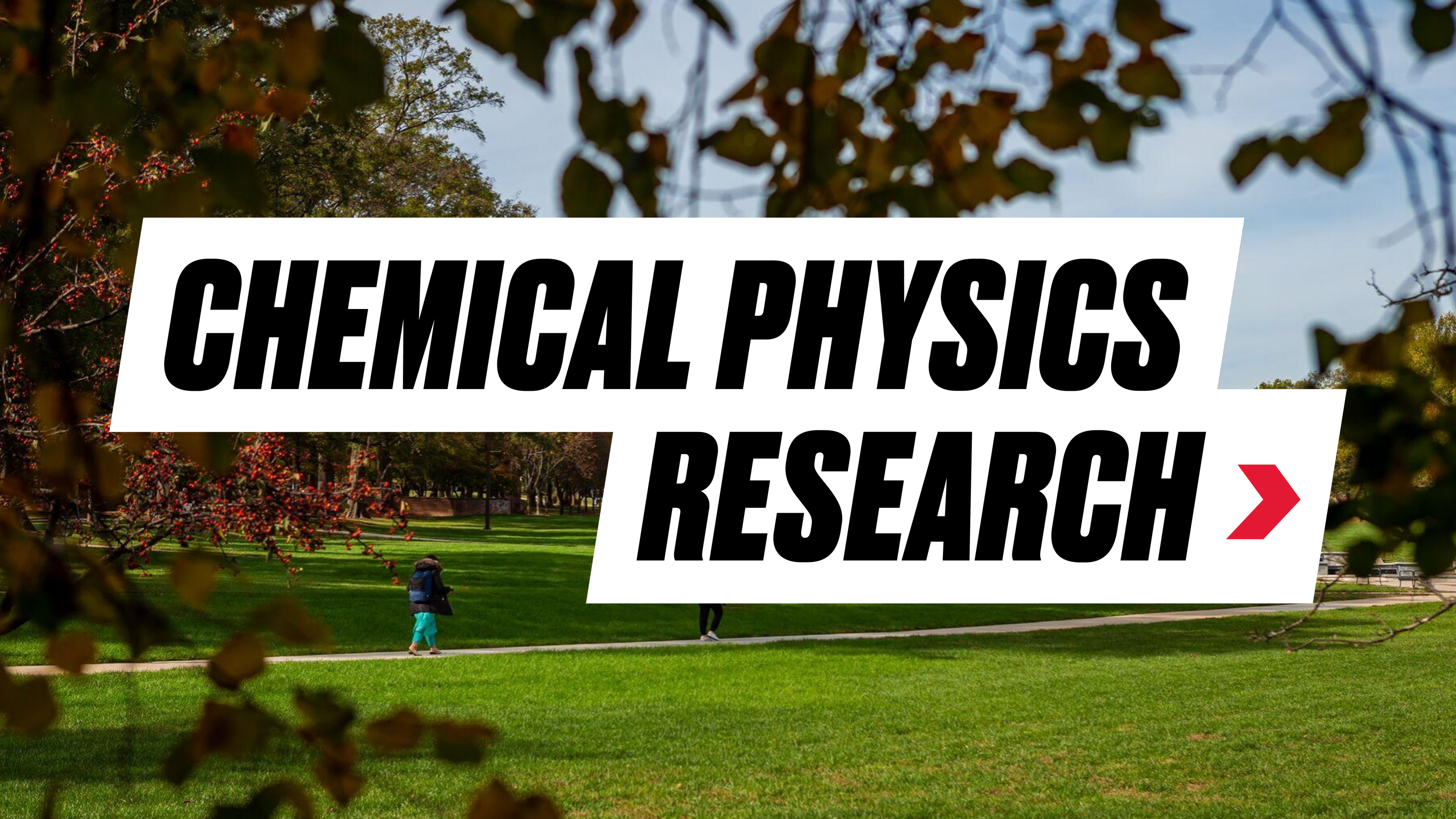
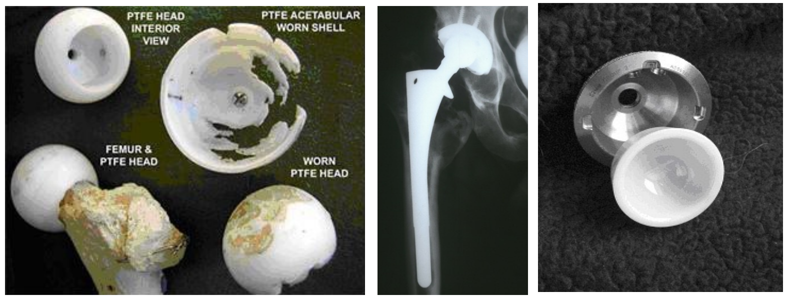
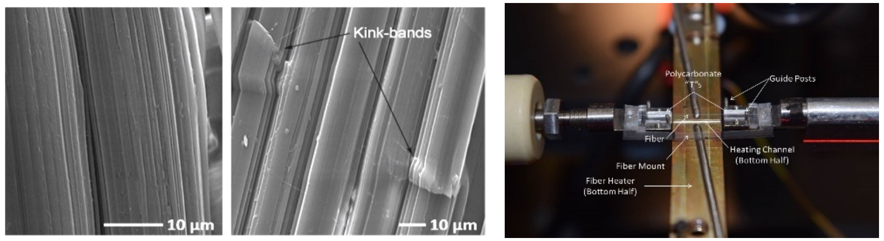

CHEMICAL PHYSICS
RESEARCH

Mohamad Al-Sheikhly-Laboratory for Radiation and Polymer Science

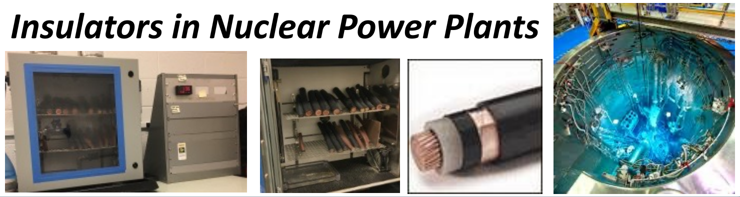
1. *Irradiation of UHMWPE for Hip Replacement*



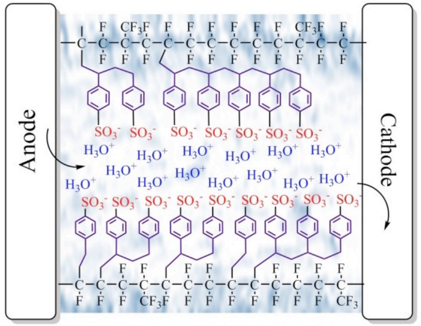
5. *Long Term Stability of Ultra High Molecular Weight Polyethylene Fibers as Soft Ballistic Inserts*



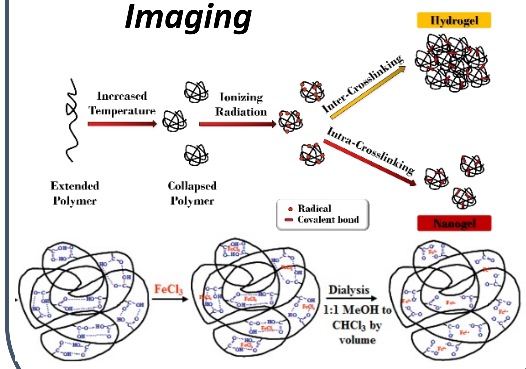
2. *Effects of Ionizing Radiation on Polymeric Cable Insulators in Nuclear Power Plants*



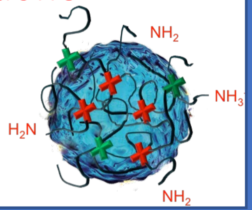
6. *Fabrication of Polymer Electrolyte Membranes for Fuel Cells using Radiation Grafting*



7. *Biocompatible Nanomaterials for Drug Delivery & Magnetic Nanocomposites for Imaging*



3. Functionalization of Polvinylpyrrolidone nanogel for drug delivery systems

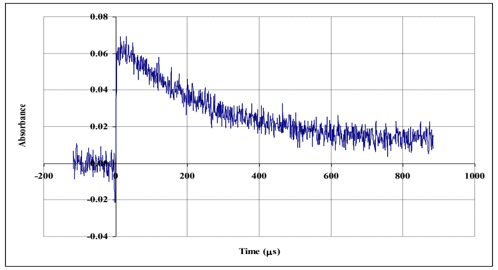


4. *Critical Hydrogen Concentration Determination in Alpha Particle Irradiated Water*

$$ {}^{10}_{5}B + {}^{1}_{0}n \rightarrow {}^{7}_{3}Li + \alpha $$

$$ \alpha + H_2 \rightarrow e^{-}_{aq}, {}^{\cdot}H, {}^{\cdot}OH, H_2, H_2O_2, O_2, \ldots $$

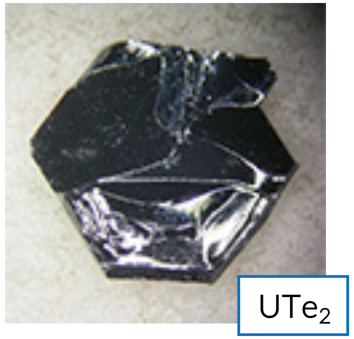
8. *Polymerization reactions of 2-Ethylhexyl Acrylate*



Quantum Materials: Magnetism, Superconductivity, Topology

Materials Synthesis

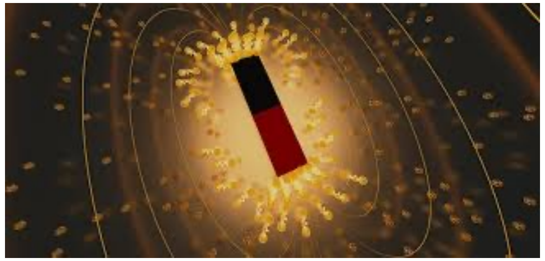
Cu_2OSeO_3



UTe_2

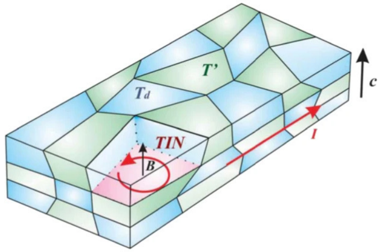
USb_2

Quantum + Topological Physics



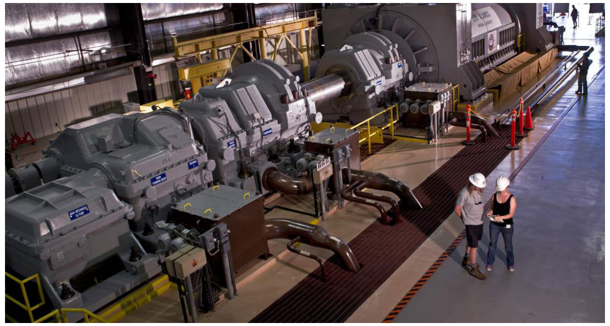
“Lazarus” extreme high field reentrant superconductor (UTe_2)

Chiral surface states in a topological superconductor (UTe_2)

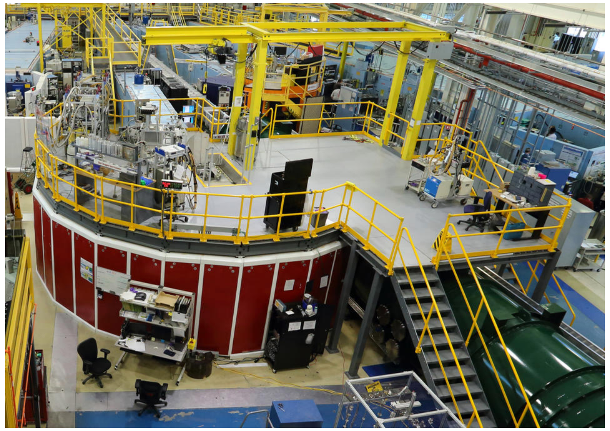


Topological Interface Network under pressure ($MoTe_2$)

Extreme Environments, Big Experiments



Pulsed Field Facility, Los Alamos National Lab – high magnetic field experiments to 65 T and up



NIST Center for Neutron Research (nearby) – studying quantum magnetic excitations

Nicholas Butch
NIST & Physics

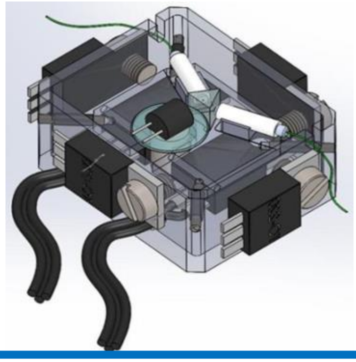
Yanne Chembo's Group @UMD

Photonic Systems Laboratory

The group currently has 8 members, including one PhD student from CHPH

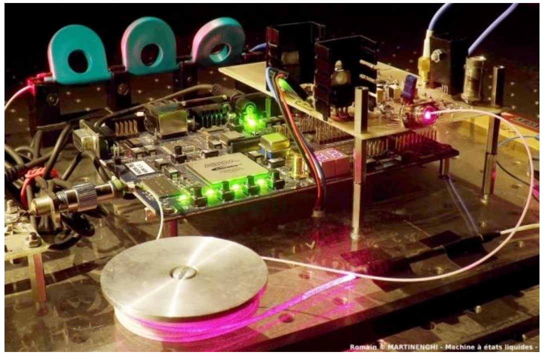
Aerospace Engineering

- Ultra-low phase noise optoelectronic oscillators
- Kerr optical frequency comb generation
- Navigation and sensing



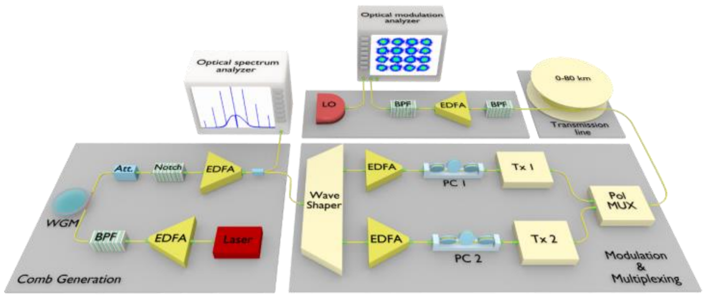
Photonic Neuromorphic Computing

- Fundamental principles
- Application to ultrafast classification tasks



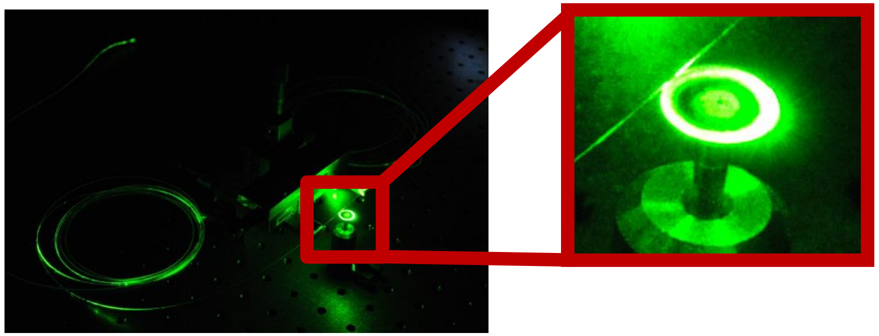
Telecommunication Engineering

- Optical chaos communication
- Wavelength division multiplexing using Kerr combs



