EVENT PROGRAM

CONDUCTED BY NEBRASKA EPSCoR WITH FUNDING FROM
NATIONAL SCIENCE FOUNDATION AWARD OIA-2044049

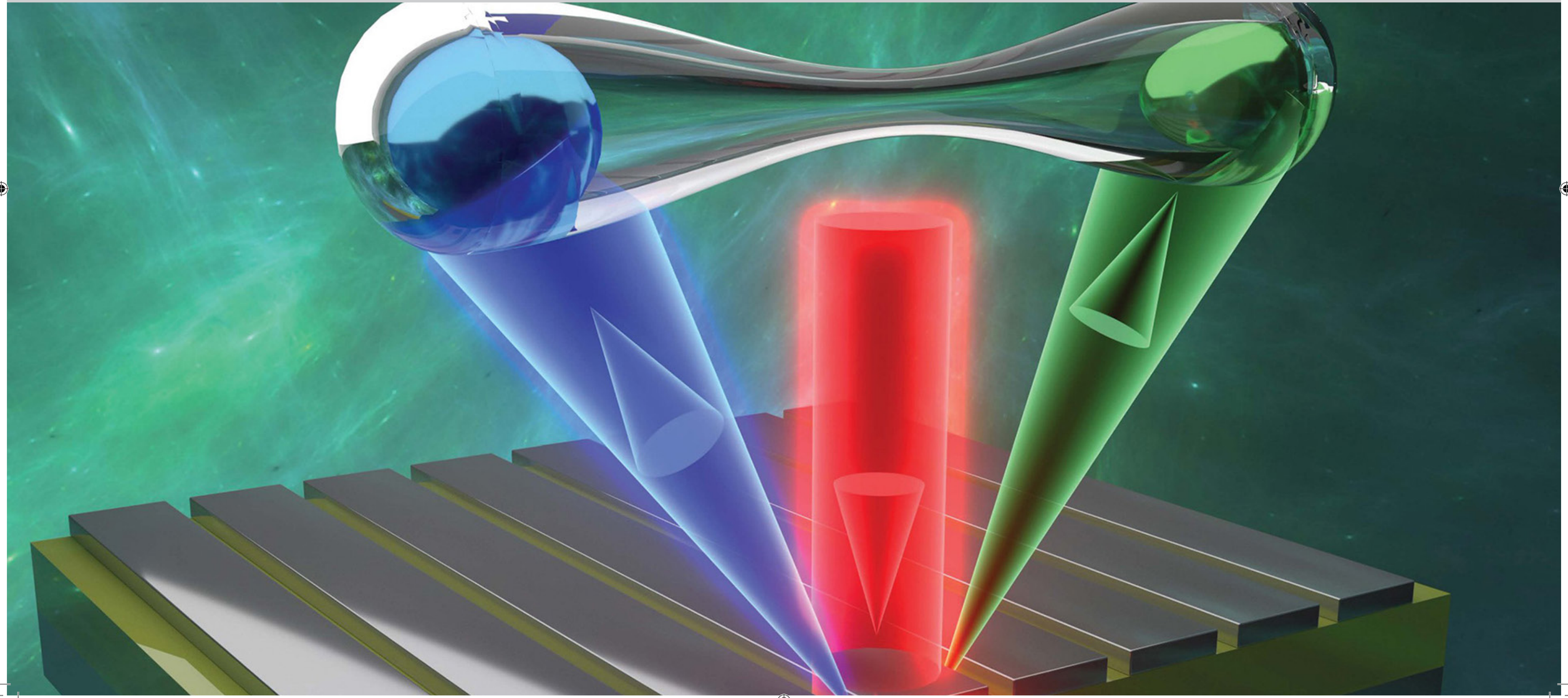
epscor.nebraska.edu | equate.unl.edu

This material is based upon work supported by the National Science Foundation under Grant No. OIA-2044049.
Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

2022 Nebraska Research & Innovation Conference

COMMERCIALIZING QUANTUM TECHNOLOGIES IN NEBRASKA: FROM RESEARCH TO LICENSING

APRIL 14 | LINCOLN, NEBRASKA



SPECIAL THANKS
to the partners who helped
NEBRASKA EPSCoR
conduct this event:

NATIONAL SCIENCE FOUNDATION

NUTECH VENTURES

UNIVERSITY OF NEBRASKA-LINCOLN OFFICE OF RESEARCH AND ECONOMIC DEVELOPMENT

UNIVERSITY OF NEBRASKA SYSTEM

Message from the Nebraska EPSCoR Director

Welcome to the 2022 Nebraska Research & Innovation Conference (NRIC)! Thank you to our speakers for sharing their time and expertise with us, and thanks to this event's partner organizations -- NUtech Ventures, the University of Nebraska System, and the University of Nebraska-Lincoln Office of Research and Economic Development.

Today's event extends an annual series of conferences and symposia that Nebraska EPSCoR has been organizing to advance research activities in this state. This year's conference connects thematically with Emergent Quantum Materials and Technologies (EQUATE), our five-year project funded by the National Science Foundation.

In EQUATE's Year 1, this symposium gathers leaders from industry and academia, with Nebraska's quantum commercialization opportunities at the forefront.

Please enjoy NRIC's knowledge transfer and networking opportunities, including this afternoon's poster session, for further relevant topics.

Best,

Matthew T. Andrews, Ph.D.
Director, Nebraska EPSCoR
Principal Investigator, Emergent Quantum Materials and Technologies (EQUATE)

P.S. When posting to social media about this event, please use:
#NebEQUATE, #NRIC22, and #WorldQuantumDay (April 14, 2022)!

Notes:

Table of Contents

EQUATE Leaders

Scientific Director -- Christian Binek, Ph.D. &
Associate Scientific Director--Rebecca Lai, Ph.D. (UNL)

FRG1 -- Xia Hong, Ph.D. (University of Nebraska-Lincoln)
FRG2 -- Abdelghani Laraoui, Ph.D. (UNL)
FRG3 -- Jonathan Wrubel, Ph.D. (Creighton University)

Learn More

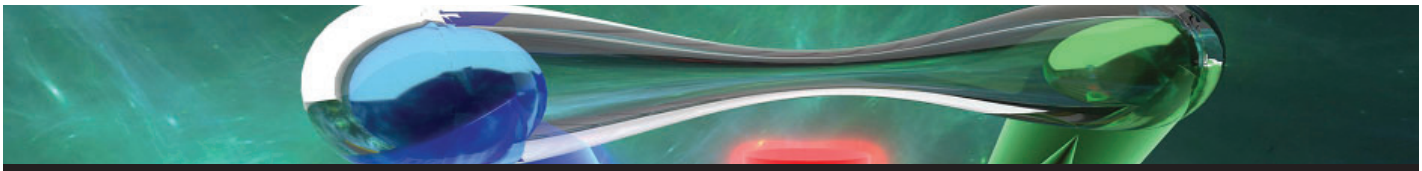
Emergent Quantum Materials and Technologies:
equate.unl.edu

Nebraska EPSCoR Staff

Carole Allen Communications Specialist
Aaron An, Accounting Technician
Jodi Sangster, PhD, Outreach Coordinator
Nancy Simnitt, Executive Assistant

COVER ART: IMAGE ACKNOWLEDGEMENT

Reproduced from RSC Nanoscale with permission from the Royal Society of Chemistry. The presented work—by Boyuan Jin, Dhananjay Mishra and Christos Argyropoulos (funded by Nebraska's NSF-funded EQUATE project, OIA-2044049)—demonstrates a new efficient ultrathin entangled single-photon pair nanophotonic source based on spontaneous parametric down-conversion working at room temperature.*
**Nanoscale, 2021, 13, 19903-19914*

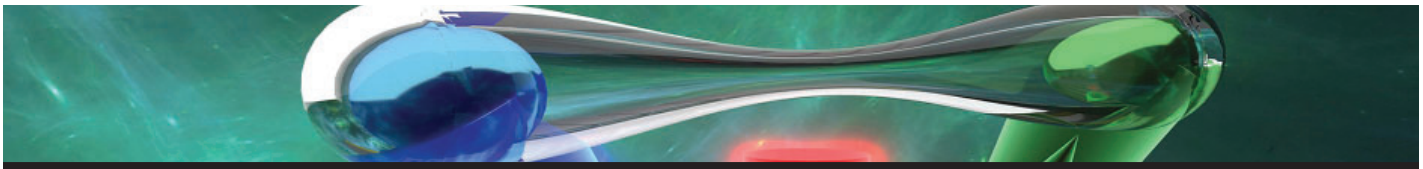


NRIC 2022 | COMMERCIALIZING QUANTUM TECHNOLOGIES IN NEBRASKA

A G E N D A — Thursday, April 14
WiFi Network: Embassy Mtg | WiFi Password: EPSCoR2022

