

Research Instrumentation

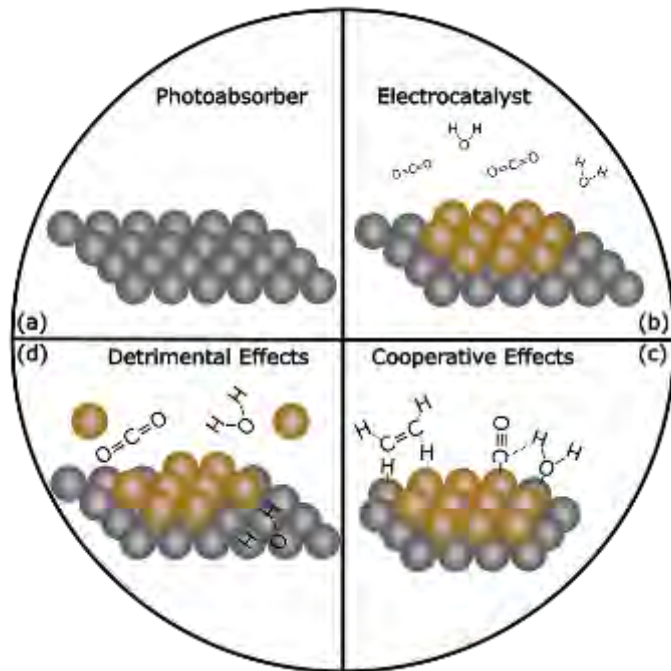
Interfacial Photochemistry

- **Dr. Jared P. Bruce**
- Assistant Professor
- Department of Chemistry and Biochemistry
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- Website: jpbruce.faculty.unlv.edu

Expertise

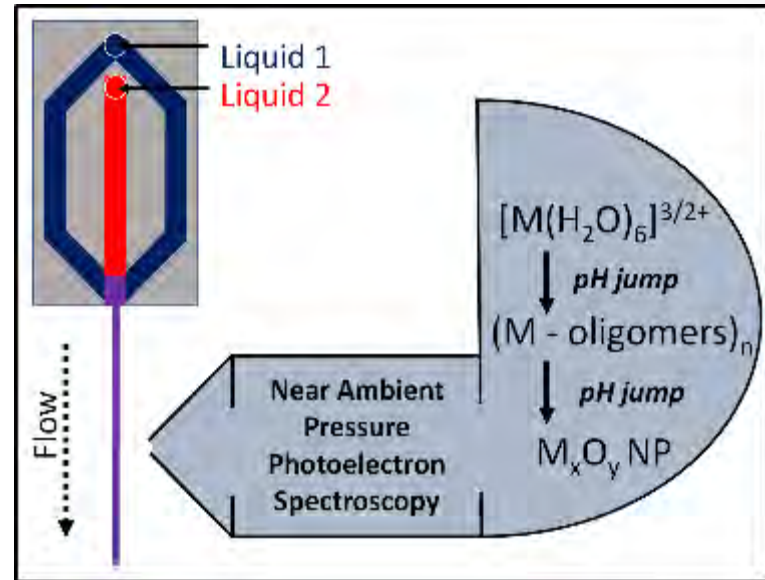
- Heterogeneous Photochemistry
- Electrocatalysis
- Photocatalysis
- Atmospheric Chemistry
- Surface Chemistry and Interfacial Characterization
- Near Ambient Pressure Photoelectron Spectroscopy

Hybrid Co-Catalyst/Photoabsorber Photochemical Interfaces



- Metals often make good electrocatalysts
- Semiconductors make good photoabsorbers
- The combination of the two create a new, complex interface that can be leveraged to increase the efficiency of co-catalyst/photoabsorber devices

Mixing Liquid Jet Photoelectron Spectroscopy



- Dynamic processes are tricky to study at the liquid surface
- A small liquid jet (20 μm dia.) is used to investigate the liquid surface
- Microfluidic chips provide mixing chamber to induce chemical reactions

