1], Felix G. Kaps[2], Thales V. A. G. de Oliveira[1], Lukas M. Eng[2], Manfred Helm[1,2]

P70. Transferable Mirrors for Strong Light–Matter Coupling in Two-Dimensional Materials.....56
Atanu Patra*, Subhamoy Sahoo, Johannes Düreth, Simon Betzold, Sven Höfling

P71. Geometry-Induced Enhancement and Tunability of Silver Nanocube–SiC Phonon-Polariton Cavities....57
Alisa Perutski[1]*, Michael Klein[1], Jean-Paul Hugonin[2], Itai Epstein[1]

P72. Growth and characterization of 3R – MoS_2.....58
Gabriele Politi*[1], Elena Blundo[1], Kalaiarasan Meganathan[2], Zdeněk Sofer[2], Jonathan J. Finley[1]

P73. Enhanced absorption of interlayer excitons in bilayer MoS_2 via Purcell engineering of critical coupling 58
Saroj Poudyal[1], Anabel Atash Kahlon[1], Michael Klein[1], Matan Meshulam[1], Thomas Poirier[2],
James H. Edgar[2], Seth Ariel Tongay[3], Itai Epstein[1,4,5,*]

P74. Gate-Tunable Excitonic Features in TMD Monolayers and Heterostructures.....59
Laura Rojo Guerrero[1*], Niklas Schmidt[1], Elena Blundo[1,2], Jonathan J. Finley[1,3]

P75. Topological Zero Modes in Graphene Chevrons: Fabry–Pérot Control Toward Qubit Applications 59
Boris Rotstein*, Eric Akkermans

P76. Isotope Engineered Symmetry Breaking in Polar van der Waals Crystals.....60
Nihar Ranjan Sahoo[1], Thiago S. Arnaud[2], Ryan Spangler[3], Jon Paul Maria[3], Josh Caldwell[2] and Thomas Folland[1*]

P77. Fast Programming of In-Plane Hyperbolic Phonon Polariton Optics through van der Waals Crystals using the Phase-Change Material In_3SbTe_2 61
Umberto Saldarelli[1]*, Lina Jäckering[1], Lukas Conrads[1], Matthias Wuttig[1], Pablo Alonso-González[2,3], and Thomas Taubner[1]

P78. ZrNCl: A Wide-Bandgap 2D Semiconductor to Twisted Superconductivity 62
Soumyajit Samal[1,2*,] Jules Lefeuvre[1,2], Sushmita Chandra[3], Claudia Felser[3],
B. Andrei Bernevig[4,5,6], Dmitri K. Efetov[1,2]

P79. Oscillator strength of electrostatically confined excitons 63
Moritz Scharfstädt[1]*, Lefan Dolg[2], Max Wegerhoff[1], Michael Köhl[1], Stefan Linden[1], Bernd Beschoten[2], Christoph Stampfer[2], Lutz Waldecker, Dante Kennes[2], Silvia Kusminskiy[2], and Andrea Bergschneider[1]

P80. Interlayer coupling in a magnet/semiconductor 2D heterostructure 63
Niklas H.T. Schmidt*[1], Elena Blundo[1,2], Riccardo Silvioli[1], Andreas V. Stier[1], Jonathan J. Finley[1,2]

P81. Towards establishing a sample-independent phase diagram of magic-angle twisted bilayer graphene .64
Giorgio Di Battista*[1], Leon Schubert[1], Jaime Díez-Mérida[2], Simrandeep Kaur[1], Kenji Watanabe[3], Takashi Taniguchi[4], Dmitri K. Efetov[1,5],

P82. Nano-electrical characterization of moiré systems 64
Suhail Shah[1], Ankit Sharma[1], Mirko Bacani[1], Balazs Sipos[1], Jiacheng Zhu[2], Kin Fai Mak[2,3]

P83. Cryogenic scanning quantum sensing of emergent magnetic textures 65
Ankit Sharma[1]*, Clemens Schäfermeier[1], Christopher Kelvin von Grundherr[1], Mirko Bacani[1], Dieter Andres[1], Khaled Karraï[1], Andrea Morales[2], Jan Rhensius[2], Gabriel Puebla-Hellmann[2]

P84. Interlayer Excitons in CVD Grown Lateral/Vertical Heterostructures 65
Sai Shradha[1]*, Luc F. Oswald[1], Md Tarik Hossain[2], Lukas Krelle[1], Julian Führer[1], Nicole Engel[1], Daria I. Markina[1], Andrey Turchanin[2], Bernhard Urbaszek[1]

P85. Fingerprint of magneto-optical Faraday rotation in Raman spectra of MoS_2 66
Florian Sigger[1],*, Thomas Dieing[2], Sabrina Hakelberg[2], Patrick Altmann[2], Shadi Sorayya[1], Mirko Bacani[1]

P86. Ultimate Precision Navigation in Cryogenic Confocal Microscopy: The CFM Base Kit with trueNAV 67
Florian Sigger[1]*, Anna Rupp[2], Félice Dierick[2], Alexander Högele[2] Tobias Lindenberg[1], Julia Bürger[1], Roman Rück[1]

P87. Purcell-enhanced quantum yield of spin defects using open resonators 67
Anuj Kumar Singh[1], Atanu Patra[1], Paul Konrad[2], Subhamoy Sahoo[1], Simon Betzold[1], Vladimir Dyakonov[2,3], Sven Höfling[1,3]

P88. Probing high-bias criticality via near-field photovoltage in a bilayer graphene moiré superlattice 68
Subhajit Sinha[1]*, Sergi Batlle Porro[1]*, Riccardo Bertini[1], Xueqiao Wang[2], Joep Kapma[1], Site Li1, Paul Jais[1], Sergio Salvia[1], Kenji Watanabe[3], Takashi Taniguchi[3], Pablo Jarillo-Herrero[2], Roshan K. Kumar[1,4], Frank H. L. Koppens[1,5]

P89. Bulk–Surface Electronic Contrast in 2D β-Sb_2O_3 69
Thamires C. Soares[1,2*], Wesley Kardex C. de Oliveira[1], Catalina Ruano Merchán[1], Alan C. R. Souza[3], Helio Chacham[3], Mario S. C. Mazzoni[3], Alisson R. Cadore[4,5], Luiz Fernando Zagonel[1], Ingrid D. Barcelos[2]

P90. Polariton memory in a van der Waals antiferromagnet 70
Philip Soul[1]*, Güven Budak[2, 3], Rafał Komar[4], Emroz Khan[5, 6, 7], Kseniia Mosina[9], Zdenek Sofer[9], Sebastian Bange[1], Vinod M. Menon[5, 8], Andrea Alù[5, 6, 7], John Lupton[1],Florian Dirnberger[2, 3, 10]

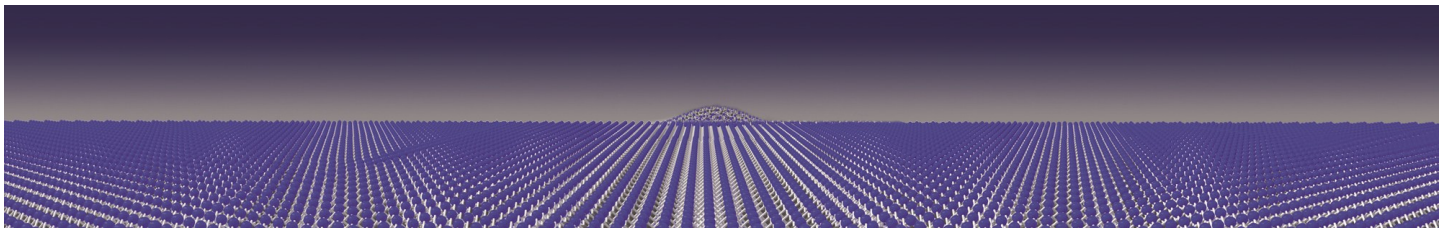
P91. Substrate Driven Polariton Phenomena in Graphene Nanoribbon Heterostructures 71
Sabina Špoljar[1,2]*, Janja Vuković[1,3], Ana Jurković[1,3], Ana Senkić[1,4], Šimun Mandić[1,2], Gabriela Borin Barin[5], Zdeněk Sofer[6], Nataša Vujičić[1], Marko Kralj[1,2]

P92. Dimensionality-Dependent Exciton Dispersion in a Single-Band Mott Insulator 72
Zhibin Su

P93. Revealing enhanced magnetic interactions in Ni-Substituted Fe_5GeTe_2 by scanning quantum microscope 72
Yumeng Sun[1], Ruoming Peng[1], Fazhan Shi[2], Jorg Wrachtrup[1]

P94. Stability Analysis of MXene Materials in the Context of Substrate-Isolated Deposition 72
Michał Szczęsny*, Anna Dychalska, Mirosław Szybowicz

P95. Edge polaritons at metal-insulator boundaries in a phase separated correlated oxide 73



Javier Taboada-Gutiérrez[1], Weiwei Luo[1,2], Adrien Bercher[1], Claribel Dominguez[1], Javier del Valle[3,4], Jérémie Teyssier[1] & Alexey B. Kuzmenko[1]

P96. Magnetic-induced p-doped Wigner crystal dressed exciton in WSe_2 74
Xintong Tan[1]*, Ningyuan Chen[1], Yingzhou Huang[1], Xinyue Huang[1,2,] Yu Ye[1,3,4†]

P97. Electrostatic Control of Moiré Exciton-Polaritons 75
Julian Trapp

P98. Local photoconductivity dynamics in semiconductors investigated by THz near-field microscopy 75
T. Troha*, H. Němec, P. Kužel

P99. High-Energy Interlayer Exciton Ensembles in $MoSe_2/WSe_2$ Heterostructures by Laguerre-Gaussian Excitation 76
Mirco Troue,[1, 2] Johannes Figueiredo,[1, 2] Gabriel Mittermair,[1, 2] Jonas Kiemle,[1, 2] Sebastian Loy,[1, 2] Hendrik Lambers,[3] Takashi Taniguchi,[4] Kenji Watanabe,[5] Ursula Wurstbauer,[3] and Alexander W. Holleitner[1, 2]

P100. Towards Quantum Twisting Microscopy of Twisted Bilayer Graphene: Clean Stack Assembly utilizing van der Waals sliding 77
A.Vadlamani[1], M. Bhatt[1], M. Chen[1], J. Li[1], M. Daschner[1], S. Kaur[1], L. Benoist[1], B. Brouwer[1], P. Altpeter[1], C. Obermayer[1], A. Heindl[1], K. Watanabe[2], T. Taniguchi[2], G. Di Battista[1], D. K. Efetov[1]

P101. Excitons in Monolayer-hBN-Separated WSe_2 Bilayers 77
Miao.Wang1*, Ting-Jing Sun1, Zhen-Zhou Gao1, Kai-Qiang Lin1

P102. Coherent interaction of exciton states in TMDC monolayers 78
Max Wegerhoff*, Moritz Scharfstädt, Stefan Linden, Andrea Bergschneider

P103. Modal Phase Matching and Hybrid Integration for 3R-MoS_2 Nonlinear Nanophotonics 78
O. Williams,,* O. Wolley, D. Gillard, X. Hu, and A.Tartakovskii

P104. Excitonic dynamics in 2D materials revealed by THz excitation 80
T. Venanzi[1], E. Wietek[1,2], K. Mavridou[3], E. Uykur[3], D. Kim[4], L. Ju[4], M. Helm[1,3],
A. Chernikov[1], S. Winnerl[3]*

P105. Compact, open, and tunable two-dimensional Fabry-Pérot cavity 81
Bruno Bender, Andrea Bergschneider, Marcel Baer, Martin Kroner, and Wolf Wüster*

P106. Giant edge magnetism from current-driven valley splitting across the topological gap 81
Tianyi Xiao

P107. Mid-Infrared Driven Modulation of Single-Photon Emitters in Hexagonal Boron Nitride 81
Karin Yamamura[1, 2]*, Xinyang Yu[1, 2], Chaohao Chen[1, 2], Mehran Kianinia[1 ,2], Christophe Galland[3] , Igor Aharonovich[1, 2]

P108. Quantum Optical Twist and Scan Microscopy 82
F. Emre Yazici[1]*, Takahiro Uto[1], Johannes Eberle[1], Stefan Fält[1,2], Martin Kroner[1], Shahal Ilani[3] and Atac Imamoglu[1]

P109. Near-field refractometry of van der Waals crystals 82
Martin Nørgaard,[1] Torgom Yezekyan,[1,2] Stefan Rolfs,[2] Christian Frydendahl,[2,3] N. Asger Mortensen,[1,4] and Vladimir A. Zenin[2]

P1. Intrinsic plasmon canalization in the natural biaxial van der Waals material $MoOCl_2$

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We investigate directional, natural near-infrared plasmon polaritons in mechanically exfoliated bulk molybdenum oxychloride ($MoOCl_2$) flakes on SiO_2 substrates. $MoOCl_2$, a natural van der Waals material, supports low-loss, in-plane hyperbolic plasmon-polaritons across the visible and near-IR spectral ranges and exhibits a unique biaxial optical response depending on the polarization of the incident light. When the polarization aligns with the flake's short axis, $MoOCl_2$ behaves metallic, whereas alignment with the long axis yields a dielectric response [1-3]. To probe spatial dispersion across a wide infrared spectrum, we utilize near-field excitation and detection using a scattering-type scanning near-field optical microscope, in combination with a widely tunable Stuttgart Instruments IR laser. Gold nanoantennas of 20 nm thickness and a size of 0.6 µm × 1 µm are fabricated on the $MoOCl_2$ flakes, which allow coupling IR light into plasmon-polaritonic modes. Tuning the Stuttgart Instruments laser across a wide infrared wavelength range from 2.3 – 7 µm lets us map the propagation behavior of the plasmon polaritons. We find intrinsic plasmon canalization around 4.6 µm wavelength for a flake thickness of 45 nm, just where the dispersion of $\varepsilon(\omega)$ crosses zero. At higher wavelengths the dispersion is elliptical, whereas for shorter wavelengths, it is hyperbolic. In the future, we will explore the potential to utilize this directional plasmon canalization effect for coupling between dimer elements, oligomers, waveguides, as well as coupling to quantum emitters or molecular vibrations.

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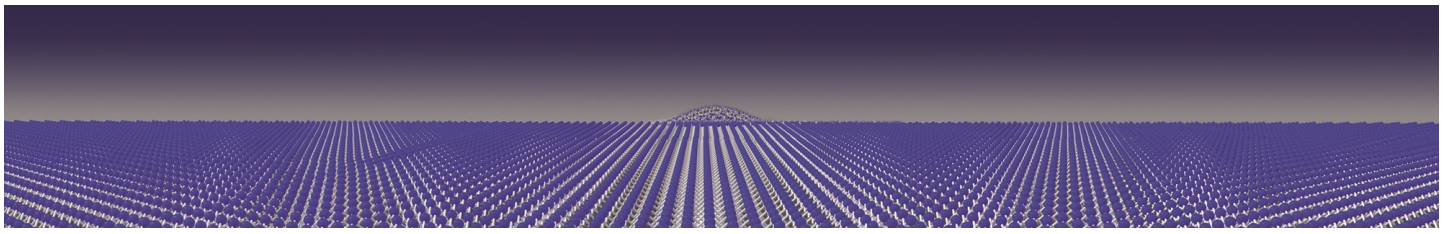

P2. High-Performance Ultrathin MoS_2 Nanoribbon Phototransistors

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Two-dimensional transition metal dichalcogenides, especially MoS_2, are promising materials for future nanoscale optoelectronic devices because of their atomically thin nature, strong light–matter interaction, and excellent gate control. Nanoribbon channels are particularly attractive because reducing the channel width can enable highly scaled device architecture. However, fabricating MoS_2 nanoribbons at tens-of-nanometers dimensions remains challenging. Monolayer TMDs are vulnerable to delamination during lithography, etching, and wet processing. In addition, aggressive patterning can introduce edge roughness, surface contamination, lithography-induced defects, poor contact formation, and edge-related scattering, all of which may degrade transport and photo response. These challenges make it important to evaluate whether ultrathin MoS_2 nanoribbons can maintain reliable electrical and optoelectronic performance after fabrication.

In this work, MoS_2 nanoribbon phototransistors with channel widths down to 20 nm were fabricated and characterized with channel length in few tens of nm. Electrical measurements show clear gate-tunable transistor behavior, with drain current strongly modulated by both gate voltage and drain-source bias. Dark-current measurements further confirm bias-dependent transport across the nanoribbon devices. Phototransistor performance was investigated under visible spectrum. All devices show enhanced photocurrent compared with dark conditions, confirming successful light detection. The fabricated ultrathin phototransistors showed strong light-detection performance in terms of responsivity, detectivity and external quantum efficiency. Time-dependent measurements demonstrate repeatable photocurrent switching under different wavelengths, indicating stable and reversible photo response. Overall, these results suggest that ultrathin MoS_2 nanoribbons can overcome key fabrication challenges and serve as promising candidates for high-performance visible-light photodetectors and future nanoscale optoelectronic systems.

P3. Scanning Near-Field Optical Microscopy in Liquid with Graphene

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Photoswitchable lipids are molecular tools for controlling lipid bilayer properties with light. Recent studies have shown that scattering-type scanning near-field optical microscopy enables the investigation of photoswitching dynamics at the single vesicle level. However, this approach is limited by constraints in measurement stability and sensitivity when probing soft matter systems in aqueous environments. Here, we address these limitations by enhancing near-field spectroscopic measurements through the use of an ultrathin graphene capping layer. Graphene enables improved confinement and protection of the sample while maintaining accessibility for near-field probing. We demonstrate an approach combining graphene encapsulation with near-field spectroscopy to investigate photoswitchable lipid systems. We aim to resolve photoswitching dynamics with higher

spatial resolution and improved signal sensitivity compared to existing methods, enabled by the exceptional mechanical strength and atomic thickness of graphene. This work is expected to advance the study of light-controlled lipid systems and, in the future, may contribute to applications in drug delivery, nanocarrier design, and controlled release systems.

P4. Controlling the spin-polarized light emission of an antiferromagnetic 2D material

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Van der Waals (vdW) magnetic materials have emerged as a primary platform for studying the interplay between magnetic order and optical properties. In particular, the metal phosphorus trichalcogenides (MPX_3) are a family of layered antiferromagnetic materials with promising capabilities for spintronic technologies. Among them, $NiPS_3$ and $FePS_3$ have already shown a remarkable coupling between antiferromagnetic ordering and excitonic effects, as evidenced by polarization-resolved magneto-optical experiments. In contrast, the optical anisotropy of $MnPS_3$ remains underexplored.

Previous reports observed a signature of the antiferromagnetic transition of $MnPS_3$ in its photoluminescence (PL), where both the emission energy and integrated intensity of the PL peak exhibit a transition at the Néel temperature (T_N = 78 K). While this result demonstrates that the magnetic phase plays a major role in the optical phenomena of $MnPS_3$, a detailed investigation of the optical anisotropies is fundamental to comprehending how light emission couples to the spin polarization in $MnPS_3$.

Here, we employ polarization-resolved PL experiments under different conditions for a 2D $MnPS_3$, revealing a strongly modulated anisotropic optical response. We observe a transition of the PL anisotropic orientation and degree of linear polarization (DLP) at the Néel temperature, evidencing a spin-polarized light emission. We demonstrate that this anisotropy depends on the polarization and energy of excitation. While the PL anisotropy is increased for co-polarized excitations, the emission orientation and DLP are distinct for on-resonance and off-resonance excitations. Finally, we show that an external out-of-plane magnetic field also impacts the $MnPS_3$ optical anisotropy, in agreement with the induced spin reorientation. These results highlight a potential use for tuning polarization effects in $MnPS_3$, providing a new perspective on the spin-polarization-driven optical properties of 2D magnets.

P5. Mem-emitting capabilities in a device based on Clinochlore/$MoSe_2$

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Layered materials (LMs) have attracted significant interest since the successful isolation of single atomic layers, or monolayers (1Ls), notably exemplified by graphene [1]. Within this class, transition metal dichalcogenides (TMDs) are particularly prominent due to their semiconducting nature and distinctive electronic properties [2]. As the monolayers are typically encapsulated by an insulator, researches are exploring alternative insulating substrates that enable novel functionalities in two-dimensional (2D) materials, while enhancing the photoluminescence (PL) emission quality [3,4].
Clinochlore, an atomically flat and lamellar phylosilicate mineral, represents one such insulating material. Due to its natural origin, clinochlore contains defects and impurities, as well as water nanochannels with an ice-like structure [4], which can interact with 1L-TMDs and give rise to new physical phenomena, including memory capabilities [5]. Hysteresis is a tipical feature of electrical memory devices, indicating the capacitity of the device to retain physical properties and modulate them by external stimuli, but it is poorly explored to optical emissions [5]. Recently, the interaction between the substrate and the emergence of a memory behavior was observed in a gated device comprising a 1L-MoSe2 on clinochlore [6]. In this device, called a memory-emitting device (mem-emitter), the photoluminescence emissions of excitonic complexes were modulated by external electric fields and other external parameters (e.g., excitation laser power and voltage sweep time), showing a hysteretic behavior for both emission energy and intensity. These emissions are modulated by transient changes in internal variables, such as polarization and charge dynamics resulting from the interaction with the clinochlore substrate [5,6]. The study of this mem-emitter device elucidates the potential for natural insulators to facilitate emergent optoelectronic phenomena in 2D semiconductors.
Acknowledgements to FAPESP, CNPq and CAPES for the funding.