Nonlinear and Quantum Photonics

- Laser-based all-optical signal processing using ultra-high-Q cavities
- Quantum communications

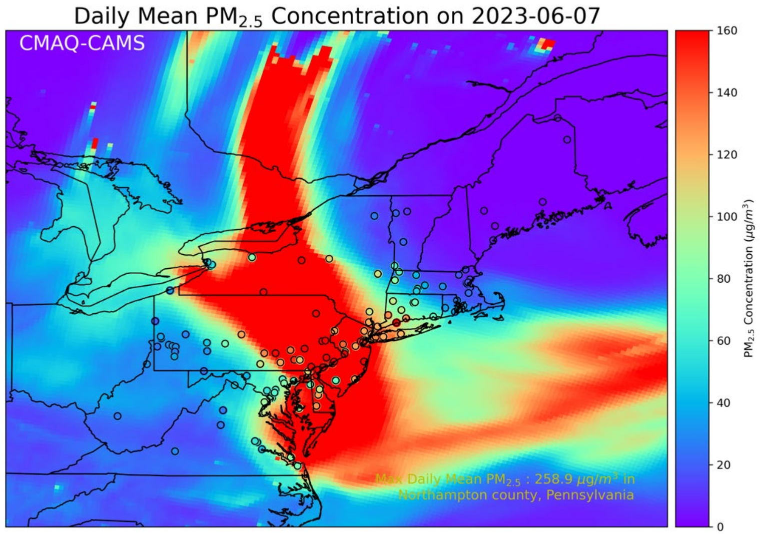


Prof. Russ Dickerson, AOSC

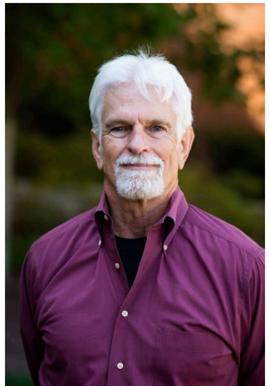
Topics: Atmospheric Chemistry and Physics, Air Quality, Climate, and Environmental Justice

Methods: In situ and remote measurements
Numerical simulations

Support: NOAA, NASA, NIST, DOE, MDEs

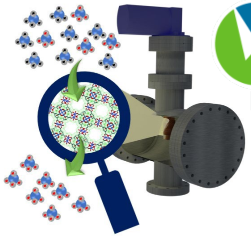


Canadian wildfires generated the worst air quality in decades: impacts on health and climate

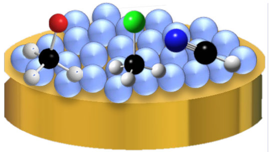


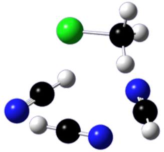
Dodson Group Chemistry/Chemical Physics Research

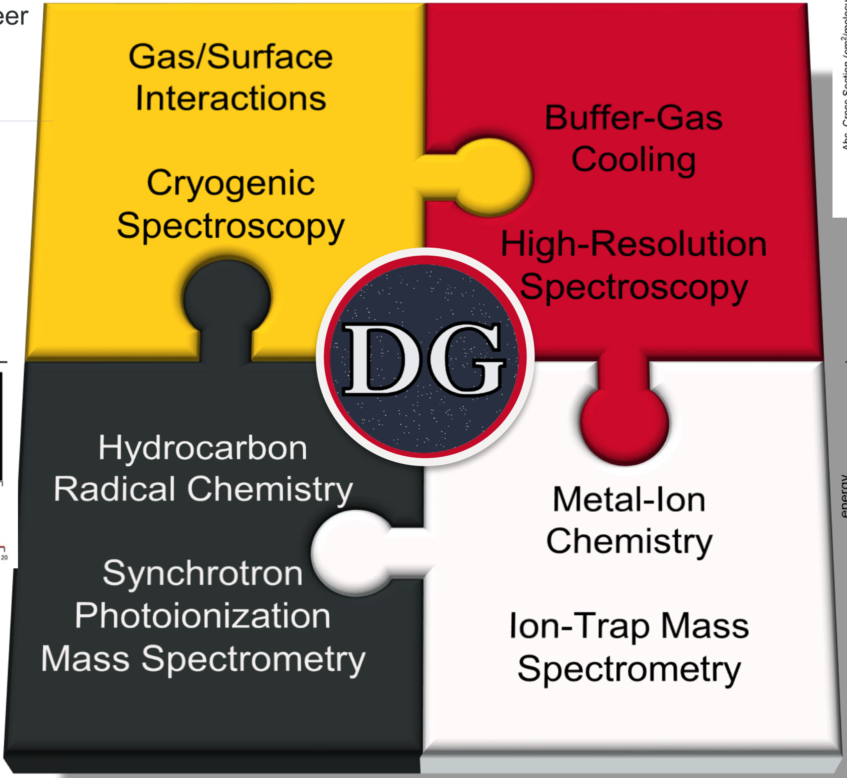
ACS PRF
65547DNI6

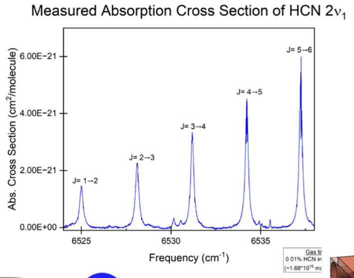


U.S. DEPARTMENT OF ENERGY AWARDEE™
Early Career

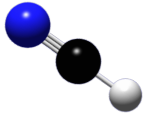


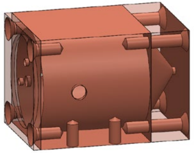




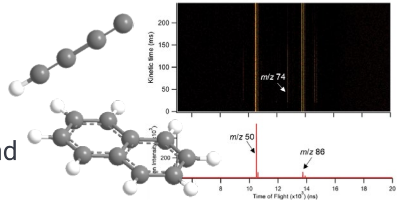


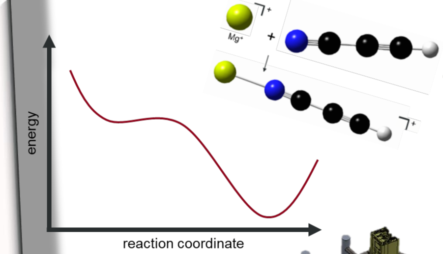
NSF
2154055





UNIVERSITY OF MARYLAND 1856
Catalyst Fund





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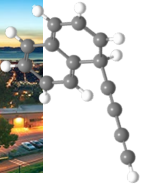
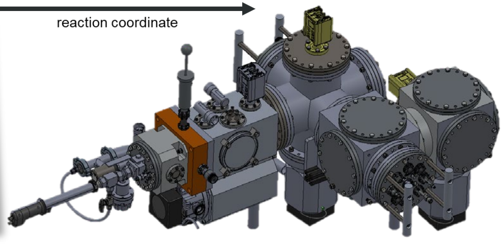




@Dodson_Group

dodsongroup_umd

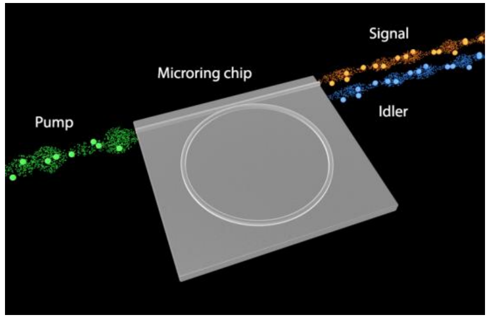
NASA
Partner

BSF Startup
1972-2022
B S F

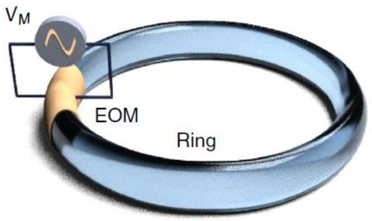
Dutt FloQuET Lab @ UMD

floquet.umd.edu | avikdutt@umd.edu

FearLess Optics, Quantum Engineering and Technology



Quantum nanophotonics
(entangled/ squeezed light generation, quantum frequency conversion)

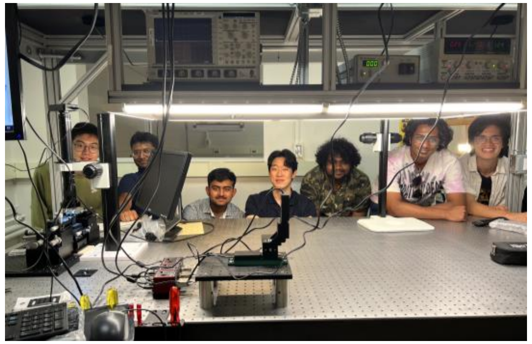


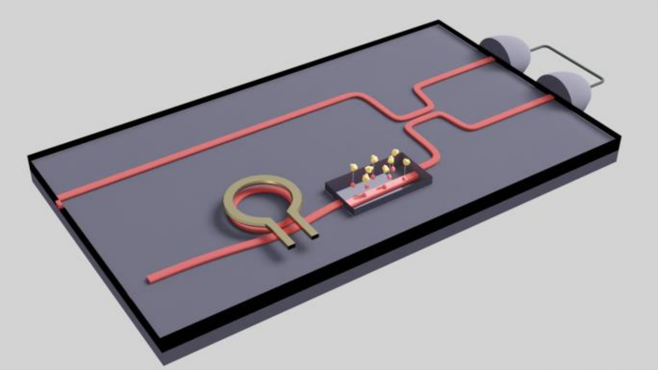
Topological photonics
(higher-order phases, high dimensions, quantum Hall effects, phase transitions)

arxiv:2305.02238

A. Dutt et al., Science (2020); Nat. Comm. (2019); Wang*, Dutt* et al., Science (2021)

Nonlinear photonics
(frequency combs, spectroscopy, metrology)



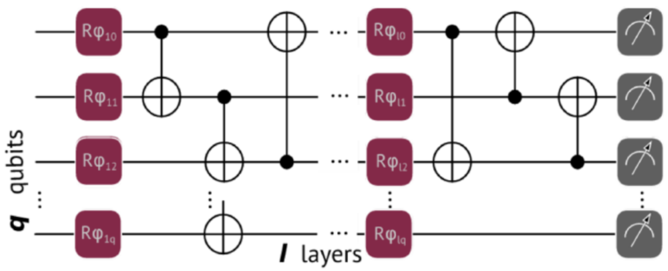


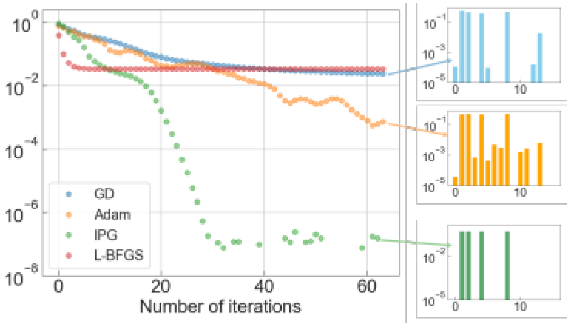
- For studying novel emergent phases of light and matter
- For applications in ultrafast, resource-efficient devices for (quantum-enhanced) communications, computing and sensing

Quantum sensing using squeezed light
Featured on ⟨quantum|gov⟩

INSTITUTE FOR PHYSICAL SCIENCE & TECHNOLOGY

A. JAMES CLARK SCHOOL OF ENGINEERING



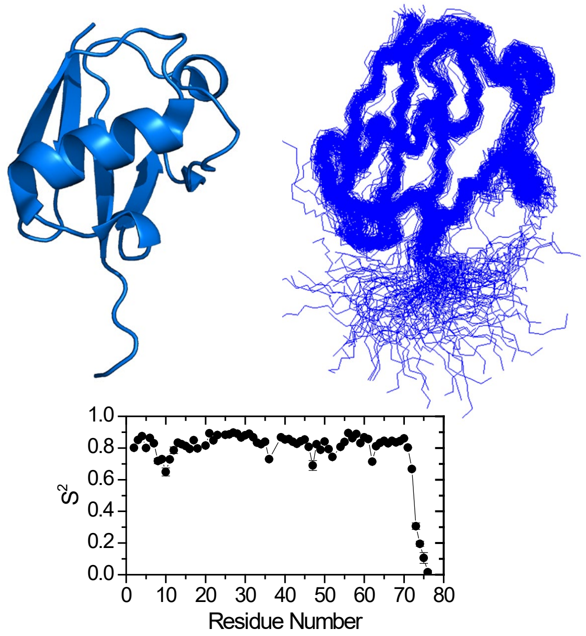


QLab NATIONAL QUANTUM LABORATORY | IONQ | UNIVERSITY OF MARYLAND

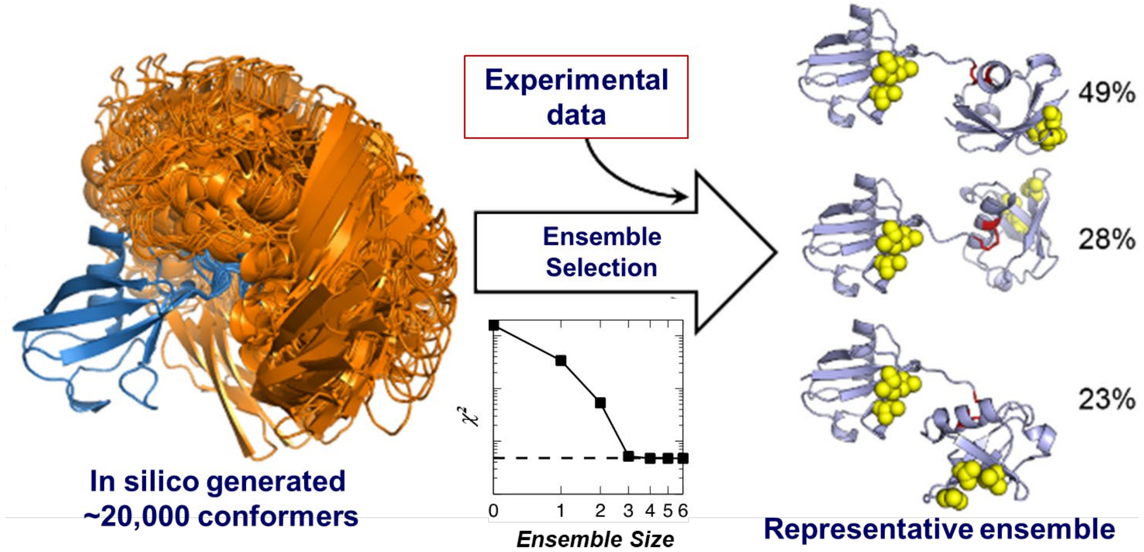
arxiv:2309.09957

Most research projects involve three or more aspects ∈ {theory, simulation, design, nanofabrication, experiments}