7:30 - 8:30AM	Conference Check-in & Refreshments
8:30 - 8:45	Event Welcome and Introductions Matthew T. Andrews, Ph.D. - Nebraska EPSCoR Director
8:45 - 9:15	The Science and Technology of EQUATE Christian Binek, Ph.D. - Scientific Director, NSF EPSCoR EQUATE (Emergent QUAntum materials and TEchnologies)
9:15 - 9:45	Workforce Development and Mentoring Activities of EQUATE Rebecca Lai, Ph.D. - Associate Professor, UNL Chemistry
9:45 - 10:00	BREAK
10:00 - 11:15	NUtech Ventures: the Process of Technology Commercialization Presenters from NUtech Ventures include Joy Eakin, Cheryl Horst, and Zane Gernhart
11:15AM - NOON	Small Tech, Big Dreams: Finding Your Purpose in the Valley of Death Matthew S. Hull, Associate Director - Innovation & Entrepreneurship Program Manager, Institute for Critical Technology and Applied Science / Virginia Tech University; Owner, NanoSafe, Inc.
NOON - 1:00PM	LUNCH
1:00 - 1:30	Guidance from the Nebraska Business Development Center Josh Nichol-Caddy, MBA, CGBP - Technology Commercialization Director, NBDC / University of Nebraska at Omaha
1:30 - 3:00	Faculty Entrepreneurs Share Their Stories • Michael E. Flatté, Ph.D. - Professor, University of Iowa Dept. of Physics and Astronomy; Founder & Chief Scientist, QuantCAD, LLC • Ravi Saraf, Ph.D. - Lowell E. & Betty Anderson Professor, UNL Chemical & Biomolecular Engineering; Vajra Instruments, Inc.
3:00 - 3:15	BREAK
3:15 - 4:15	Panel discussion / Q&A
4:15 - 4:30	Transition to Poster Session
4:30 - 5:30	POSTER SESSION

On Twitter, follow @NebraskaEPSCoR and include #NRIC22 and #NebEQUATE in your tweets related to this event. THANK YOU for joining this Nebraska event in coordination with #WorldQuantumDay!



Thursday, April 14

CHECK-IN & MORNING REFRESHMENTS

EMBASSY SUITES HOTEL, LINCOLN NE

7:30 - 8:30 A.M.

EVENT WELCOME & INTRODUCTIONS

MATTHEW T. ANDREWS, Ph.D.
Director, Nebraska EPSCoR

8:30 - 8:45 A.M.

The Science and Technology of EQUATE

CHRISTIAN BINEK, Ph.D.
Charles Bessey Professor of Physics, University of Nebraska-Lincoln; Director, Nebraska Center for Materials and Nanoscience; Director, Nebraska Nanoscale Facility: National Nanotechnology Coordinated Infrastructure; Scientific Director, NSF EPSCoR EQUATE (Emergent QUAntum materials and TEchnologies)

8:45 - 9:15 A.M.

Workforce Development Activities of EQUATE

REBECCA LAI, Ph.D.
Associate Professor of Chemistry, University of Nebraska-Lincoln; Associate Scientific Director, NSF EPSCoR EQUATE (Emergent QUAntum materials and TEchnologies)

8:45 - 9:15 A.M.

MID-MORNING BREAK

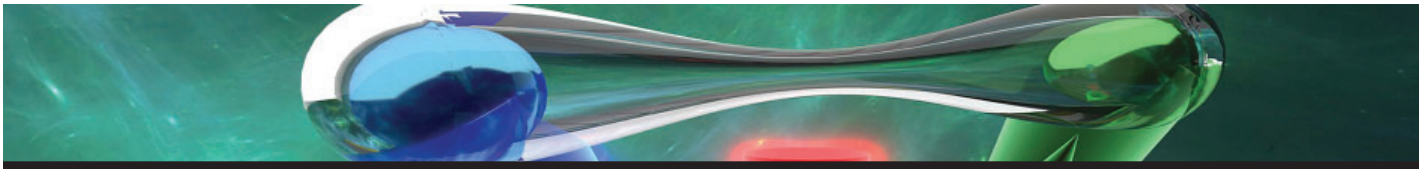
HOSTED BY NEBRASKA EPSCoR

9:45 - 10:00 A.M.

NUtech Ventures: the Process of Technology Commercialization

JOY EAKIN, CHERYL HORST, AND ZANE GERNHART
NUtech Ventures

10:00 - 11:15 A.M.



Small Tech, Big Dreams: Finding Your Purpose in the Valley of Death

MATTHEW S. HULL, Ph.D.
Associate Director - Innovation & Entrepreneurship Program Manager, Institute for Critical Technology and Applied Science / Virginia Tech University; Owner, NanoSafe, Inc.

11:15 A.M. - NOON

ABSTRACT: Small technologies, from microscale systems to advanced materials and emerging quantum devices offer extraordinary opportunities to solve some of humankind's greatest challenges. But who can translate these sophisticated laboratory marvels into practical solutions that actually benefit society? The path from ground-breaking discovery to a commercially-viable enterprise can be a treacherous one that surprisingly few are willing to take. This talk will share lessons learned along one such path, and highlight resources to help a new generation of innovators and entrepreneurs find their purpose in the "Valley of Death."

BIO: Matthew Hull serves as Associate Director for Innovation and Entrepreneurship for the NSF-funded US National Nanotechnology Coordinated Infrastructure (NNCI) and Virginia Tech's Earth and Environmental Nanotechnology (NanoEarth). He also serves as Research Scientist and Associate Director for the Virginia Tech Nanoscale Characterization and Fabrication Laboratory (NCFL), managed by the Institute for Critical Technology and Applied Science (ICTAS). He received his Ph.D. in Civil Engineering from Virginia Tech in 2011 and an M.S. in Biology from Virginia Tech in 2002. He received his B.S. in Environmental Science from Ferrum College in 2000. Hull is also President and Owner of NanoSafe, Inc., a provider of nanotechnology human and environmental health and safety (EHS) services and nano-enabled sustainability solutions he founded in 2007.

LUNCH

EMBASSY SUITES HOTEL, LINCOLN NE

NOON - 1:00 P.M.

Tech Startup Guidance from the Nebraska Business Development Center

JOSH NICHOL-CADDY, MBA, CGBP
Technology Commercialization Director, NBDC / University of Nebraska at Omaha

1:00 - 1:30 P.M.

Faculty Entrepreneurs Share Their Stories

1:30 - 3:00 P.M.

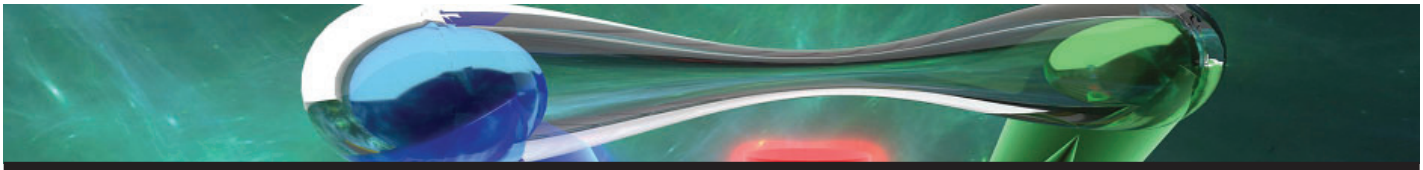
PRESENTER:

MICHAEL E. FLATTÉ, Professor - University of Iowa Department of Physics and Astronomy; Founder & Chief Scientist, QuantCAD, LLC

Starting a Quantum Deep Tech Company During a Quantum Revolution

ABSTRACT: Decades ago concrete protocols were proposed to perform remarkable tasks, including breaking widely-used encryption, generating unbreakable codes, and rapidly searching huge databases. However, to achieve these goals new types of devices are required, relying on physical components with coherent quantum-mechanical properties that would persist for nearly unimaginably long times. How does a startup find a niche in this active research and development space, with governments willing to commit billions and large companies (Google, IBM, Microsoft) orienting towards development and commercialization? I will describe one path, including surprises, painful lessons, and successes.