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P6. Rotational AFM/CFM for quantum optical twisting microscopy

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Moiré systems created by twisting stacked 2D van der Waals materials form an rich playground for studying a wide variety of physical phenomena [1]. Quantum twisting microscopy (QTM) enables tunability of electrical, optical and magnetic properties in situ [2], and realizes various momentum-resolved probing techniques, that are equivalent of STM and SET, along with the classic transport are realized [3]. Here we present preliminary results with a rotational atomic force microscopy/confocal microscopy (AFM/CFM) platform designed for quantum optical twisting microscopy (QOTM), implemented in ultra-low-vibration closed-cycle cryostat attoDRY2200. The microscope employs self-sensing piezoresistive cantilevers [4] and supports two configurations that allow either tip or sample rotation with direct in-situ optical tracking via a high-NA LT-APO objective.

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P8. Importance of pure dephasing in the optical response of excitons in high-quality van der Waals heterostructures

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Excitons in monolayer transition metal dichalcogenides (TMDs) dominate their optical response due to exceptionally large binding energies arising from their two-dimensional nature. Understanding their physical behavior and accurately modeling their response is crucial for both fundamental research and the development of TMD-based optoelectronic devices. In recent years, several theoretical models have been proposed to describe this excitonic behavior, however, it remains unclear which model most accurately captures the underlying physical properties of the response.
Different models present distinct perspectives on exciton physics, relating to various physical constituents in the description of the optical response of excitons in monolayer TMDs. While some models characterize the optical response using two parameters (radiative and non-radiative decay rates), others incorporate additional ones, such as pure dephasing or inhomogeneous broadening, to capture more subtle effects.

In this study [1], we experimentally measure the optical response of excitons in hBN-encapsulated monolayer TMDs at various temperatures and compare it to different theoretical models proposed in the literature. This comparison enables evaluation of which model most appropriately describes the excitonic optical response, with direct implications for predicting excitonic behavior in complex heterostructures and optoelectronic devices.
We examine the accuracy of the different models by calculating the root mean square (RMS) error as a figure-of-merit for fitting to experimental reflection contrast measurements at various temperatures. Our analysis reveals that the model accounting for quantum mechanical interactions in the form of quantum pure dephasing univocally exhibits the best fit to the experimental results across all different materials and configurations. This finding demonstrates that quantum pure dephasing plays a dominant role in high-quality TMD heterostructures compared to classical decay mechanisms or inhomogeneous broadening effects. These findings establish a robust framework for understanding and predicting the optical properties of TMD-based heterostructures, crucial for both fundamental research and optoelectronic applications.

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P9. Phase Modulation in the Visible Spectrum Using Nanocube Resonators

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While metasurfaces have demonstrated efficient phase manipulation, their implementation in the visible regime typically relies on complex nanofabrication and is limited in scalability. Nanocube systems provide an alternative platform for manipulating light at the nanoscale, as each nanocube can act as an individual antenna supporting strongly confined gap-plasmon modes. When metallic nanocubes are placed near a metallic substrate, localized cavity resonances form in the nanometric gap, enabling strong interaction with the incident field. In this work, we explore the potential of such nanocube-based resonators to enable phase control in the visible spectral range. Building on previous demonstrations of near-perfect absorption in nanocube systems, we investigate a configuration in which the nanocubes replace conventional lithographic metasurface elements. By incorporating an active material, such as indium tin oxide (ITO), into the gap region, we aim to electrically tune the optical response and provide a route toward dynamic control of the reflected phase. Our approach offers a scalable and fabrication-friendly alternative to conventional metasurface designs, opening new possibilities for compact and tunable optical elements operating in the visible regime.

P10. Visualizing Stray Field Distributions in Ni Micromagnets and CoRuCrSi Polycrystals via Low-Temperature Quantum Diamond Microscopy

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Over more than a decade, wide-field nitrogen-vacancy (NV) diamond magnetometry has emerged as a powerful platform for quantitative imaging of magnetic stray fields, offering sub-micron spatial resolution alongside a millimetre-scale field of view and broad applicability across condensed matter systems. Here, we present low-temperature wide-field NV magnetic imaging experiments performed using a cryogen-free attoDRY1000 closed-cycle cryostat integrated with a home-built quantum diamond microscope (cryo-QDM). In the first set of experiments, we image the stray field distributions of lithographically patterned arrays of Ni microdisks, fabricated directly on the diamond surface. Wide-field ODMR measurements before and after in-plane (easy-axis) magnetization, compared with micromagnetic simulations, provide a direct quantitative benchmark of the sensor–sample standoff, spatial resolution, and magnetic sensitivity of the cryo-QDM setup.
Next, we investigate the unusual low-temperature magnetic phase of the bulk quaternary Heusler alloy CoRuCrSi. Bulk magnetization measurements identify a transition near 20 K, with the virgin M–H curves exhibiting a slope anomaly at a characteristic penetration field H_p, demarcating a region in H–T space hosting a suspected unusual magnetic phase. Wide-field imaging in zero-field-cooled (ZFC) and field-cooled (FC) states, as a function of applied field and temperature, reveal the emergence of spatially extended, filamentary magnetic clusters whose size and contrast are strongly dependent on the preparation protocol and thermodynamic coordinates. Spatial surveys over a 500 × 300 μm² area confirm the inhomogeneous nature of these stray-field textures, and zero-field ODMR measurements evidence significant magnetic remanence from the sample. Crucially, the filamentary domain structure uncovered here is inaccessible to bulk magnetization measurements, underscoring the indispensable role of local real-space imaging in unraveling the microscopic magnetic texture of complex ordered phases.

P11. Self-hybridized non-Hermitian exciton-polaritons in triclinic rhenium diselenide

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Polaritons, hybrid light-matter coupling between photons and various excitations in materials, such as excitons, plasmons, and phonons, have garnered significant attention in the field of nanophotonics. Recent studies have demonstrated that low symmetry crystals such as monoclinic β-Ga_2O_3, support a new type of polariton called hyperbolic shear polariton, with anisotropic and asymmetric in-plane propagation, due to non-zero off-diagonal components in the dielectric tensor even after diagonalizing its real part [1]. In this study, we investigate rhenium diselenide ($ReSe_2$), a triclinic van der Waals (vdW) crystal with reduced in-

plane symmetry. $ReSe_2$, a member of the group VII transition metal dichalcogenides (TMDCs), exhibits distinct anisotropic characteristics that set it apart from more commonly studied TMDCs (MX_2; M=Mo, W; X= S, Se). Previous literature report polarization-sensitive photoluminescence and transmission [2] in the near-infrared arising from the anisotropic excitons in $ReSe_2$, with some studies also presenting anisotropic exciton polaritons in rhenium dichalcogenides [3]. Our work employs low temperature polarized Fourier transform infrared microscopy to probe the optical anisotropy of $ReSe_2$. By measuring co- and cross-polarized reflectivity from $ReSe_2$ flakes of different thicknesses on gold, we observe rich self-hybridized anisotropic exciton-polariton branches and significant polarization conversion. We utilize transfer matrix method [4] to fit the reflectivity calculated from a dielectric function model comprising of directional Lorentzian oscillators to the experimental polarized reflectivity. This technique allows us to extract the anisotropic in-plane dielectric function of $ReSe_2$, similar to spectroscopic ellipsometry. Our results show that the two prominent excitons are non-orthogonal and result in a non-diagonalizable dielectric tensor, establishing a platform to realize elliptical shear polaritons and non-Hermitian topology. Our work provides a framework for characterizing low-symmetry vdW crystals, such as $ReSe_2$, and positions them as promising candidates for applications in directional light propagation, polarization and phase control of light, and polarization-sensitive photodetectors.

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P12. Investigating strain effects on the far-infrared optical response of $SrTiO_3$ membranes

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Phonon polaritons (PhPs), hybrid light–lattice excitations, provide strong field confinement within Reststrahlen Bands (RBs), where the real part of the permittivity is negative. SrTiO3 membranes were recently shown to host far-infrared PhPs [1, 2]. Here, we explore mechanical strain, applied using a piezoelectric strain device, to tune the vibrational and polaritonic response of SrTiO3 membranes transferred onto flexible polyimide. The strain application approach [3] is described, along with first far-field infrared measurements. Ultimately, this work aims to explore how strain can control PhP propagation, providing a versatile platform for infrared photonics.

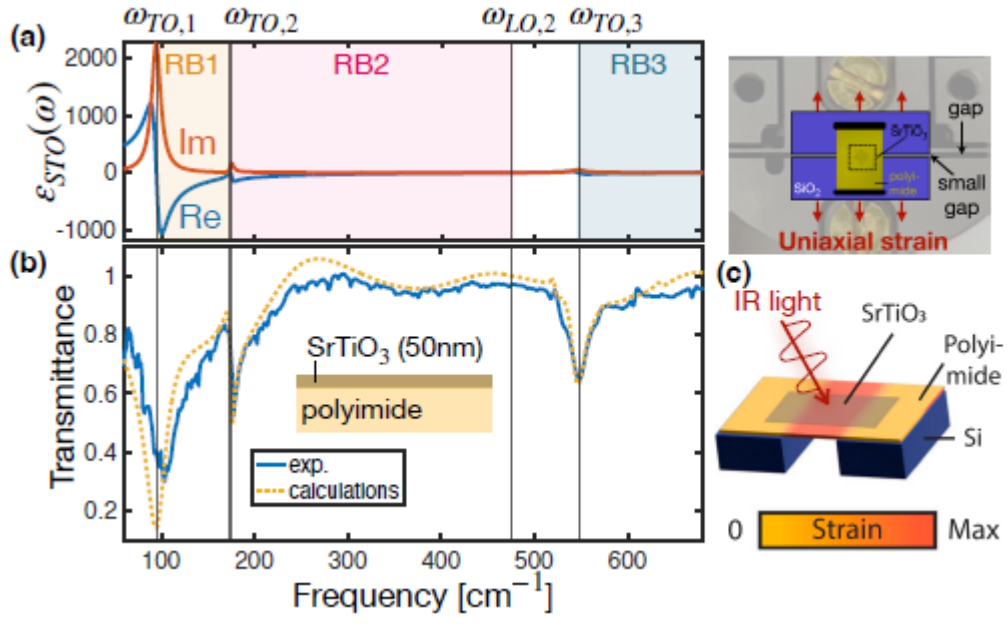

Figure 1. a) Complex dielectric function of SrTiO3, real part (blue) and imaginary part (red) of the permittivity. b) Experimental transmittance (blue) of a SrTiO3 50 nm membrane on a flexible substrate (polyimide) compared with calculations (yellow dotted line). c) Mounting of the sample on the piezoelectric strain cell.

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P13. Engineering strong bosonic correlations in 2D materials

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P14. Towards Experimental Realization of M-Point Moiré Systems

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Twisted bilayer graphene has established moiré superlattices as a platform for correlated electron physics. In contrast to the K valleys of graphene, M-point materials such as ZrS_2 and $SnSe_2$ host their lowest-energy states at the M points of the Brillouin zone, leading to three inequivalent valleys. Twisting monolayers of these materials is predicted to generate M-point moiré superlattices with an emergent kagome geometry in momentum space, leading to flat bands with momentum-space non-symmorphic symmetries. These flat bands are expected to exhibit six-flavour Hubbard physics that can host Mott insulating states, with a strongly one dimensional character[1,2,3].
Here, we report progress toward the experimental realization of M-point moiré systems. We demonstrate material preparation via mechanical gold mesh exfoliation and characterize exfoliated ZrS_2 monolayers through transport measurements. These results establish a foundation for accessing strongly correlated electronic phases in M-point moiré platforms.

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P15. Development of a Cryogenic Quantum Twisting Microscope: System Buildup, Conducted Measurements and Fabrication of Clean, Gated Twisted Devices

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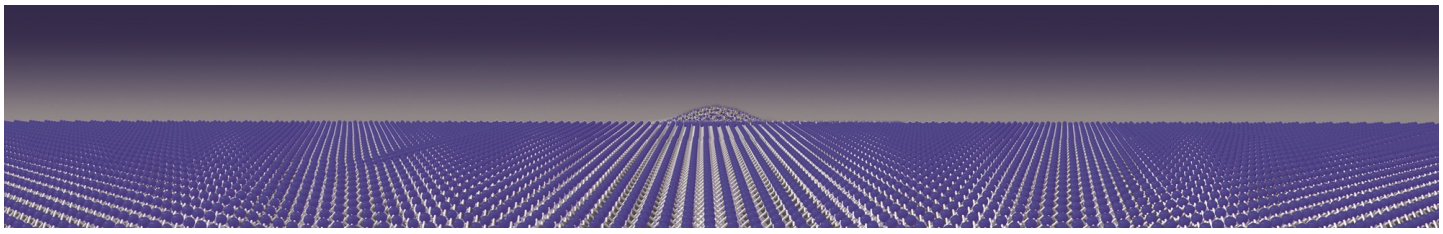
Quantum Twist Microscopy (QTM) is a local measurement technique that enables energy- and momentum-resolved tunneling spectroscopy through continuous, in-situ twisting of van der Waals materials. It has already demonstrated itself to be a versatile and powerful tool for studying band structures, both at room



temperatures by revealing interesting electron-electron interaction effects (1), as well as at low temperatures by clarifying the phonon spectrum in TBG (2) and the flat-bands in MATBG (3).
After successfully creating and operating a room temperature QTM, we here report on the working of our home-built cryogenic QTM setup. We look at the buildup process, including setting up piezoresistive movers, scanners and rotators, developing custom QTM cantilevers and combining everything in a cryogenic sample holder capable of counteracting angle mismatch between tip and sample. We then go over the operation procedure and demonstrate underlying navigational and alignment techniques. We also showcase successfully conducted measurements at both room and cryogenic temperatures. Finally, we cover the current and future plans of measurement and device optimizations, including fabrication techniques for gated twisted bilayer devices capable of tunneling as well as the development of gated graphene-based tips. The goal is to measure QTM spectra for twisted bilayer graphene devices in milli-Kelvin temperatures as well as under electric and magnetic fields in order to study novel phenomena.

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P16. Scanning-Probe and Magneto-Optical Studies of Integer and Fractional Moiré Chern Insulators

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Moiré bilayers of van der Waals (vdW) materials are a perfect playground for studying the properties of Chern insulators. We present here a selection of remarkable results achieved with attocube systems technology in labs of attocube customers with emphasis on integer and fractional moiré Chern insulators (MCIs) in vdW materials.

Scanning magnetometry of an integer MCI $MoTe_2/WSe_2$ shows that its magnetization can be flipped with a very low current [1], which is appealing for utilization in energy-efficient magnetic memories. A magneto-optical study of the same heterostructure discovered a valley-coherent nature of the quantum anomalous Hall state in this material [2]. A scanning single electron transistor (SET) study [3] established the high field flavor phase diagram of the magic angle twisted bilayer graphene (MATBG), identified earlier as an integer MCI at high field [4]. Scanning magnetometry also reveals the mosaic of MCIs with different Chern numbers induced by local variations in the Berry curvature as a function of the filling factor [5]. Moreover, MATBG can also host fractional Chern insulating states (FCIS) even in low magnetic fields $B < 12$ T [6]. Finally, FCIS that survive in $B = 0$ have been identified magneto-optically in twisted bilayer $MoTe_2$ using trion sensing [7].

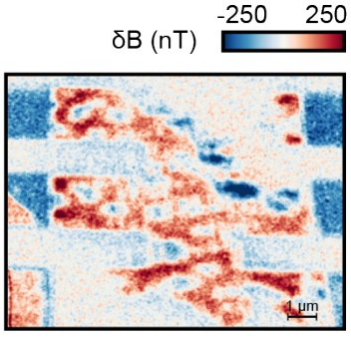

Fig.1. NanoSQUID scan of a Chern magnet with nonuniform magnetization [1]

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P17. Ferroelectric interlayer excitons with electrically switchable dipole moments in bilayer WSe_2

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Interlayer excitons in van der Waals semiconductors offer a powerful platform for exploring many-body physics and developing optoelectronic devices, thanks to their large binding energies and built-in electric dipoles. However, in conventional heterostructures, the exciton dipole direction is set by the static band alignment and is therefore difficult to actively control. Here, we show that rhombohedral bilayer WSe_2 hosts ferroelectric interlayer excitons whose permanent dipoles can be reversibly switched through sliding ferroelectricity. By applying an electric field, we drive in-plane layer sliding, which reverses the type-II band alignment and thus flips the interlayer exciton dipole. This electrically controlled switching is revealed by hysteretic Stark shifts in absorption and photoluminescence. We further show that the effect persists for charged excitonic states under electrostatic doping. Spatially resolved measurements across independently gated regions reveal programmable ferroelectric domains and enable nonvolatile multi-bit excitonic memory within a single bilayer. These results establish sliding ferroelectric semiconductors as a platform for electrically programmable excitonic devices and circuits.

P18. Role of photonic interference in exciton-mediated magneto-optic responses

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Coupled optical and magnetic excitations can give rise to remarkably strong magneto-optic responses. This is particularly evident in van der Waals magnets, such as the antiferromagnet CrSBr, where excitons and magnons emerge from the same electronic orbitals. While previous work has primarily focused on uncovering the magneto-electric origin of the resulting exciton–magnon interactions, the influence of photonic effects has received comparatively little attention. Here, we use numerical simulations to disentangle exciton–magnon coupling from the exciton-mediated magnon-photon interactions observed in optical experiments. Our simulations show the strong dependence of these interactions on photonic interference and dispersion effects near excitonic resonances. Such effects shape the optical response to coherent magnons and make it intrinsically non-linear in the magnon-induced exciton energy shift. Thermal magnons, which have a particularly pronounced impact on excitons, are found to even produce qualitatively different trends in optical signatures. Depending on weak or strong coupling of excitons and photons, the

same exciton–magnon interaction can lead to a red-shift of optical modes, a nearly vanishing response, or their blue-shift. Finally, we demonstrate first steps towards optimizing the multi-parameter problem of efficient magnon–photon transduction using a machine-learning approach.

P19. Engineering strong correlations in 2D materials

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Two-dimensional van der Waals heterostructures have emerged as a powerful, tunable platform for engineering many-body interactions and exploring emergent quantum phases. The ability to combine different atomically-thin materials with controlled crystallographic alignment enables tailoring of electronic band structures beyond conventional band theory. At the same time, quantum confinement and reduced dielectric screening at the monolayer limit strongly enhance Coulomb interactions, while electrostatic gating enables continuous control of carrier density and displacement fields. This combination provides access to a wide range of interaction-driven phenomena including Wigner crystals, Mott insulating states and tunable quantum phase diagrams. In this context, dipolar excitons offer a particularly powerful direction for investigating such collective quantum phenomena due to their long lifetimes, electrical tunability and strong interactions.

Here, we experimentally realize a heterostructure in which long-lived dipolar excitons experience a strong periodic potential by utilizing a twisted hexagonal boron nitride (hBN) bilayer to separate $MoSe_2$ and WSe_2 monolayers [1]. We observe strongly correlated fermionic states within each layer together with pronounced interlayer correlations enabled by the dual-moiré potential landscape. While these heterostructures provide a powerful platform for investigating correlated electronic phases and dipolar excitonic phenomena, homobilayer systems, such as bilayer MoS_2, have gained significant interest as a platform for interlayer excitons with enhanced oscillator strength arising from hybridization with intralayer excitons [2]. At the same time, suppressed interlayer tunneling together with atomically small layer separation opens new opportunities to explore coherent excitonic and interlayer-correlated quantum states [3].

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P20. Electrical current control of anomalous Hall effect in WTe_2/Fe_3GeTe_2 bilayers

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We demonstrate the reversible electrical manipulation of the anomalous Hall effect (AHE) in a 2-dimensional WTe_2/Fe_3GeTe_2 (FGT) stack. By pushing a charge current I in bilayer WTe_2, an unconventional z-polarized spin accumulation is generated. The spin polarized electrons act on the adjacent FGT with perpendicular anisotropy and lead to a strong modification of the AHE, $\Delta R_{AHE}/R_{AHE}$ (0), by more than 200%, where ΔR_{AHE} is the change of AHE resistance, and R_{AHE} (0) the AHE resistance for I = 0. Further study shows that the effect vanishes for pure FGT, and the modifications become weaker for thicker FGT films, indicating the modification is an interfacial effect resulting from the absorption of the spin accumulation. We propose that the z-polarized spin current modifies the exchange splitting of FGT[1], which leads to a modification of the Berry curvature and affects the AHE in a nontrivial way. The electrical control of AHE by the z-polarized spin current in van der Waals perpendicular magnet shows potential applications for next-generation spintronic devices and opens doors for future control of quantum magnets.