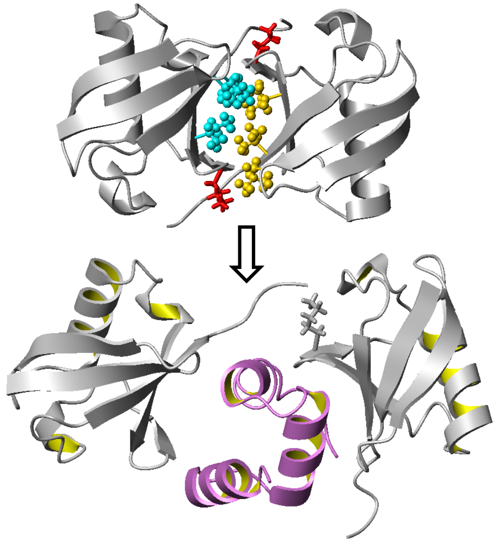
Proteins in motion: dynamics as the bridge between structure and function



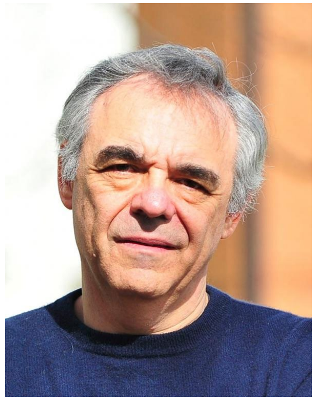
Elucidating motions inside a protein



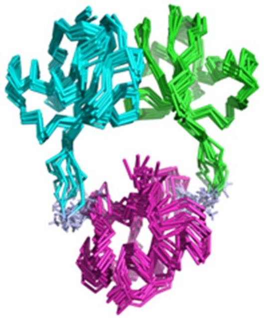
Representing multi-domain proteins as dynamic conformational ensembles



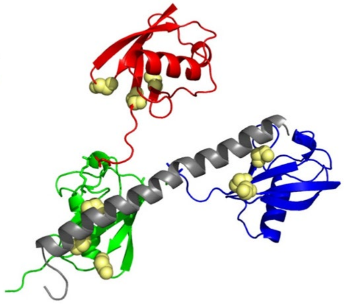
Mechanisms of cellular signaling by poly-Ubiquitin chains and how to modulate them



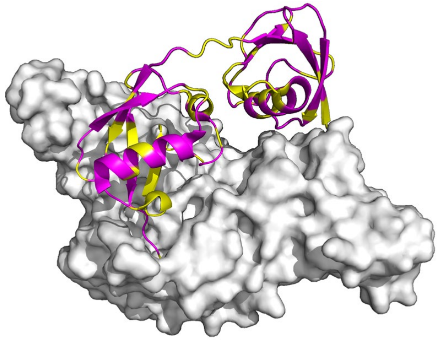
David Fushman



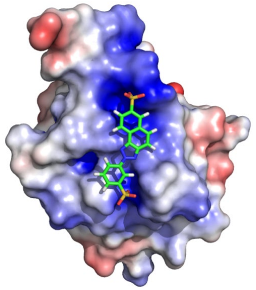
Structure, 2020



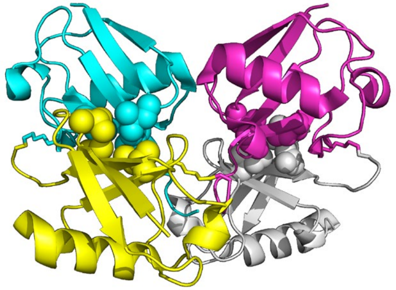
Structure, 2013



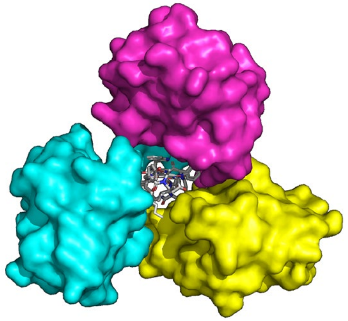
Nature Comm, 2023



Structure, 2017



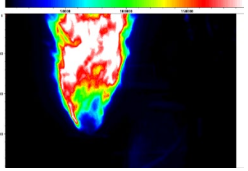
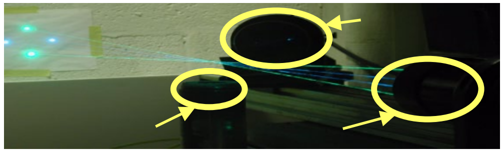
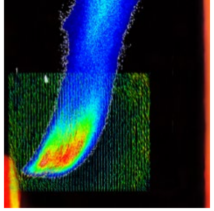
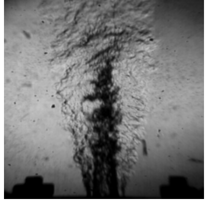
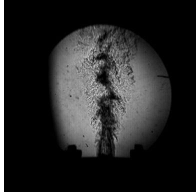
Nature Comm, 2023



Nature Comm, 2023

We combine experiments (NMR, X-ray, SAXS/SANS) and computer modeling to determine the structure, dynamics, and function of proteins and to address the challenge of painting an adequate portrait of a protein as a dynamic ensemble of multiple structures



The Combustion Laboratory at UMD

State of the art Lab. with comprehensive Diagnostics & Experimental facilities

Theme: Clean and efficient combustion of fossil and future fuels

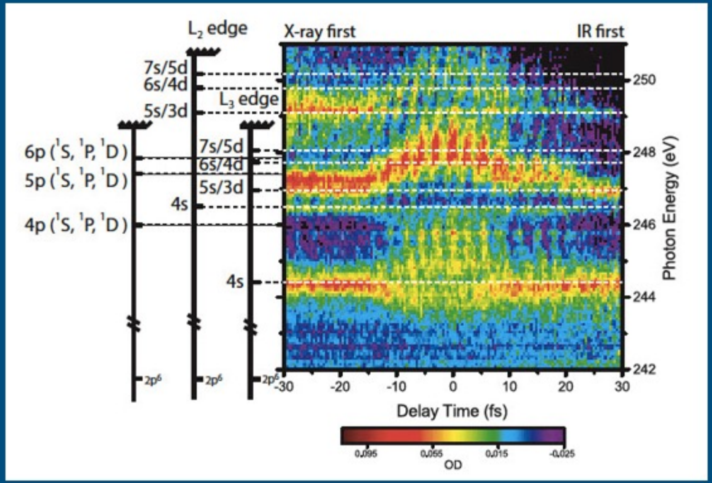
Sample Projects

- Gasification, pyrolysis and Waste to clean fuel conversion
- Colorless Green Distributed Combustion (CDC) for gas turbine application using High Temperature Air Combustion Technology (HiTAC)
- High speed combustion/Propulsion
- Micro-combustor with regeneration using gas and liquid fuels
- Sensors and diagnostics for combustion control in combustors and power plants
- Sulfur and energy recovery from acid gases
- Underwater propulsion and two phase mixing
- Mixing and ignition in rocket injectors

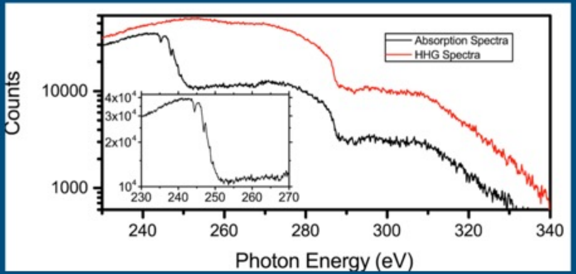
Contact Info.: Ashwani K. Gupta, Distinguished University Professor
E-mail: akgupta@umd.edu ; Tel.: 301-405-5276, FAX: 314-9477
Website: http://www.enme.umd.edu/combustion/

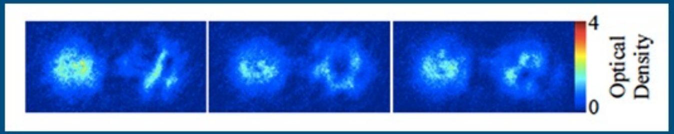
Wendell Hill's AMO Lab

Quantum dynamics under extreme conditions

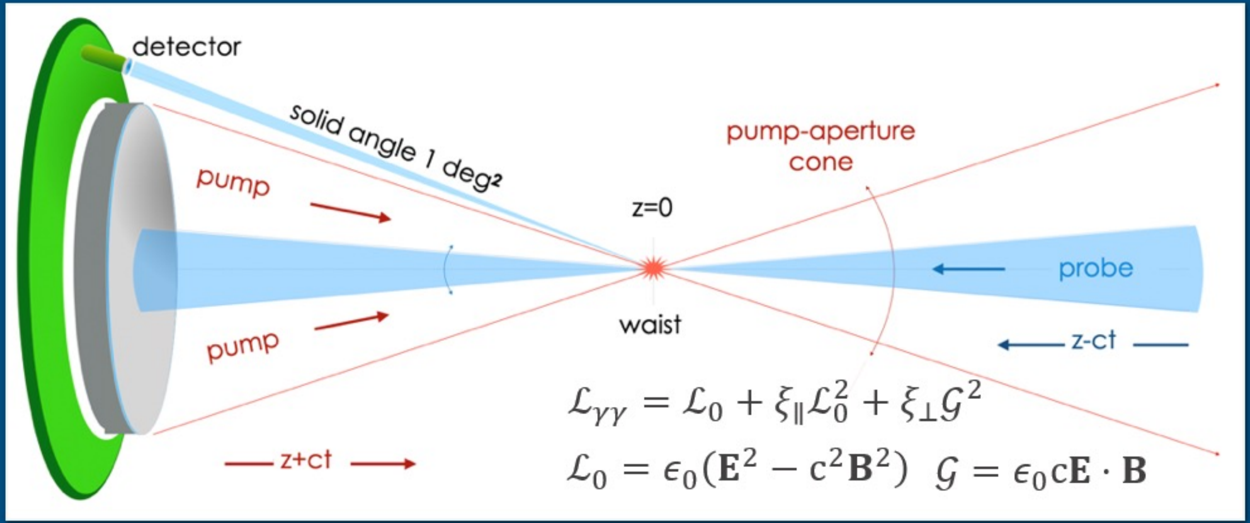


Ultrafast charge migration probed with femto and attosecond pulses
Phys Rev A 97, 031407





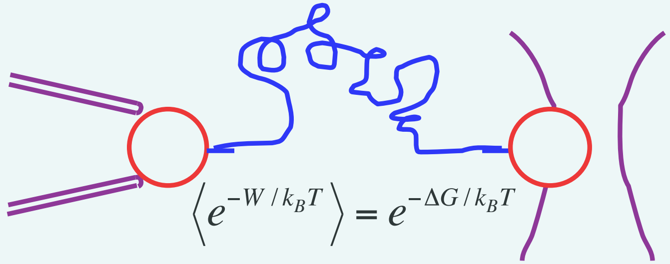
Exploiting ultracold degenerate atomic ensembles to explore fundamental processes
Phys. Rev. A **93**, 063619



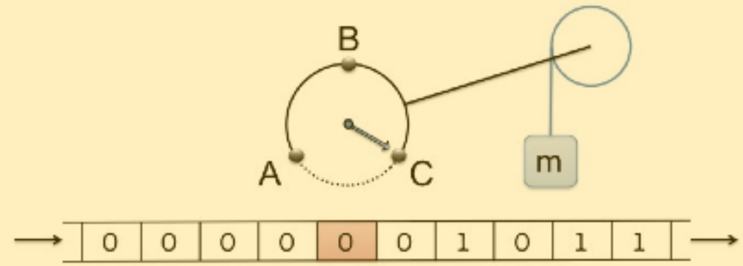
Nonlinear quantum electrodynamics (QED) induced at extreme intensities:
New J. Phys. **24**, 025010.

Theory and Computation in the Jarzynski group

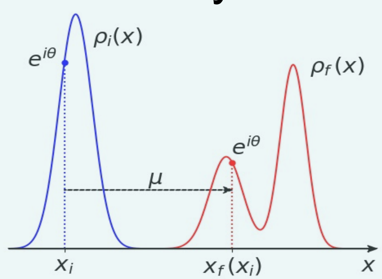
Thermodynamics at the nanoscale



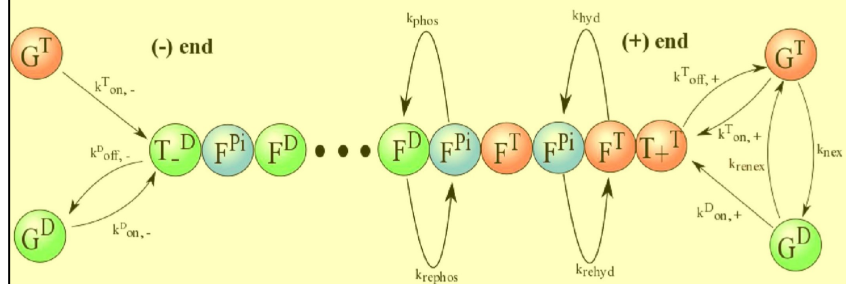
Physics of information processing



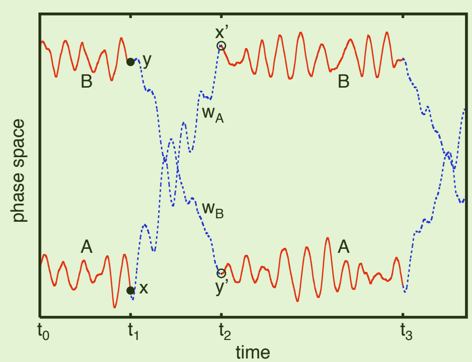
Quantum dynamics and thermodynamics



Biophysics out of equilibrium



Computational thermodynamics

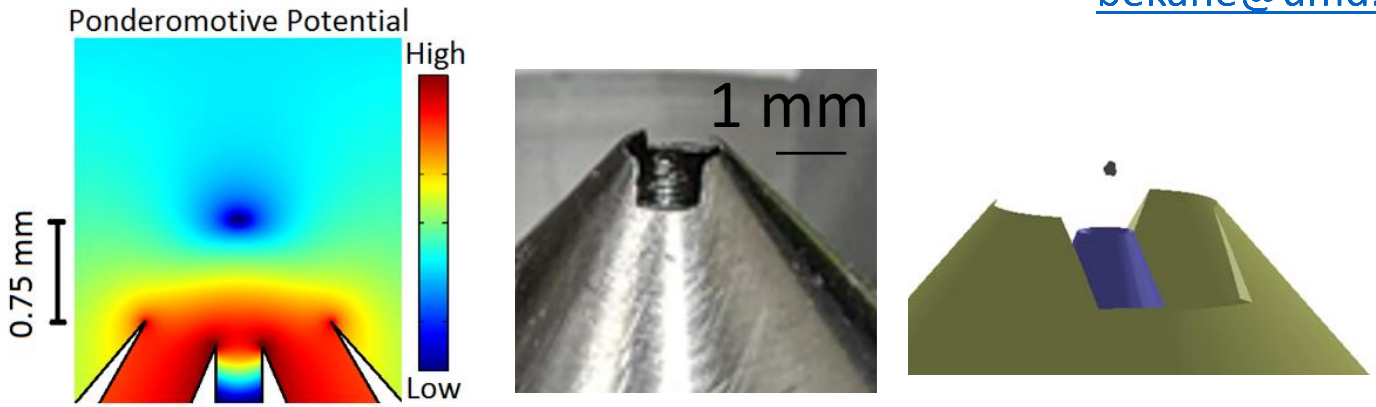


Chris Jarzynski
cjarzyns@umd.edu
(301) 405-4439

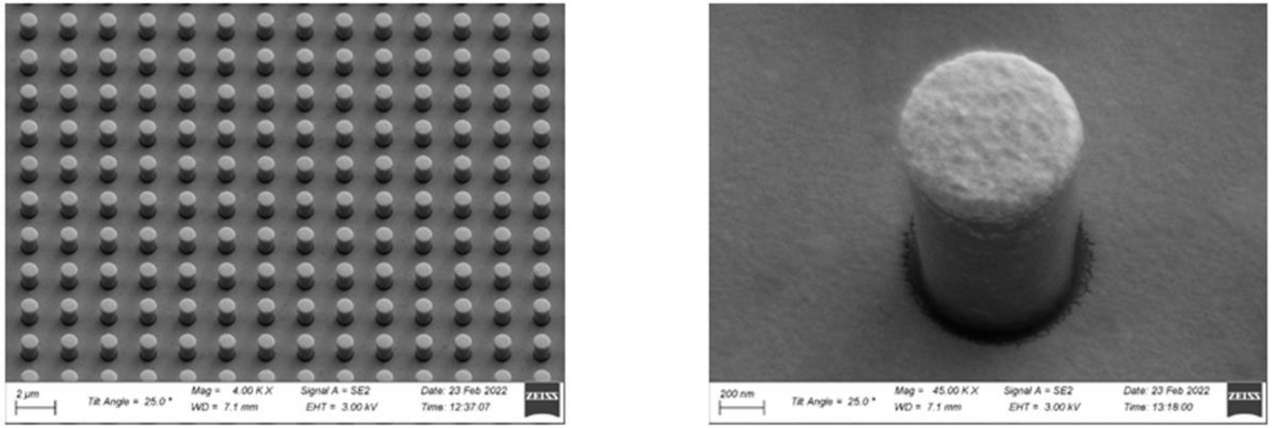
Research in levitated nanomaterials at the Laboratory for Physical Sciences (LPS)