Geochronology and Thermochronology

- **Dr. Cody Colleps**
- Assistant Professor
- Department of Geoscience
- Email: cody.colleps@unlv.edu
- Website: www.CoCoGeo.com

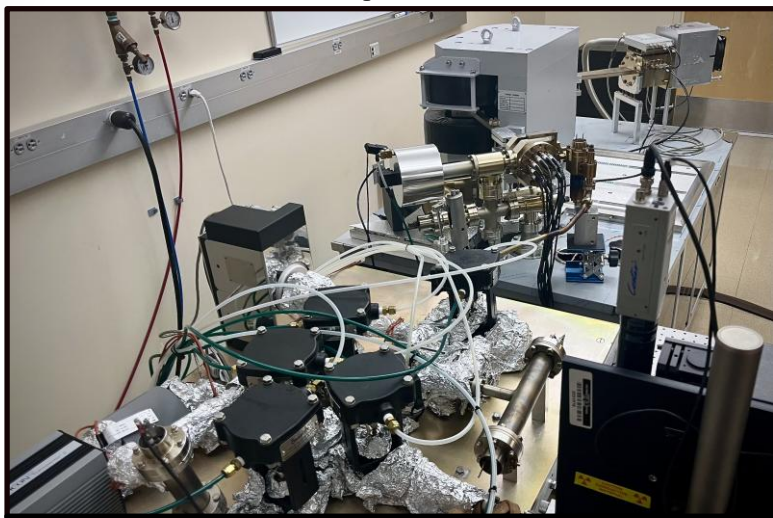
Expertise

- Noble gas-based thermochronology
- Geochronology
- Tectonic and climatic interactions
- Deep-time erosional processes
- Himalayan geology
- Irradiation of geological materials

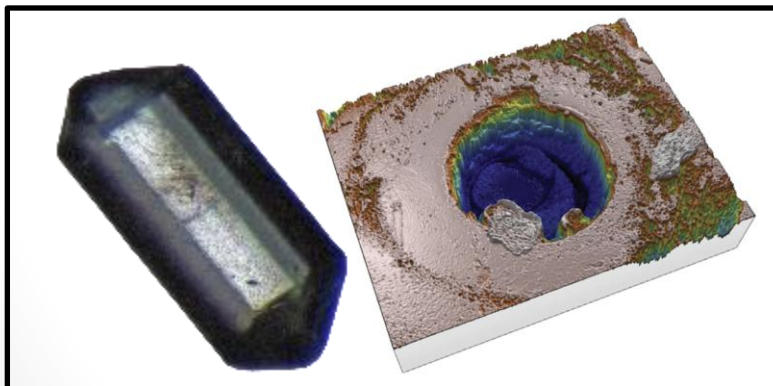


What drives crustal exhumation, and how do distinct erosional events impact Earth's dynamic systems?

Nevada Isotope Geochronology Laboratory (NIGL)



Isotopx NGX-600 Mass Spectrometer for $^{40}\text{Ar}/^{39}\text{Ar}$ Dating



Laser Ablation (U-Th)/He Dating of Apatite and Zircon

We develop and apply novel analytical dating techniques to obtain high-resolution insight into crustal exhumation across multiple temporal and spatial scales.

Greater Himalaya of Northwest India



Electronic and Magnetic Properties at High Pressure

Dr. Andrew Cornelius

Department of Physics & Astronomy

Phone (702) 895-1727

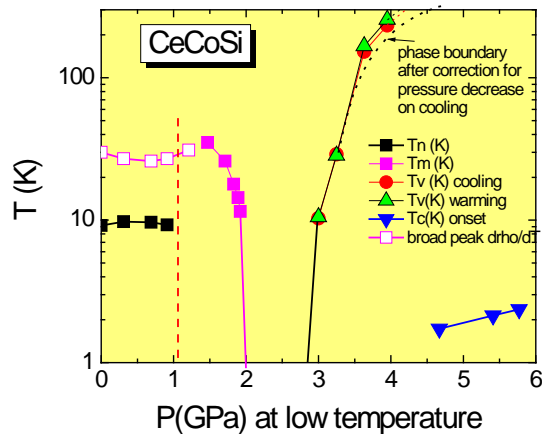
Expertise:

- Experimental high pressure measurements
- Magnetism
- Superconductivity

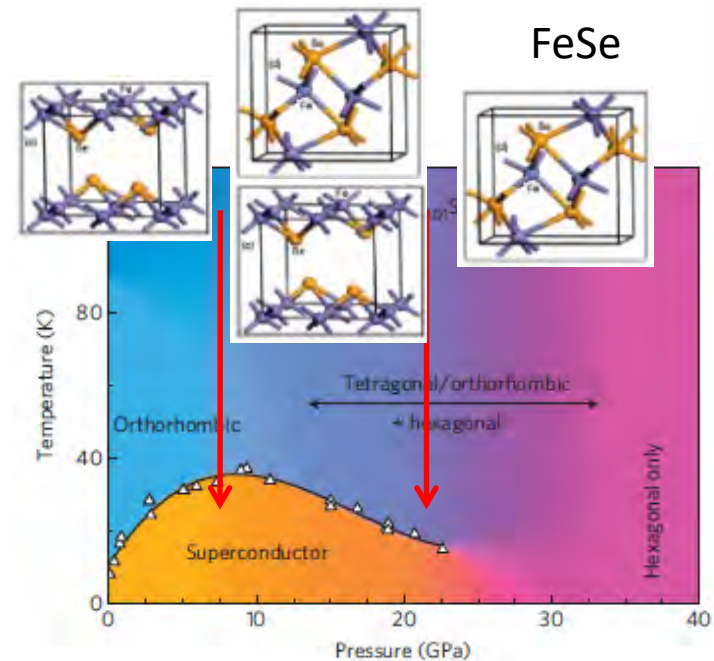
Superconductivity

Quantum Design PPMS at UNLV

- Measurements from 0.3 K to 400 K
 - Heat capacity, electric and thermal transport, and AC/DC magnetization
- Pressure cells to measure electrical properties (clamp to 3 GPa and diamond anvil cell to >100 GPa)



Addition of high pressure synchrotron experiments (diffraction and X-ray absorption) allows mapping of complex superconducting phase diagrams