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P21. Resolving Symmetry-broken States with Quantum Twisting Microscope in Rhombohedral Graphene

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P22. Characterizing carbon doping in hBN utilizing near-field hyperbolic phonon-polariton propagation

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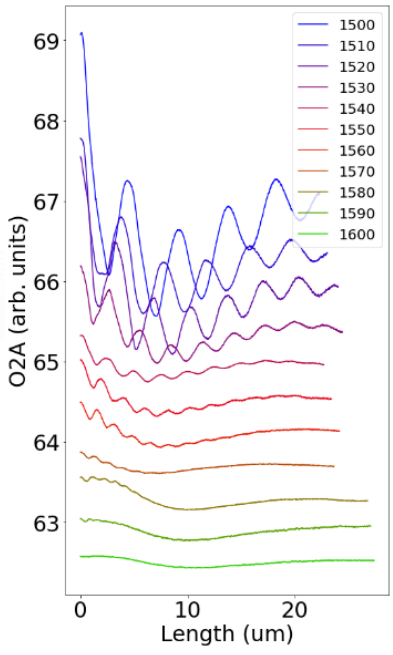
Hexagonal boron nitride (hBN) has become a widely investigated Van der Waals material over the past decade due to many of its intriguing optical properties such as its large negative dielectric function and optical anisotropy [1]. Recently, doped hBN has been the source of developing highly localised single photon emitters (SPEs) with the potential for applications with on-chip photonic circuits [2,3]. While the optical properties of the emitters have been extensively researched, the emitters themselves are nanoscale and their specific bonding properties have not been well understood. In this work, we investigate the nanoscale near-field optical properties of pristine hBN and carbon doped hBN within the reststrahlen type-II spectral region. Launching phonon-polaritons from the apex of a cantilever tip reveals fringe oscillations seen in Fig 1, based on interference from tip launched and edge-reflected phonon polaritons. Using an analytical model, we extract the dispersion relation from Fourier analysis of the s-SNOM fringes. Pristine hBN is then used as a baseline model to compare to carbon-doped hBN revealing vast differences in the dispersion (Fig. 2). It is clear from our results: the high frequency permittivity, $\varepsilon\infty$, decreased with carbon doping, the LO phonon mode shifted to lower frequencies by 10 cm-1 and no change seen in the TO phonon frequency. As a result, these observations allow us to qualitatively discuss how the long-range electrostatic lattice properties are modified by carbon defects rather than short-range bonding properties. This work greatly enhances our understanding of the nature of carbon defects within hBN.



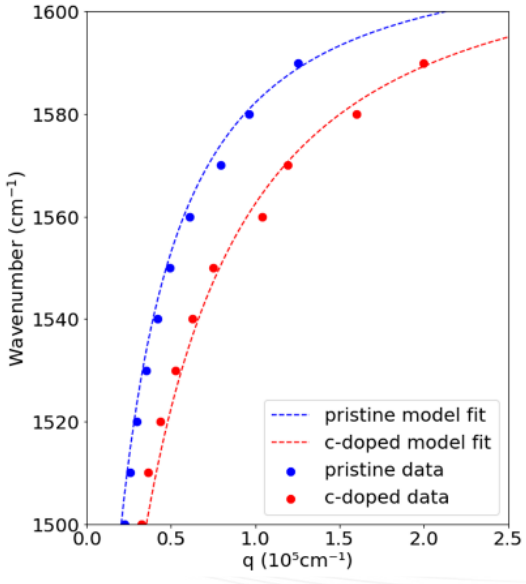


Fig. 1, 2nd harmonic s-SNOM amplitude of phonon-polaritons oscillations in a 355 nm thick hBN flake.

Fig. 2, in-plane phonon-polariton momentum, q, as a function of wavenumber. The dashed blue and red lines show the results from a fitted model describing the polaritons with differing phonon permittivity properties.

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P23. Dynamic Engineering of Two-Dimensional Materials and Their vdW heterostructures via Rectified Femtosecond Laser Shock Peening

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P24. Toward a Quantum Twisting Microscope for cryogenic applications

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The Quantum Twisting Microscope (QTM) [1,2] extends the spectroscopic toolkit by introducing twist angle as a continuously tunable in situ parameter within a local probe architecture. In the QTM, a van der Waals tunneling junction is formed between a tip and a sample, allowing coherent, momentum-resolved electron tunneling whose phase space can be continuously tuned via relative rotation of the two layers.
Motivated by the experimental [3-5] and theoretical [6-12] potential of the cryogenic quantum twisting microscope, we present the design and implementation of a low-temperature QTM operable within a dilution refrigerator under strong magnetic fields. We provide a comprehensive description of the instrument architecture, including the associated electronic setup.

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P25. Enhanced Phonon-Assisted Tunneling in Metal-Twisted Bilayer Graphene Junctions

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Tunneling measurements are cornerstone of modern device electronics, and the advent of van der Waals materials has unveiled new regimes and functionalities of this versatile tool. In this work, we emphasize planar tunneling spectroscopy measurements between metal and graphene heterostructures, separated by few layers of WSe2 as a barrier. Experiments performed in Bernal bilayer graphene (BLG) and twisted bilayer graphene (TBLG) suggest phonon-assisted tunneling and the significantly high density of states within the moiré bands. The key finding indicates a more relaxed in-plane momentum matching criterion favors enhanced phonon-assisted tunneling in twisted bilayer graphene compared to Bernal bilayer graphene. Theoretical calculations of phonon dispersions enable us to identify low-energy phonon modes in both Bernal and twisted bilayers of graphene, thereby elucidating the underlying mechanism of tunneling. Our results establish planar tunneling as a versatile tool to further understand electron−phonon coupling in van der Waals materials.

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P26. Segregation channels in V-doped monolayer WS2 revealed by X-ray nanoprobes and Raman spectroscopy

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Defect engineering is a powerful strategy to tune the optoelectronic and magnetic properties of two-dimensional (2D) materials. In transition metal dichalcogenide (TMD) monolayers, substitutional doping with magnetic elements such as vanadium enables the emergence of room-temperature ferromagnetism and novel excitonic functionalities relevant to spintronic and valleytronic technologies. However, the practical implementation of such systems is hindered by the lack of direct, chemically resolved mapping of dopant distributions over extended length scales. While atomic-resolution techniques provide chemical sensitivity, they are limited in spatial coverage, whereas optical and scanning probe methods offer large-area imaging but lack chemical specificity.

In this work, we introduce synchrotron-based X-ray fluorescence (XRF) microscopy as a non-destructive and chemically selective approach to map substitutional dopants in monolayer WS2 with nanoscale resolution across large areas. Using V-doped WS2 as a model system, we identify a non-uniform dopant distribution characterized by a higher dopant concentration along bisector directions linking the center and the corners of triangular flakes. To rationalize these findings, we develop a continuum adsorption–growth–diffusion model, which quantitatively reproduces the observed dopant profiles and captures the thermodynamic evolution of dopant incorporation during growth. Raman hyperspectral imaging, corroborated by DFT calculations, reveals that dopant segregation induces non-uniform spatial modulation of electron–phonon coupling. By decoupling strain and charge effects, we uncover a localized tensile strain field along the bisectors, associated with a subtle topographic uplift. This emergent and spatially deterministic strain landscape provides a pathway for exciton funneling and controlled quantum emissions in doped 2D semiconductors. Moreover, these results establish XRF microscopy as a key tool for large-area chemical mapping in 2D materials and offer a predictive framework for controlling dopant distributions, advancing the design of scalable spintronic and valleytronic devices.

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P27. Quantum Imaging of Nanoscale Electronic Transport in Graphene with Scanning Diamond Magnetometry

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Since the discovery of graphene in 2004, the study of electronic transport in graphene-based two-dimensional materials has remained at the forefront of condensed matter physics. To date, most experiments were based on bulk resistance measurements without direct access to microscopic details of the spatial transport pattern. Here, we present nanoscale imaging of current flow in graphene-based devices for unveiling novel electronic transport phenomena, using a scanning nitrogen-vacancy (NV) magnetometer that exploits an atomic-sized defect in diamond as a single-spin quantum sensor.

First, we present direct imaging of magnetotransport in a graphene-metal hybrid device. By bringing the nanoscale resolution and ac quantum sensing to above 0.5T, which to our knowledge is the highest reported bias magnetic field for scanning NV microscopy, we manage to observe key spatial features of magnetotransport, including current deflection due to the Lorentz force and reorganization of currents through the hybrid structure. By combining the local current distribution with global resistance measurements, we reveal that transport properties of the hybrid are governed by a complex interplay of intrinsic magnetoresistance around the Dirac cone, carrier hydrodynamics, interface resistance, and nanoscale device geometry. Furthermore, accessing the local transport pattern across the interface enables quantitative mapping of spatial variations in contact resistance, which is commonly present in electronic devices made from two-dimensional materials yet non-trivial to characterize. Our demonstration underscores the importance of material interfaces in magnetotransport and showcases the potential of nanoscale current imaging techniques to address complex transport questions in hybrid devices.

Second, we present our recent results about visualizing non-reciprocal transport in graphene. Over the past decade, characteristic fluid flow profiles, such as Poiseuille flow and vortices, have been observed in solid-state systems, which provide direct evidence of viscous electron fluids that obey the linearized Navier-Stokes equation. However, the convective acceleration of fluids represented by the nonlinear term in the Navier-Stokes equation, which is responsible for non-reciprocity and turbulence, has not yet been directly demonstrated for electrons. Here, we show evidence of non-reciprocal electron flow in graphene at room temperature, which can be well accounted by the convective term in the Navier-Stokes equation. Our observation demonstrates the power of local imaging techniques for uncovering exotic transport phenomena that are difficult to probe by resistance-based measurements.

P28. Thermoelectric Studies of Heavy Fermion Physics in Magic-Angle Twisted Bilayer Graphene

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The thermoelectric effect in strongly correlated electron systems provides direct information on the dominant carrier type, effective mass, and scattering mechanism making it particularly useful for probing the coexistence of light and heavy quasiparticles [1] in magic-angle twisted bilayer graphene (MATBG), a dichotomy previously identified in transport and spectroscopic measurements and theoretically described within the framework of the topological heavy fermion (THF) model [2]. Building on our previous work of photothermoelectric response in MATBG [3], we implement an improved device geometry that enables on-chip measurements of thermoelectric coefficients at lower temperatures and under an applied perpendicular magnetic field. This improved measurement scheme extends our experimental capabilities, allowing us to further investigate the interplay between light and heavy carriers in MATBG.

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P29. TBA

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P30. Enhanced exciton interaction in semiconducting MoS2/WSe2 moiré superlattices

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Excitons in two-dimensional semiconducting transition metal dichalcogenides (TMDs) exhibit large binding energies, excellent tunability, and compatibility with various photonic platforms. When TMD monolayers are stacked into heterobilayers with type-II band alignment, interlayer excitons consisting of spatially separated electron-hole pairs can form, providing a platform for exploring emergent many-body phenomena. Here, we report significant atomic reconstruction in MoS_2/WSe_2 heterobilayers with large lattice mismatch, directly visualized by atomic force microscopy in peak force quantitative nanomechanics mode. In this system, we observed a pronounced blueshift of the interlayer exciton with increasing exciton density, together with the emergence of interlayer biexcitons at room temperature. By contrast, previously reported interlayer biexcitons have only been observed at cryogenic temperatures. These results open new opportunities for exploring strongly correlated states at elevated temperatures.

P31. In-Liquid Scattering Scanning Near-Field Optical Microscopy using Thin Polaritonic Membranes

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Surface phonon polaritons (SPhPs) in thin polar dielectric membranes exhibit long propagation lengths and strong confinement. Their dispersion is governed by material properties, enabling tuning of the polariton wavelength within the restrahlen band. Hybridized SPhP modes in free-standing SiC membranes have previously been reconstructed using sSNOM nano-FTIR. Extending near-field polariton interferometry to liquid environments is challenging due to increased damping, reduced refractive index contrast, tip contamination, and other experimental constraints associated with operating scanning probes in liquids. Here, we demonstrate in-liquid scattering scanning near-field optical microscopy (sSNOM) using thin polaritonic membranes. We measure near-field line scans in a liquid environment and reconstruct the Fourier-domain response to analyze fringe formation, dispersion, and propagation length of SPhPs under liquid conditions. This approach establishes in-liquid polaritonic near-field microscopy as a platform for nanoscale optical studies in chemically and biologically relevant environments, extending near-field techniques beyond air-based platforms.

P32. Exciton Polaritons vs Plasmons Polaritons: Nonlocal corrections, confinement and loss

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Interband-based VIS/NIR in-plane exciton polaritons in two-dimensional materials, such as transition-metal-dichalcogenides (TMDs), provide an excitonic alternative to plasmonic systems. We compare the properties of such in-plane exciton polaritons supported by monolayer TMDs to the equivalent configuration of SPPs supported by thin metallic films, known as the short-range-SPPs (SRSPPs). Taking into account both excitonic and plasmonic nonlocal corrections, which play a major role in large momentum modes, we find that in-plane exciton polaritons provide confinement factors that are an order of magnitude larger than those of SRSPPs, and with six times lower propagation losses. These properties make in-plane exciton polaritons promising candidates for VIS/NIR nanophotonics and strong light-matter interaction. In addition, we show a means of directional excitation of in-plane exciton polaritons thanks to their excitons' coupling with the valley degree of freedom in TMDs. Altogether our investigation provides an in-depth understanding of the physical nonlocal polaritonic properties of these excitonic modes.

P33. TBD

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P34. Imaging of Complexity in vdW Magnets: From Spin Glass State to Stacking Fault-Induced Subsystems

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Two-dimensional van der Waals (vdW) magnets host a rich variety of emergent magnetic ground states which spatial complexity of occurring magnetic orders can be significantly different from conventional orderings, thus requiring new ways of descriptions [1]. Here, we present cryogenic magnetic force microscopy (MFM) studies of two fundamentally distinct manifestations of this complexity: slow spin-glass dynamics in $NbFeTe_2$ and stacking fault-induced coexisting magnetic subsystems in $CrBr_3$.

In ferromagnetic $CrBr_3$ films of intermediate thickness, MFM imaging revealed the intrinsic coexistence of two overlapping magnetization textures, which consisted of an ordered stripe domain pattern and a disordered large-domain pattern characteristic of atomically thin films. Fast Fourier Transform (FFT)-based deconvolution isolated the two subsystems. To further understand the reasons for their occurrence, simulations have been conducted with varied exchange interactions within the layers, simulating the presence of stacking faults which could lead to changes in interlayer coupling. Usage of structural similarity index (SSIM) ξ, helped to quantify their correlation, with values $|\xi| \ll 1$ indicating weakly correlated states and the occurrence of multiple domain subsystems, meaning that weak vdW interlayer coupling and the presence of antiferromagnetic stacking faults can lead to a rise of complexity in the domain formation [2].

In thin $NbFeTe_2$, cryogenic MFM revealed hour-scale relaxation of magnetic domain clusters, identifying a spin-glass state down to tens-of-layers thickness. MFM phase range and multiscale structural complexity [3] tracked the evolving magnetic microstructure: while global metrics decrease gradually, local spatial complexity took different relaxation paths across image subregions - a behaviour which can be interpreted through a rugged free energy landscape with spatially distributed local minima and region-dependent relaxation timescales.

Together, these results demonstrate that cryogenic MFM, augmented by quantitative image analysis, such as SSIM-based correlation metrics and multiscale complexity deconvolution, provides a powerful framework for resolving competing magnetic orders in vdW systems, from structurally imposed subsystems to time-domain glassy dynamics.

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P35. Imaging electron-phonon coupling in graphene moiré superlattice

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Moiré superlattices in twisted graphene host correlated quantum phases in which electron-phonon interactions are expected to play an important yet elusive role. While optical spectroscopy has provided important insights into phonon-electron interactions, resolving how different phonon symmetries couple to electronic excitations and how these interactions vary locally remains challenging. Here, we develop an electrostatically tunable scanning near-field optical microscopy platform that enables symmetry-resolved characterization of electron-phonon coupling in graphene and graphene moiré superlattices with nanoscale spatial resolution. By systematically varying external electrostatic conditions, we selectively activate distinct coupling channels associated with phonon modes of different symmetry, each producing characteristic spectroscopic signatures in the near-field response with distinct spatial modulation across different regions of the moiré landscape. Our work establishes nano-IR spectroscopy as a versatile platform for disentangling symmetry-dependent lattice-electronic interactions in quantum materials, with particular relevance to graphene moiré superlattices and phonon-mediated phenomena in correlated systems.

P36. Silicon On-Chip Light Sources Based on MoS_2/WSe_2 Heterobilayers

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Silicon photonics is a premier platform for large-scale optical integration. However, the realization of efficient on-chip light sources remains a significant challenge due to the indirect bandgap of silicon. Semiconducting transition metal dichalcogenides (TMDs) offer a promising solution through bandgap engineering via van der Waals stacking. In this work, we push the interlayer exciton light emission beyond 1300 nm by precise twist angle control in MoS_2/WSe_2 heterobilayers at room temperature, aligning it with the standard telecom O-band. By integrating these heterobilayers with silicon asymmetric nanobeam cavities, we achieve a waveguide-integrated light source characterized by high temporal coherence (~3.8 mm) and a narrow linewidth (~0.2 nm). This work establishes a novel architecture for high-performance, chip-scale light sources on the silicon platform using 2D materials.

P37. Observation of spin chirality with nonlinear optics

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Chiral spin textures, such as spin spirals and skyrmions, are key to advancing spintronics by enabling ultrathin, energy-efficient memory, and high-density data storage and processing. However, their realization remains hindered by the scarcity of suitable host materials and the formidable experimental challenges associated with the characterization of these intricate chiral magnetic states. Here, we report the observation of tunable chiral magnetic textures in van der Waals magnet $CrPS_4$ with nonlinear optics. These tunable textures exhibit strong chiral third-order nonlinear optical responses, driven by interlayer and intralayer spin couplings under varying magnetic fields and temperatures. These pronounced chiral nonlinear optical responses highlight the potency and high sensitivity of the nonlinear optical readout for probing non-collinear magnetic orders. Moreover, our findings position van der Waals magnets and their heterostructures as an exceptional platform for reconfigurable spin-photonics and spintronics, unifying optical, electrical, and magnetic properties through unique intralayer and interlayer spin coupling properties and effective spin interaction between photons and electrons.

P38. Magnetoabsorption as a source for spin polarization in 2D systems

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Carriers confined in two-dimensional systems are susceptible to quantization of their in-plane motion into circular orbits through Landau-level (LL) formation when an external out-of-plane magnetic field is applied, modifying electronic and optical properties. Here, by employing quantum well (QW) systems with distinct spin lifetimes, we show that photoexcited carriers within a specific excitation-energy window undergo absorption resonances via energy matching a series of Landau subbands [1]. Consequently, pronounced and spin-dependent intensity oscillations arise as the magnetic field is swept. We further demonstrate that these resonances, when coupled with coherent relaxation toward the ground-state optical levels, give rise to spin-polarization peaks. To support this mechanism, population rate equations for the spin-split states that include magnetoabsorption generation terms are developed, indicating that spin lifetimes close to or larger than radiative recombination times are required to produce the observed polarization oscillations. This requirement ensures that spin orientation is preserved from carrier excitation to optical recombination, which we validate experimentally by investigating the spin dynamics of a type-II QW [2], where electron-hole spatial separation is known to extend spin lifetimes relative to type-I nanostructures. Our findings reveal how magnetoabsorption spin polarization can be an indirect tool to probe spin lifetimes while also uncover a new mechanism for spin orientation based on spinresolved resonant absorption with LLs, which is a fundamental task towards implementation of nanodevices for quantum information processing [3].

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P39. Probing Theoretical Limit of Polaritonic Loss in Isotopically Engineered hBN

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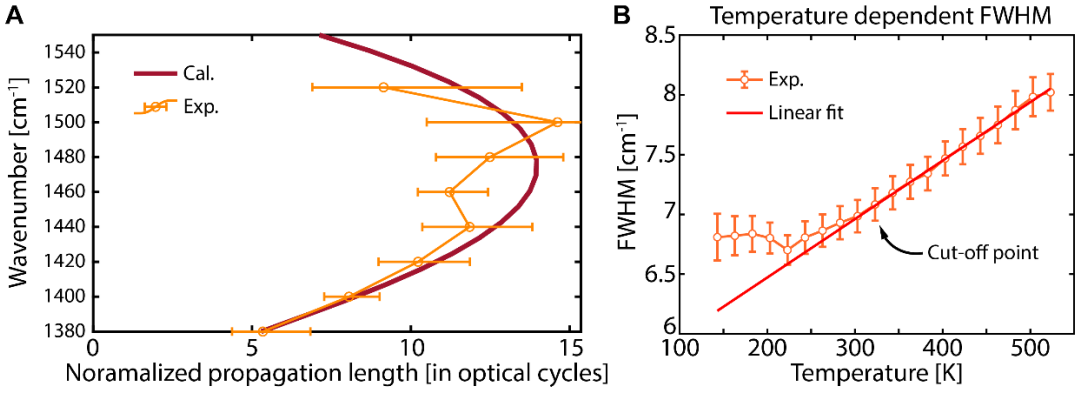
The use of isotopically pure boron or nitrogen is a critical strategy for minimizing losses in hBN hyperbolic phonon polaritons (HPhPs). Natural boron consists of approximately 80% 11B and 20% 10B (while natural nitrogen is ~99.6% 14N). In phonon vibrational modes, these minority isotopes act as impurities within the primary lattice, significantly increasing polariton damping. Previous studies employing Density Functional Theory (DFT) have predicted that isotopically pure hBN should exhibit remarkably low loss compared to its natural counterpart, with an expected lifetime of approximately 5 ps. However, experimentally reaching this theoretical threshold has remained an elusive goal, making its experimental demonstration a highly significant milestone in the field.