Dr. Bruce Kane, LPS,UMD,JQI

bekane@umd.edu



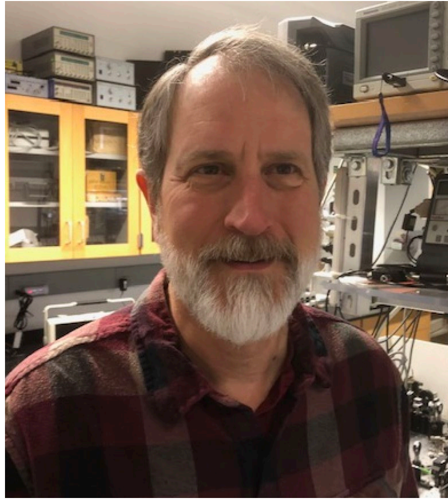
Levitation of sub-µm materials in an electric quadrupole ion trap



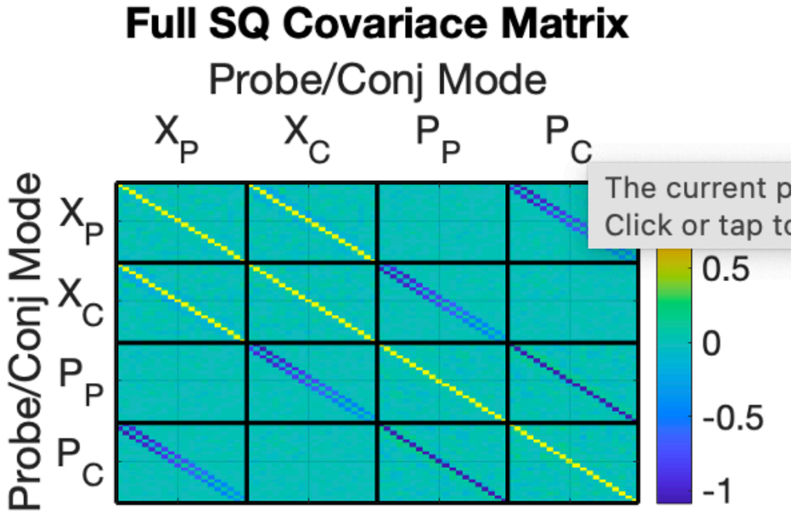
Preparation of samples in LPS clean room

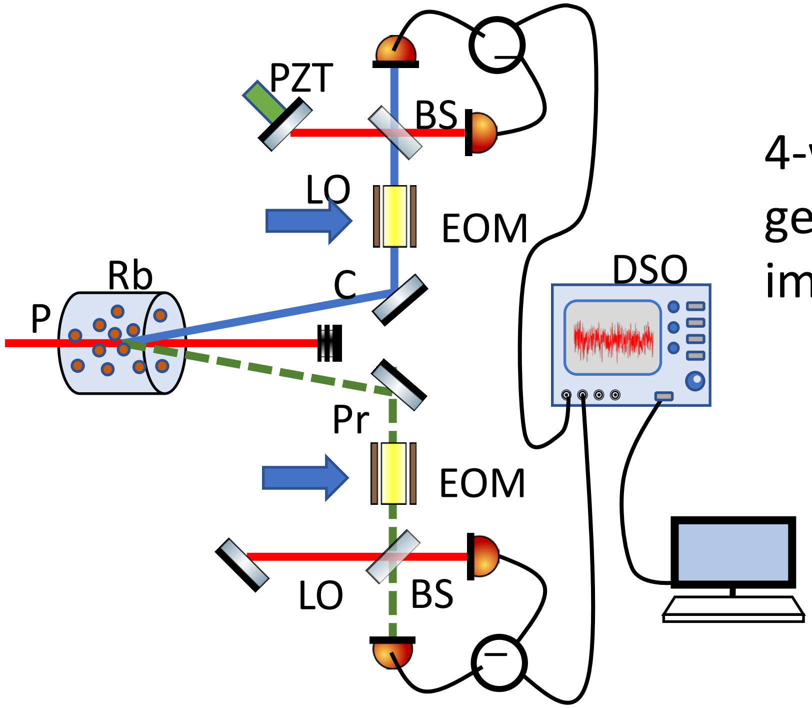
Thermal, mechanical, and chemical properties of levitated samples determined from optical scattering

Nonlinear/Quantum Optics

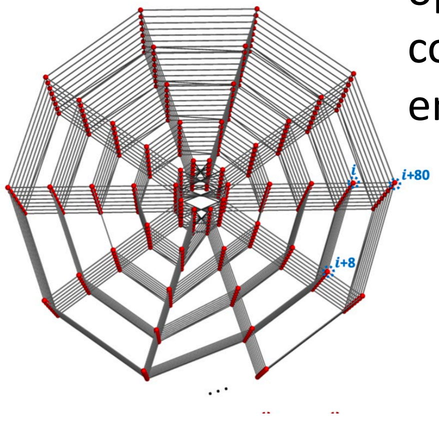


Paul D. Lett – National Institute of Standards and Technology / Joint Quantum Institute
UMD Chemical Physics Program

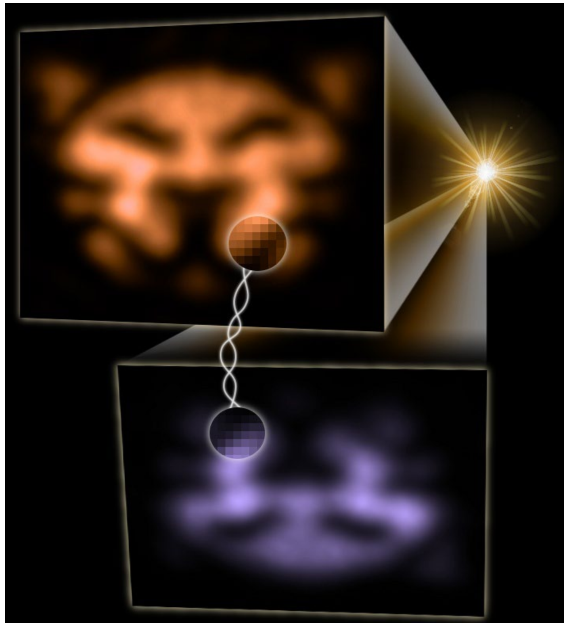




4-wave mixing in atomic vapors to generate quantum-entangled images and improve measurements.



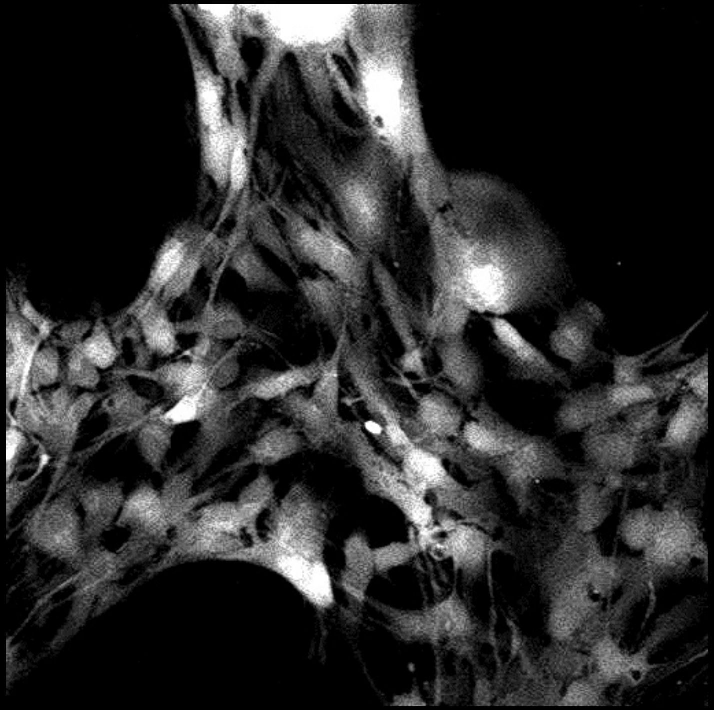
optical cluster states covariance matrix and entanglement structure



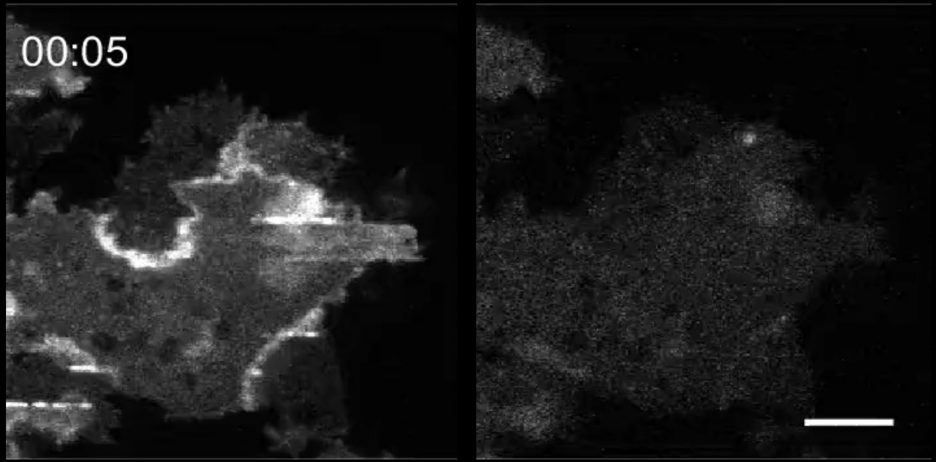
We study both the fundamental physics of entangled atoms and photons, as well as their applications to precision measurements and quantum sensing.

Dynamics of Living Systems Lab

Living Neural Networks – Multimodal Dynamics

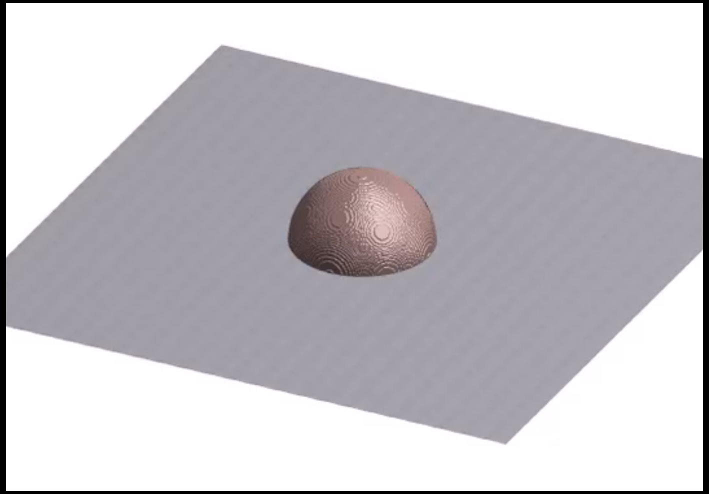


Mechano-chemical Waves as Primary Sensors of the Physical Environment



Yang et al *PNAS* (2023)

Information in Shapes, Dynamics and Rhythms



Herr et al , CommsPhys (2022)

Wolfgang Losert losertlab.umd.edu

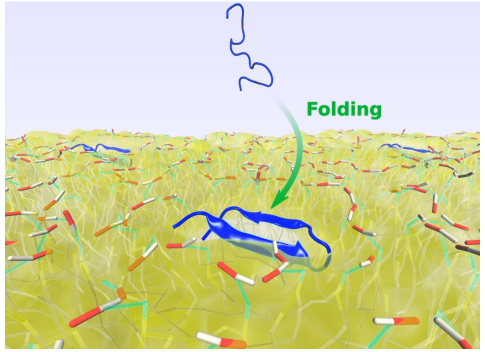
Recruiting one biophysics PhD student per year with interest in microscopy, cell biophysics, or data analytics/machine learning

Biomolecular Modeling: *Self-assembly processes*

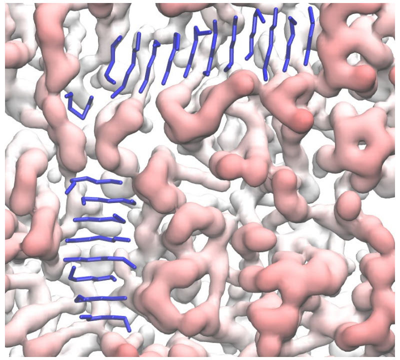
Silvina Matysiak
matysiak@umd.edu

Peptide folding and aggregation in complex environments

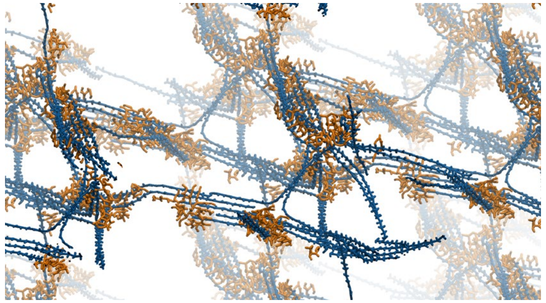
Membrane induced peptide folding [1]



Peptide aggregation in lipid bilayers [2]