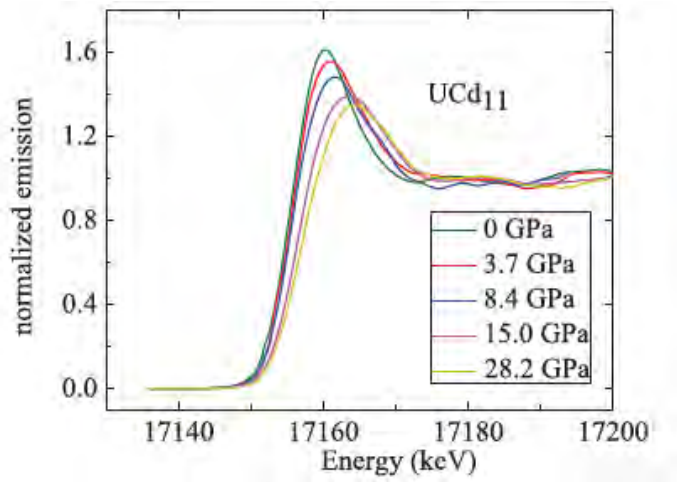
Correlated-Electron Systems

Modified periodic table

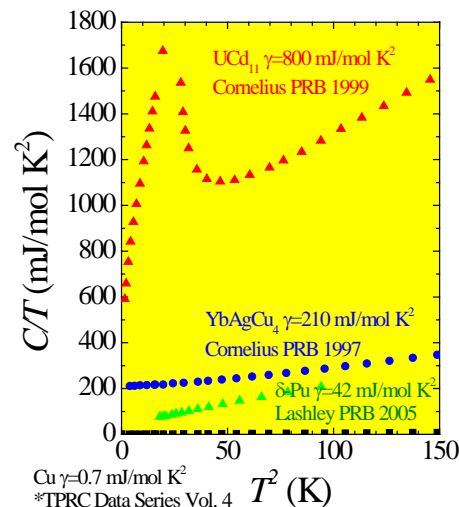
Empty Shell	Partially Filled Shell														Full Shell		
4f	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
5f	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		
3d	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn						
4d	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd						
5d	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg						

↑ Increasing Localization

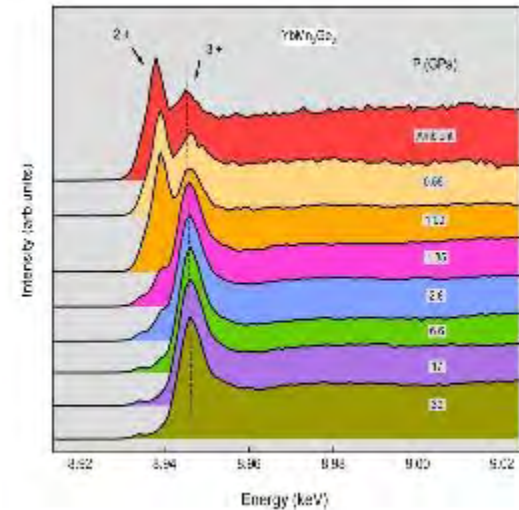
- Going from localized to delocalized electrons one often finds strong electron-electron correlations
- Correlated electron systems can yield interesting behavior: fluctuating valence, superconductivity, non-Fermi liquid, heavy fermion and many more



f-electron delocalization
X-ray absorption



Heavy fermions
Heat Capacity



Fluctuating valence
X-ray fluorescence

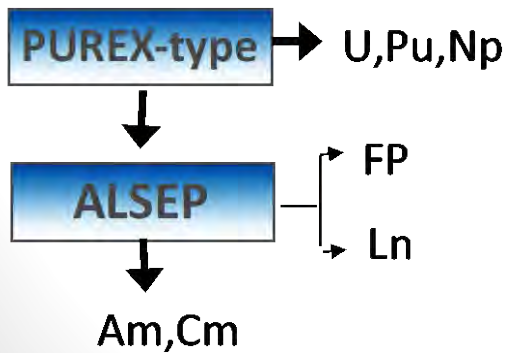
Art Gelis

Director, Radiochemistry Program

Actinide Separations and Recovery

Design and Testing of Advanced Separation Processes using Additive Manufacturing

- Liquid-Liquid Extraction and Separation of Plutonium, Uranium, Minor Actinides, Lanthanides and Fission Products
- Twenty-seven 3D-printed acrylic centrifugal contactors (CC), fabricated at Argonne National Lab are available at UNLV
- Contactors can be 3D-printed in stainless steel or any alloy
- Solvent extraction separations can be tailored to a specific goal
- Example: **Actinide Lanthanide SEP**aration process - **ALSEP**, designed and tested for DOE-NE