CONTINUES, NEXT PAGE



BIO: Michael E. Flatté received his A.B. degree in physics from Harvard University in 1988, and his Ph.D. degree in physics from the University of California at Santa Barbara in 1992. He is a Professor in the Department of Physics and Astronomy, at the University of Iowa (UI). He has an adjunct appointment as a Professor at the Department of Applied Physics, Eindhoven University of Technology, Eindhoven, The Netherlands. He has over 270 publications and ten patents. His research interests include optical and electrical control of spin dynamics in materials, novel spintronic devices, quantum sensors, and solid-state realizations of quantum computation. Dr. Flatté is a fellow of the American Association for the Advancement of Science and the American Physical Society.

In 2009 Dr. Flatté founded QuantCAD LLC to license for commercialization the optoelectronics software developed in his research group at UI. Since then this software has been licensed to company, national lab, and university users. In 2021 QuantCAD LLC was accepted into the first cohort of Duality, the nation's first quantum company business accelerator, to commercialize software that simulates noise in quantum devices. QuantCAD is also a partner organization of Quantimony, a European Innovative Training Network in Quantum Technologies.

PRESENTER:

RAVI SARAF, Ph.D.
Lowell E. and Betty Anderson Distinguished Professor
Department of Chemical & Biomolecular Engineering
University of Nebraska-Lincoln College of Engineering; Vajra Instruments

Building a Technology for Early Detection of Cancer

ABSTRACT: It is agreed that early detection of cancer has a very high (literally 100%) positive prognosis. The discovery of floating nucleic acids in biofluids some 15 years ago has opened the exciting possibility of developing a simple blood test to screen for cancer a decade before the disease takes hold. However, weaving through the world of life sciences as an engineer and physical scientist has been a challenge. I will very briefly discuss our failures and successes in developing a "commercial tool" for liquid biopsy.

BIO: Ravi Saraf spent 11 years at IBM's TJ Watson Research Center before moving to academia. Before coming to UNL 17 years ago, he spent 4 years at Virginia Tech. He earned his PhD in polymer science from University of Massachusetts, Amherst, and B.Tech in Chemical engineering from IIT/Kanpur, India. He has over 50 US Patents and over 100 publications.

Vajra Instruments started developing the diagnosis tool some five years ago. The tool is a desktop instrument to quantify molecules at a sensitivity in sub-femtomolar to nanomolar range. The technology is primarily funded by National Institutes of Health. If successful, the desktop tool will allow a simple genomic analysis to screen for specific cancer using 1 mL of blood.

AFTERNOON BREAK

HOSTED BY NEBRASKA EPSCoR

3:00 - 3:15 P.M.

PANEL DISCUSSION

Presenters from sessions throughout the day will regroup to address relevant questions beyond the prior sessions.

3:15 - 4:15 P.M.

TRANSITION TO POSTER SESSION

EMBASSY SUITES HOTEL, LINCOLN NE

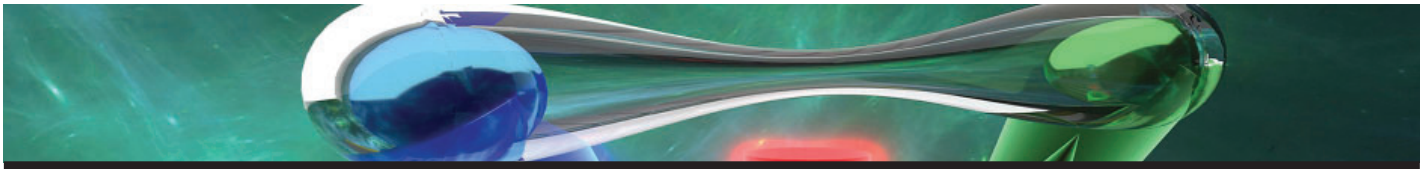
4: 15 - 4:30 P.M.

POSTER SESSION

SPONSORED BY NUTECH VENTURES, UNL OFFICE OF RESEARCH AND ECONOMIC DEVELOPMENT, AND THE UNIVERSITY OF NEBRASKA SYSTEM

4:30 - 5:30 P.M.

FOR A LIST OF POSTER TITLES AND PRESENTERS, PLEASE SEE THE FOLLOWING PAGES



POSTERS

Edward Schwartz, Alexey Kovalev, Bo Li

Meron Hall Effect Signatures of BKT transition **POSTER #1**

We have analyzed the meron Hall response and spin superfluidity, in a 2D easy-plane Heisenberg model, near the BKT transition. Below the BKT temperature, merons are expected to appear only in tightly bound pairs, suppressing vorticity current. Above the BKT temperature, the thermal contribution to the free energy of the system is sufficient to break these bonds, resulting in a nonzero free meron density. These unbound merons behave as free (topological) charge carriers which are driven in the transverse direction relative to an injected spin current, allowing for a significant vorticity Hall current. Using a combination of numerical methods including Monte Carlo, and spin dynamics simulations, we have calculated this Hall response for different values of anisotropy as a function of temperature. We give proposals how this Hall current may be used to detect the BKT transition in a 2D easy plane ferromagnetic insulators.

Alexander Ruder, Megan Stokey, Sean Knight, Steffen Richter, Philipp Kuhne, Vallery Stanishev, Rafal Korlacki, Klaus Irmsher, Petr Neugebauer, Vanya Darakchieva, Mathias Schubert

Terahertz electron paramagnetic resonance generalized spectroscopic ellipsometry **POSTER #2**

Electron paramagnetic resonance (EPR) is a well-established tool in investigating defect-induced spin states in solid-state materials which can be utilized as qubits for quantum applications. Here we demonstrate a high-frequency terahertz (THz) EPR method making use of generalized spectroscopic ellipsometry (THz-EPR-GSE). THz-EPR-GSE dispenses with the need of a cavity, permits independently scanning field and frequency parameters, and does not require field or frequency modulation. Here, we show example measurements performed on 4H-SiC and β Ga_2O_3. From these THz-EPR-GSE measurements, we can fully determine polarization properties of the spin transitions, and we can obtain the k coordinated nitrogen g and hyperfine splitting parameters using magnetic field and frequency dependent Lorentzian oscillator line shape functions of 4H-SiC. Magnetic-field line broadening presently obscures access to h parameters. We show that measurements of THz-EPR-GSE at positive and negative fields differ fundamentally and hence provide additional information. We propose frequency-scanning THz-EPR-GSE as a versatile method to study properties of spins in solid state materials.

Syed Ibrahim Gnani Peer Mohamed, Siamak Nejati

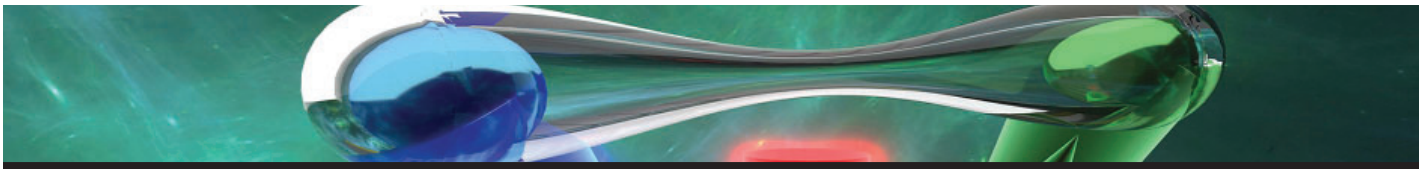
In-situ bottom up synthesis of Covalent Organic Frameworks **POSTER #3**

Due to their promising characteristics, such as intrinsic porosity and tunable electronic and optical properties, covalent organic frameworks (COFs) have attracted widespread attention. Porphyrins and its derivatives are one of the building blocks of COF. Due to a large number of delocalized pi-electrons, porphyrins are of special interest in optoelectronic applications. Additionally, they can coordinate with transition metal atoms, forming organic-inorganic complexes resembling that of heme and the active center of carbonic anhydrase. Here, we demonstrate the feasibility of assembling van der Waals heterostructures, based on the porphyrin derivatives and create porphyrin-based COF materials. We unravel the importance of a set of parameter, defining the assembly of tetrakis (4-aminophenyl) porphyrin (TAPP). Rational adjustment of these parameters enables us to actively control the growth of the crystalline domains of the polymerized-TAPP. Moreover, our results reveal the importance of co-crystallization of porphyrinic frameworks with additives (e.g., pyridine) and a structure-to-function relationship between the ordering of the covalent organic polymers.