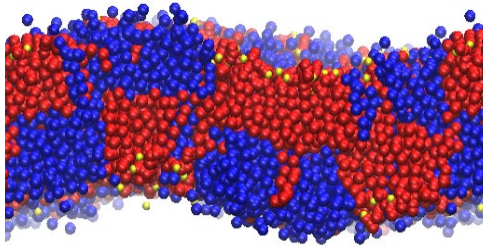


Peptide aggregation in extracellular matrix mimetics



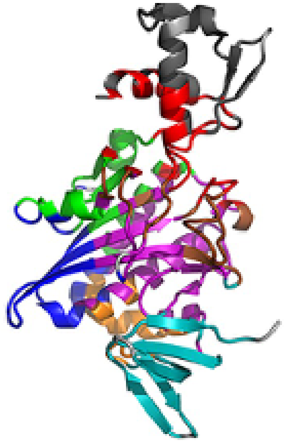
Biophysical properties of lipid bilayers

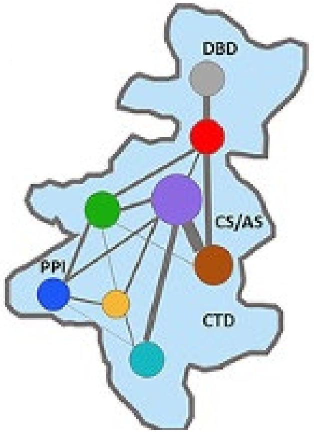
Lipid domain formation [3]



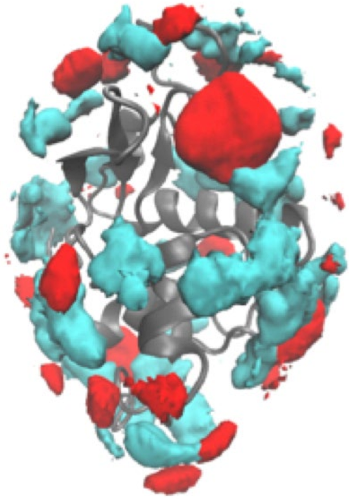
Protein allostery/evolution and stability

Biotin Protein ligases [4]



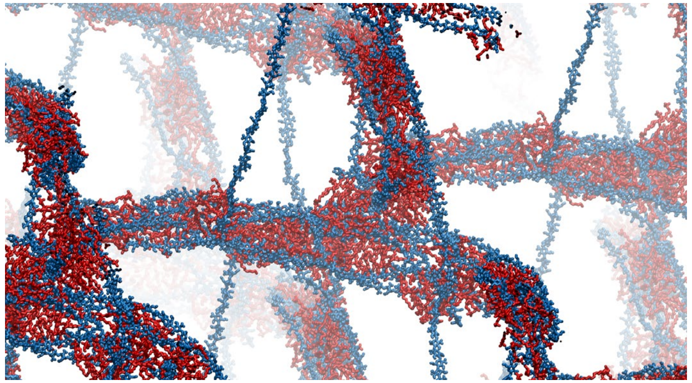


Protein stability in non-conventional solvents [5]



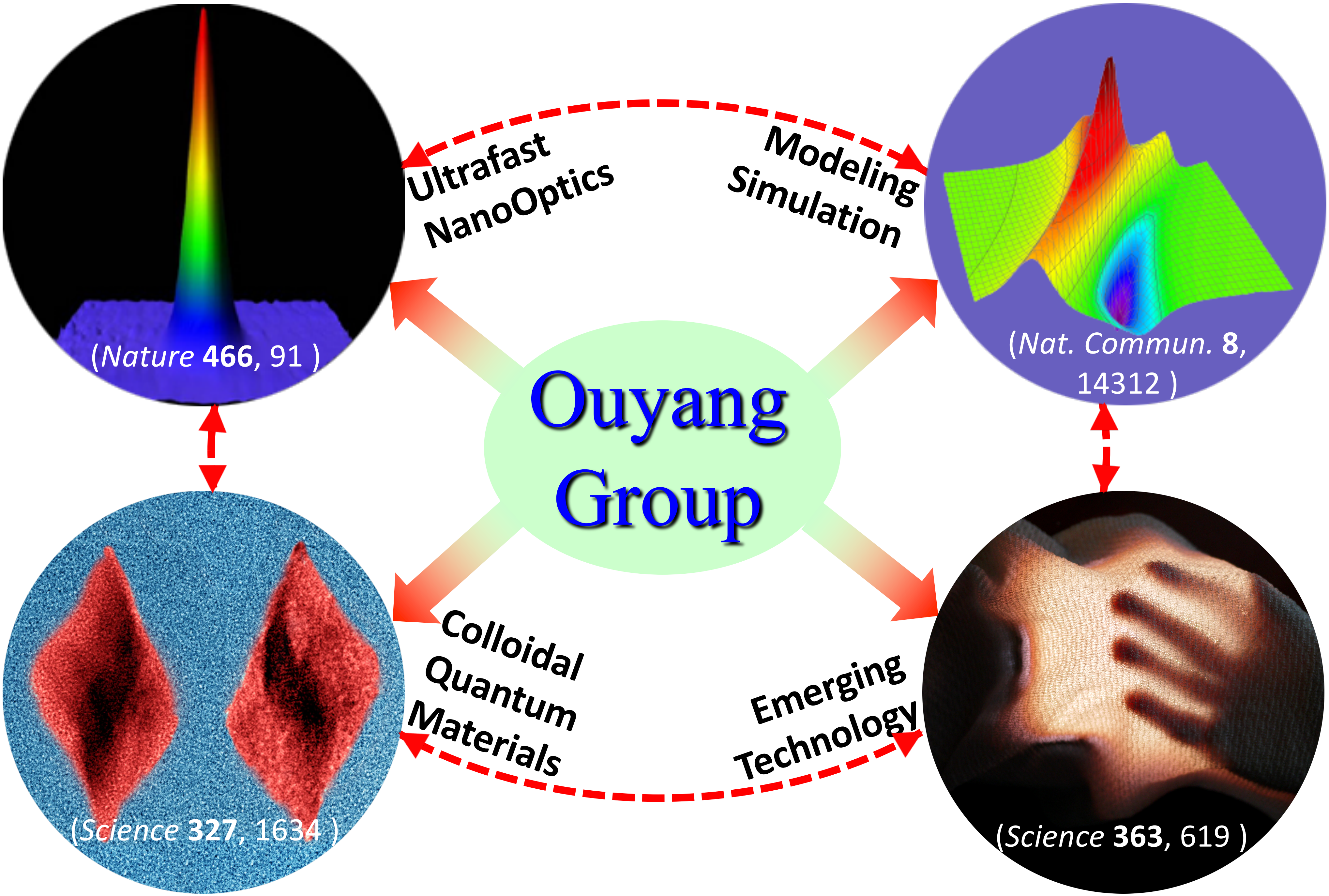
Mechanical properties of hydrogels

Polysaccharides/surfactants Hydrogels [6]



[1] Phys. Chem. Chem. Phys. **18**, 17836 (2016). [2] Phys. Chem. Chem. Phys. **21**: 8559 (2019). [3]*J. Phys. Chem. B* **124**: 7327 (2020). [4]Biochem. **59**: 790 (2020). [5]*Phys. Chem. Chem. Phys.*. **22**: p19779 (2020). [6]*Chem*. Commun. **13**: 7373 (2017).

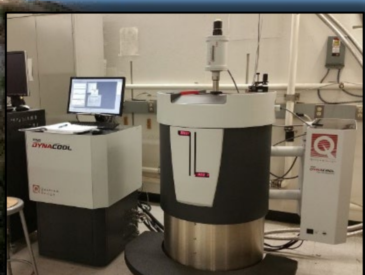
Probing and Controlling Nanoscale Chemical and Physical Processes

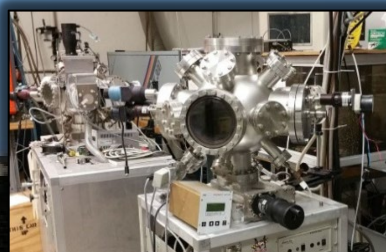


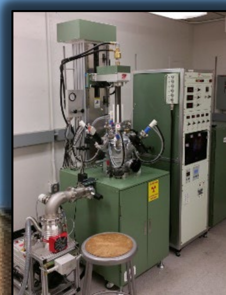
mouyang@umd.edu

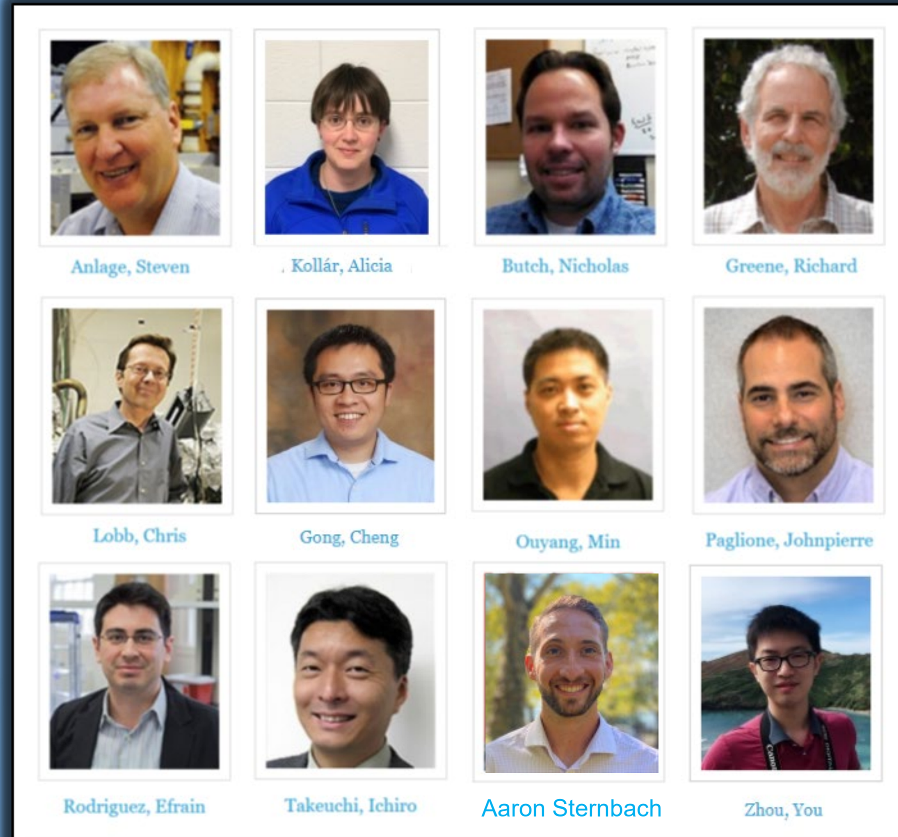
QMC Quantum Materials Center

12 faculty
27 affiliate members
8 research scientists
30 postdocs
55 grad students
20 undergrads
4 tech/admin staff









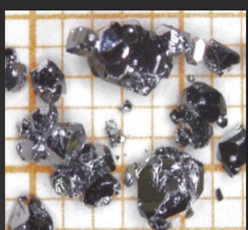
Research Facilities:

- 15 shared labs
- bulk materials synthesis
- thin-film synthesis (PLD + MBE)
- physical properties (mK, 20T, Mbar)
- XRD facilities
- ion mill, sputtering, evaporation
- AFM, STM, surface probes