In this work, we present scattering-type scanning near-field optical microscopy (s-SNOM) measurements that closely approach the numerically predicted damping coefficients. By directly imaging the polaritonic near-field, s-SNOM allows for the visualization of propagation and the precise quantification of confinement and propagation lengths. Using the tip-launched polariton model, we extracted the wavevectors in the second Reststrahlen band (RB2) to plot the polariton dispersion. Since the hyperbolic phonon polaritons in RB2 are supported by the in-plane E1u optical phonon mode—which induces a negative in-plane permittivity—we derived the Lorentz-Drude parameters, including the RB boundaries (ω_TO, ω_LO), high-frequency permittivity (ε_∞), and the optical phonon loss (γ). Our s-SNOM results reveal near-field profiles that are significantly clearer and longer-propagating than previously reported hBN data. Rigorous quantitative analysis shows that our hBN achieves a Figure of Merit (Q=k^'/2πk") of 12.5 and a maximum lifetime of 5.8 ps (Fig.1A). These results are in agreement with theoretical predictions and represent a two-fold improvement over recent experimental reports [1].
Furthermore, we investigated anharmonicity, another pivotal factor in polariton loss. While changes in the hBN decay rate under cryogenic conditions have been documented, experimental evidence regarding temperature-dependent variations above room temperature remains scarce. Generally, there exists a cut-off temperature where all acoustic phonon modes in hBN become active; near and above this threshold, the loss behavior deviates from cryogenic trends. In this study, we observed this transition for the first time. Through FWHM analysis of FTIR spectra, we measured the polariton loss variations across a wide temperature range (130 K to 550 K) for samples with various isotopic compositions. Surprisingly, the anharmonicity-driven changes resulted in up to a 30% variation in loss. Notably, we confirmed that the cut-off frequency of hBN occurs near room temperature (~300 K), where a distinct transition in the loss profile was identified (Fig.1B).



[Fig.1] (A) Normalized propagation length from isotopically enriched $h^{11}BN$ measured by s-SNOM (B) FWHM from FTIR refelction spectrum and cut-off frequency of hBN

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P40. SQUID-on-Lever, the hybrid scanning probe with sub-100 nm spatial resolution

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Scanning superconducting quantum interference device (SQUID) microscopy is a magnetic imaging technique combining high field sensitivity with nanometer-scale spatial resolution. We demonstrate a scanning probe that combines the magnetic and thermal imaging with the tip-sample distance control and topographic contrast of a non-contact atomic force microscope. [1] We pattern the nanometer-scale SQUID, including its weak-link Josephson junctions, via neon or helium focused ion beam milling on a niobium coated cantilever. These SQUID-on-lever probes overcome many of the limitations of existing devices, achieving spatial resolution better than 100 nm, magnetic flux sensitivity of 0.3 μΦ0/√Hz, operation in magnetic fields up to about 0.5 T and the incorporation of a third Josephson junction for shifting its phase. Its advanced functionality, high spatial resolution, and the ease of use of a cantilever-based scanning probe, extends the applicability of scanning SQUID microscopy to a wide range of magnetic, superconducting, and quantum Hall systems. We demonstrate magnetic imaging of skyrmions at the surface of bulk Cu2OSeO3 and image modulated magnetization patterns with a period of 65 nm. [2]

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P41. Hyperbolic Metasurfaces as Platforms for Purcell Enhancement of Quantum Emitters in 2D Materials

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P42. Imaging of plasmon-phonon polaritons in wide bandgap semiconductors

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P43. Facile Van der Waals hBN Encapsulation and Stabilization of Perovskite Quantum Dots Emission

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All-inorganic perovskite quantum dots (PQDs) are promising room-temperature single-photon sources, but practical application is limited by their rapid photodegradation, blinking, and spectral instability at the single-emitter level. Here, we realize a facile van der Waals (vdW) hexagonal boron nitride (hBN) encapsulation of PQDs that facilitates effective diffusion barriers to avoid rapid photodegradation. Compared with pristine PQDs (P-PQDs) the hBN encapsulated PQDs (hBN-PQDs) exhibit a nearly 50-fold increase in saturation power (P_{sat}) as well as remarkably suppressed blinking and photobleaching. At single PQD level, it is revealed that the spectral shift and photostability of hBN-PQDs were essentially reinforced, enabling clear photon antibunching at room temperature. Finally, the preserved spectral emission is maintained even by dissolving the hBN-PQDs in polar solvents (water and N,N-dimethylformamide), substantiating the robust optical photostability. The encapsulation strategy provides a promising passivation of PQDs, paving the way toward quantum-light applications of PQDs.

P44. Nanometer-Scale Cavities For Mid-Infrared Radiation via Image Phonon Polariton Resonators

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Surface polaritons (SPs) play a pivotal role in strong light–matter interactions at the nanoscale due to their ability to confine electromagnetic radiation to dimensions that are orders of magnitude smaller than their free-space wavelength. Generally, the confinement of SPs can be further increased by placing the polaritonic material near a metallic surface. In this configuration, the metallic surface imitates the presence of the polaritonic surface through image charges, resulting in a high-momentum antisymmetric mode commonly referred to as the image polariton (IP).

A promising class of materials exhibiting surface polaritons is polar dielectrics, which support surface phonon polaritons (SPhPs). Since their pioneering realization and measurements by s-SNOM, SPhPs have been utilized for thin-film biological sensing, and super-resolution imaging, for example. However, while SPhPs provide inherently low losses, they have not been fully exploited due to their limited ability to reach large confinement factors compared to other SPs.

In this work [1], we demonstrate the generation of extremely confined and high-momentum SPhPs via the experimental realization of their antisymmetric image phonon polariton (AIPhP) mode. We achieve this by realizing AIPhP resonators in a system composed of nanometer-sized silver cubes deposited on a SiC polar dielectric. AIPhP resonators can confine mid-infrared radiation to extremely small mode volumes which are almost a billion times smaller than their free-space mode volume. Moreover, due to their inherently low losses, AIPhPs exhibit quality factors surpassing values of 180. Finally, we also show that the spectral response and intensity of the AIPhP resonators can be precisely controlled by adjusting the size and concentration of the nanocubes.

Our method is general, scalable, and applicable to any polar dielectric, opening the path for controlling and manipulating strong light–matter interactions at the nanoscale in the long-wavelength range.

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P45. Optically Addressable Molecular Spins at 2D surfaces

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Optically addressable surface spins constitute a long-sought goal in quantum sensing, offering a pathway to probe quantum phenomena with atomic-scale precision. Here, we introduce a novel architecture in which pentacene (Pc) spin molecules are anchored onto two-dimensional hexagonal boron nitride (hBN) and self-align with the underlying lattice. This configuration yields robust optically detected magnetic resonance (ODMR) signals from 4 K to room temperature. Through isotope purification and dynamical decoupling, the spin-coherence time is extended to T_2 > 30 µs and T_2,DD > 300 µs, approaching the intrinsic triplet state lifetime limit of Pc molecules. Meanwhile, it is also available for the platform to sense nearby proton nuclear signals and magnetic responses of two-dimensional magnets beneath hBN layer. We further demonstrate ensemble spin sensing of Fe_3GaTe_2 (FGT), as well as different positioning of Pc molecules. This work represents the first demonstration of surface molecular spin sensor, integrating long coherence, optical addressability and interfacial functionality, thereby enabling quantum sensing beyond conventional solid-state spins.

P46. Emergence of Chiral Polaritons in CrSbr via In Situ Twisting

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Twisting two thin flakes of van der Waals material generates rich emerging physics of moiré excitons, Hubbard model simulators, tuneable polaritons, etc. Recent work [1] demonstrated that it's possible to change the angle between flakes in situ, allowing to measure in a single device all twist configurations. Here we expanded this concept to a setup that has the optical access and operates at cryogenic temperatures. The systems under study are excitons in twisted bilayer TMDs and exciton-polaritons in CrSBr slabs. The latter is a novel 2D antiferromagnet [2] with a strong anisotropy of the dielectric tensor, that allows great tunability of polaritonic absorption and emission spectrum of the stack. We present the first measurements of this systems. Chiral polaritons emerge in CrSBr, allowing the handedness of absorbed (and emitted) light to be switched via the twist angle between two slabs. This tuning covers a 90° range with 2° resolution.

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P47. KPFM on Molecular 2D TMDC Heterostructures

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Kelvin Probe Force Microscopy (KPFM) enables high-resolution mapping of surface potential and work function variations in two-dimensional (2D) materials and hybrid heterostructures, offering insights into local

electronic structure. In molecularly functionalized 2D systems, KPFM is particularly effective for identifying charge transfer, local doping effects, and electronic inhomogeneities with nanometer-scale spatial resolution. When combined with complementary techniques such as photoluminescence (PL), Raman spectroscopy, and scattering-type scanning near-field optical microscopy (s-SNOM), it provides a comprehensive view of structure-property relationships in complex, multi-component systems. This correlative approach reveals how molecular functionalization influences local dielectric environments, excitonic behavior, and polariton propagation, even in the presence of structural or compositional inhomogeneities. KPFM thus serves as a sensitive, non-destructive tool for probing local electronic interactions and complements optical methods in the study of emerging 2D material systems.

P48.

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Twisted MoTe2 bilayers are correlated flat-band magnets that host ferromagnetic metallic, integer Chern insulating, and fractional Chern insulating phases.[1-5] While static transport, optical, and local magnetometry measurements have established much of their phase diagram, the dynamics of the underlying spin polarization remain less explored.[6] These dynamics are particularly relevant near magnetic phase boundaries and in the presence of multiple magnetic domains.Here we use optical time-domain measurements to study spin/valley dynamics in a 3.5° twisted MoTe2 bilayer, motivated by the recent demonstration of optical control over the spin polarization in t-MoTe2.[7-9] First, we perform resonant pump-probe measurements at the attractive-polaron resonance to inject 'bubbles' of opposite spin polarization in a magnetic field that disfavors the injected state. The resulting false-vacuum bubbles decay over timescales spanning at least four orders of magnitude as magnetic field and pump power are varied. Under intermediate conditions, we observe bubbles that remain stable for 10s of ms before collapsing. At integer filling, where the system forms an integer Chern insulator, the decay time increases distinctly, suggesting that the dynamics may depend on the underlying gapped topological state.[10]Second, we use photon-correlation measurements of circularly polarized trion photoluminescence to probe fluctuations near the displacement-field-driven loss of spin polarization. We observe enhanced microsecond-scale correlations and slowing down near the magnetic phase boundary, consistent with increased spin fluctuations. However, the bunching amplitude and correlation time depend on the photoluminescence pump power, indicating that the current measurement is affected by the optical probe.

Taken together, these preliminary results indicate that optical time-domain measurements can probe spin/valley dynamics in twisted MoTe2. Future work will include further explorations of the dynamics of optical switching and photon-correlation experiments at lower power approaching the weak-probe limit.

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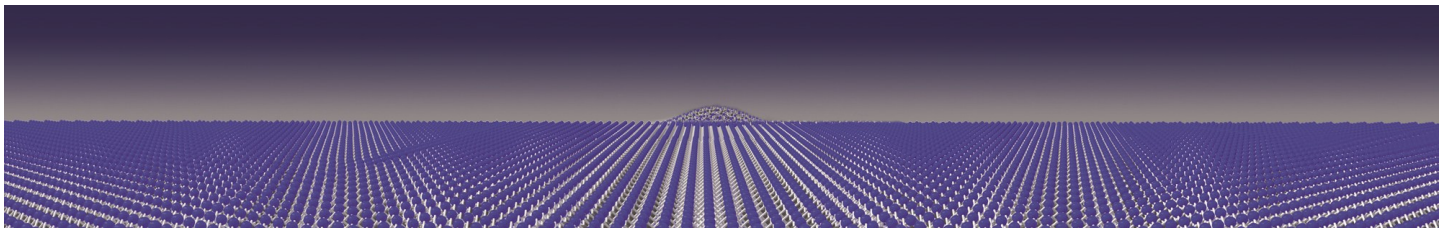

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P49. Photophysical Properties of Yellow Quantum Emitters in Electron-Irradiated Hexagonal Boron Nitride

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Quantum emitters in hexagonal boron nitride (hBN) have gained popularity in recent years as sources of high-quality, room-temperature single-photon emitters across a wide spectral range (IR-UV), making them promising candidates for future quantum technology applications. We use a deterministic method for creating bright and stable quantum emitters in hBN via electron-beam irradiation, yielding high-quality room-temperature single-photon emitters with emission at around 575 nm. To enable their integration into quantum photonic platforms, it is essential to achieve a better understanding of their microscopic nature.
This work presents a comprehensive photophysical characterization of these emitters. Confocal photoluminescence (PL) measurements on individual emitters reveal key single-photon characteristics (quantum nature, excited-state lifetime, and polarization dynamics). To probe emitter-environment interactions, temperature-dependent PL measurements from 4.5 K to 300 K were performed. Increasing temperature enhances phonon-assisted emission, enabling spectral tuning of the response. The spatial formation of the emitters was investigated by hyperspectral mapping across irradiated hBN flakes, and reveals a strong correlation between emitter locations and the electron-beam exposure.
This study provides a systematic understanding of the photophysical properties of yellow hBN emitters, advancing efforts toward uncovering their microscopic origin and paving the way for their integration into quantum photonic technologies.

P50. Ultrafast dnamics in strain-engineered 2D semiconductors

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Encoding and manipulating digital information in quantum degrees of freedom is one of the major challenges of today's science and technology. The valley indices of excitons in transition metal dichalcogenides (TMDs) have emerged as a strong candidate to addressing this challenge. Here, we employ mechanical strain to manipulate intervalley interactions and tune the valley polarization dynamics of excitons across a broader range of momentum space in monolayer TMDs [1]. We use strain engineering to control the energy hierarchy of valleys via their contrasting response to mechanical strain [2]. We demonstrate formation of strain-controlled valley-hybridized excitons [3] that combine the advantages of bright intravalley excitons, where the valley index directly couples to light polarization, and dark intervalley excitons, characterized by low depolarization rates. These valley-hybridized excitons exhibit signatures of coherently coupled states with a 100-fold reduction in valley depolarization rate and up to a 5-fold increase in steady-state valley polarization compared to previously studied excitons [1]. Our findings of strain-tunable valley character of excitons advance the applications of TMDs in valleytronics.

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P51. Spatially resolved current-induced phenomena in $tMoTe_2$

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Twisted molybdenum ditelluride ($tMoTe_2$) is a material that has been recently shown to host the Fractional Quantum Anomalous Hall effect[1,2], the Quantum Spin Hall effect[3], signatures of superconductivity[4], as well as a series of flat bands mimicking Landau Levels at zero magnetic field[5]. We use local scanning SQUID-on-

tip (SOT) magnetometry to probe the spatial distribution of current-induced orbital magnetization and hence reveal the topological structure of the 3.1° twist angle $tMoTe_2$. Application of sufficiently high AC electric current through the large sample allows for resolution of transport parameters translating into topological properties. The numerical treatment[6] of both microscopic band structure and the transport continuity equation opens the path to reveal the topological gap size as well as the local Berry curvatures at various fillings. Moreover, the signatures of current-induced magnetic switching in the correlated insulator phase are deduced from the same high AC current experiment, complementing the recently observed optically induced switching[7–9]. The results establish the high-current regime, which is typically overlooked, as a sensitive probe of the microscopic structure of 2D materials as well as confirm $tMoTe_2$ to be universal system for the collective quantum phenomena.

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P52. Wideband superresolution covariance magnetometry: from techniques to probing spin dynamics in the van der Waals magnet $Cr_2Ge_2Te_6$

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In the first part, we experimentally demonstrate a method for measuring correlations of wideband magnetic signals with spatial resolution below the optical diffraction limit. Our technique employs two nitrogen-vacancy (NV) centers in diamond as nanoscale magnetometers, spectrally resolved by inhomogeneous optical transitions. Using high-fidelity optical readout and long spin coherence time, we probe correlated MHz-range noise with sensitivity of 15 nT Hz−1/4. In addition, we use this system for correlated T1 relaxometry, enabling correlation measurements of GHz-range noise. Under such externally applied noise, while individual NV centers exhibit featureless relaxation, their correlation displays rich coherent and incoherent dynamics reminiscent of superradiance physics. This capability to probe high-frequency correlations provides a powerful tool for investigating a variety of condensed-matter phenomena characterized by nonlocal correlations. In the second part, we apply this technique for noise spectroscopy of criticality and spin dynamics in the van der Waals magnet Cr2Ge2Te6. We observe strong critical fluctuations and slowing down near the phase transition, and evidence of low-frequency coherent spin dynamics in the ferromagnetic phase.

P53. Tunable Many-Body Effects in Multilayer Graphene Probed by Quantum Twisting Microscopy

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The Quantum Twisting Microscope (QTM) has recently emerged as a powerful scanning probe platform that enables local, momentum-resolved tunneling spectroscopy through twist-controlled van der Waals tunneling junctions. By exploiting coherent interlayer tunneling, the QTM has provided direct access to electronic band structures and many-body interaction effects in monolayer and twisted bilayer graphene, including the observation of subtle electron–electron interaction that can be described by Hartree-Fock (HF) approximation even at room temperature. [1-2] In this work, we extend the capabilities of our home-built QTM beyond monolayer graphene to systematically investigate multilayer graphene systems with controlled charge carrier density, electric field, local pressure, and stacking orders. By probing momentum-resolved tunneling spectrums of multilayer graphene, we explore how interlayer coupling and electron many-body effects can be tuned by these external parameters. These results establish QTM as a versatile tool for controlling and investigating quantum coherence and electronic interactions in graphene systems.

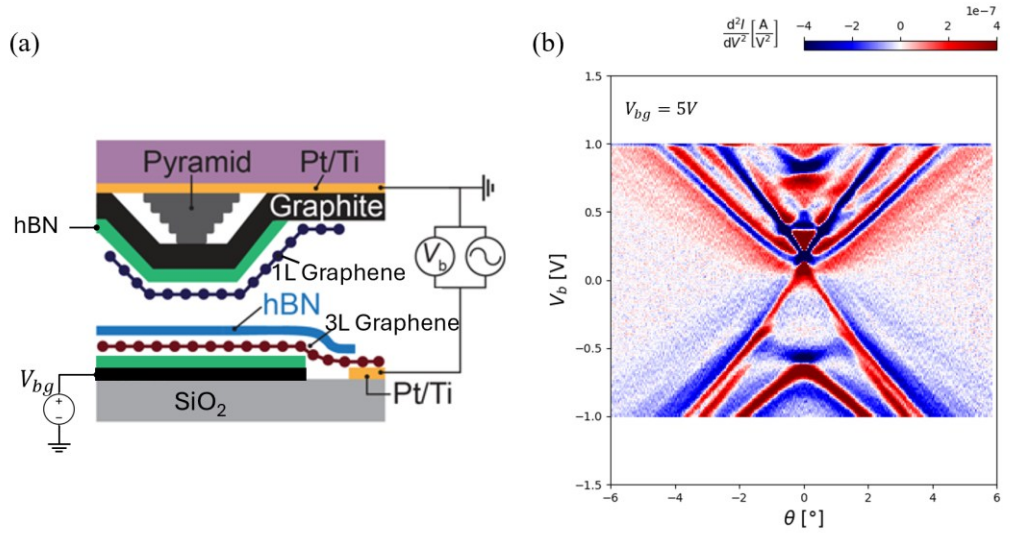

Fig 1. (a) Schematic diagram of the room temperature QTM setup. (b) QTM spectrum of Bernal trilayer graphene sample at the back gate voltage of 5V.

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P54. Spin Orbit Interactions of Light for Resonance Fluorescence Measurements

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Resonance fluorescence measurements of quantum emitters are typically performed in an epifluorescence geometry, where separating the weak signal from the much stronger excitation laser remains a central challenge. In conventional approaches, this separation relies primarily on polarization filtering.

In this contribution, we elucidate how the coupling of the polarization degree of freedom to the spatial beam profile enables efficient suppression of the excitation laser. While this effect is widely exploited in practice, its underlying mechanisms are often not fully understood. We provide a clear physical description of key optical elements showing how their influence prevents the excitation field from coupling into the detection fiber, while preserving the isotropic emission of the quantum emitter.