Emma Williams, Matthew Hilfiker, Ufuk Kilic, Yousra Traouli, Nate Koeppe, Jose Rivera, Assya Abakar, Megan Stokey, Rafal Korlacki, Zbigniew Galazka, Klaus Irmscher, Mathias Schubert

Zinc Gallate Optical Analysis at Elevated Temperatures Using Spectroscopic Ellipsometry **POSTER #4**

Zinc Gallate (ZGO) is a promising material for use in high-power electronics. The material contains an ultrawide bandgap and isotropic structure, which is advantageous compared to current high-power device materials such as GaN. These devices are commonly operated at elevated temperatures, where material properties can drastically change. In this work, a spectroscopic ellipsometry approach is used to model the optical properties of ZGO at temperatures between 22 °C and 600 °C. At each 50 °C interval a Cauchy dispersion equation is applied to the transparent region of the data where the refractive index and high-frequency refractive index is derived. Furthermore, a critical point model is implemented across the spectral range of 1 eV to 6.5 eV. This allows for the determination of the bandgap, which is found to red-shift linearly with temperature with a slope of -0.72(4) meV K-1, resulting from the thermal expansion of the lattice. The linear decrease in the bandgap energy when exposed to increasing elevated temperatures is in congruence with behavior shown by common wide bandgap metal oxides. However, the reduction of bandgap width as a function of temperature is significantly less than what is shown for the ultrawide bandgap Ga_2O_3, further justifying ZGO as a suitable high-power device.



Jeremy R. Armstrong, Neelam Shukla, Artem G. Volosniev

Properties of Dipolar Impurities in a Dipolar Medium **POSTER #5**

We calculate properties of a static impurity placed into a three dimensional Bose gas made of trapped dipoles. We assume that the impurity-boson interaction potential has a short-range part and a long-range tail. To find the self-energy of the impurity, we solve a Gross-Pitaevski equation. We also compute the induced impurity-impurity interaction, which can be highly anisotropic for strong dipolar interactions. Finally, we relate our findings to a Bose-polaron problem. In this case, we transform into a frame co-moving with the impurity, and obtain a modified Gross-Pitaevskii equation, which we numerically solve. The polaron self-energy is obtained as a function of the strength of the dipole-dipole interaction and trap confinement parameters.

Ahsan Ullah, B. Balasubramanian, Y. Jin, R. Pahari, D. J. Sellmyer, R. Skomski

Berry-Phase Hysteresis in Exchange-Coupled Nanomagnets **POSTER #6**

Magnetic hysteresis, which has shaped public science awareness for more than one century, is based on a phase transition between an ordered low-temperature and a disordered high-temperature phase. This is in contrast to topological phase transitions, an exhilarating development that permeates areas such as superfluids and superconductors, basic quantum mechanics, fractional quantum-Hall effect, and topological insulators. Topological phase transitions do not increase or decrease order parameters but consist in changes of topological numbers. This leads to the question whether such transitions lead to hysteretic features beyond magnetic hysteresis. Here, we use experiments, model calculations, and micromagnetic simulations to identify a topological phase transition in a monodisperse Co-nanoparticle thin film and discover a qualitatively new type of hysteresis, namely Berry-phase hysteresis. This hysteresis was not recognized in earlier research, because available systems had micron-size rather than nanoscale feature sizes, causing difficulty in detecting the Berry curvature in Hall-effect measurements. Berry-phase hysteresis is strikingly different from the iconic magnetic hysteresis and is one aspect of 21st-century reshaping of our view on nature at the borderline of physics, chemistry, mathematics, and materials science.

Ufuk Kilic, Matthew Hilfiker, Alex Ruder, Shawn Wimer, Sema G. Kilic, Christos Argyropoulos, Mathias Schubert, Eva Schubert

Mueller matrix spectroscopic ellipsometry based chiroptical characterization of glancing angle deposited all-dielectric distorted L-shape metamaterial platform **POSTER #7**

Chirality phenomenon is one of the most intriguing inherent properties of material in which one can not be made superimposable on its mirror image by simple symmetry operations. The recent studies showed that one can obtain strong and tunable chiral response using subwavelength scale structures so-called metamaterials. As a promising large-scale area, bottom-up 3D nanomorphology fabrication method with precise sample stage manipulation ability, the glancing angle deposition (GLAD), is envisioned as a promising route to the experimental realization of strong and tunable chiroptical responses. [1] Here, we propose a simplistic chiral-nano-platform: all-dielectric spatially coherent, super lattice type, distorted L-shape metamaterials so-called chiral-nanoboomerangs. The structure consists of two achiral silicon nano-columnar segments, but the sample stage is rotated prior to the fabrication of second segment. Using a Mueller matrix spectroscopic ellipsometry based chiroptical characterization method, we found that our proposed metamaterial platform exhibits extremely broadband, large, tunable, and bi-signate chiroptical response within the near infra-red to vacuum ultraviolet spectral range. We believe that this new material platform is a strong candidate for a myriad of next generation photonic integrated technological applications including but not limited to chiral sensors, drug-delivery systems, and chiral-topological insulators. [1] 1.Kilic,U.,et al., Advanced Functional Materials, 31(20), 2010329, (2021).

Shawn Wimer, Ufuk Kilic, Matthew Hilfiker, Eva Schubert, Mathias Schubert

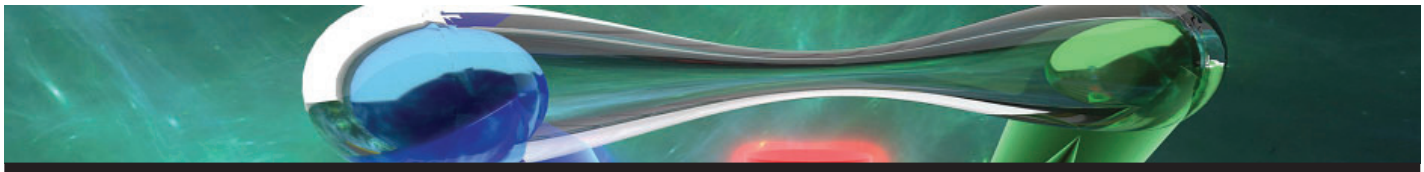
Microstructural analysis of silicon-noble metal periodic nanostructures **POSTER #8**

The elemental, crystalline, and nanoparticle surface characteristics of individual silicon-noble metal nanostructures in dense films are investigated through S/TEM. Individual nanoparticles are crystalline (fcc), with smooth features and little intermixing between silicon and metal. A difference in behavior by metal is noted, with silver particles inhabiting their intended location and taking spherical shapes, while gold particles decorate the surface and taking distended shapes. The overall shape of the structure has limited effect on the nanoparticles, with the notable exception of Si/Au particles in helices exhibiting disorder. The statistics of silver nanoparticle sizes are calculated. The microstructure of amorphous silicon is demonstrated and the contribution to the fanning behavior of GLAD structures is identified.

Alexey Kovalev, Utkan Gungordu

Majorana bound states with chiral magnetic textures **POSTER #9**

We show that elongated magnetic skyrmions can host Majorana bound states in a proximity-coupled two-dimensional electron gas sandwiched between a chiral magnet and an s-wave superconductor. Our proposal requires stable skyrmions with unit topological charge, which can be realized in a wide range of multilayer magnets, and it allows quantum information transfer by using standard methods in spintronics via skyrmion motion. We also show how braiding operations can be realized in our proposal.