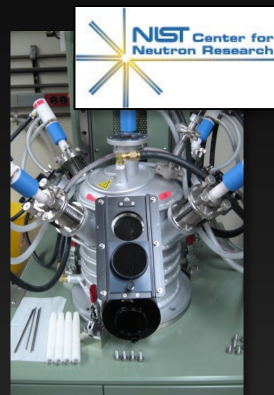
materials synthesis facilities

QMC Quantum Materials Center

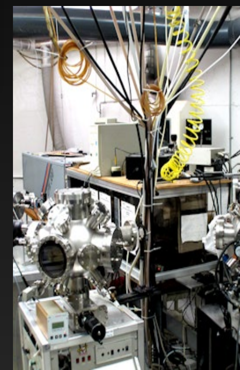
Molten Flux Solvent



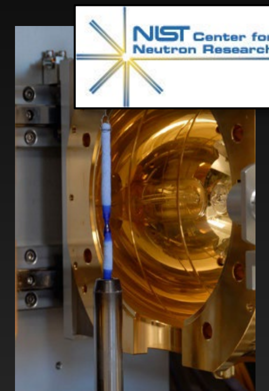
Bridgman Gradient



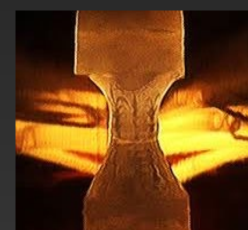
Czochralski Tetra-Arc



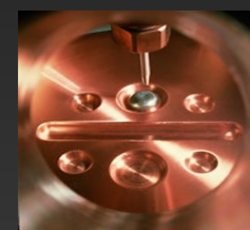
Pulsed Laser Deposition



Optical Floating Zone

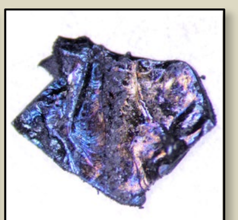


single-arc melters

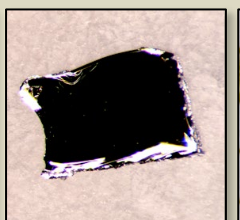


1700C argon furnaces

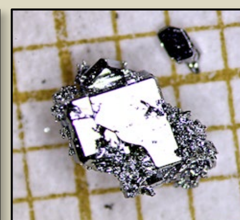
Fe-based superconductor $BaFe_2As_2$



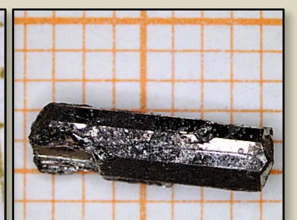
Correlated $KFe_{2-x}Co_xSe_2$



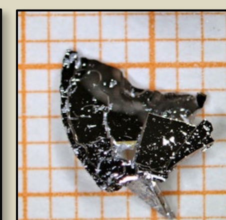
Ferro-TI $Sb_{2-x}V_xTe_3$



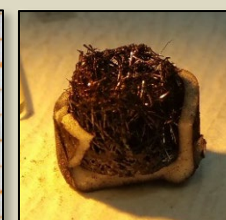
Dirac semimetal $RhSb_3$



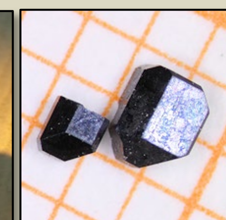
Heavy fermion $YbAu_3$



Kondo-FM CeAlGe



Quasi-1D $Rb_2Cr_3As_3$

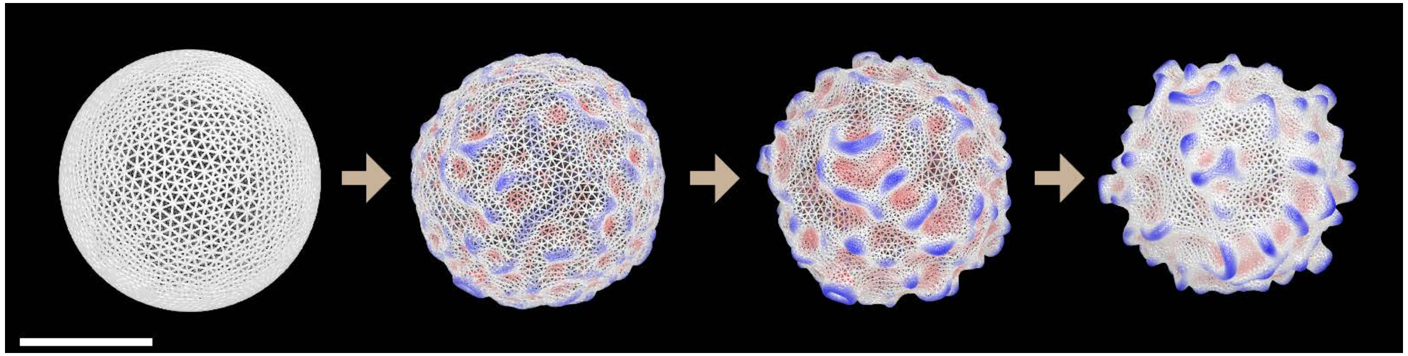


Kondo-TI SmB_6

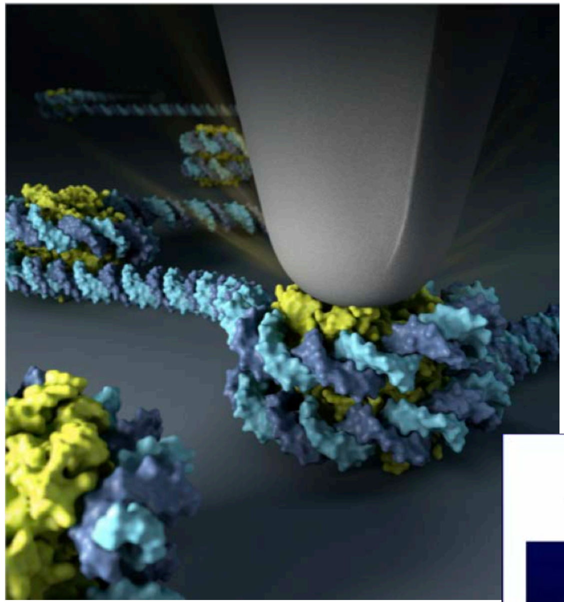
Biological Active Matter. Statistical Mechanics. Protein Physics.

Garegin Papoian

Molecular Modeling of the Cell

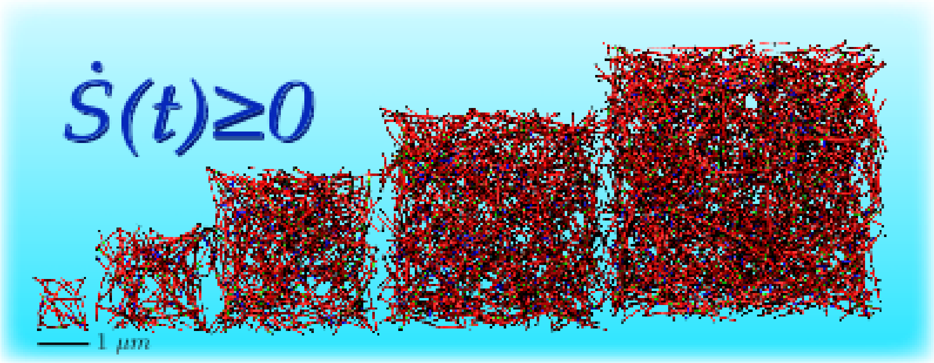


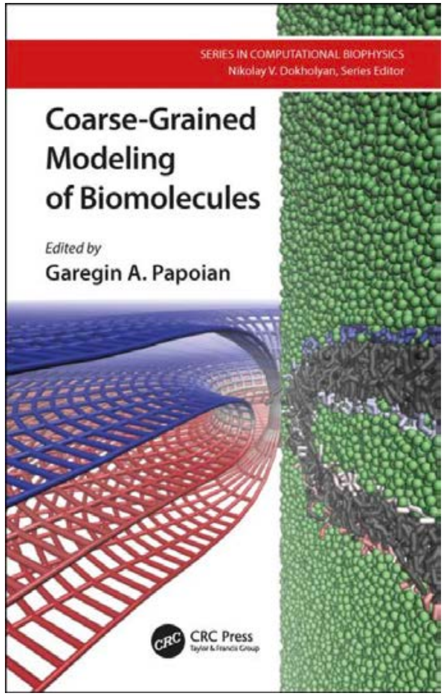
Chromatin



Molecular Dynamics

Entropy Production of the Cytoskeleton

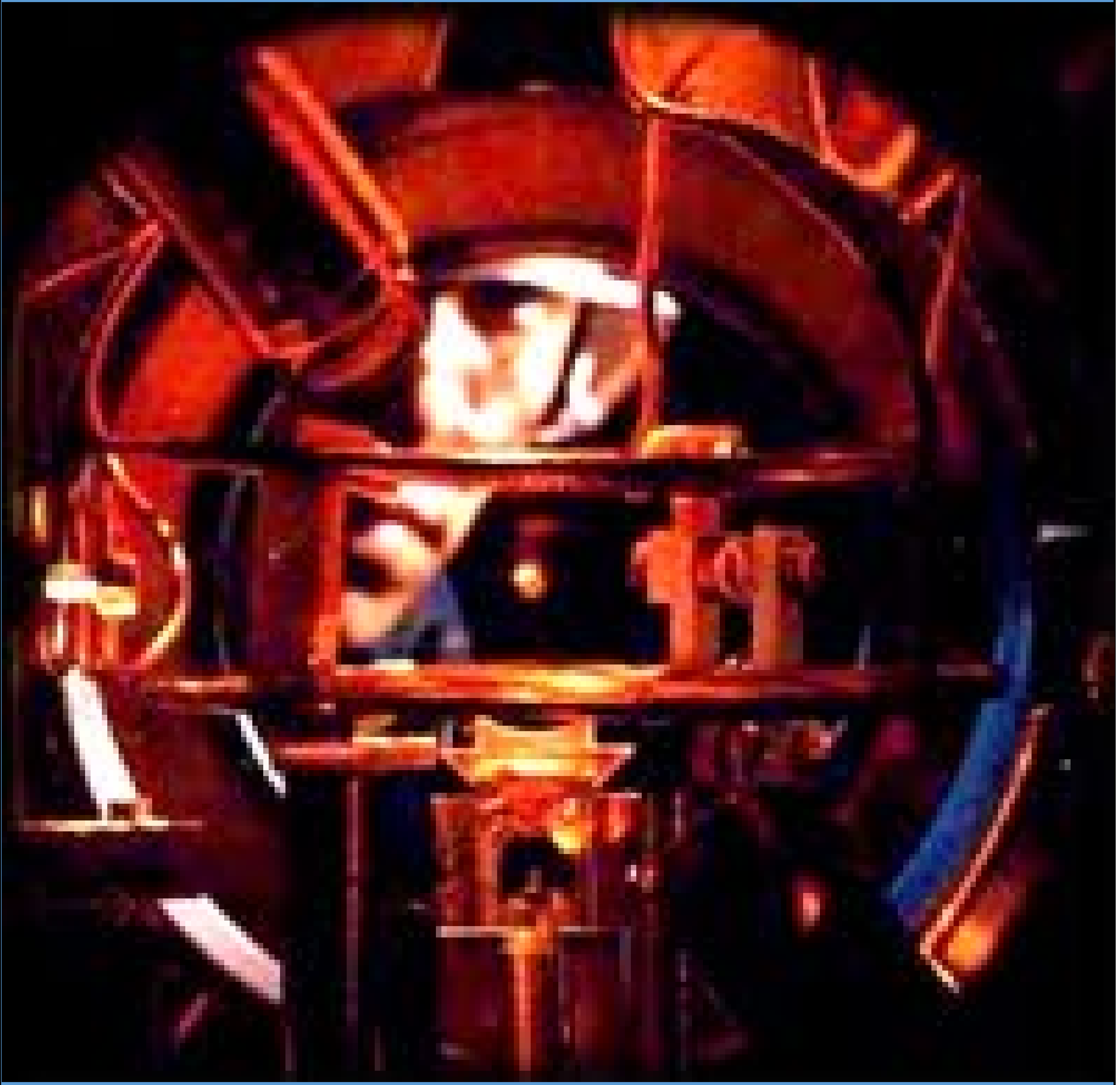




Coarse-Graining

PNAS 2019 DOI: 10.1073/pnas.1911880116; Interface Focus 2019 10.1098/rsfs.2018.0078; ”Coarse-Grained Modeling of Biomolecules, Publisher CRC Press, edited by G. A. Papoian

microkelvin atoms suspended in vacuum



william.phillips@nist.gov wdp@umd.edu

Laser Cooling and Trapping Group: NIST/JQI

In laboratories on both the National Institute of Standards and Technology and University of Maryland campuses of the Joint Quantum Institute, our group studies the coldest materials in existence. Cold atoms and quantum degenerate gases are the starting points for a variety of research directions in experimental and theoretical quantum science:

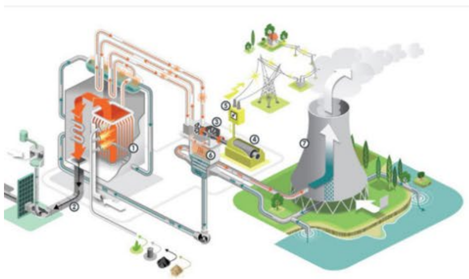
- Cold quantum chemistry
- Quantum Information Science
- Quantum simulation and computing
- Squeezed light—beyond quantum limits
- Topological matter
- Quantum thermodynamics
- Atomtronics
- More…

THE DEPARTMENT *of* MATERIALS SCIENCE AND ENGINEERING

Prof. Oded Rabin

Thermoelectric Materials for Energy & Space

Energy Production



Space Exploration

Hypersonic Flight

NATIONAL ENERGY TECHNOLOGY LABORATORY

NASA

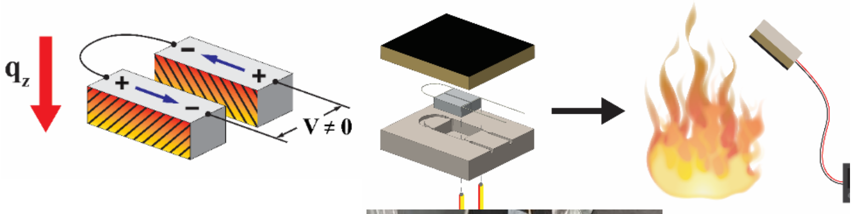
Oded Rabin
oded@umd.edu
301-405-3382

Solid-state physics guided:

- **Fabrication of materials & nanostructures**
- **Computer guided design**
- **Construction and testing of thermoelectric devices**

Hi-T Heat Flux Sensor

(*MOST RECENT WORK*)



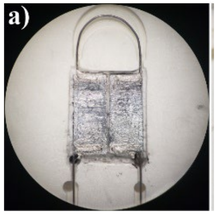
Goals:

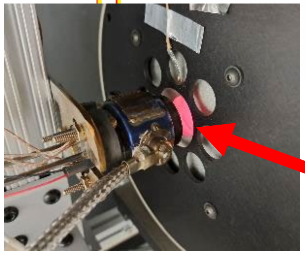
- Operation at extreme temperature
- Operation at extreme speeds
- Waste heat to electricity conversion
- Accurate measurements of heat fluxes

<u>Collaborative & Interdisciplinary</u>

Materials-AERO-Fire Protection

UMD-Germany-Czech Rep





1000°C in here

Complex Fluids and (Soft) Nanomaterials Group

COMPLEX FLUIDS & NANOMATERIALS

Prof. Srinivasa R. Raghavan

Patrick & Marguerite Sung Professor
Dept. of Chemical & Biomolecular Engineering
University of Maryland, College Park

Office: 1227C Chem-Nuc Building

Phone: (301) 405-8164

Email: sraghava@umd.edu

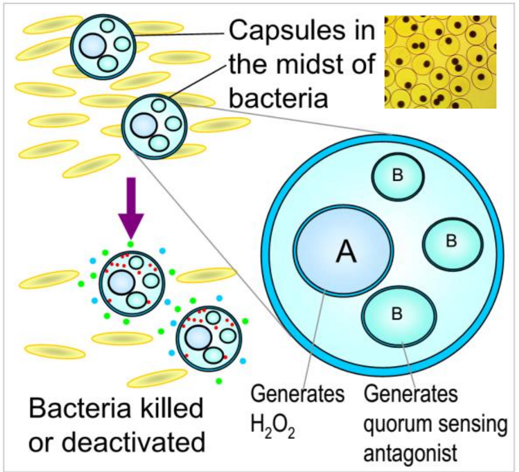
Bio | CV | Google Scholar

https://complexfluids.umd.edu

Polymers that Stop Bleeding

We have invented polymers that convert liquid blood into a gel via self-assembly.

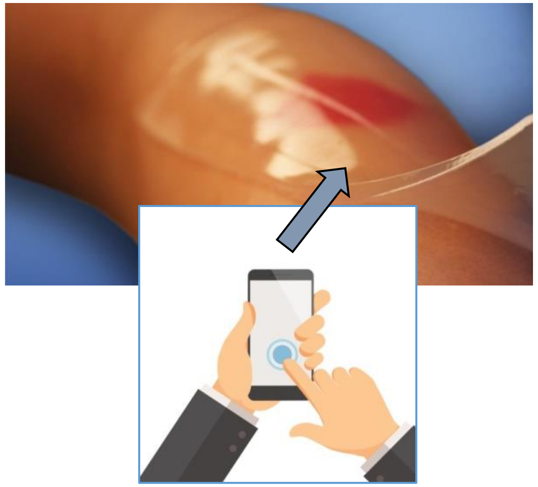
A gel to stop bleeding based on it is available at CVS/Walgreens.



Cell-Like Microcapsules

We have made capsules with many inner compartments, similar to organelles in a cell.

These are being used as agents to kill or deactivate bacteria.



Smart Gels for Drug Delivery

We are using electrical signals as well as irradiation by X-rays to induce drug delivery.

One use is in wireless delivery of drugs through skin to treat pain.