Our results establish a comprehensive physical framework for the systematic design of high-extinction confocal microscopes, paving the way for advanced, background-free resonance spectroscopy of quantum dots, color centers, and two-dimensional materials.

P55. Interaction Between Vibrational, Electronic, and Magnetic Degrees of Freedom in CrSBr

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The novel van der Waals antiferromagnet CrSBr has recently attracted considerable interest due to the strong interplay between its lattice, electronic, and magnetic degrees of freedom. In this work, we study how these interactions evolve across the magnetic phase transition by combining temperature-dependent polarization-resolved Raman spectroscopy with optical absorption and photoluminescence excitation (PLE) measurements. Under 1.96 eV excitation, the A_g^1, A_g^2, and A_g^3 Raman modes display a pronounced discontinuity in the vicinity of the Néel temperature, correlating with changes in the oscillator strength of excitonic transitions and resonances in PLE. The temperature evolution of the Raman tensor elements reveals selective coupling of individual phonon modes to specific excitonic states. Crucially, excitonic transitions are suppressed above the Néel temperature, directly linking the observed Raman modes behavior to the onset of magnetic order. We propose that these observations are indicative of an indirect spin–phonon coupling mechanism mediated through excitonic transitions. These findings position CrSBr as a promising platform for exploring quasiparticle interactions in 2D magnets, with potential implications for quantum sensing and communication.

P56. Local Tuning and Reversible Lateral Nanofocusing of Hyperbolic Phonon Polaritons

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Achieving a full spatial control over the propagating low-dimensional polaritons in van der Waals crystals remains an unresolved challenge in nanophotonics, as existing schemes rely primarily on structuring the polaritonic crystal itself or introducing binary substrate patterning.

We introduce a conceptually distinct approach based on the substrate-engineered dispersion and present a platform enabling local control of propagating polaritons via a newly developed sinusoidally corrugated gold substrate compatible with thin van der Waals crystals. In our system, the smoothly varying gap between the gold and the crystal is used as a precision tool to tune the dispersion locally. We experimentally demonstrate the local control over the momentum of hyperbolic phonon polaritons in a 33 nm-thick hBN, achieving a nearly threefold continuous tuning of the polariton wavelength through substrate modulation alone.

Building on this platform, we further demonstrate reversible lateral nanofocusing and defocusing of propagating phonon polaritons in hBN along the propagation direction driven by substrate geometry. We observe wavelength compression and decompression by a factor of approximately 2.5. To the best of our knowledge, this is the first experimental demonstration of lateral nanofocusing achieved purely through substrate modulation, rather than via tapering of the van der Waals material demonstrated in [A. Y. Nikitin et al., ACS Photonics 3, 924 (2016)].

The demonstrated ability to locally tailor polariton wavelength and achieve reversible focusing and defocusing through substrate geometry establishes advanced substrate-engineering as a new degree of freedom for polariton control.

P57. Spectroscopy of Wigner crystal polarons in an atomically thin semiconductor

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Wigner crystals (WC) are a paradigmatic example of correlated electronic states: a homogeneous 2D electron gas can spontaneously break translational symmetry and enter an ordered, crystalline phase when Coulomb interactions dominate over kinetic energy. With the advent of 2D quantum materials based on van der Waals heterostructures, sufficiently large ratios of interaction to kinetic energy could be achieved to realize this elusive state of matter without an external magnetic field. More recently, it was demonstrated that optical

spectroscopy can be used to probe the periodic charge order formed in transition-metal dichalcogenides, which manifests as an additional Umklapp peak in the optical response. Here, we study the complementary regime of strong coupling between excitons and collective excitations of the WC by uncovering Wigner crystal polarons (WP). In cryogenic reflectance contrast spectra of a charge-tunable WSe2 monolayer, WPs appear as two additional resonances within the same temperature and doping density range as the exciton Umklapp feature. Unlike the latter, the energies of the WPs are determined not only by the electronic lattice constant but also by hybridization with attractive exciton-polarons, with the coupling strength controlled by electronic interactions. We further demonstrate that the spin state of WC can be controlled by both optical pumping and applied magnetic fields, where the Wigner crystal polarons exhibit the same behavior as the respective attractive polarons. With these results, we establish a framework for investigating hybrid light-matter interactions in correlated electronic phases.

P58. Temperature-Dependent Optical and Polaritonic Properties of Excitons in hBN-Encapsulated Monolayer TMDs

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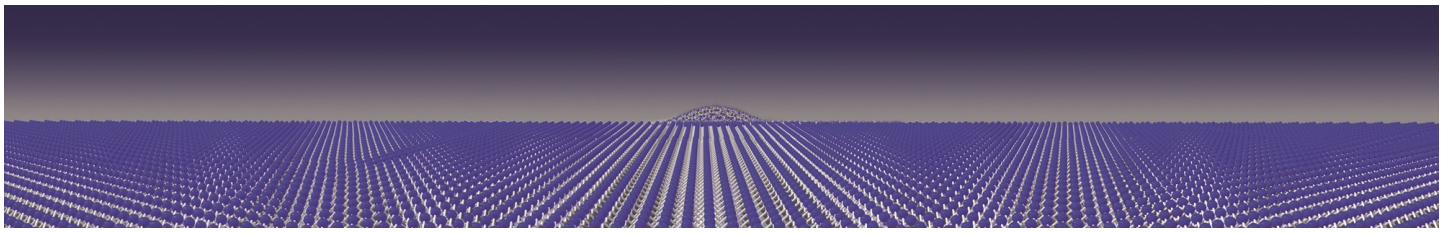
Monolayer transition metal dichalcogenides (TMDs) support robust excitons in the visible to nearinfrared spectral range. Their reduced dielectric screening results in large binding energies, and combined with a direct bandgap in monolayer form, these excitons dominate the optical response of TMDs. While excitons in monolayer TMDs have been widely studied before, previous investigations were often constrained by conditions that obscured the intrinsic optical properties or were limited to a single TMD. In this work [1], we present a comprehensive investigation of the temperature-dependent optical and polaritonic properties of high-quality WS_2, MoS_2, WSe_2, and $MoSe_2$ monolayers, encapsulated by hBN, in the full temperature range between 5 – 300K. Using reflection spectroscopy measurements, we evaluate and compare the optical and polaritonic constituents of the TMD excitons in terms of oscillator strength, linewidth, and complex permittivity. We find that, contrary to the predominant views, identifying WS2 as having the strongest optical response, under such optimal conditions and at low enough temperatures, it is MoSe2 that exhibits the most pronounced optical and polaritonic response, stemming from its rapid linewidth narrowing at low temperatures, as compared to the temperature-dependent response of the other TMDs. In addition, we find that all four TMDs exhibit a temperature-dependent negative real part of their permittivity, thus supporting surface-exciton-polaritons. We derive their dispersion relation, confinement factors, and losses, similarly revealing that MoSe2 exhibits enhanced polaritonic properties. These findings establish a comparative framework for understanding the optical and polaritonic properties of monolayer TMDs, with implications on their utilization in optoelectronic devices based on 2D semiconductors.



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P59. Ultrafast and ultracold nanoscopy of 2D materials

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Here, we present ultrafast and ultracold nanoscopy based on infrared and terahertz scattering-type scanning near-field microscopy (s-SNOM), enabling optical pump and optical probe measurements with femtosecond temporal and nanometer spatial resolution. Ultrafast nanoscopy enables study of dynamic processes in nanomaterials such as InAs nanowires or 2D heterostructures. Recent advances extend the capabilities of s-SNOM towards being a versatile platform for 2D material characterization by combining electrical, thermal and optical measurements in the same device – while also allowing for active control of the sample properties via external electrical signals, full environmental enclosure and temperature control from 375 K down to 10 K.

P60. Quantum Electrodynamics of excitons in Bilayer Graphene

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Cavity quantum electrodynamics has been a cornerstone in understanding light-matter interactions. In the so-called strong-coupling regime, these interactions cannot be described as a simple combination of their light and matter components. Instead, light and matter form new hybrid states. This project aims to push beyond into the ultrastrong coupling (USC) regime, where the interaction strength becomes comparable to the system's transition frequencies. In this regime, quantum vacuum fluctuations and elementary excitations become significant. This enables not only the control of quantum effects but also the modification of a material's ground state, even in the absence of external light. To that end, we explore the coupling between confined hyperbolic phonon polaritons (HPhPs) in hexagonal boron nitride (hBN) and excitons in bilayer graphene (BLG). The hyperbolic nature enables deep subwavelength confinement, enhancing the photonic density of states. In BLG, extended dipole transitions exhibit a nonlocal optical response, in which propagating HPhPs allow momentum-dependent transitions and access to a continuum of electronic final states. This leads to enhanced emission rates and to each exciton effectively coupling to multiple polaritonic modes, ultimately reaching a regime where the coupling strength compares to the transition frequency. This platform opens new possibilities for quantum technologies and non-perturbative light-matter engineering.

P61. Rabi oscillations of a monolayer quantum emitter driven through its excited state

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Single-photon sources (SPS) in atomically thin layers of transition metal dichalcogenides (TMD) have been relatively recently discovered and still have to come a long way in order to reach state-of-the-art solid-state SPS, e. g. based on III-V semiconductors. While recent advances in engineering of devices based on TMD SPS render them promising [1], the sources are typically prone to spectral noise and wandering, which severely limits the ability to observe quantum interference and thus makes their use in some quantum applications unjustified. Additionally, recently accessed exciton-phonon coupling contributes to their limited performance [2, 3]. To mitigate the impact of the environment, the single photon sources can be driven resonantly. However, coherent resonant excitation of TMD-based single quantum emitters has not yet been shown.

In this work, we demonstrate control over ground state population of a single quantum emitter in a monolayer WSe_2 via excitation through its excited state. We observe emergence of Rabi oscillations in intensity of the emission over varying driving pulse area. We model the observed behavior via solving the Lindblad master equation for a three-level system.

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P62. Twist-tuned exchange and hysteresis in a bilayer van der Waals magnet

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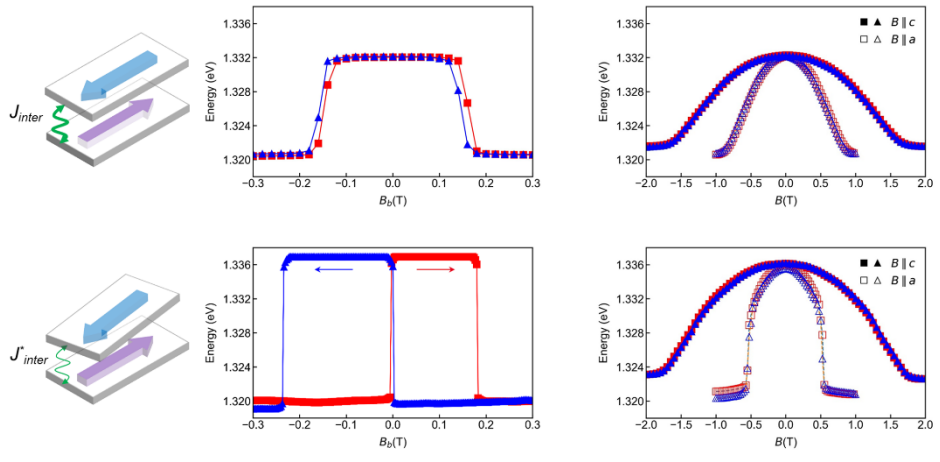
Recent Two-dimensional magnets have emerged as key platforms for exploring layer-dependent magnetic phenomena. CrSBr is a recently identified van der Waals magnet with strong excitonic features and layered antiferromagnetic (AFM) order. While pristine bilayers show no magnetic hysteresis, we find that a ~3° twist induces clear hysteresis and can even stabilize a zero-field ferromagnetic state [1]. Field-dependent photoluminescence tracks this behaviour through hysteretic exciton energy shifts that match the magnetic configuration. A two-sublattice model explains the response via twist-reduced interlayer exchange, allowing both parallel and antiparallel spin states. Although moiré sublattice exists in principle, the bilayer behaves as an effective monodomain, switching cleanly into the AFM state without forming spin textures. These results highlight twist engineering as a route to programmable magnetic memory in 2D magnets.



Photoluminescence Evolution with Magnetic Field at 4K.
Top: Pristine Bilayer . Bottom: Twisted Bilayer

[1] P. Mondal et al. *arXiv preprint arXiv:2510.08018* (2025)

P63. General purpose magnetometer – Comparison of scanning NV, MFM and MOKE

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Magnetic force microscopy (MFM) and magneto-optical Kerr effect (MOKE) measurements are well-established techniques in magnetism research [1,2]. Recently, nitrogen-vacancy (NV) center magnetometry, where a spin defect in diamond serves as an atomic-scale magnetic sensor, has gained increasing adoption [3]. Beyond static field imaging, NV magnetometry enables advanced techniques such as ferromagnetic resonance (FMR) spectroscopy and spin-wave imaging [4].

In this work, we present a comparative study of scanning NV magnetometry, MFM, and MOKE on a BiYIG sample, measured with the same magnetometer. This setup allows for direct imaging of the same sample region with all three techniques, enabling a comprehensive study with the complementary nature of these techniques providing a broader understanding of the sample's magnetic properties.

Finally, we discuss the strengths and limitations of each technique, highlighting scenarios where one method may be more advantageous than another.

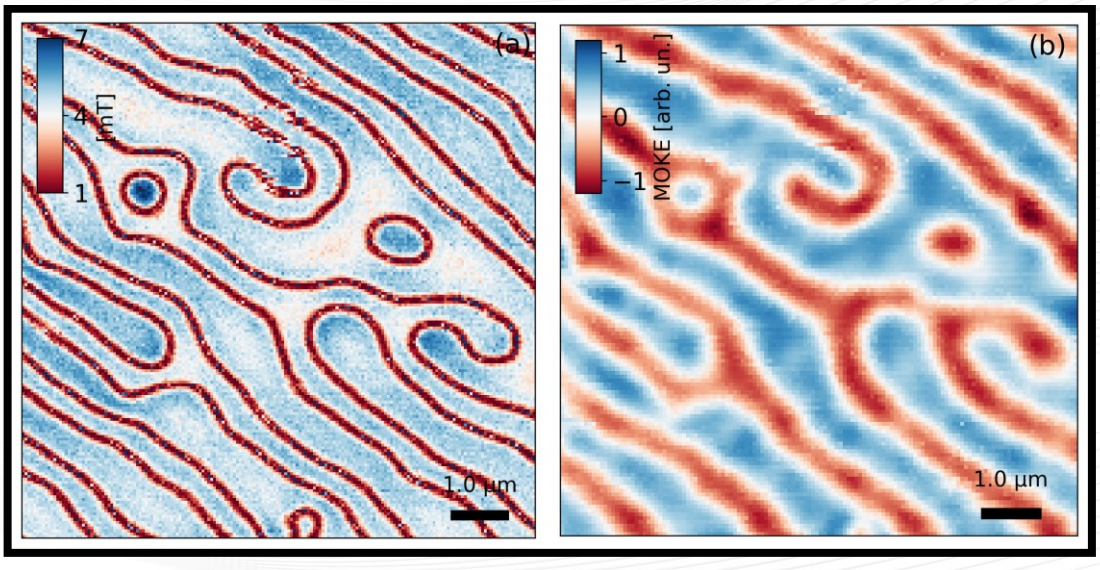

Figure 1. Sample: BiYIG (a): NV magnetometry (b): MOKE. The NV measurement shows the stray magnetic field from the sample surface, most pronounced on the domain walls whereas the MOKE image shows the magnetic domains.

[1] O. Kazakova et al; Journal of Applied Physics, 2019, 125, 060901.
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[4] van der Sar, T. et al Nat Commun, 2015, 6, 7886.s

P64. Charge density wave phase transition in 1T-TaS_2

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Charge density wave (CDW) phases in two-dimensional materials provide a rich platform for studying correlated electronic phenomena. Here, we present a systematic Raman spectroscopy study of temperature-dependent CDW phase transitions in few-layer 1T-TaS_2 with varying thicknesses. Distinct vibrational modes are used to track transitions between incommensurate (IC), nearly commensurate (NC), and commensurate (C) phases. We observe that while thicker samples (~20 nm) exhibit well-defined IC–NC and NC–C transitions at ~320–360 K and ~140–180 K, respectively, thinner samples (~5 nm) show a pronounced shift of the NC–C transition to higher temperatures and a reduced visibility of the IC–NC transition, likely associated with enhanced hysteresis and dimensional effects. These results provide a consistent experimental baseline for understanding thickness-dependent CDW behaviour in 1T-TaS_2 and offer a foundation for future studies of correlated and nonlinear phenomena in low-dimensional CDW systems.

P65. An ultrastable open cavity platform for closed-cycle cryostats and high magnetic fields

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P66. THz Nanoscopy and Sum-Frequency Microscopy of Structural Domains in van der Waals Quaternary Oxides

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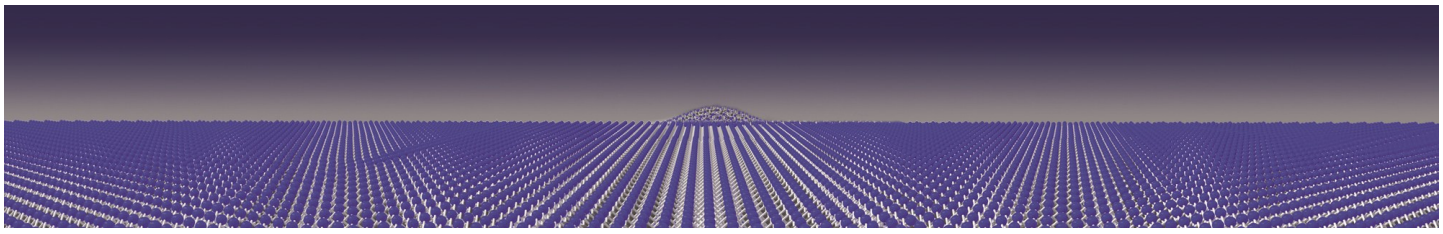

Nanophotonics based on light-matter hybrid states such as phonon polaritons in polar van der Waals crystals are a thriving research field for nanoscale manipulation of infrared-to-THz light.[1] For these studies, van der Waals quaternary oxides $ATeMoO_6$ with A = Mg, Zn, Co, Mn have emerged as a new in-plane anisotropic materials class that combine deeply sub-diffractional in-plane hyperbolic polaritons[2] with a crystal structure lacking inversion symmetry, with tremendous potential for nonlinear infrared nanophotonics. Here, we showcase a combined study using nonlinear infrared microscopy using infrared-visible sum-frequency microscopy[3] on the one hand, and THz near-field imaging using s-SNOM coupled with an infrared free-electron laser[4] on the other hand, to explore this materials class for nonlinear nanophotonics. In particular, we discovered ubiquitous and extended structural stripe-domains naturally emerging in these crystals, and which are characterized by near-perpendicular in-plane orientation of the crystal structure between neighboring domains. Due to the in-plane hyperbolicity in this crystal family, these domains are associated with alternating propagating direction of the hyperbolic polaritons. We use both microscopy techniques to characterize the domains, and present first near-field data on polariton interaction with and across the domain walls. Twin domains in quaternary oxides present a novel and very promising platform for lateral van der Waals heterostuctures in THz near-field optics.

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P67. Polariton Jackiw Rebbi Edge States in hBN/WSe2 Double Grating Heterostructures

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P68. Programmable phonon-assisted resonant energy transfer between moiré cells in charge-tunable $MoSe_2$-WS_2 moiré superlattices

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We report on resonant photoluminescence (PL) studies on charge-tunable moiré superlattices in $MoSe_2$-WS_2 moiré heterobilayers at cryogenic temperatures. In these experiments, we tune a Ti:Sapphire laser into close resonance with excitonic moiré transitions of MoSe2 and compare the resulting PL spectra to off-resonant PL, using a 532nm laser, and white light reflectance contrast experiments of this type-I heterostructure (HS). We identify multiple resonant energy transfers (RET) in the samples: When exciting resonantly with the excited moiré exciton or the excited charged moiré exciton, a direct one-phonon relaxation into the moiré exciton (M_1) using a A_{1g} phonon or the charged moiré exciton (M_1*) using two A1g phonons, respectively, can be observed. In the case of exciting M_1, a weaker phonon-assisted $E_{2g}{}^1$ relaxation into the M1* state is observed. All RET effects can be enhanced or quenched via electrostatic doping of the HS.
We interpret our results as follows: In a recent study, it was suggested that M_1 is strongly localized in a moiré cell[1]. In the case of charging the moiré superlattice, electrons localize as well. When exciting M_1 resonantly, a phonon-assisted RET from a localized M1 state to a neighboring charged moiré cell results in a localized M_1*, which then recombines radiatively. This interpretation is supported by the observation of a maximum transfer rate at a moiré cell filling of $\nu \approx 1/2$. We further interpret, tentatively, the phonon-assisted RET effect as a phonon-assisted tunneling between moiré cells as the primary energy transfer mechanism, since for phonon-assisted resonant Förster transfer, no significant temperature dependence is expected[2]. Thus, we report on an all-optical signature of lateral transport in a charge-tunable $MoSe_2$-WS_2 moiré HS[3].