Jenna Knudtson, Rafal Korlacki, Megan Stokey, Mathias Schubert, Vanya Darakchieva

Strain/Stress Deformation Potentials for Longitudinal Optical (LO) Phonon Modes in β -Ga_2O_3 **POSTER #10**

Strain and stress are inherent in heteroepitaxial materials due to thermal expansion and lattice mismatch. A material of recent interest is Ga_2O_3, an ultrawide bandgap material attracting significant research attention due to its potential for high-power switching devices. [2] β - $Ga_2O_3$is the first monoclinic material to be widely considered for use in electronic systems. The relationships between strain and stress and the resulting energy shifts help us understand key performance parameters in monoclinic materials. We have previously reported success using linear perturbation theory to predict frequency shifts in transverse optical (TO) phonon modes for β - Ga_2O_3 as an example. [1] Energy shifts due to strain and stress can be described using a set of deformation potentials; one for each independent strain/stress tensor element. Our linear model was created from a dataset of 64 different structures, and this best-match fit was compared with the Density Functional Theory (DFT) calculated frequency values. We show that the same principle is also valid for longitudinal optical (LO) phonon mode frequencies, but also applicable to a range of other properties, including the magnitudes of transition dipoles. Different strain patterns affect the order of phonon modes differently, which is another feature unique to monoclinic crystals. [1] R. Korlacki, M. Stokey, A. Mock, S. Knight, A. Papamichail, V. Darakchieva, and M. Schubert, Phys. Rev. B 102, 180101(R) (2020). [2] R. Korlacki, J. Knudtson, M. Stokey, M. Hilfiker, V. Darakchieva, and M. Schubert, Appl. Phys. Lett. 120, 042103 (2022). [3] M. Schubert, A. Mock, R. Korlacki, and V. Darakchieva, Phys. Rev. B 99, 041201(R) (2019)

Ralph Skomski, Ahsan Ullah, Abdelghani Laraoui, Balamurugan Balasubramanian

Rare-Earth Exchange Interactions in Dilute Solids **POSTER #11**

Many-sublattice effects in dilute rare-earth magnets are investigated by model calculations. The considered materials, which are of interest in optics, rare-earth quantum-information processing, permanent magnetism, and magnetic refrigeration, include RE-iron garnets and 2:17/1:5 RE-cobalt alloys. The exchange behavior of these compounds is dominated by the TM sublattice interactions, complemented by substantial corrections due to the RE-TM intersublattice interactions, whereas RE-RE interactions are often negligible. RE atoms have similar sizes and similar chemical properties, which leads to a large degree of solid-solution miscibility, but many physical properties of the mixed compounds do not superpose. For example, the mean-field Curie temperature Tc is obtained by diagonalizing the intersublattice interaction matrix and therefore a nonlinear function of the exchange constants. The diagonalization can be performed easily for two sublattices and, with some labor, for three sublattices, while no general solutions exist for four or more sublattices. However, an exact diagonalization is possible once the weak RE-RE interactions are ignored. An analytical formula is obtained that predicts Tc as a function of the exchange constants and of the individual concentrations of the rare-earth elements. We also discuss correction due to quantum entanglement.

Kayleigh McElveen, Rifat Mahbub, Martha D. Morton, Jeffrey E. Shield, Peter A. Dowben, Rebecca Y. Lai

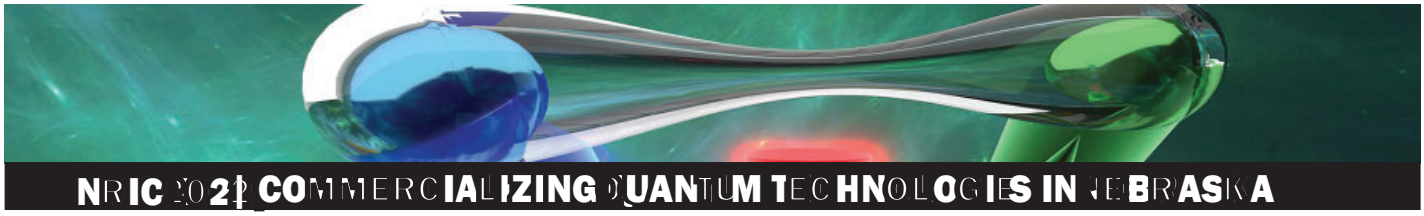
Solvent-Dependent Spin Crossover Properties of Coordination Polymer [Fe(Htrz)2(trz)](BF_4) **POSTER #12**

Triazole-based Fe(II) polymeric complexes are often studied because they provide a ligand field around the Fe(II) ideal for spin crossover and exhibit similar properties in both the nanoscale and the bulk. [Fe(Htrz)2(trz)](BF_4) has a sharp and defined hysteresis loop centered around 340 K, making it a commonly researched spin crossover molecule. With increasing development of spin crossover devices, there is a need to study solvent effects as solvents are often added during various fabrication techniques such as spin coating and ball milling. Addition of solvents in post-fabrication may also allow for the tunability of the spin transition. Most reported results for solvent effects on related Fe(II) molecules are for solvents that have been introduced during the synthesis and not to a dried powder. In this study, nine solvents of varying degrees of polarity were introduced to as-synthesized [Fe(Htrz)2(trz)](BF_4) and compared. All samples of [Fe(Htrz)2(trz)](BF4) underwent the same synthetic protocol with anhydrous ethanol being used as the solvent. Results demonstrated that solvents with a greater relative polarity shifted the spin transition for heating and cooling to a higher temperature while solvents with a low relative polarity like hexane or benzene shifted the transition to a lower temperature.

Dhananjay Mishra, Christos Argyropoulos

Nonlinear Plasmonic Metasurfaces as Efficient Entangled Single-Photon Pair Quantum Sources **POSTER #13**

Spontaneous Parametric Down-Conversion (SPDC) is a quantum optical process where a photon spontaneously splits into a pair of lower energy entangled single-photons. Here, we demonstrate that the quantum effect of SPDC can be substantially boosted at room temperature by utilizing nonlinear plasmonic metasurfaces. The presented plasmonic metasurface design is composed of silver nanostripes grown on a bulk lithium niobate ($LiNbO_3$) crystal terminated by a silver substrate. The quantum-classical correspondence principle is used to compute the SPDC entangled photon pair generation rate by the classical sum frequency generation (SFG) nonlinear optical process. The generated signal and idler frequencies are matched to the metasurface fundamental and higher order resonances leading to substantially boosted SFG efficiency and, consequently, significantly enhanced SPDC generation rate. The quantum SPDC process is at the heart of many quantum optical emerging apparatuses, since single-photon generation at room temperature is required in a plethora of applications in quantum communications, cryptography, and sensing.



Detian Yang, Xiaoshan Xu **POSTER #14**

Influence of oxygen pressure on interfacial reconstruction and intrinsic exchange bias in $NiCo_2O_4$(111)/Al_2O_3(0001) thin films

Epitaxial $NiCo_2O_4$(111) thin films have been grown on sapphire substrates by pulsed laser deposition. An interfacial layer between the $NiCo_2O_4$ thin film and the substrate was observed by thickness-resolved reflection high energy electron diffraction patterns and x-ray diffraction. Exchange bias was induced by this interfacial reconstruction and its interfacial nature was shown by its thickness dependence. And such interfacial reconstruction and intrinsic exchange bias were proved to be adjustable by oxygen pressure, which indicating the essential role of oxygen vacancies in the mechanism of the interfacial reconstruction phenomenon. The low density fitted from from x-ray reflection further confirm significant oxygen vacancies in the interfacial layer. This study reveals the essential role of oxygen pressure in interfacial reconstruction and suggest the strategy of adjusting thin film properties by manipulating interfacial reconstruction.

Syed Qamar Abbas Shah, Ather Mahmood, Arun Parthasarathy, Christian Binek

Axion electrodynamics with magnetoelectric Chromia **POSTER #15**

The magnetoelectric (ME) susceptibility, α, of ME materials such as Cr_2O_3 (Chromia) can be composed into a trace free tensor component and a pseudoscalar or axion piece component with isotropic ME response. Powder samples have been suggested as a pathway to fabricate isotropic ME materials which effectively only have a pseudoscalar ME response. However, activating a non-vanishing axion piece requires a ME field cooling protocol which tends to induce preferred axes. In our work we noticed shortcomings in the literature on ME powders where effects of the magnitude of the ME annealing field product on the ME response have been ignored. We investigate the evolution of ME susceptibility in powder chromia samples for various ME field cooling protocols. A strong dependence of the functional form of α vs. T of Chromia powders on the ME field cooling protocol is observed. It provides a pathway to realize the elusive isotropic ME response. In addition, we invest the macroscopic magnetic monopole response of an isotropic ME material when excited by the electric field of an electric point charge.