Keywords associated with research:

- *Self-assembly; smart fluids; nanostructured fluids; micelles; vesicles; rheology; neutron scattering*
- *Bionanotechnology; drug delivery; hydrogels; microcapsules; stimuli-responsive/smart materials*

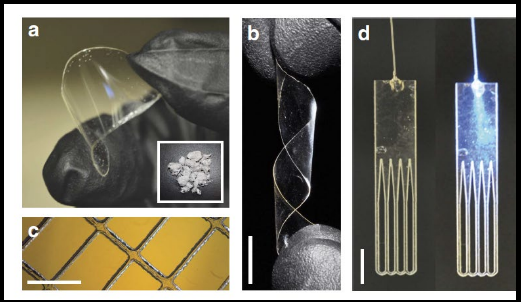
Light-Matter Interactions in the Bio-Universe

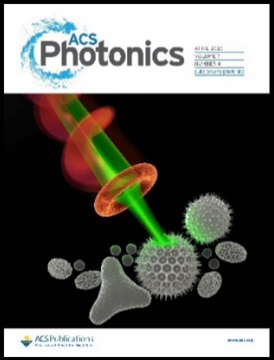
G. Scarcelli

Imaging through turbid media

Edrei & Scarcelli, Optica (2016)
Edrei & Scarcelli, Nature Comm. (2021)

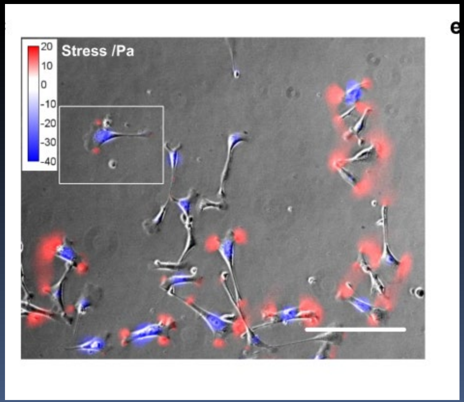
Bio - Optics





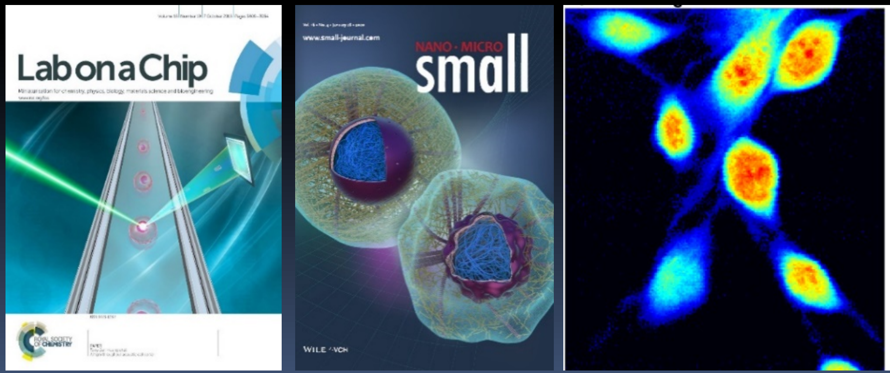
Nizamoglu et al. Nature Comm. (2016)
Edrei & Scarcelli, ACS photonics 2020

Soft-matter "lasers" to map forces



Kronenberg et al, Nature Cell Bio (2017)

Photon-phonon probe to map stiffness

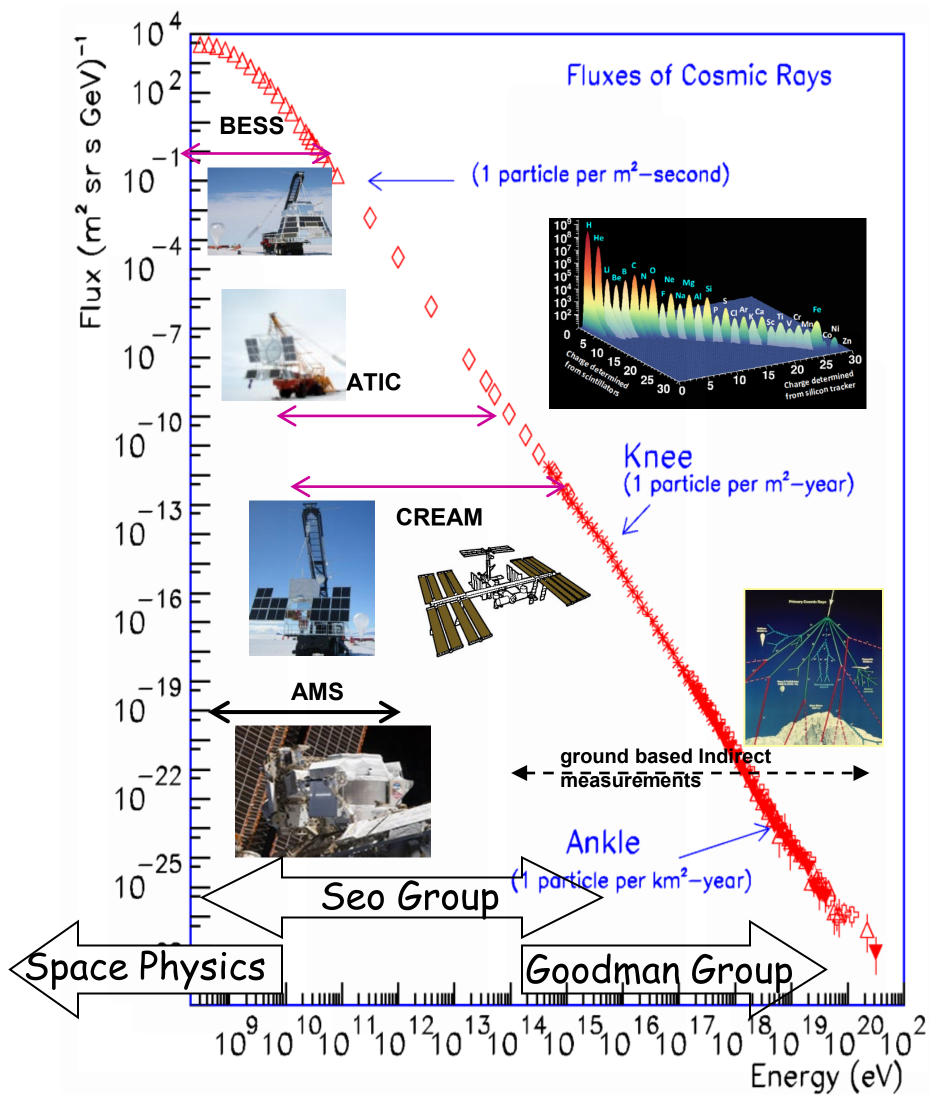


Scarcelli & Yun, Nature Photonics (2008)
Scarcelli et al, Nature Methods (2015)
Zhang and Scarcelli, Nature Protocols (2021)

Cosmic Ray Physics Group

http://cosmicray.umd.edu/

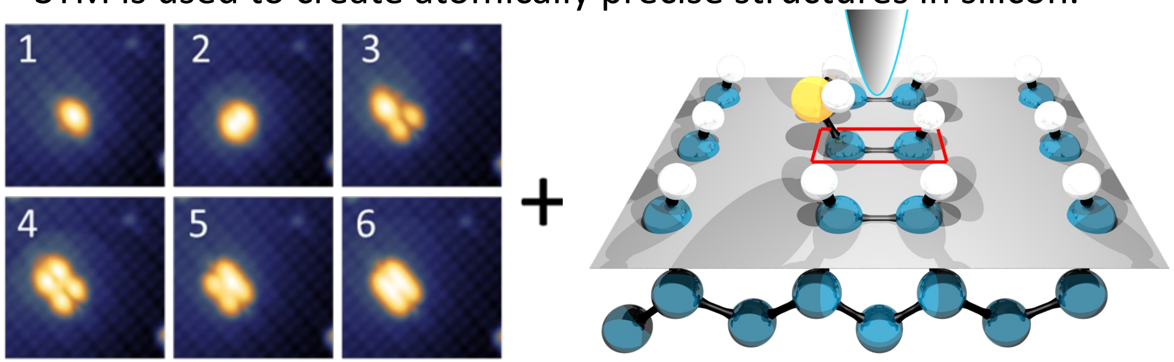
- This group's precision measurements fill the gap between space- and ground- based research activities of other groups on campus.
- The AMS, ATIC, BESS, and CREAM instruments are based on particle detectors like those used at accelerators, but they are flown in space for cosmic ray measurements
- The instruments are for the most part built in-house by students and young scientists, many of them currently working in the on-campus laboratory.
- The CREAM Science Operation Center at UMD remotely controls the instruments flying in Antarctica by sending commands and receiving data via satellite.



Solid-State Atom-Based Devices for Quantum Computing and Analog Quantum Simulation

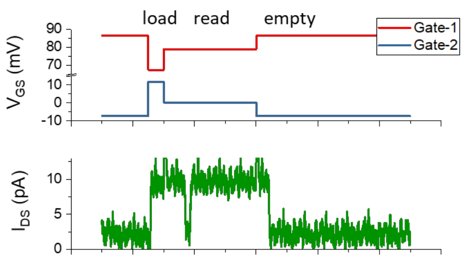
Richard Silver, Chemical Physics Program UMD, Dept. of Physics UMD, and NIST

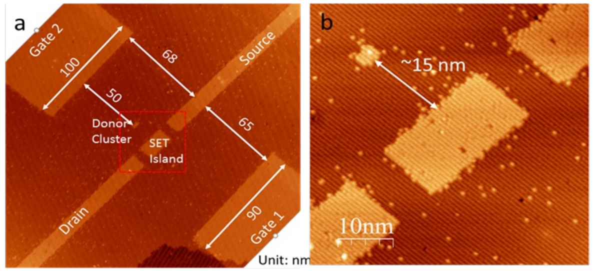
STM is used to create atomically precise structures in silicon.



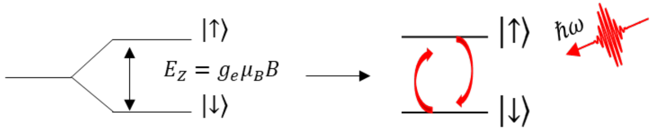
We use single electron transistors as charge sensors to measure the spin of individual electrons. These charge sensors, coupled to single or few atom structures, form the basis of electron spin qubits for applications in quantum computing.

Single Shot Electron Spin Readout



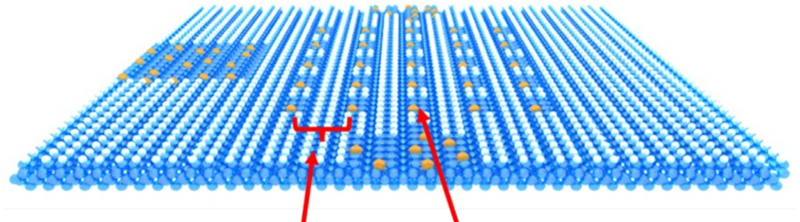


Magnetic field induced Zeeman energy splitting.



Wyrick J, Wang X, Namboodiri P, Schmucker SW, Kashid R, Silver R. M. Nano Letters 2018, 18 (12).
Wyrick, J., Wang, X., Namboodiri, P., Kashid, R., Fei, F., Fox, J., Silver, R. M., ACS Nano Nov. 2022.

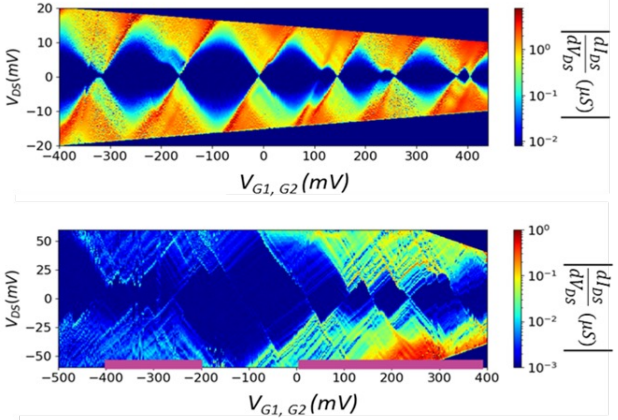
We fabricate atomically precise arrays of atoms to perform the analog quantum simulation of quantum systems such as the extended Fermi Hubbard model. These simulators are used to investigate quantum mechanical systems beyond the scope of classical computation.



$$H_{array} = H_t + H_\mu + H_U + H_J$$

Controlled by spacing and electrostatic gates.

Controlled by adsorbed species, number of atoms per site, and electrostatic gates



Tunable Parameters in the Hubbard array:

- **Tunnel coupling**

$$H_t = \sum_{<i,j>\sigma} (-t c^\dagger_{i\sigma} c_{j\sigma} + H.c.)$$

- **Coulomb Interactions**

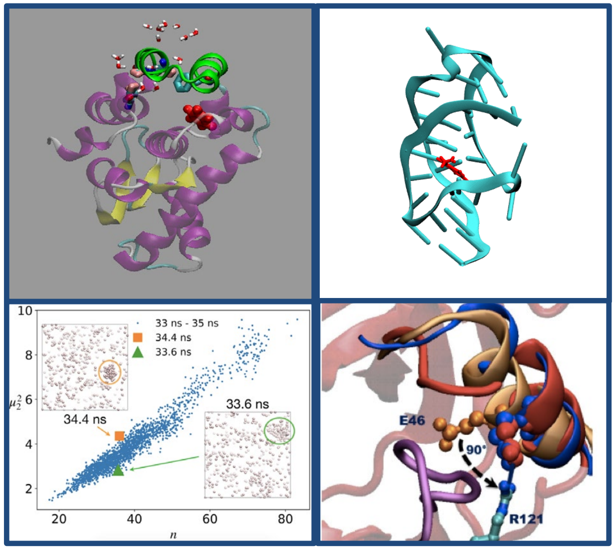
$$H_U = \sum_i U_i n_{i\uparrow} n_{i\downarrow} + \sum_{i,j} [U_{i,j}(n_{i\uparrow} n_{j\downarrow}) + \cdots + V_{i,j}]$$

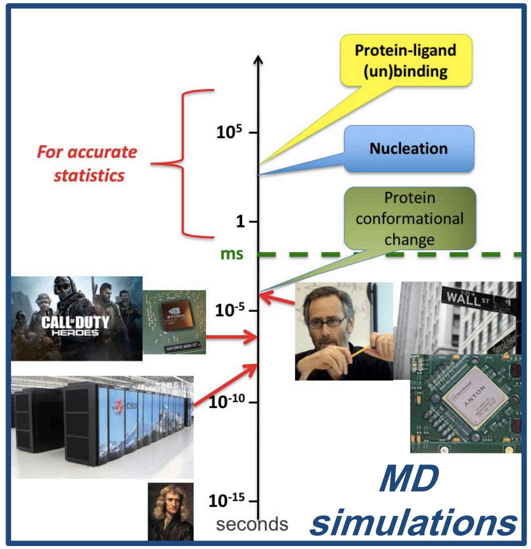
- **Chemical potential/electron occupation**

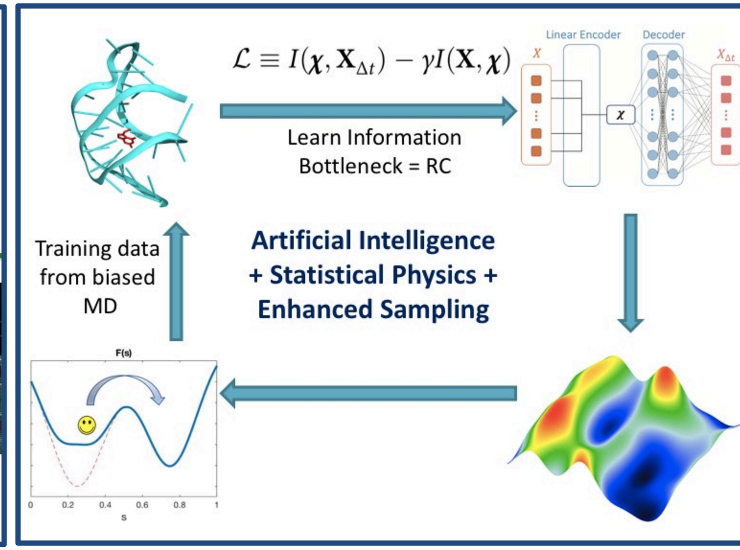
$$H_\mu = \sum_{i\sigma} (\mu_i n_{i\sigma} + E_{bi})$$

X. Wang, E. Khatami, F. Fei, J. Wyrick, P. Namboodiri, R. Kashid, A. Rigosi, G. Bryant, and R. M. Silver, Quantum Simulation of an Extended Fermi-Hubbard Mode…", Nature Comm. 13, No. 6824 (Nov. 2022).