10+1 acrylic CC

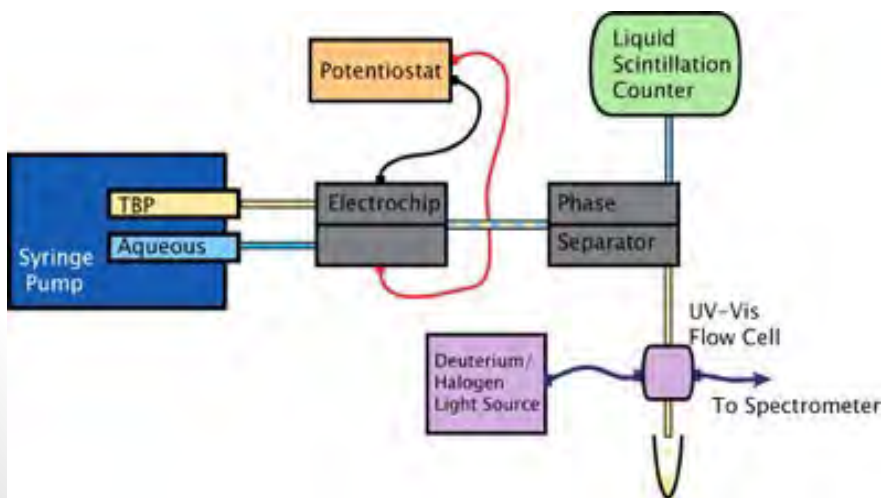
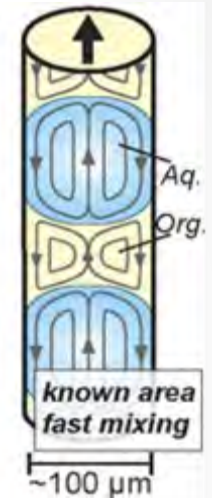


Steel CC



Microfluidic Systems for Rapid Radionuclide Separation and Detection

- Microfluidic device to combine aqueous and organic phases, rapidly mix, then separate phases, following by analysis
- Selective Extraction of radionuclides on a very small scale
- Can be implemented either as a bench-top setup or as a portable detector
- Potential applications: rapid Pu separation and detection from Uranium and FP for safeguards; "dirty bomb" analysis

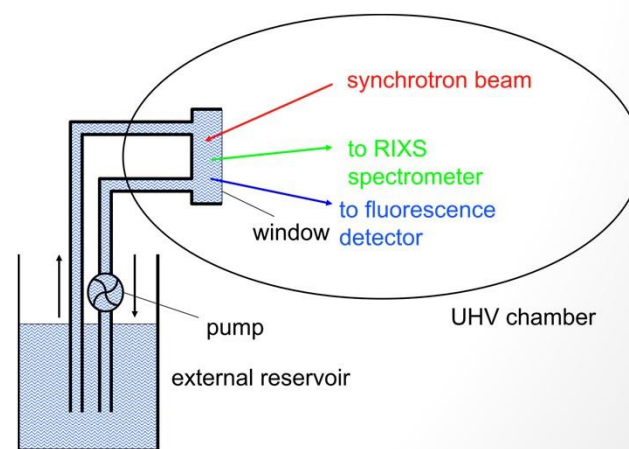
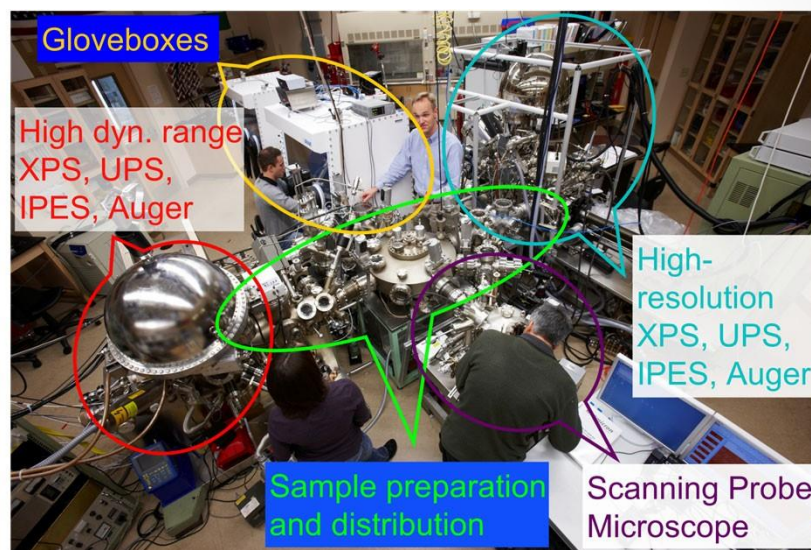