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P69. Time-resolved near-field spectroscopy of III-V semiconductor core-shell nanowires

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High-quality epitaxial III–V nanowires, such as (In)GaAs, are promising for ultrafast optoelectronic devices due to their direct bandgap and high electron mobility. Contactless probing of average charge carrier concentration and mobility is enabled by terahertz time-domain spectroscopy, while spatially resolved measurements on individual NWs can be achieved using scattering-type scanning near-field optical microscopy (s-SNOM), providing resolution beyond the diffraction limit. Introducing a delayed excitation pulse relative to a broadband probe enables time-resolved s-SNOM spectroscopy, combining nanoscale spatial and femtosecond temporal resolution.

Here we report two types of near-field pump-probe experiments on doped GaAs/ InGaAs core-shell nanowires.

(1) In the NIR-pump/MIR-probe configuration, interband excitation leads to a pronounced blue shift of the plasma resonance, which we consistently observe in nanowires with different doping levels [1]. Analysis of time-dependent near-field spectra allowed us to estimate the carrier density and the scattering rate, providing insight into the roles of chemical doping and surface states in shaping recombination and mobility. Our measurements reveal recombination times ranging from a few picoseconds at high excitation to ~100 ps at low excitation, dominated by bimolecular recombination.

(2) In the MIR-pump/MIR-probe experiments, intense mid-infrared pulses from free-electron laser FELBE excited free carriers in the highly-doped GaAs/InGaAs nanowires [2]. This excitation induced intraband transitions, resulting in a red shift of the plasma resonance attributed to electron heating in the conduction band. Simulations of hot-carrier distributions indicated a significant population of the higher-energy L- and X-valleys of GaAs. A two-temperature model was applied to quantitatively describe the evolution of the electron gas temperature under varying excitation conditions.

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P70. Transferable Mirrors for Strong Light–Matter Coupling in Two-Dimensional Materials

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Two-dimensional transition metal dichalcogenides (TMDCs) host a rich variety of excitonic complexes and support exciton–polaritons even at room temperature. Their strong light–matter interaction, combined with valley-dependent physics, opens new avenues for novel photonic and optoelectronic devices, including unconventional light sources. In monolayer TMDCs, the Rabi splitting, a signature of strong coupling, typically ranges from 30 to 60 meV [1, 2]. Realizing exciton–polaritons requires integrating these materials into optical microcavities, commonly formed using distributed Bragg reflectors (DBRs). However, conventional top-mirror deposition techniques, such as plasma-enhanced chemical vapor deposition and sputtering, can degrade or damage the embedded active layers.
Here, we demonstrate a fabrication strategy for micron-scale monolithic cavities using transferable dielectric mirrors via a dry-transfer technique, a widely used technique for van der Waals heterostructures. The microcavity consists of SiO_2/TiO_2 Bragg mirrors and a monolayer WS2 active medium. The schematic and optical image of the fabricated device are shown in Fig. 1(a) and Fig. 1(b), respectively. This approach enables the realization of fully dielectric microcavities with a quality factor of $Q \sim 1198$. We observe clear signatures of strong exciton–photon coupling at room temperature, as evidenced by the dispersion shown in Fig. 1(c), confirming the formation of exciton–polaritons. This approach provides a viable route to integrate van der Waals materials while preserving emitter integrity, with potential applications in integrated photonics, low-threshold light sources, and valleytronic devices.

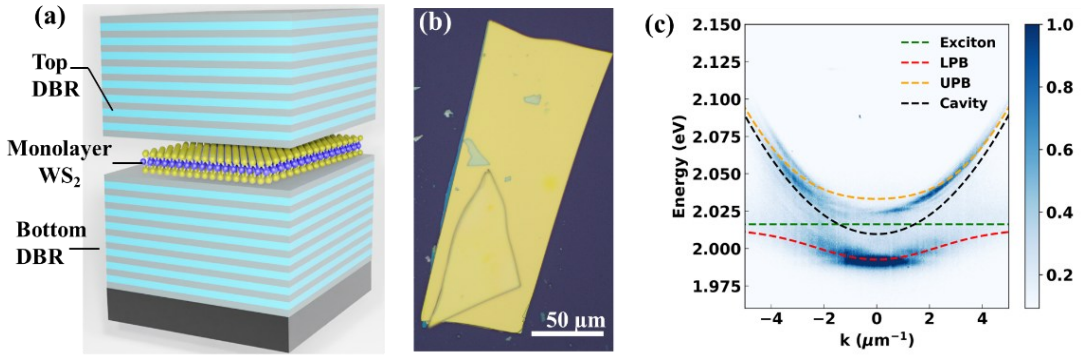

Figure 1: (a) Schematic diagram of the cavity structure consisting of a monolayer WS_2 embedded between top and bottom DBR mirrors formed by alternating layers of SiO_2/TiO_2. (b) Optical image of the transferred sample. (c) Angle-resolved photoluminescence spectra measured at room temperature, showing the lower and upper polariton.

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P71. Geometry-Induced Enhancement and Tunability of Silver Nanocube–SiC Phonon-Polariton Cavities

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Nanocube-based resonators are widely employed in polaritonic systems due to their ability to strongly confine electromagnetic fields and enhance light–matter interactions at the nanoscale. Surface phonon polaritons (SPhPs) supported by polar dielectrics provide a particularly low-loss platform for such studies, especially in the mid-infrared regime. When a polar dielectric surface is coupled to a nearby metallic nanocube, high-momentum antisymmetric image phonon polariton modes can emerge, offering deeply subwavelength confinement and high-quality factors. In this work, we examine the effect of nanocube shape, size, and density on the optical response of silver-nanocube–SiC phonon-polaritonic resonators. By comparing standard cubes with sharper-edged cubes of the same volume, we observe up to a five times enhancement in optical response. simulations reveal that under each nanocube, a localized cavity resonance forms between the cube edges and the substrate, resembling a Fabry–Perot interferometer. Sharper edges improve field localization and momentum compensation within this cavity, leading to stronger coupling between the metallic nanostructure and the underlying SPhP mode, as well as higher Q-factors. Furthermore, by tuning the cube size, we introduce a direct means of spectral control: larger cubes shift the resonance toward longer wavelengths. Each cube size correlates with a distinct point on the SPhP dispersion curve, allowing precise control over the interaction frequency. These results highlight the critical role of

nanocube geometry in controlling light–matter interactions in phonon-polaritonic systems and open new pathways for tunable, high-performance mid-infrared resonators for sensing, spectroscopy, and nonlinear photonics..

P72. Growth and characterization of 3R – MoS_2

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In recent years, rhombohedral 3R-stacked transition metal dichalcogenides (TMDs) have attracted increasing interest due to their emerging sliding ferroelectricity and their non-centrosymmetric structure, enabling second harmonic generation (SHG) independently of the layer number. Controlled growth of this metastable phase is essential to achieve ferroelectric domains with well-defined size and distribution, as well as to enable their reliable characterization. In this work, we present our progress on the growth of 3R MoS2 single crystals and on the optical investigation of exfoliated flakes. Photoluminescence and SHG measurements are employed to probe the excitonic response and symmetry-related properties. These results provide initial insights into the interplay between ferroelectricity and optical signatures in this class of materials, opening the doors to the realization of devices based on optically-controllable 2D ferroelectrics. We gratefully acknowledge the European Union for financial support via the Project 101223116 — 2DFERROPLEX.

P73. Enhanced absorption of interlayer excitons in bilayer MoS_2 via Purcell engineering of critical coupling

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Interlayer excitons (IXs) in layered semiconductors possess electrons and holes distributed across adjacent atomic layers. This spatial separation gives them long lifetimes and an out-of-plane electric dipole, making them attractive for studying interaction-driven many-body physics and for excitonic device applications.
However, the same separation reduces electron-hole wavefunction overlap, leading to low oscillator strength and intrinsically weak optical absorption.

Here, we demonstrate enhanced optical absorption of layer-hybridized interlayer excitons in bilayer MoS_2 by Purcell engineering of critical coupling in a planar van der Waals cavity. The cavity consists of bilayer MoS_2 encapsulated in hexagonal boron nitride (hBN) and placed on a gold mirror. Using transfer-matrix modelling together with decay-rate analysis, we tailor the cavity geometry to match the cavity-enhanced radiative decay rate of the interlayer exciton to its nonradiative decay rate through the Purcell effect.
We observe that the absorption of the hybridized interlayer exciton can be increased to nearly half that of the bright intralayer exciton, representing a substantial enhancement over its intrinsic optical response. These results establish Purcell engineering of critical coupling as a practical and scalable route to control light-matter interaction in interlayer exciton systems. This approach improves the optical accessibility of interlayer excitons and provides a pathway toward more efficient interlayer-exciton-based optoelectronic devices and better controlled studies of collective excitonic phenomena in two-dimensional materials.

P74. Gate-Tunable Excitonic Features in TMD Monolayers and Heterostructures

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Two-dimensional (2D) semiconducting materials provide a unique platform for studying strongly bound excitons and their interactions due to reduced dielectric screening and quantum confinement. By controlling layer composition, twist angle, applied electric field, and doping, both interlayer and intralayer excitons can be engineered.
We investigate gated MoSe2 monolayer and MoSe2-based heterostructure devices using photoluminescence and reflectance contrast spectroscopy. Through these measurements we probe how carrier density influences excitonic resonances and many-body interactions.
This work contributes to a deeper understanding of light-matter interactions in low-dimensional systems and supports the development of next-generation optoelectronic and quantum photonic devices based on 2D materials.

P75. Topological Zero Modes in Graphene Chevrons: Fabry–Pérot Control Toward Qubit Applications

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We introduce a minimal subsystem of graphene — a six-hexagon, three-fold-symmetric chevron junction coupled to three short plaquette chains — that retains the topological vacancy physics of the extended honeycomb lattice in a finite setting. Zero modes in graphene are zero-energy bound states born from

vacancies; they are protected by sublattice symmetry, their envelope decays as 1/r [1,2], and their phase carries a real-space wavefront dislocation [3] whose integer winding identifies the underlying topology [4]. The reduced structure inherits all of this on a sample of fewer than a hundred atoms. Crucially, in this geometry the topology of the zero mode becomes directly accessible to a scattering analysis.

Each plaquette chain is an SSH chain carrying an evanescent zero mode and attaches naturally to the chevron as a lead; the chevron, sitting at the junction of three such generalised SSH chains, acts as the unique three-port scatterer — a planar Fabry–Pérot cavity [5] whose zero-energy resonances are pinned by topology. The scattering phases acquired across the cavity wind by the same integer that labels the topological invariant of the zero mode.

Coupling two chevrons by an intra-sublattice bond produces a tunable two-level system built from topological zero modes; its level spacing is set by the inter-chevron coupling. The mechanism is independent of microscopic realisation and extends to graphene's experimental analogues — photonic waveguide arrays, cavity-polariton lattices, microwave honeycomb networks — making the chevron junction a minimal building block for topological qubit engineering across 2D platforms.

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P76. Isotope Engineered Symmetry Breaking in Polar van der Waals Crystals

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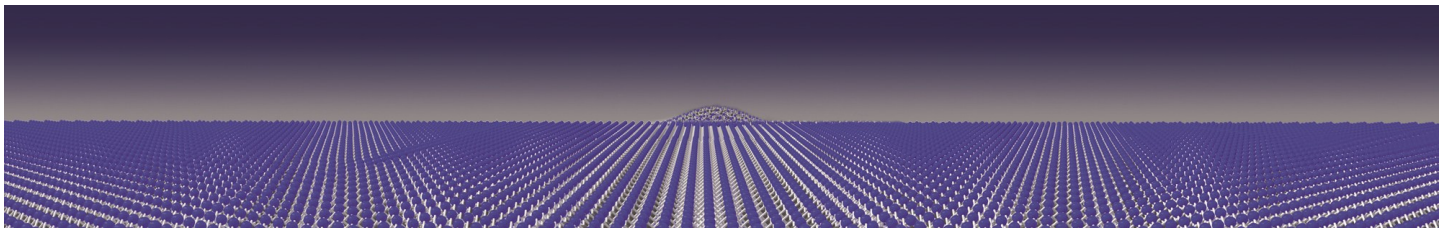
Polaritons—hybrid light–matter quasiparticles arising from resonant photon–phonon coupling—enable extreme optical anisotropy and nanoscale light manipulation in polar crystals. Traditionally, shear polaritons have been associated with intrinsically low-symmetry materials such as β-Ga_2O_3 or $CdWO_4$, where non-orthogonal vibrational modes give rise to asymmetric dispersion and directional energy flow. However, achieving tunable control over such symmetry-broken polaritonic responses remains challenging due to material constraints.

In this work, we demonstrate that shear-like polariton behavior can be induced even in a nominally symmetric vdW crystal, α-MoO_3, through a combination of isotopic loss engineering and interlayer twist control. By systematically varying the isotopic composition of molybdenum and oxygen, we tailor the phonon damping while maintaining the underlying lattice symmetry. When two isotopically distinct α-MoO_3 layers are twisted with respect to one another, the resulting heterostructure exhibits pronounced



asymmetry in polariton propagation—shear behavior emerging purely from controlled loss imbalance and twist geometry. Our analytical and numerical models establish a generalized framework to quantify shear polaritons independent of crystal thickness, revealing that the phenomenon depends solely on permittivity anisotropy and twist-induced phase mismatch, confirmed by the experimental results as well. This approach opens a new paradigm for realizing symmetry-breaking polaritonic phenomena in otherwise symmetric materials, offering a scalable and tunable pathway to engineer anisotropic light transport in van der Waals systems.

P77. Fast Programming of In-Plane Hyperbolic Phonon Polariton Optics through van der Waals Crystals using the Phase-Change Material In_3SbTe_2

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Alpha-phase molybdenum trioxide (α-MoO_3), a van der Waals material, supports in-plane hyperbolic phonon polaritons (HPhPs) characterized by high confinement, low losses, and extremely directional propagation [1]. This strong directionality has enabled new strategies for guiding and controlling energy transport at the nanoscale. However, efficient excitation of HPhPs still relies on conventional nanofabrication techniques, which are both costly and time-consuming. Rapid prototyping of nanostructures for tailoring polaritons can be achieved using the plasmonic phase-change material In_3SbTe_2 (IST) [2], which can be reversibly switched between amorphous and crystalline phases via laser-induced heating. This concept has already been demonstrated for programmable resonator structures in hBN [3]. Here we combine α-MoO_3 with IST to optically program a variety of launching and confining structures for polaritons [4]. Optical writing directly through the flake after deposition enables fast and precise alignment with the crystal axes of launching stripes to steer HPhP propagation. Furthermore, optical programming of a circular structure enables polariton focusing, yielding confinement and tunability comparable to conventional gold disks [5, 6]. Finally, we take a step toward the first experimental realization of a cavity for in-plane HPhPs by optically programming a double disk configuration. By reconfiguring the distance between the disks, the confinement and field enhancement can be tuned. Overall, our results provide a route toward rapid design of reconfigurable nanostructures and offer an all-optical material platform for controlling in-plane HPhPs.

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P78. ZrNCl: A Wide-Bandgap 2D Semiconductor to Twisted Superconductivity

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β-ZrNCl is a wide bandgap 2D semiconductor and a promising platform for moiré-engineered correlated states. Monolayer and few-layer ZrNCl are air-stable van der Waals semiconductors with an indirect gap of nearly 2 eV (Γ-VBM, K-CBM)1,2, high electron mobility, and strong layer-dependent Raman signatures.3 Upon electron doping by intercalation or ionic-liquid gating, ZrNCl undergoes an insulator-superconductor transition, realizing an ultra-thin (~1.8 nm) 2D superconducting state with a dome-shaped Tc versus carrier density and a wide quantum-metallic regime dominated by vortex dynamics.4 Recent high-throughput studies identify ZrNCl as a "twistable" K-valley insulator whose weak-SOC band edge enables controlled moiré band formation.2 Twisting can strongly enhance the density of states and is predicted to raise Tc toward ~40 K5 (from ~14.8 K as seen in ionic liquid-gated ZrNCl)4, and at large twist angles may realize topological superconducting ground states6. We present an experimental headstart in device characterization, showcasing our progress toward achieving these moiré-engineered superconducting states in 2D device geometry.

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P79. Oscillator strength of electrostatically confined excitons

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Excitons in transition metal dichalcogenides (TMDs) exhibit exceptionally high binding energies, small Bohr radii, and consequently high oscillator strengths [1]. While this makes them attractive for light–matter coupling, the small Bohr radius renders interactions weak and short-range; consequently, nonlinear effects are suppressed. Spatial confinement of excitons can be employed to circumvent this limitation of free excitons.

In our study, excitons in MoSe2 are confined using in-plane electric fields, as first demonstrated in [2]. Using polarization-resolved reflection measurements, we show that the motional states exhibit reduced linewidth and oscillator strength, in agreement with previous studies, while featuring a rich brightness profile: the lowest n-state is the brightest, followed by higher even-numbered energy states, while the odd-numbered states are dark due to symmetry. These results are in good agreement with ab initio calculations [3].

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P80. Interlayer coupling in a magnet/semiconductor 2D heterostructure

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The advent of optically active van der Waals magnetic materials opened many new avenues to study the coupling between them and other 2D materials. Of particular interest is chromium sulfur bromide (CrSBr) due to its rich excitonic landscape and magnetic texture.

Here, we aim to elucidate the coupling between three-layer CrSBr and monolayer MoSe2. To this end, multiple samples are studied using photoluminescence (PL) and PL excitation (PLE) spectroscopies. To investigate further, two devices with electrostatic control over the charge density in MoSe2 were fabricated. Interestingly, the heterostructure shows evident changes in the MoSe2 PL spectrum if compared to the spectrum of pristine MoSe2, highlighting the presence of a strong electronic coupling between MoSe2 and CrSBr. Modulating the charge density allows to probe the dependence on fermi sea occupation, giving insights into the nature of the observed emission.

P81. Towards establishing a sample-independent phase diagram of magic-angle twisted bilayer graphene

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Magic-angle twisted bilayer graphene (MATBG) is a two-dimensional system obtained by stacking two graphene sheets with a relative twist of approximately 1.1°, generating a moiré superlattice that profoundly reshapes the electronic band structure. The resulting flat bands enhance electronic interactions and give rise to a rich variety of correlated phases, including superconductivity, correlated insulators, and non-Fermi liquid metals. However, microscopic device details, such as substrate effects, twist-angle inhomogeneity, and local strain can influence the stability of these phases, leading to device-to-device variability in the reported phase diagrams. We perform a systematic study of the temperature-dependent resistivity across multiple MATBG devices fabricated using the same protocol. By comparing several samples within a unified analysis framework, we identify robust and reproducible transport features to construct a sample-independent low-temperature phase diagram. Building on this extensive dataset, we can resolve the still open questions in the MATBG phase diagram by interpreting the most reproducible transport features within the theoretical framework of the topological heavy-fermion model.

P82. Nano-electrical characterization of moiré systems

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Moiré bilayers have emerged as established playgrounds for exploring various strongly correlated electronic and topological phenomena, such as unconventional superconductivity and Chern insulator phases. Characterizing the electrical properties of moiré systems at the nanoscale can greatly enhance the understanding of their diverse electronic features. By leveraging the versatility of correlative and cryogenic scanning probe microscopy (SPM), we demonstrate a comprehensive research process on layered graphene structures, spanning from the identification of regions of interest with Kelvin probe force microscopy (KPFM) to the revelation of their local electrical and electromechanical properties using conducting-tip atomic force microscopy (ct-AFM) and piezo-response force microscopy (PFM). We have achieved a lateral resolution of

<10 nm in these moiré bilayers, which is remarkable for a dry-cryostat environment, and renders cryogenic SPM both suitable and user-friendly for studying moiré systems

P83. Cryogenic scanning quantum sensing of emergent magnetic textures

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Understanding and controlling nanoscale magnetic phenomena at cryogenic temperatures is critical for harnessing the quantum states that drive next-generation technologies. NV magnetometry offers a unique approach by combining quantum sensing with scanning probe precision, achieving magnetic field mapping at resolutions and sensitivities beyond conventional limits. We present cw-ODMR imaging of materials hosting emergent quantum and topological magnetic phenomena, including Abrikosov vortices in BSCCO and YBCO [1], moiré-induced ferromagnetism in twisted double bilayer CrSBr, and topological spin structures such as skyrmions and merons in multilayers and synthetic antiferromagnets.

The measurements were performed using the cryogenic scanning NV magnetometer integrated into a closed-cycle cryostat with turnkey operation from 2–300 K without any special sample preparation. The system achieves ≤3 μT/√Hz sensitivity with automated ODMR, low-noise AFM control, and remote operation for quantitative stray-field mapping [2]. These experimental demonstrations underscore the versatility of cryogenic NV magnetometry in quantitatively resolving nanoscale magnetic textures, establishing a highly sensitive, turnkey quantum sensing tool in a fully commercial system for probing superconductivity, correlated magnetism, and emergent spin textures in quantum materials.