Qiuchen Wu, Alyssa Simpson, Kun Wang, Xia Hong

Ferroelectric domain studies on free-standing PbZr0.2Ti0.803 (PZT) membranes **POSTER #16**

Free-standing ferroelectric oxide membranes are promising materials for building flexible, wearable electronics. For exploiting ferroelectric domain structures to represent the binary logic for information storage, it requires fundamental understanding of the static configuration and dynamic response of the ferroelectric domain walls (DW). In this study, we report the fabrication of nanoscale free-standing ferroelectric PbZr0.2Ti0.803 (PZT) membranes, and scanning probe microscopy studies of DW in these samples. We deposit 50 nm epitaxial single crystalline PZT thin films on $Sr_3Al_2O_6$ (SAO) buffered $LaAlO_3$ (LAO) substrates using off-axis RF magnetron sputtering. By water etching of the SAO buffer layer, we achieve suspended PZT membranes, and transfer the samples onto Au and LSMO/STO substrates. Piezo-response force microscopy (PFM) measurements reveal a uniform polarization down state for the as-prepared samples. We also systematically examine the DW roughness and creep behavior of the PZT membranes. Our study provides critical material information for the domain properties of PZT membranes for data storage applications.

Bo Zhang, Shuo Sun, Yinsheng Guo

Direct Visualization of General Ferroelasticity in Lead Halide Perovskites **POSTER #17**

Lead halide perovskite (LHP) is a kind of emerging high-performance optoelectronic material with facile synthesis. Owing to their tunable absorption, relatively high carrier mobility, extended long charge carrier lifetime, and long charge diffusion length, LHP have been applied in solar cells, light-emitting diodes, and photodetectors. However, compared with considerable progress in power conversion effi ciency improvement, fundamental knowledge of origin of LHP's performance is still limited. For example, relationship between structural ferroelasticity-related lattice strain and carrier dynamics properties comes into focus only recently. To image these ferroelastic twin domains, polarized light microscopy has long been the standard optical method based on their optically anisotropic character. Surprisingly, non-polarized light microscope used in our work is able to monitor ferroelastic phase transitions driven by spontaneous strain and identify LHP's ferroelastic twin domains. We fi nd such optical contrast comes from refl ections due to the non-alignment of optical axes across the interface (domain wall) within crystal bulk. The generality of ferroelasticity has been revealed in both hybrid $CH_3NH_3PbBr_3$ and all-inorganic $CsPbBr_3$ lead halide perovskites by experimental together with theoretical methods.

Gautam Gurung, Ding-Fu Shao, Evgeny Tsymbal

Transport spin polarization of noncollinear antiferromagnetic antiperovskites **POSTER #18**

Antiferromagnets with a non-spin-degenerate band structure can efficiently spin-polarize electric currents, even though their net magnetization is zero. Among the antiferromagnetic metals, the noncollinear antiferromagnetic antiperovskites $ANMn_3$ (A=Ga, Ni, Sn, or Pt) with high Néel temperatures are especially promising. They also have a good lattice match to perovskite oxide substrates, offering possibilities of high

structural quality heterostructures based on these materials. Here, we investigate the spin polarization of antiferromagnetic $ANMn_3$ metals using first-principles density functional theory calculations. We find that the spin polarization of the longitudinal currents in these materials is comparable with that in widely used ferromagnetic metals and thus can be exploited in magnetic tunnel junctions and spin transfer torque devices. Moreover, for certain film growth directions, out-of-plane transverse spin currents with a giant charge-to-spin conversion efficiency can be achieved, implying that the $ANMn_3$ antiperovskites can be used as efficient spin sources. These properties make $ANMn_3$ compounds promising for application in spintronics.

Archit Dhingra, Xuedong Hu, Mario F. Borunda, Talat Rahman, Joe F. Johnson, Christian Binek, Jonathan Bird, Alpha T. N'Diaye, Jean-Pascal Sutter, Emilie Delahaye, Eric D. Switzer, Enrique del Barco, Peter A. Dowben

Molecular Transistor Logic Gates as Substitutes for Quantum Information Applications **POSTER #19**

Applications of quantum information science (QIS) generally rely on the generation and manipulation of qubits. Still, there are ways to envision a device with a continuous readout, but without entangled states. This perspective includes discussion of an alternative to the qubit, namely the solid-state version of the Mach-Zehnder interferometer, where local moments and spin polarization replace light polarization. In this context, we provide some insights into the mathematics that dictates the fundamental working principles of quantum information processes involving molecular systems with large magnetic anisotropy, in the context of a logic gate that does not require entangled states. Furthermore, some novel approaches, worthy of some consideration, exist to address issues pertaining to the scalability of quantum devices, but face the challenge of finding the suitable materials for desired functionality that resembles what is sought from QIS devices.

Kai Huang, Ding-Fu Shao, Evgeny Y. Tsymbal

Ferroelectric control of magnetic skyrmions in two-dimensional van der Waals heterostructures **POSTER #20**

Magnetic skyrmions are chiral nanoscale spin textures, which are usually induced by Dzyaloshinskii-Moriya interaction (DMI). Recently, magnetic skyrmions have been observed in two-dimensional (2D) van der Waals (vdW) ferromagnetic materials, such as Fe_3GeTe_2. The electric control of skyrmions is important for their potential application in low-power memory technologies. Here, we predict that DMI and magnetic skyrmions in a Fe_3GeTe_2 monolayer can be controlled by ferroelectric polarization of an adjacent 2D vdW ferroelectric In_2Se_3. Based on density functional theory and atomistic spin-dynamics modeling, we find that the interfacial symmetry breaking produces a sizable DMI in a Fe_3GeTe_2/In_2Se_3 vdW heterostructure. We show that the magnitude of DMI can be controlled by ferroelectric polarization reversal, leading to creation and annihilation of skyrmions. Furthermore, we find that the sign of DMI in a $In_2Se_3/Fe_3GeTe_2/In_2Se_3$ heterostructure changes with ferroelectric switching reversing the skyrmion chirality. The predicted electrically controlled skyrmion formation may be interesting for spintronic applications.

Tianlin Li, Hanying Chen, Kun Wang, Yifei Hao, Le Zhang, Qiuchen Wu, Kenji Watanabe, Takashi Taniguchi, Xia Hong **POSTER #21**

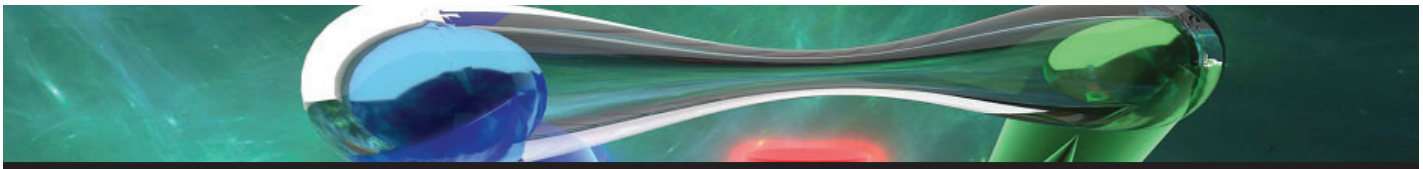
Tunable extra Dirac points in one-dimensional graphene superlattice induced by periodic ferroelectric domains

In this work, we investigate the transport signature of one-dimensional (1D) superlattice (SL) in monolayer graphene induced by prepatterned periodic domains in a ferroelectric bottom gate. We work with 50 nm single crystalline ferroelectric $Pb(Zr,Ti)O_3$ (PZT) films deposited on $(La,Sr)MnO_3$ buffered $SrTiO_3$ substrates, and create periodic polarization up (P_{up}) and down (P_{down}) stripe domains on PZT using conductive atomic force microscopy. The domain periodicity varies from 200 nm to 300 nm, and the number of periods changes from 30 to 50. We then transfer hBN-graphene stacks onto the pre-patterned domains and fabricate them into top-gated field-effect devices. The difference in carrier density between the two polarization regions reaches around 3×10^{13} cm^{-2} at 2 K due to the pyroelectric effect. We observe extra Dirac points in $R(V_g)$ by applying voltage to the hBN top gate, which is attributed to the SL modification of the band structure. We discuss the effects of the SL period and the width ratio between the P_{up} and P_{down} domains on the position of the extra Dirac points, and the magnetotransport properties of these 1D SLs.

Jia Wang, Zahra Ahmadi, David Lujan, Xiaoqin Li, Jeffrey E. Shield, and Xia Hong

Growth of two dimensional antiferromagnetic $CrCl_3$ flakes down to monolayer thickness **POSTER #22**

The van der Waals (vdW) $CrCl_3$ is a two-dimensional (2D) antiferromagnet. Previous reports have mainly focused on mechanically exfoliated samples, while controlled synthesis of high quality $CrCl_3$ thin flakes is critical for their application in 2D spintronics. Here, we report the growth of ultrathin $CrCl_3$ flakes with well-defined shapes down to monolayer thickness (~0.7 nm) via physical vapor transport technique. Confocal Raman measurements show that the $CrCl_3$ flakes are crystalized in the monoclinic structures at room temperature, consistent with high-resolution transmission electron microscopy results. We carry out atomic force microscopy and electrical characterizations on $CrCl_3$ flakes with various thicknesses as a function of time. Thick $CrCl_3$ flakes (>50 nm) show excellent ambient stability for up to 5 months after growth, while ultrathin flakes show sign of degradation in 5 days. We also investigate the electrical properties of graphene/$CrCl_3$/graphene heterostructures.