From atoms to mechanisms: with a little help from AI and Stat Phys







Complex problems in chemical and biophysics

We develop & apply new simulation methods

Tiwary research group, University of Maryland

DEPARTMENT OF CHEMISTRY & BIOCHEMISTRY

@tiwarylab

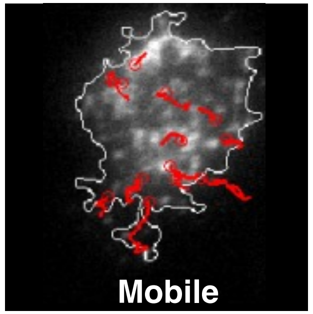
Institute for Physical Science & Technology IPST

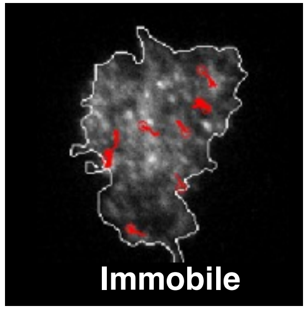
Ribeiro, Bravo, Wang, Tiwary ***J. Chem. Phys. 2018***
Wang, Ribeiro, Tiwary ***Nature Comm. 2019***
Smith, Ravindra, Wang, Cooley, Tiwary ***J. Phys. Chem. B 2020***
Tsai, Smith, Tiwary ***J. Chem. Phys. 2019***
Ravindra, Smith, Tiwary ***Mol. Sys. Des. Engg. 2020***
Tsai, Kuo, Tiwary ***Nature Comm. 2020***

Mechanobiology of immune response and gene regulation

Immune receptor dynamics

Regulation of T & B cell signaling

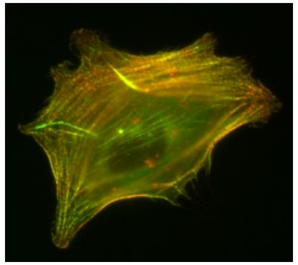




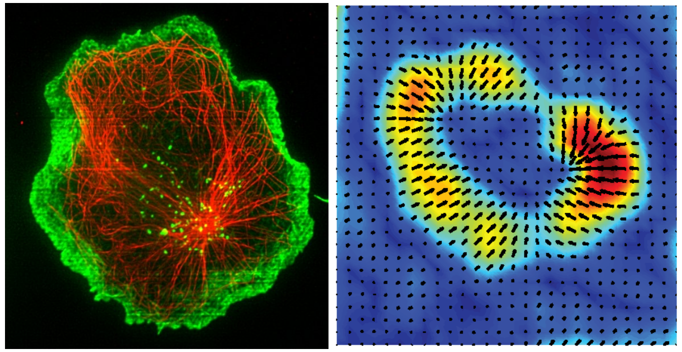
Biophys J. 2014, Nature Comm., 2020

Arpita Upadhyaya

arpitau@umd.edu



Cellular Force generation



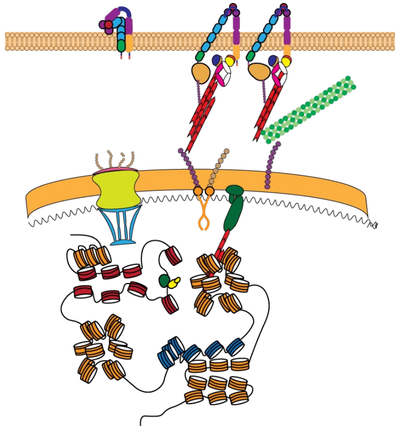
Mol. Biol. Cell 2015, PNAS, 2018

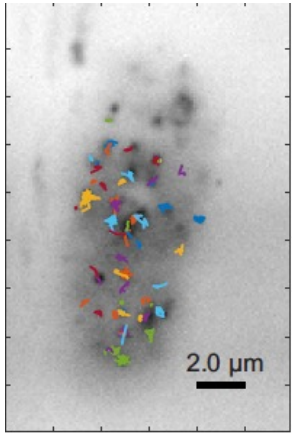
How do cells sense and respond to physical cues?

- Stiffness
- Topography
- Mobility

Gene regulation

Imaging of transcription factor dynamics in live cell nuclei



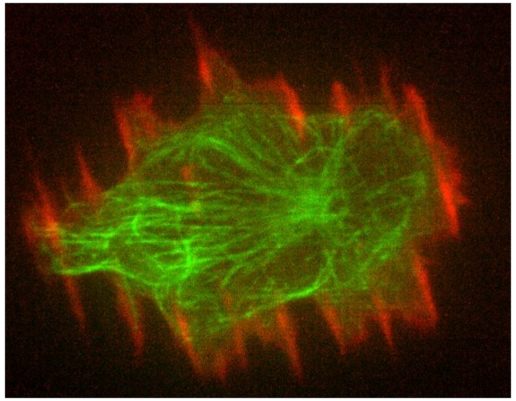


Molecular Cell, 2019

Techniques:

Single molecule imaging
Traction force microscopy
Super-resolution microscopy
Computational image analysis

Cytoskeletal dynamics



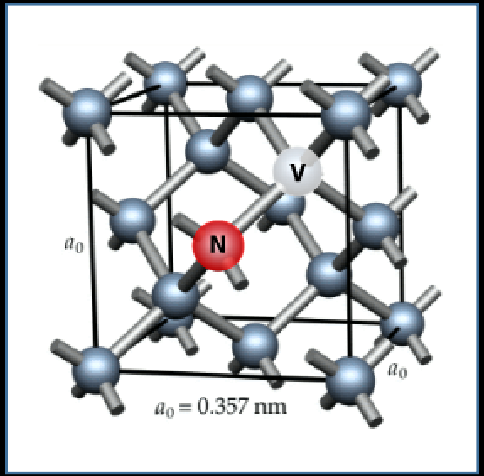
Mol. Biol. Cell 2018

Quantum sensing & imaging
=> Life & chemical sciences

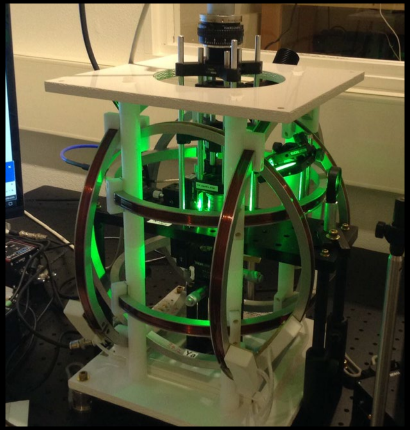
Ronald Walsworth

walsworth.umd.edu

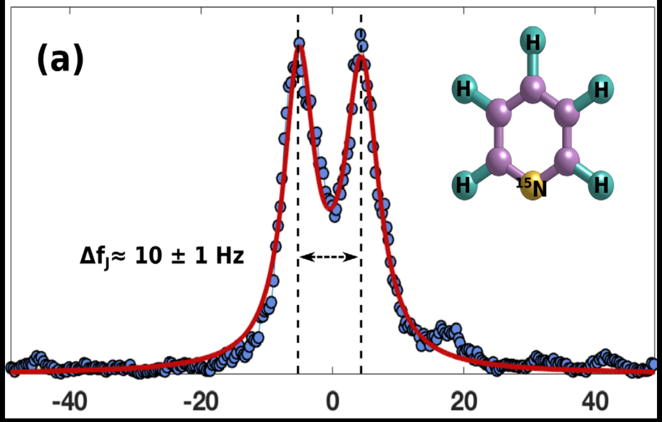
Quantum defects in diamond



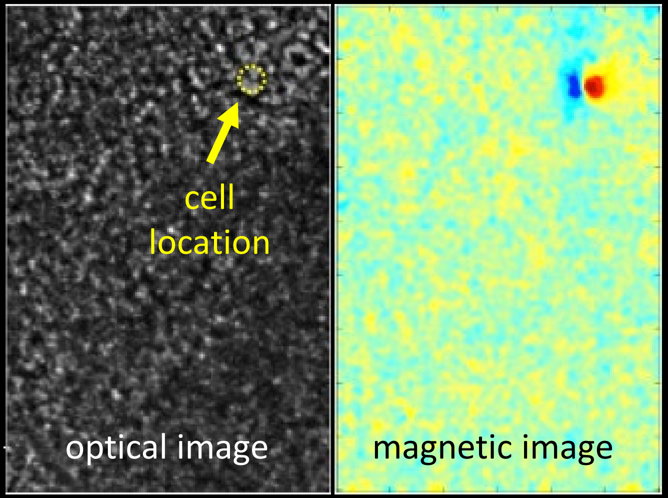
Quantum Diamond Microscope



NMR of single cells & proteins
=> metabolomics

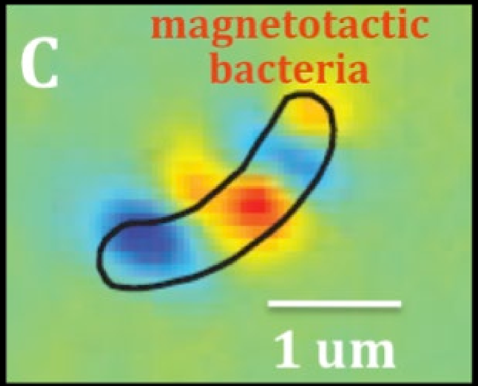


Single cell & biomarker detection

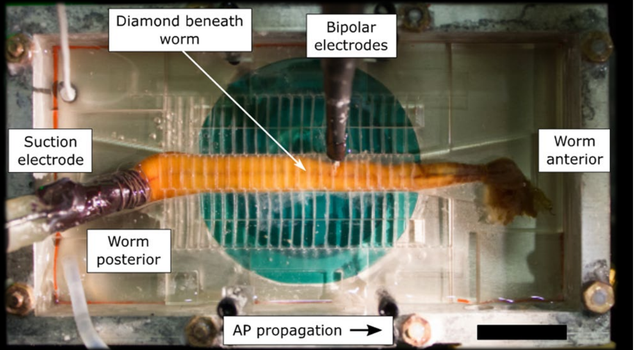


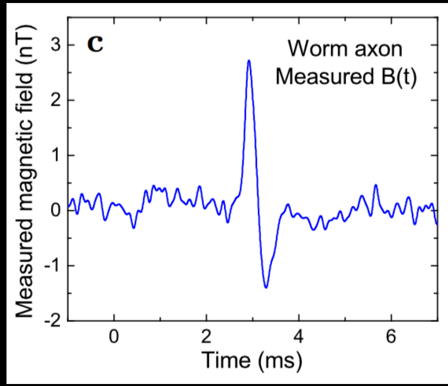
Nanoscale sensor of fields, temperature, forces
+
robust biocompatible material

Live cell magnetic imaging



Single-neuron MEG in whole animals

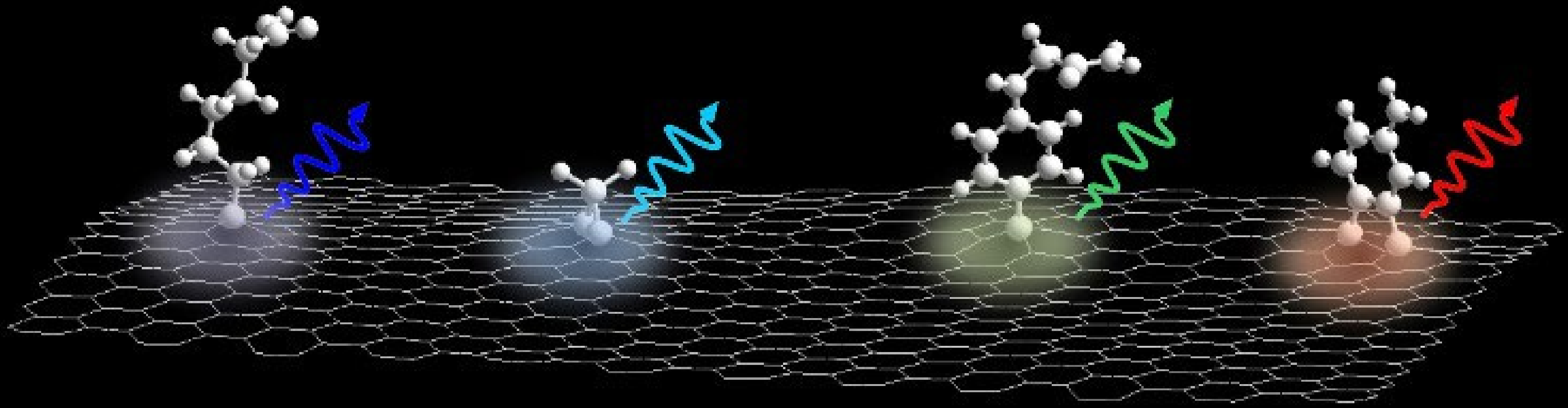




Organic Color-Center Quantum Defects

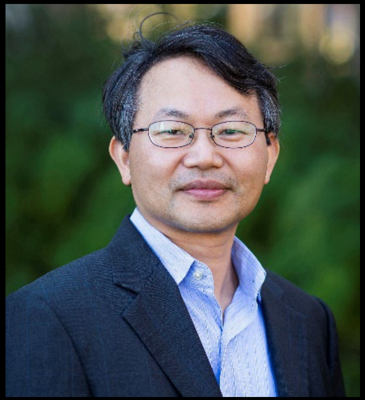
E=mc^2 & beyond

addressing fundamental challenges in Energy, biomedical, and quantum technologies through Materials Chemistry of Carbon and beyond



- *What happens when organic chemistry meets quantum physics?*
- *How does an exciton—electron-hole pair—in an atomic defect trap respond to local chemical perturbation?*
- *What if chemical information can be gathered, transformed, and transmitted at the Heisenberg limit of sensitivity and precision?*

Recent papers on the subject
"Selective filling of n-hexane in a tight nanopore"
""Nanosensor-based monitoring of autophagy-associated lysosomal acidification in vivo,""
"Single Particle Imaging in Live Brain Slices at Ultra-Low Excitation Doses"
"Probing Trions at Chemically Tailored Trapping Defects"
"Single-defect spectroscopy in the shortwave infrared"
"organic colour-centre quantum defects" – a review
""Engineering Defects with DNA." "



Interested? Please contact:
Prof. YuHuang Wang (yhw@umd.edu)
http://www2.chem.umd.edu/groups/wang/