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P84. Interlayer Excitons in CVD Grown Lateral/Vertical Heterostructures

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Heterostructures of semiconducting transition metal dichalcogenides (TMDs) are platforms that host several different excitonic species such as interlayer excitons in vertical heterostructures and charge-transfer

excitons in lateral heterostructures [1]. These excitons are promising candidates to observe phenomena such as Bose-Einstein condensation and for applications in optoelectronics.
In this work, we focus on hybrid heterostructures of MoSe2/WSe2 grown via chemical vapor deposition (CVD) [2]. The novelty of these samples is twofold: (i) They display highly efficient formation of interlayer excitons leading to intense photoluminescence (PL) emission from these interlayer excitons, (ii) They provide simultaneous access to interlayer and charge-transfer excitons [1]. We trace the PL from various excitonic species and find that in the vertical heterobilayer region, the interlayer emission dominates from temperatures of 4 K up to 300 K, indicating high interface quality of these samples. Furthermore, we probe the formation of the interlayer exciton singlet and triplet using photoluminescence excitation (PLE) spectroscopy at various temperatures. We observe distinct temperature-dependent behaviour, possibly indicating different relaxation pathways and coupling strengths to phonon modes.

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P85. Fingerprint of magneto-optical Faraday rotation in Raman spectra of MoS_2

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We perform Raman scanning microscopy on a MoS2 flake at 2K and in varying magnetic field (B), for both parallel (VV) and perpendicular (VH) polarization configuration of polarizer and analyser. We observe suppression of the $\boldsymbol{A1}'$ Raman signal of MoS2 in B=9T in the VH configuration. Raman maps were recorded in different B for both VV and VH configurations, and the intensity ratio of Raman signals $\boldsymbol{A1}'$ and $\boldsymbol{E}'$ was inferred from them. The observed changes in suppression of $\boldsymbol{A1}'$ are in good agreement with previous literature data [2]. However, in another set of published data [3] this change could have only been detected at significantly higher B. Beside the influence of B on the oscillation modes of a crystal, one must also consider the impact of the magneto-optical Faraday effect. For this purpose, we recorded in addition a series of Raman spectra of the Si substrate as the function of B and polarization. The MoS2 and Si peak ratios show approximately the same dependence on B, which indicates the dominant cause for the changes in the detected Raman signals being the Faraday effect. As the Faraday rotation angle is linear with B, it is straightforward to compensate for it, which can even be automated in the cryogenic Raman microscope that we have developed.

P86. Ultimate Precision Navigation in Cryogenic Confocal Microscopy: The CFM Base Kit with trueNAV

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High-resolution cryogenic confocal microscopy increasingly depends on reliable, automated navigation across millimeter-scale sample areas to repeatedly revisit sub-micron points of interest (POIs) such as single emitters. In practice, repositioning is often limited by the fact that conventional cryogenic encoder concepts do not control the *real* sample position, which leaves crosstalk, runout, and drift only partially observable and therefore hard to correct. attocube systems GmbH has developed the CFM Base Kit with trueNAV, an interferometric, feedback-controlled sample positioning solution that integrates external sensors into an ultra-stable microscope housing and measures the sample holder position for closed-loop control. Verified performance demonstrates repeatability across the entire travel range: along a single axis, >95% of returns fall within 50 nm; in 2D, bi-directional repeatability is typically ~200 nm, enabling reliable return to any POI without manual re-alignment. trueNAV further enables active drift compensation during demanding magneto-optical experiments (e.g., wide magnetic field sweeps), minimizing micrometer-scale drifts that otherwise shift the sample under the optical axis. In addition, trueNAV compensates lateral runout during z-focusing by controlling the sample holder position directly, reducing crosstalk and correcting axis errors that integrated sensors cannot detect. Motion is operated via the AMC300 controller through an intuitive WebApp or automation API, supporting streamlined workflows and faster time-to-result in cryogenic quantum- and magneto-optics experiments.

P87. Purcell-enhanced quantum yield of spin defects using open resonators

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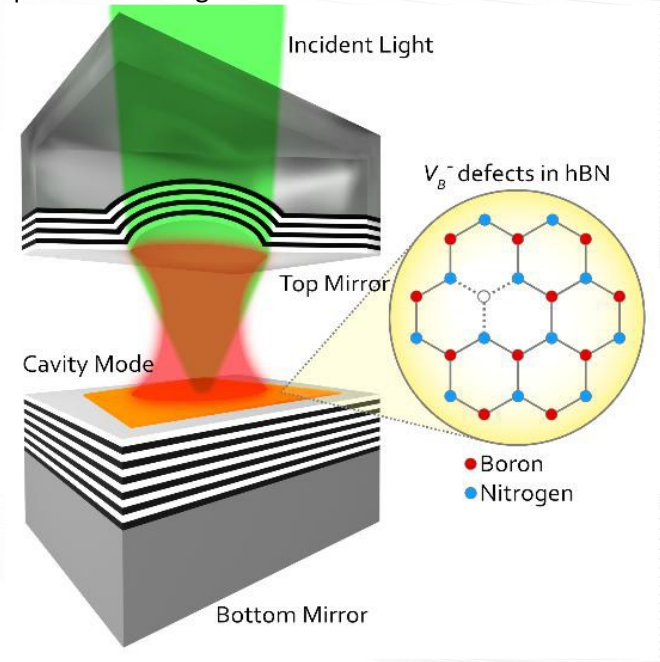
Two-dimensional materials are the emerging materials for quantum photonic applications. Hexagonal boron nitride (hBN) has attracted significant interest due to the defect states, which provide emission across the ultraviolet to near-infrared range at room temperature. While many of the defects act as single photon emitters, the negatively charged boron vacancy ($VB-$) in the hBN exhibits spin-dependent optical response1. Spin qubits from these $VB-$ defects are promising for quantum sensing applications, similar to the nitrogen

vacancy centres in diamond. The two-dimensional nature of hBN and the ability to create defects at its surface make it a favourable platform for integration with photonic chips compared to NV centres in diamond or other bulk systems. Despite these advances, $VB-$ defects suffer from low quantum efficiency due to the faster intersystem crossings being non-radiative and faster by many orders of magnitude than radiative decay. One approach to solve this problem is to make radiative decay faster using Purcell enhancement. Here, we use open micro resonators, concentrating the electric field by enhancing the light-matter interaction2. When the number of states available to emitters in the cavity is reduced and the radiation is directed into specific modes, the emitter's properties are enhanced through the Purcell effect3. Recent advances in Focused Ion Beam (FIB) fabrication now let researchers create concave features with minimal radii of curvature4. This enables ultra-small mode volumes at the scale of the wavelength. This facilitates a sizable Purcell effect even in the bad emitter regime, where the homogeneous linewidth of the emitter is larger than the linewidth of the cavity mode. We assume that this method not only opens up a new tunable approach for enhancing the quantum yield of the $VB-$ defects but also enriches the field of quantum sensing.



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P88. Probing high-bias criticality via near-field photovoltage in a bilayer graphene moiré superlattice

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Nonlinear transport regimes in graphene-based moiré superlattices expose physics far beyond equilibrium. At high current densities, these systems access extreme-field phenomena — including Schwinger-like electron–hole pair creation [1,2], negative differential conductance (NDC) [3], and Cherenkov phonon emission [4] — that are inaccessible in linear response. In bilayer graphene aligned to hexagonal boron nitride (BLG/hBN), the moiré-folded band structure enables a critical peak in differential resistance whose traversal unlocks a bistable electronic state with single-photon sensitivity [3].

We employ cryogenic scanning near-field optical microscopy (cryo-SNOM) at mid-infrared frequencies to study the spatially resolved photovoltage (PV) in BLG/hBN as the dc bias is tuned across this critical peak. Near criticality, the PV response is dominated by bulk bolometric contributions, while the spatial extent of the PV phase-reversal boundary broadens. These observations establish near-field optoelectronic microscopy as a nanoscale probe of photovoltage generation mechanisms under strong in-plane electric fields, complementing recent nano-infrared imaging of current-driven nonequilibrium electrodynamics in graphene [4]. Our results may enable spatially resolving the interplay between Schwinger pair creation, negative differential conductance, and bolometric heating in moiré superlattices.

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P89. Bulk–Surface Electronic Contrast in 2D β-Sb_2O_3

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Understanding how dimensional reduction modifies electronic structure is central to the development of next-generation wide-bandgap materials [1,2]. Here, we report a combined experimental and theoretical investigation of mechanically exfoliated two-dimensional β-Sb_2O_3 (valentinite) flakes, focusing on the contrast between bulk and surface electronic behavior. While conductive AFM measurements demonstrate robust insulating behavior with dielectric breakdown fields between 0.17 and 0.36 V/nm, scanning tunneling spectroscopy reveals a near-zero apparent energy gap at the flake surface at room temperature. Cathodoluminescence measurements indicate broad defect-related emission extending up to ~3.2 eV, establishing a lower bound for the optical bandgap. First-principles calculations suggest a wide bulk bandgap (~2.8 eV, HSE06) and predict strong surface-induced band modulation depending on termination. These results uncover a pronounced bulk–surface electronic contrast in 2D β-Sb_2O_3, highlighting the critical role of surface structure in wide-bandgap materials and opening opportunities for surface-engineered electronic functionalities.

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P90. Polariton memory in a van der Waals antiferromagnet

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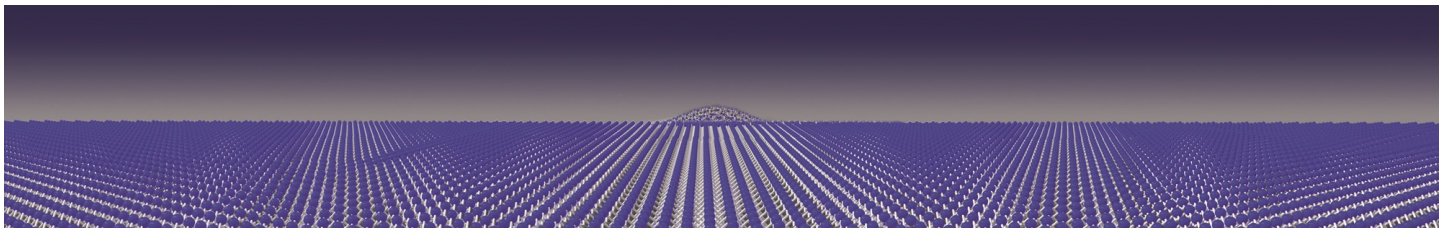
Van der Waals magnetic crystals were recently found to exhibit optical quasiparticles called exciton-polaritons tied to magnetic order. Here, we demonstrate that such optical modes can be programmed in the layered antiferromagnet CrSBr. Magnetic phases encode the interference of light inside bulk crystal cavities.



Field-induced phase changes can cut-off short-wavelength modes or lead to smooth shifts with contrast correlations for long-wavelength polaritons. Exciting magnetic phase mixtures by light induces hysteresis of polariton energy and non-linear emission intensity. Numerical analyses help unwrap the dynamics of magnetic phase nucleation and growth underpinning these phenomena. Ultimately, our experiments seek to realize a multistate polariton memory platform that can be integrated into photonic networks for neuromorphic computing applications.

P91. Substrate Driven Polariton Phenomena in Graphene Nanoribbon Heterostructures

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Atomically precise graphene nanoribbons (GNRs) have emerged as promising low-dimensional materials for optoelectronic and quantum technologies. Through the bottom-up synthesis approach it is possible to precisely control their growth, width and edge structures. [1] Of their many types, armchair-edged GNRs (AGNRs) have been the only class successfully integrated into electronic devices, primarily due to their robustness and chemical stability under ambient conditions. [2] They also possess a bandgap which can be precisely tuned by controlling the ribbon width. [1] Their robustness, stability and tunability makes them attractive candidates for integration into hybrid heterostructures.

Despite the rapidly growing interest in GNRs, the optical properties of GNR/2D-material hybrid systems remain largely unexplored. In particular, it is still unclear how the incorporation of a GNR layer modifies the intrinsic optical and polaritonic properties of layered materials, and whether interfacial coupling induces emergent phenomena absent in the individual constituents. Understanding these interactions is essential for the development of future optoelectronic and photonic devices.

In our work, we plan to investigate hybrid heterostructures combining bottom-up synthesized AGNRs with WS2, ZrS3, and hBN. The study will focus on possible charge and energy transfer processes, structural modifications induced by stacking, changes in optical emission, and the influence of GNR layers on polariton propagation phenomena supported by the underlying 2D materials.

Prior to GNR transfer, the selected materials were systematically pre-characterized using Raman spectroscopy, PL spectroscopy and mapping, and s-SNOM. In particular, polariton imaging was performed to correlate propagation and extinction behavior with flake thickness in the investigated materials. These measurements establish the baseline optical and nanophotonic properties necessary for subsequent investigation of modifications in the hybrid heterostructures.

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P92. Dimensionality-Dependent Exciton Dispersion in a Single-Band Mott Insulator

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P93. Revealing enhanced magnetic interactions in Ni-Substituted Fe_5GeTe_2 by scanning quantum microscope

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Searching for room-temperature two-dimensional (2D) magnetism is crucial for advancing spintronic technologies. Recent studies have shown that nickel (Ni) substitution into Fe_5GeTe_2 significantly enhances magnetic ordering well above room temperature. Here, we employ scanning quantum microscopy based on nitrogen-vacancy (NV) centers in diamond to visualize the magnetic properties of Ni-substituted FGT (Ni-FGT) at the nanoscale. We present the first spatially resolved magnetic maps of Ni-FGT flakes, revealing robust long-range magnetic order persisting up to 340 K. Local variations in Ni concentration generate low-frequency Barkhausen noise, resulting in linewidth broadening of optically detected magnetic resonance (ODMR). Spatial mapping of this linewidth broadening uncovers internal stress associated with the Ni distribution. Further spin-relaxation measurements reveal strong magnon noise in the GHz regime, surpassing that observed in previously studied 2D magnets, and reinforce the role of Ni substitution in strengthening magnetic interactions. Our results establish a new approach for probing local magnetic substitution and identify substitution-induced internal stress as a key mechanism for enhancing magnetic order in 2D systems.

P94. Stability Analysis of MXene Materials in the Context of Substrate-Isolated Deposition

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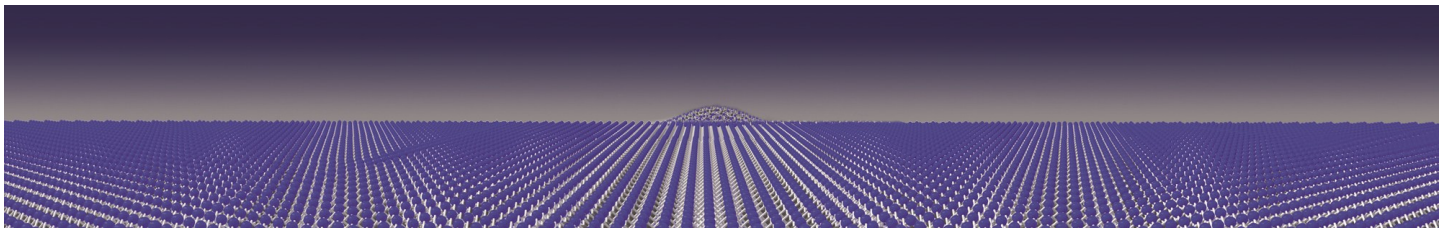
MXene materials, alongside graphene and transition metal dichalcogenides (TMDs), constitute one of the most rapidly advancing classes of two-dimensional materials[1]. Their exceptional properties, including high electrical conductivity, excellent mechanical flexibility, and a large specific surface area suitable for efficient ion storage, render them highly promising for applications in supercapacitors, batteries, sensors, and



electrical engineering[1,2]. Nevertheless, significant challenges persist, particularly with respect to long-term stability and the influence of the substrate on charge transfer, mechanical strain, phonon coupling, and dielectric screening[3]. In this study, the degradation mechanisms of selected MXene materials, specifically Ti_3C_2 and V_2C, were systematically investigated under ambient conditions, elevated humidity, and ultraviolet irradiation. The primary objective of the research was to develop a methodology enabling the reduction of substrate-induced effects on the properties of MXene materials. To this end, comprehensive characterization was performed using Raman spectroscopy (RS), Fourier-Transform Infrared Spectroscopy (FTIR), and X-ray diffraction (XRD).

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P95. Edge polaritons at metal-insulator boundaries in a phase separated correlated oxide

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Correlated transition metal oxides, such as nickelates, are typically classified as “bad metals” because high electromagnetic losses suppress the conventional plasmonic effects observed in noble metals or graphene1. These materials undergo first-order metal-insulator transitions (MIT) that lead to spontaneous phase separation and the formation of metal-insulator (MI) boundaries, which are highly promising for nanophotonics as the sign change in dielectric permittivity across the interface can host confined polaritonic modes1,2. Using mid-infrared scattering-type scanning near-field optical microscopy (s-SNOM), we demonstrate the emergence of strongly confined, long-propagating edge polaritons (EPs) of mixed phonon-plasmon nature at MI boundaries in NdNiO3 thin films. These modes are fingerprinted by a pronounced peak in the near-field signal phase2, which remains robust whether the transition is triggered by ambient temperature changes or local Joule heating from an electric current. Finite-element simulations and amplitude-phase correlation analysis reveal that the physical nature of these EPs depends on boundary smoothness: abrupt edges host one-dimensional optical edge states, while broader boundaries are driven by epsilon-near-zero (ENZ) absorption. Our results highlight the critical role of nonlocal plasmonic effects and demonstrate that correlated oxides can support functional polaritonic modes despite high intrinsic losses, opening new avenues for infrared nanophotonics.

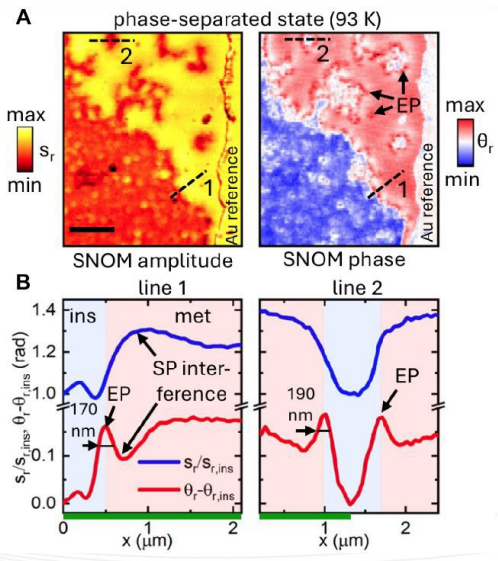

Figure 1. Correlative amplitude-phase s-SNOM imaging of phase-separated NdNiO3 films. A Maps the amplitude sr (left) and phase θr (right) of a 10nm-thick NNO film at 93K. B Line profiles along the dashed lines in (A) normalized to their values of the insulator state.

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P96. Magnetic-induced p-doped Wigner crystal dressed exciton in WSe_2

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The Wigner crystal represents a paradigmatic strongly correlated electronic phase arising when Coulomb interactions dominate over kinetic energy and drive carrier localization into an ordered state. Monolayer WSe_2, with its large valence-band effective mass, provides an ideal platform to access this regime, as supported by previous transport studies indicating enhanced interaction effects. In this work, we report the observation of the magnetic-induced Wigner crystal phase in a p-doped monolayer semiconductor WSe_2, utilizing optical reflection spectroscopy as a sensitive probe, exhibits ahigh melting temperature (T_c≈20-30"K"). With increasing doping, the umklapp peak gradually disappears, signaling a transition from a Wigner crystal to a Fermi-liquid state. This transition is accompanied by a pronounced spectral kink and the emergence of a high-energy polaron branch. Furthermore, helicity-resolved magneto-optical measurements reveal a valley-dependent response. Our experiments provide compelling evidence for the transition from a Wigner crystal to a Fermi-liquid state, offering new insight into the interplay between excitons, trions, and strongly correlated electrons in monolayer semiconductors.

P97. Electrostatic Control of Moiré Exciton-Polaritons

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Moiré exciton-polaritons, formed by coupling excitons in a semiconductor moiré heterostructure to cavity photons, offer a versatile platform for exploring strongly correlated states and exciton polariton lattices. Here, we use electrostatic gating to establish the polaritonic phase diagram of a dual-gated $MoSe_2/WS_2$ heterobilayer coupled to an open fiber cavity. Leveraging the dual-gate architecture, we achieve signatures of hybridization between inter- and intralayer exciton-polaritons and demonstrate active control of a moiré-induced optical nonlinearity via field-driven modification of the moiré potential. Upon electron doping, we observe coupling between polaritons and correlated insulating states at fractional and integer fillings of the moiré lattice, resulting in a renormalization of the light-matter coupling. Our results establish moiré exciton-polaritons as a versatile probe of correlated electronic phases with independently tunable field and doping control.