Ather Mahmood[1], Will Echtenkamp[1], Syed Qamar Abbas Shah[1], Jamie Weaver[2], Jeffrey Lynn[2], Christian Binek[1]

Effects of Boron diffusion on the surface Néel temperature revealed by magnetotransport and cold neutron depth profiling in B-doped Cr_2O_3 films **POSTER #23**

Multi-functional thin films of boron (B) doped Cr_2O_3 grown by pulsed laser deposition exhibit voltage-controlled and nonvolatile Néel vector reorientation in the absence of a magnetic field. Isothermal toggling of antiferromagnetic states is demonstrated in prototype device structures at CMOS compatible temperatures between 300 and 400 K. Although isothermal switching is achieved, selecting a single domain state via a magnetoelectric annealing protocol is hampered most likely by a thermally activated runaway effect of the Néel temperature. This behavior can be understood by considering B diffusion within the thin Cr_2O_3 film. Cold Neutron Depth Profiling (cNDP), performed at National Institute of Standards and Technology, points at progressing depletion of B atoms in the bulk with temperature. At the same time the B-concentration increases near the surface. The Spin Hall measurements, sensitive to the surface magnetic state, indicate a shift in T_N towards higher values associated with the increase in B-concentration near the film surface. [1]Department of Physics and Astronomy, University of Nebraska-Lincoln; [2]National Institute of Standards and Technology, Gaithersburg, MD

Ather Mahmood[1], Will Echtenkamp[1], Mike Street[1], Jun-Lei Wang[1], Syed Qamar Abbas Shah[1], Shi Cao[1], Takashi Komesu[1], Peter A. Dowben[1], Pratyush Buragohain[1], Haidong Lu[1], Alexei Gruverman[1], Arun Parthasarathy[2], Shaloo Rakheja[3], Christian Binek[1]

Voltage-controlled Néel vector rotation in zero magnetic field in high-T_N magnetoelectric thin films **POSTER #24**

Multi-functional thin films of boron (B) doped Cr_2O_3 exhibit voltage-controlled and nonvolatile Néel vector reorientation in the absence of a magnetic field, H. Toggling of antiferromagnetic states is demonstrated in prototype spin Hall magnetoresistance device structures at CMOS compatible temperatures between 300 and 400 K. The boundary magnetization associated with the Néel vector orientation serves as state variable which is read via magnetoresistive detection in a Pt Hall bar adjacent to the B:Cr_2O_3 film. Various characterization techniques support that voltage controlled, nonvolatile Néel vector rotation takes place at high-temperature in H = 0. Theoretical modeling estimates switching speeds of about 100 ps making B:Cr_2O_3 a promising multifunctional single-phase material for energy efficient nonvolatile CMOS compatible memory applications. [1]Department of Physics and Astronomy, University of Nebraska-Lincoln [2]Department of Electrical Engineering, New York University, Brooklyn, NY; [3]Holonyak Micro and Nanotechnology Laboratory, University of Illinois at Urbana–Champaign, Urbana, IL

Benjamin DalFavero, Alexander Meill, David A. Meyer, Thomas G. Wong, Jonathan Wrubel

Quantum search by the nonlinear Schrodinger equation with a generalized cubic-quintic nonlinearity **POSTER #25**

Continuous-time quantum walks, a quantum analog to the continuous time Markov chain, allow the efficient solution to spatial search problems. At low temperatures and a high number of atoms, two- and three-body interactions cause Bose-Einstein condensates to evolve according to an effective, non-linear Schrodinger equation. These effective nonlinearities can be exploited to accelerate the propagation of the walk, reaching a solution to the search problem faster than the linear case. This acceleration comes at the cost of increased precision needed in the timing of the search, as well as increased need for spatial resources. We will present our work analyzing the computational speedups afforded by continuous-time quantum walks with effective nonlinearities for search problems with multiple correct answers.

Yuanyuan Ni, Xiaoshan Xu

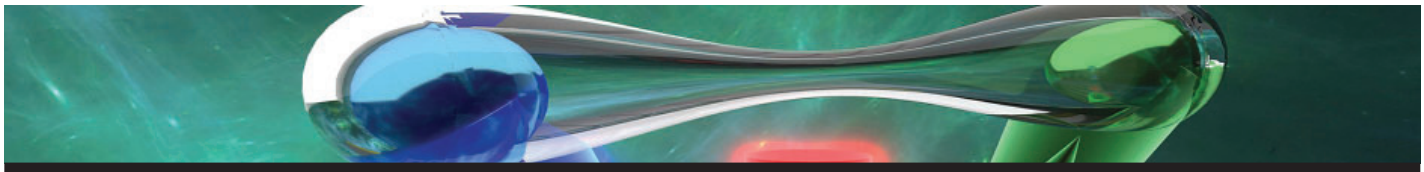
The electrical properties of organic film in high vacuum **POSTER #26**

2-methylbenzimidazole (MBI) film has been synthesized by low-temperature physical vapor deposition in our previous work. In-situ measurements of MBI film's electrical properties indicate that crystallization of the film happens in the post-deposition warming process and the crystalline quality is kept even after the film is cooled back to low temperature. To solve the issue of MBI loss in vacuum, we introduced a capping layer of lithium fluoride (LiF) on top of MBI film and study electrical properties of the MBI film in a high vacuum at room temperature. We prepared three MBI films with LiF layer thickness fixed at 1 m. Then the electrical properties of the films are measured by in situ when the pressure is decreasing at the room temperature. The MBI loss is obviously reduced.

W.N. Mei, R. Sabirianov (UNO), M. Bian, H. Zeng (SUNY Buffalo)

Covalent 2D Cr_2Te_3 ferromagnet **POSTER #27**

To broaden the scope of van der Waals 2D magnets, we report the synthesis and magnetism of covalent 2D magnetic Cr_2Te_3 with a thickness down to one-unit-cell. The 2D Cr_2Te_3 crystals exhibit robust ferromagnetism with a Curie temperature of 180 K, a large perpendicular anisotropy of 7×10^5 Jm^{-3}, and a high coercivity of ~4.6 kG at 20 K. First principles calculations further show a transition from canted to collinear ferromagnetism, a transition from perpendicular to in-plane anisotropy, and emergent half-metallic behavior in atomically-thin Cr_2Te_3, suggesting its potential application for injecting carriers with high spin polarization into spintronic devices. We discuss large anomalous Hall effect in light of the Berry curvature of this non-collinear magnet.



Suvechhya Lamichhane, Rupak Timalsina, Cody M. Schultz, Adam Erickson, Sy-Hwang Liou, Rebecca Y. Lai, Abdelghani Laraoui

T1 relaxometry of Fe Contained Biomolecules Using Nitrogen Vacancy Centers in Diamond **POSTER #28**

High resolution study of single biomolecules at ambient conditions are critical for understanding the life science. The signals (magnetic, electric, or optical) from single biomolecules are very weak and difficult to detect. Among the currently available imaging techniques, magnetic imaging based on the nitrogen-vacancy (NV) center in diamond is one of the most promising tools for high resolution nanoscale bioimaging, specifically for iron-containing proteins [1]. In this study we used 10 nm layer of NV centers doped in a diamond surface to map Cytochrome C (Cyt. C) proteins of different concentrations using NV T1 relaxometry. Cyt. C plays an important role in the electron transport chain of mitochondria, and it is in the Fe+3 paramagnetic state under ambient conditions. We found a reduction of the NV T1 from few milliseconds to hundreds of microseconds with the drop cast of Cytochrome C on diamond. The reduction of T1 (spin lattice relaxation time) is explained by the spin noise generated from the intracellular Fe spins in Cyt. C interactions with NV centers. The detail of sub cellular imaging based on NV T1 relaxation will be further investigated. [1] A. Boretti, et al., Beilstein Journal of Nanotechnology, 10, 2128-2151 (2019).