Surface and Interface Characterization of Materials for Energy Conversion

- **Dr. Clemens Heske**
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- Department of Chemistry and Biochemistry
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- Website: <https://heske.faculty.unlv.edu//>

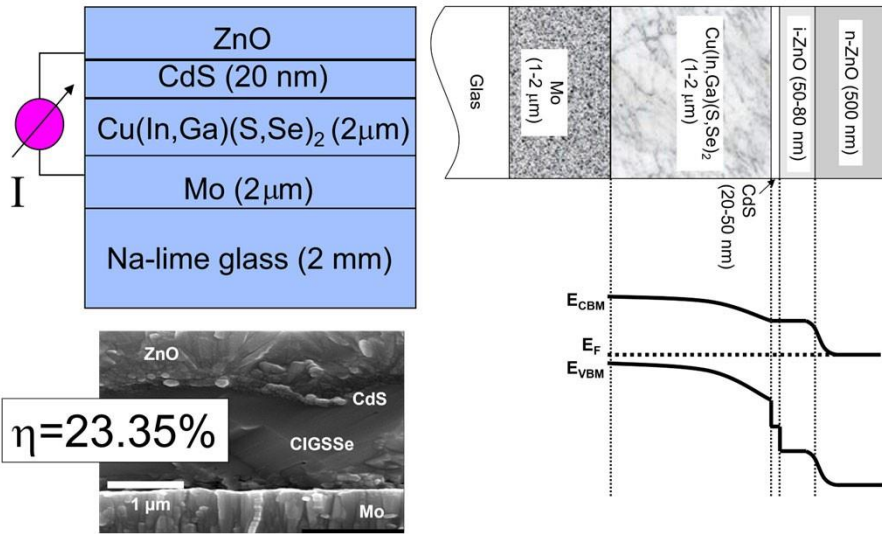
Expertise

- Electronic and Chemical Structure of Energy-Conversion Materials
- Surface and Interface Characterization
- Soft x-ray and Electron Spectroscopy
- Scanning Probe Microscopy
- Synchrotron Radiation