P98. Local photoconductivity dynamics in semiconductors investigated by THz near-field microscopy

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Near-field spectroscopy is an advanced optical technique which provides resolution down to nanometer length scale. We employ a scattering type scanning near-field microscope operating at terahertz frequencies to study ultrafast time evolution of THz conductivity after photoexcitation of single-crystal GaAs and InP wafers above the bandgap. We were able to characterize the depth profile of conductivity near the sample surface [1]. In GaAs an exponential decay of charge carriers on a sub-nanosecond timescale was observed with no significant carrier redistribution in space. Interestingly, the carrier lifetime in InP exceeds several nanoseconds and the spatial profile of the photoconductivity is influenced by the diffusion of electrons away from the photoexcited area and by their drift due to the band-bending at the surface. The THz spectra (Fig.

1a,b) were analyzed using a finite-dipole model of the interaction between light and tip-sample system [2] allowing us to assess the evolution of the electron density and electron scattering time (Fig 1c,d).

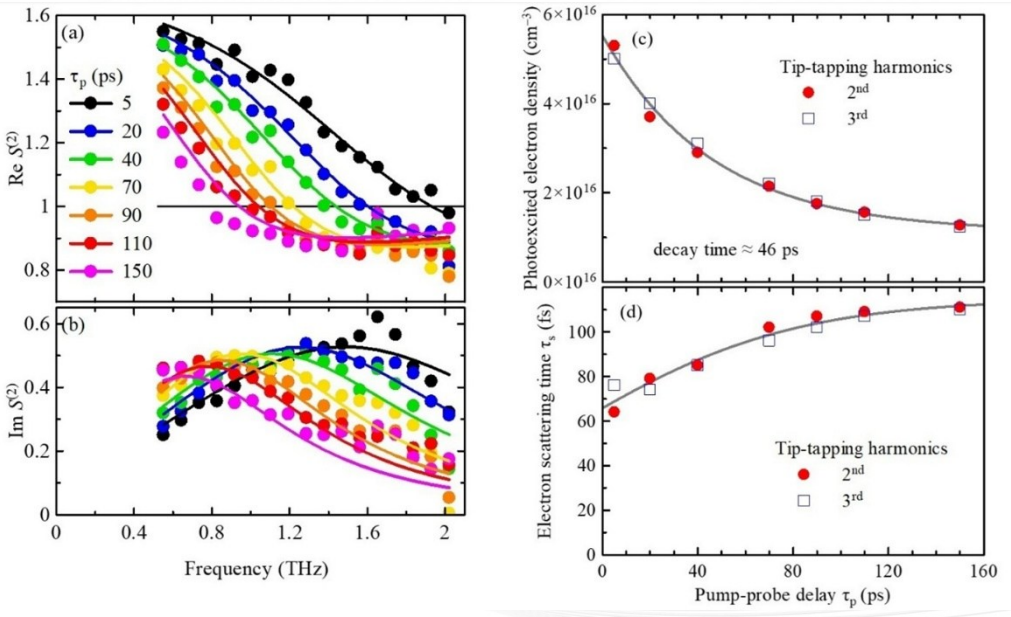

Fig. 1: (a,b) Real and imaginary part of the THz-SNOM spectra in photoexcited GaAs normalized to the signal from unexcited GaAs. A tip-sample plasmon resonance is observed which red-shifts with increasing time after photoexcitation τ_p. (c,d) Time evolution of photoexcited electron density and electron scattering time in GaAs.

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P99. High-Energy Interlayer Exciton Ensembles in $MoSe_2/WSe_2$ Heterostructures by Laguerre-Gaussian Excitation

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We reveal the higher energetic luminescence part of interlayer exciton ensembles in MoSe2/WSe2 heterostructures upon excitation by an optical Laguerre-Gaussian mode. The excitation is achieved with the help of a spatial light modulator giving rise to a ring-shaped distribution of interlayer excitons. A

hyperspectral analysis of the exciton photoluminescence suggests that the excitation scheme allows the accumulation of high-energetic excitons in the rings' center. Since the exciton luminescence exhibits a negligible variation of the energetic blue shift of the emission energy as a function of intensity across the rings, we can exclude spatially varying exciton-exciton interactions and a local phase-space filling of lower exciton states to be the dominant underlying process. An incomplete thermalization and an inward propagation of non-thermalized excitons consistently explain the accumulation of high-energetic excitons in the rings' center.

P100. Towards Quantum Twisting Microscopy of Twisted Bilayer Graphene: Clean Stack Assembly utilizing van der Waals sliding

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Quantum twisting microscopy (QTM) enables momentum-selective tunneling spectroscopy in encapsulated van der Waals (vdW) devices, offering direct access to the electronic spectral function of twisted bilayer graphene (TBG). In practice, however, the achievable energy–momentum resolution and reproducibility between devices are often limited by interfacial disorder, local strain, twist-angle inhomogeneity, and trapped contamination that form bubbles and wrinkles during assembly.

Here, we present a fabrication workflow for QTM-ready TBG heterostructures. Our approach combines dry pick-up assembly methods—commonly used for high-quality hBN-encapsulated TBG devices—with vdW sliding techniques, implemented as hBN sliding and hBN sledding, to sweep and expel interfacial contamination during stacking. This method enables large, bubble-free overlap regions with improved interface cleanliness. We assess device quality using optical microscopy (bright-field, dark-field, and laser-scanning modes) and advanced AFM techniques, including PeakForce microscopy and scanning microwave impedance microscopy (sMIM).

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P101. Excitons in Monolayer-hBN-Separated WSe_2 Bilayers

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Interlayer excitons in van der Waals semiconductors are promising platforms for exploring dipolar exciton physics owing to their large binding energies, long lifetimes, and permanent out-of-plane electric dipole moments. However, in conventional transition-metal dichalcogenide bilayers, the interlayer spacing and excitonic coupling are fixed by direct van der Waals contact, limiting control over dipole moment and hybridization. Here, we insert a monolayer of hexagonal boron nitride between two WSe_2 monolayers to form an artificial WSe_2/hBN/WSe_2 bilayer and investigate its excitonic states in a dual-gate device. The atomically thin hBN spacer increases the electron–hole separation while preserving strong interlayer Coulomb interaction, enabling interlayer excitons with enhanced dipolar character. Using electric-field-dependent optical spectroscopy, we observe an interlayer K–K exciton with a significantly enlarged out-of-plane dipole moment. Upon tuning the vertical electric field, this interlayer exciton anti-crosses with intralayer K–K excitons, indicating strong coupling and hybridization between excitonic states in different layers. We further observe a field-induced switching of the dominant excitonic species, which we attribute to electric-field control of the band alignment and associated changes in layer-resolved doping. Our results establish monolayer-hBN-separated WSe_2 bilayers as a tunable platform for engineering dipolar excitons and exciton hybridization in van der Waals heterostructures.

P102. Coherent interaction of exciton states in TMDC monolayers

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We use femtosecond pump-probe spectroscopy to study the coherent interaction of excited exciton states in WSe2 and MoSe2 monolayers via the optical Stark effect [1]. For co-circularly polarized pump and probe, we measure a blueshift which points to a repulsive interaction between the 2s and 1s exciton states. The determined 2s-1s interaction strength is on par with that of the 1s-1s, in agreement with the semiconductor Bloch equations. Furthermore, we demonstrate the existence of a 2s-1s biexciton bound state in the cross-circular configuration in both materials and determine their binding energy. In recent experiments we observed analogous interactions in WS2 and MoS2 monolayers.

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P103. Modal Phase Matching and Hybrid Integration for 3R-MoS_2 Nonlinear Nanophotonics

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Efficient second order nonlinear processes in photonic integrated circuits remain constrained by the challenge of simultaneously achieving strong $\chi^{(2)}$ nonlinearity and low-loss propagation. Established platforms such as lithium niobate provide large nonlinear coefficients and mature device architectures, while silicon nitride (SiN) offers ultra-low loss waveguides but lacks the intrinsic $\chi^{(2)}$ nonlinearity [1]. These trade-

offs between waveguide architectures motivates the development of hybrid platforms that combine highly nonlinear materials with low loss photonic circuitry.

Due to its non-centrosymmetric stacking, 3R-MoS_2 is a promising candidate, possessing a large nonlinear coefficient ($\chi^{(2)}$ = 100-1000 pm/V) whilst remaining largely transparent at both 1550 nm and 775 nm [2]. Its van der Waals nature further enables post-fabrication integration with well-established SiN waveguides. While SHG has been demonstrated along 3R-MoS_2 flakes, existing implementations typically rely on unpatterned (as-exfoliated) geometries, limiting scalability and control over guides modal properties [2]. Realising its potential in photonic integrated circuits therefore requires either precise geometrical optimisation or integration within hybrid architectures that enhance modal interaction and signal extraction.

In our work, we utilise the high $\chi_{yyy}(2)$ nonlinear coefficient of 3R-MoS_2 to design an optimised waveguide platform for SHG with inverted layer stacking. We specifically target modal phase matching between a fundamental TE_0 mode at 1550nm, and a second-harmonic TE_{01} mode at 775nm. Using Finite-Difference Eigenmode (FDE) simulations, we characterise the effective index of these respective modes and achieve a range of phase-matching conditions by precisely tuning the waveguide geometry (Fig 1a).

By evaluating the mode distribution and resulting nonlinear overlap (Fig 1b), we calculate a conversion efficiency of 37,500% $W^{-1}cm^{-2}$. This performance, facilitated by the high mode confinement and the $\chi_{yyy}(2)$ inversion introduced by an inverted 3R stacking sequence [3], demonstrates that 3R-MoS_2 is a capable short-range medium for frequency conversion. Crucially, this platform surpasses the theoretical performance of layer-poled lithium niobate (LPLN) without the need for external poling [4].

Moving towards application, we propose and discuss a hybrid integration scheme using a low-loss SiN bus waveguide. Using Eigenmode Expansion (EME) and Finite-Difference Time-Domain (FDTD) simulations, we specifically characterise the design of an adiabatic transition that allows the second-harmonic signal to transition from the 3R-MoS_2 into the SiN layer with high efficiency (Fig 1c), thereby utilising the TMD exclusively for frequency conversion and SiN for low loss propagation. This flexibility provides potential integration in periodic architectures or waveguide ring resonators, where resonant enhancement could further boost conversion efficiency within a standard PIC platform.

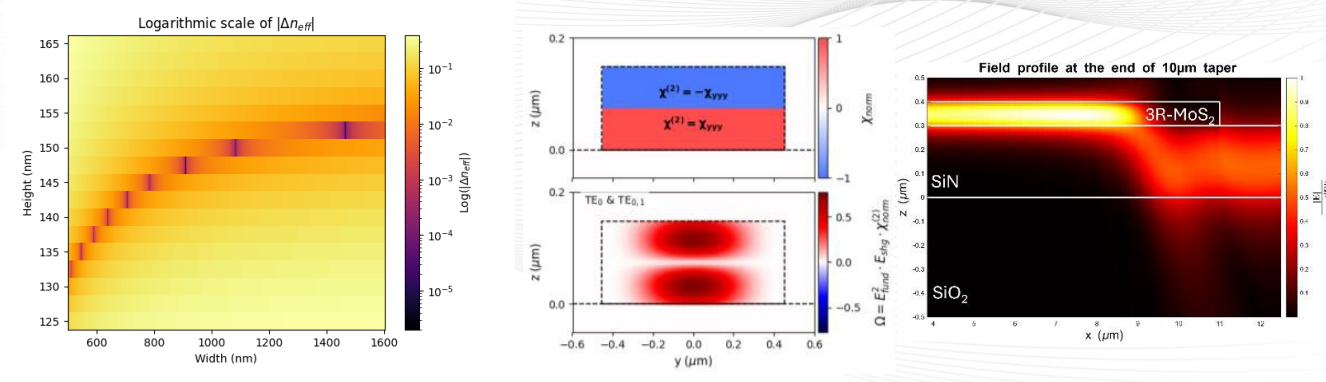

Figure 1: **a.)** Effective index matching between TE0 (pump) and TE01(SHG) **b.)** χyyy(2) inversion by inverted 3R stacking and resulting nonlinear overlap **c.)** Field profile cross section of 10µm 3R-MoS2 adiabatic taper on SiN waveguide.

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P104. Excitonic dynamics in 2D materials revealed by THz excitation

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Experimental capabilities at the free-electron laser FELBE for studying low-energy dynamics in 2D materials are presented. The user facility FELBE provides intense, narrowband, tunable radiation in the spectral range 1.3 – 60 THz (photon energy 5 – 250 meV) with a repetition rate of 13 MHz. We discuss two techniques, namely time-resolved photoluminescence and photocurrent spectroscopy, and show exemplary results regarding excitonic complexes in transition in metal dichalcogenides and gapped bilayer graphene, respectively. Notably, in both cases exfoliated materials with size comparable or smaller than the wavelength of the applied THz radiation are investigated. For experiments on the nanoscale, FELBE is furthermore equipped for scattering-type near-field microscopy [1].

Utilizing time-resolved photoluminescence combined with THz excitation, we demonstrate ultrafast switching between trion and exciton states in a $MoSe_2$ monolayer. THz-induced dissociation of a trion into an exciton and a free electron is enabled when the photon energy exceeds the binding energy (25 meV) of the trion [2]. Interestingly, such processes can be carried out at comparably low THz fluence since it is a linear process where one THz photon can dissociate one trion. In moiré-free $MoSe_2/WSe_2$ bilayers THz-induced triplet-to-singlet transitions as well as THz-induced interlayer-to-intralayer exciton transitions [3] are observed.

We also present linear and nonlinear THz photocurrent spectroscopy experiments on a bilayer graphene sample sandwiched between hBN layers and graphitic gate electrodes. Linear photocurrent spectroscopy utilizing a Fourier-transform infrared (FTIR) spectrometer reveals sharp excitonic peaks similar to previous studies [4]. Excitonic photocurrent peaks are also measured under irradiation with narrowband radiation (fixed photon energy 24 meV and 70 meV, respectively) from the free-electron laser FELBE, when the bandgap is tuned by the displacement field. Applying time-delayed pulse trains of variable delay with fluences that saturate the photocurrent response allows us to gain insights into the carrier dynamics. We determine carrier and exciton lifetimes under various conditions. We find lifetimes of the 2p exciton in the range of 500 ps at excitation with 70 meV photon energy. The technique of nonlinear photocurrent spectroscopy is well suited to explore the low-energy dynamics in 2D materials and van der Waals heterostructures.

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P105. Compact, open, and tunable two-dimensional Fabry-Pérot cavity

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In order to enhance light-matter interactions, optically active material, like a semiconductor, can be embedded into an optical cavity. For small cavity mode volumes, which are required for reaching the strong coupling regime, this is typically done by fabrication of microcavities. While guaranteeing a mechanically stable cavity, these systems lack tunability and are difficult to implement for small samples like van der Waals heterostructures (vdW). Here we present a design for a fully tunable two-dimensional (2D) Fabry-Pérot (FP) cavity which can host any material. The cavity can be freely positioned between two confocal high-NA aspheric lenses which allows for optical transmission microscopy and spectroscopy in real and momentum space. In order to maintain maximal mechanical stability, the cavity mirrors are held in a monolithic titanium frame. A pre-loaded flexure joint allows for manual coarse tuning of the cavity length and mirror parallelism, while three piezo actuators in a tripod layout can be used for fine tuning. We find cavity length fluctuations smaller than 100 pm, measure a finesse of 360 and reach the lowest accessible m=3 cavity mode (one electric field antinode within the air gap) at a minimal physical mirror separation of 380 nm. In order to demonstrate the 2D nature of the cavity mode we perform momentum space imaging in transmission as well as spectroscopy to measure the cavity dispersion.

P106. Giant edge magnetism from current-driven valley splitting across the topological gap

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P107. Mid-Infrared Driven Modulation of Single-Photon Emitters in Hexagonal Boron Nitride

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Single-photon emitters (SPEs) in hexagonal boron nitride are promising candidates for integrated quantum photonic technologies due to their bright room-temperature operation and compatibility with nanophotonic platforms. While optical excitation of these emitters is typically achieved using off-resonant visible excitation, the role of phonons in the excitation and recombination processes remains incompletely understood. In this work, we investigate the effect of mid-infrared (MIR) excitation on blue-emitting SPEs in hBN and demonstrate a reversible, nondestructive enhancement of photoluminescence under MIR coexcitation. Resonant driving of defect-localized in-plane infrared-active optical phonon modes near 7.3 µm modifies carrier recombination pathways, leading to enhanced emission intensity. Our results reveal a previously unexplored mechanism for dynamically controlling solid-state quantum emitters and provide new opportunities for room-temperature quantum photonic applications.

P108. Quantum Optical Twist and Scan Microscopy

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We combine QTM with optical microscopy and spectroscopy to access excitonic and polaronic resonances in van der Waals materials at cryogenic temperatures while retaining in-situ control over relative position and twist angle. We present the instrument concept and first experimental results. We further discuss extensions toward reconfigurable moiré potentials and nanoscale sensing using defect-bound quantum emitters in 2D materials, with the prospect of super-resolved measurements of local electric and magnetic environments. Together, these results establish Quantum Optical Twist and Scan Microscopy as a promising platform for probing and engineering correlated phenomena in 2D materials.

P109. Near-field refractometry of van der Waals crystals

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Here we demonstrate that the scanning near-field optical microscopy (SNOM) can be used not only for colorful imaging, but also for accurate and reliable measurements [1]. Specifically, we extract the anisotropic permittivity of MoS2 crystal with a relative uncertainty below 1% by measuring near-field maps of optical modes, guided by MoS2 flakes, which were exfoliated on a glass substrate (Figure 1). To achieve the high precision, we overcome several challenges, involving high quality of the samples (by selecting large, uniform, and defect-free areas of exfoliated flakes) and precise determination of the mode wavevector (by using a transmission mode of SNOM to map excited low-diverging 2D Gaussian beam, followed by analyzing this map with advanced Fourier filtering and direct-space fitting). Our proof-of-concept demonstration confirms that this technique can be used for accurate determination of optical constants for the most synthesized and natural van der Waals materials, which is challenging for standard techniques (such as ellipsometry [2-5] and goniometry) because of their high anisotropy and small, micron-scale, lateral size of exfoliated crystals.

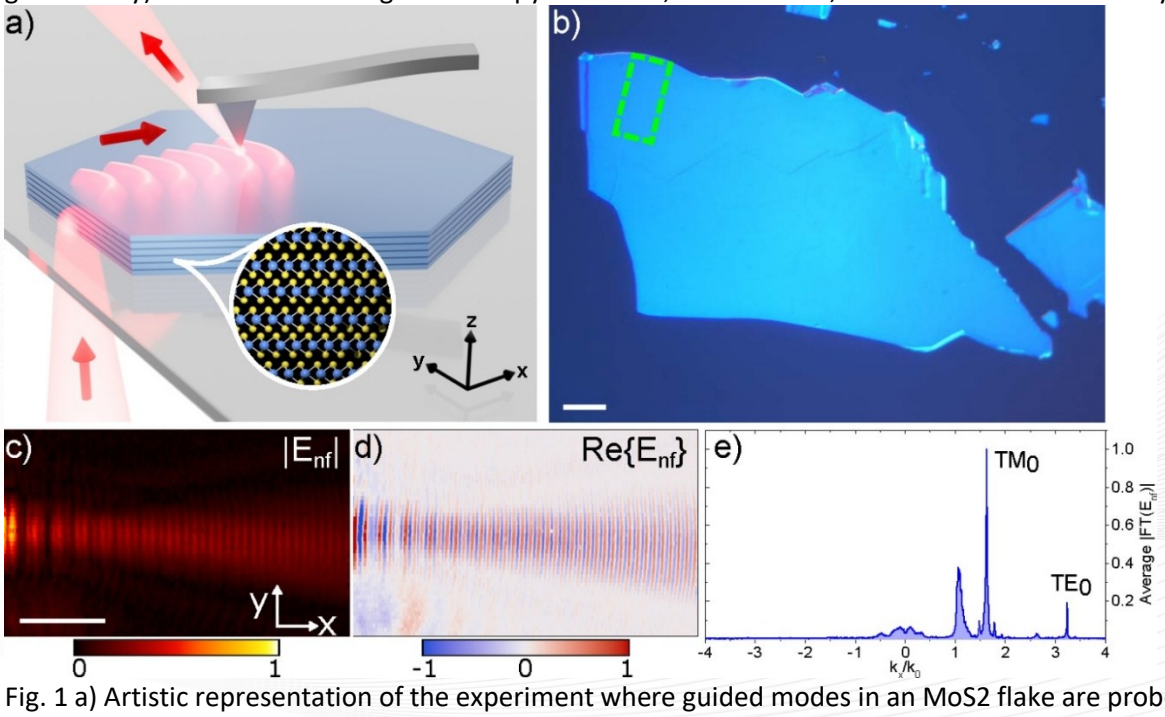

Fig. 1 a) Artistic representation of the experiment where guided modes in an MoS2 flake are probed using a transmission SNOM setup. b) Differential interference contrast image of a 185-nm-thick MoS2 flake. The scale bar is 20 µm. c-d) Amplitude |Enf| and real part Re{Enf} of the complex near-field map of the marked 40 µm by 20 µm region in panel b) (green dashed rectangle). The scale bar is 10 µm. e) Momentum-space representation of the complex near-field map, highlighting Fourier components associated with TE0 and TM0 modes.

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