Sanchaya Pandit, Yanan Wang

Optimizing Contrast Response of Wide-Bandgap 2D Perovskites **POSTER #29**

Lead halide perovskites have recently emerged as intriguing material platforms in photovoltaics and optoelectronics. In particular, the study on two-dimensional (2D) all-inorganic perovskites is of interest due to the reduced dimensionality and the possibility of exploring new functionality. For example, wide-bandgap $CsPb_2Br_5$ microplatelets can support in-situ crystallization of $CsPbBr_3$ quantum dots, and such cavity-emitter coupled structures can be used for investigating quantum electrodynamics (QED). The optoelectronic, transport, dielectric, and confinement properties are highly dependent on the dimensions. Therefore, from an application point of view, the thickness measurement is the first and crucial step. The conventional measurement techniques, such as scanning probe microscopy and Raman spectroscopy, are cumbersome and expensive, thus failing to estimate the thickness rapidly. Alternatively, optical contrast of 2D material as a measure of thin layers has gained popularity which depends on the underlying substrate and refractive index of 2D material. In this study, the optical contrast response of 2D $CsPb_2Br_5$ has been explored on various substrates. The layer dependence of the optical contrast provides an easy, rapid, and inexpensive way for determining the thickness and paves the way to further investigation of quantum light emission and cavity-QED in wide-bandgap 2D perovskites.

Renjie Tao, Kai Peng, Xiang Zhang, Wei

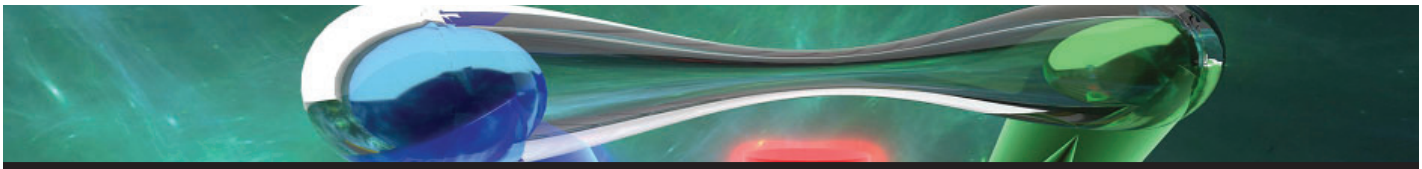
Halide perovskites enable polaritonic XY spin Hamiltonian at room temperature **POSTER #30**

Exciton polaritons, the part-light and part-matter quasiparticles in semiconductor optical cavities, are promising for exploring Bose-Einstein condensation, nonequilibrium many-body physics, and analog simulation at elevated temperatures. However, a room-temperature polaritonic platform on par with molecular-beam-epitaxy grown GaAs quantum wells at low temperatures remains elusive. Operation of such a platform calls for long-lifetime strongly interacting excitons in the stringent material system with large yet nanoscale-thin geometry and homogenous properties. Here, by solution synthesis of excitonic halide perovskite under nanoconfinement, we take a giant leap toward overcoming this challenge and demonstrate the first room-temperature polaritonic XY spin Hamiltonian. The nanoconfinement leads to ultra-smooth single-crystalline large crystals with exceptional homogeneity and enables us to unambiguously demonstrate both ferromagnetic and anti-ferromagnetic coupling configurations of XY Hamiltonian with lattice size up to 10x10. Our work not only establishes a large and homogeneous perovskite platform for simulating spin Hamiltonian but also paves the way for robust disorder-free polaritonic devices previously inaccessible at room temperature, such as topological polariton laser 4 and versatile photonic simulator with synthetic gauge field.

Renat Sabirianov, H. Zeng, M. Bian

Properties of Cr5Te8/WSe2 - 2D transition-metal dichalcogenides-based ferromagnetic heterostructures **POSTER #31**

Cr_5Te_8/WSe_2 superlattices, consisting of 2D Cr_5Te_8 conducting magnet with perpendicular anisotropy and a monolayer WSe2 investigated using DFT. We show that Cr5Te8 maintain its ferromagnetic coupling within $CrTe_2$ layer making a case of proximity effect studies. Fermi energy falls within the WSe_2 bandgap. We observe that conduction band of WSe_2 is located closer to the Fermi level on the energy scale than the valence band. There is overall charge transfer of 0.18e across the interface from Cr_5Te_8 towards WSe_2. Due to the presence of Cr at the interface, the Cr-Se bonds form that strongly affect the charge redistribution and can be detected by differential charge density. Bader charge analysis show that interfacial Cr sites have larger electron charge compared to the bulk counterparts. The obvious charge coupling between two subsystems may prevent clear observation of photoluminescence in the heterostructure. *This research is supported by NU Collaborative Research and NSF-DMREF (Grant No. 1729288).



Arjun Subedi, Detian Yang, Xiaoshan Xu, Peter A. Dowben

Reversible changes in surface charging and surface oxides of NiFe2O4 thin films: A temperature dependent x-ray photoemission study **POSTER #32**

We have observed large binding energy shifts in temperature dependent X-ray photoelectron spectroscopy (XPS) of the 2p3/2 core levels of both Ni and Fe atoms in nickel ferrite ($NiFe_2O_4$) thin films grown on Al_2O_3. The binding energies of the core level were found to be sensitive to photovoltaic charging. The apparent binding energies decreased by more than 5 eV for both core levels when temperature increased to 510 K from room temperature. This is evidence of large surface charging of the sample at lower temperatures. The XPS spectra at higher temperatures, at which the binding energies almost saturated, were observed to be different from that at lower temperatures, suggesting different surface oxides at higher temperatures. When temperature was lowered from 510 K to room temperature, the XPS measurements showed that there exist reversible changes in surface charging and surface oxides.

Adam Erickson, Rupak Timalsina, Syed Qamar Abbas, Ather Mahmood, Christian Binek, Abdelghani Laraoui

Imaging and Control of Antiferromagnetic Domains in Cr2O3 **POSTER #33**

In this study we use NV microscopy [1] to map and manipulate magnetic domains in antiferromagnetic (AFM) epitaxial Cr_2O_3 films. Cr_2O_3 thin films have been used to realize voltage-controlled AFM spintronics utilizing the peculiar boundary magnetization of single domains [2]. Boron doping can increase the Néel temperature of Cr_2O_3 to above 400 K and allow Voltage controlled Néel vector 900-rotation in zero magnetic field [3]. We present a detailed investigation of magnetic domains configuration in pure 200-nm thick Cr2O3 grown via pulsed laser deposition on Al2O3. Our study shows unique magnetic-domain structures similar to the granular Cr_2O_3 films [4]. We perform magnetic-field cooling measurements (heating above Néel temperature, then cooling under an applied field > 0.4 T) and measure the new magnetic domain configuration. We discuss plans to measure the dynamic domain wall evolution on voltage-induced domain reversal in pure and B doped films. [1] F. Casola, et al., Nat. Rev. Mat. 3, 17088 (2018). [2] N. Wu, et al., Phys. Rev. Lett. 106, 087202 (2011). [3] A. Mahmood, et al. Nat. Comms. 12, 1674 (2021). [4] P. Appel, et al.

Balamurugan Balasubramanian, Ahsan Ullah, Rabindra Pahari, Ralph Skomski, David J. Sellmyer

Chiral Spin Textures and Topological Hall Effect in B20-Ordered Co-Si **POSTER #34**

B20 magnets such as T50X50 (T = Fe, Co, Mn and X = Ge, Si) have recently attracted much attention as potential spin-electronics materials because they exhibit chiral crystal structure and form skyrmions. A significant challenge is to discover systems having such spin textures with dimensions of the order 10 nm that are stable above room temperature. In this work, we present how the exchange engineering and nanostructuring are used to achieve a critical temperature of about 330 K in Co-Si, the highest among all B20-type magnets and noncoplanar spin structures within the region of the order of 10 nm that yield topological Hall effect. This research explains the underlying physics using density-functional calculations and micromagnetic simulations, and demonstrates how nanostructuring of a chiral atomic structure can create a spin-textured material with a topological Hall effect at above room temperature. References:

1. R. Pahari, B. Balasubramanian, A. Ullah, R. Skomski, D.J. Sellmyer et al. Phys. Rev. Mater. 5, 124418 (2021)
2. B. Balasubramanian, R. Pahari, A. Ullah, R. Skomski, D.J. Sellmyer et al. Phys. Rev. Lett. 124, 057201 (2020)