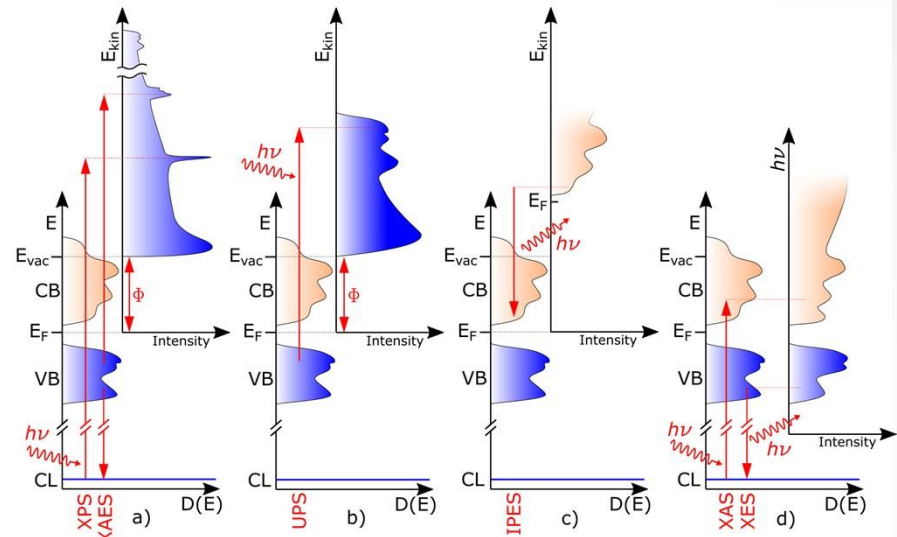


Surface and Interface Characterization of Materials for Energy Conversion

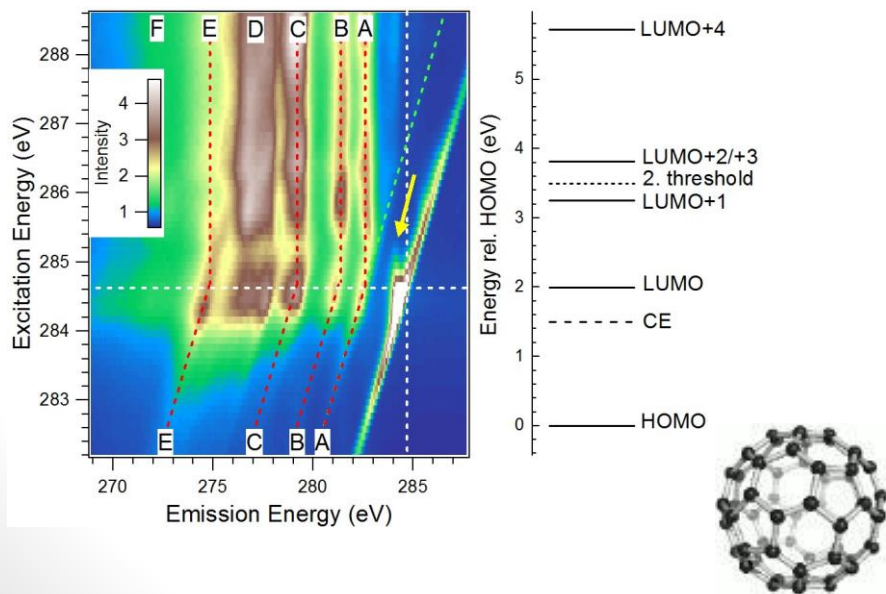
Cu(In,Ga)(S,Se)₂ Thin-Film PV Device



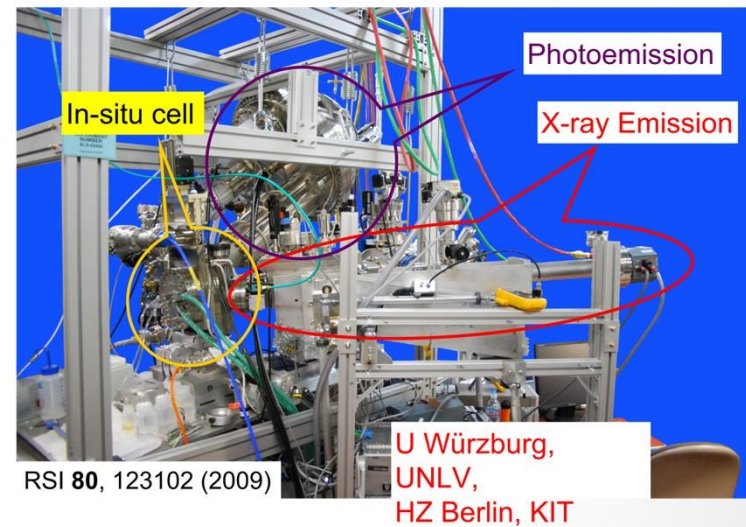
Method development



Electronic structure of C₆₀



SALSA: Solid And Liquid Spectroscopic Analysis



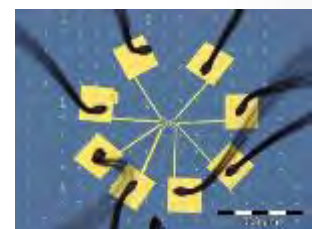
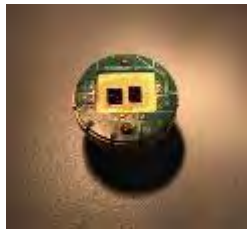
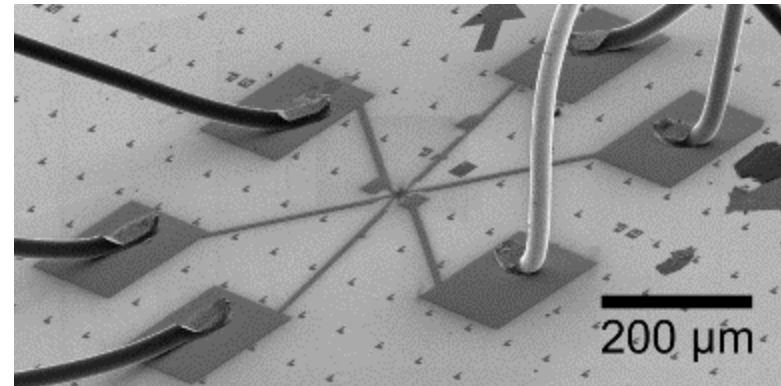
Island – Quantum computing, quantum sensing



The Nanoscale Physics Group @ UNLV

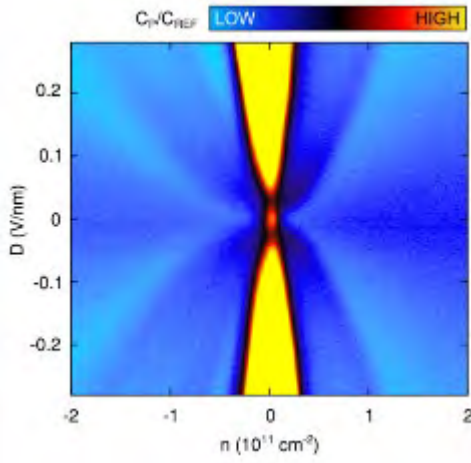
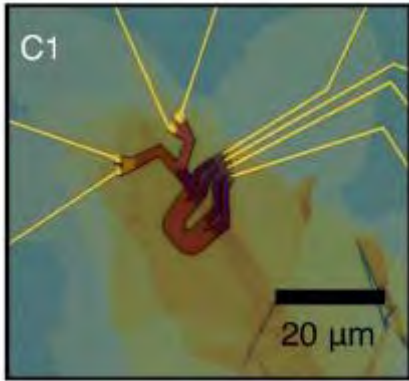
Areas of Research

- Nanotechnology, device physics
- Photodetection and quantum sensing
- Quantum computing, topological qubits
- Non-equilibrium, driven systems
- Superconductivity, proximity effects
- Low dimensional materials



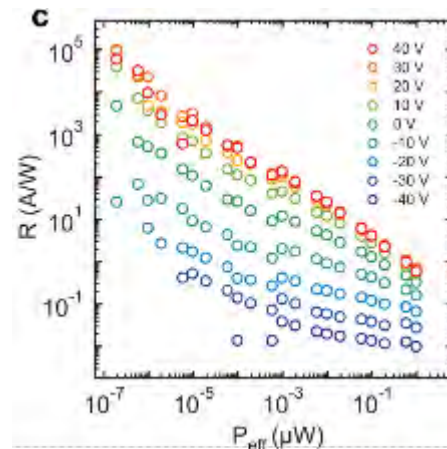
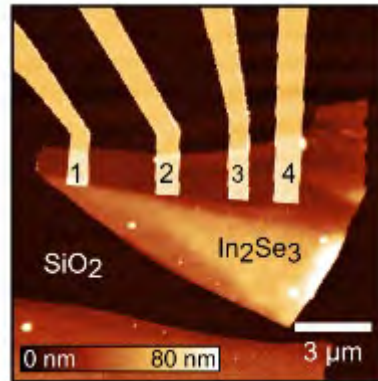
Island – Quantum computing, quantum sensing

Quantum computing:
Topological phases for fault-tolerant, universal quantum computing.



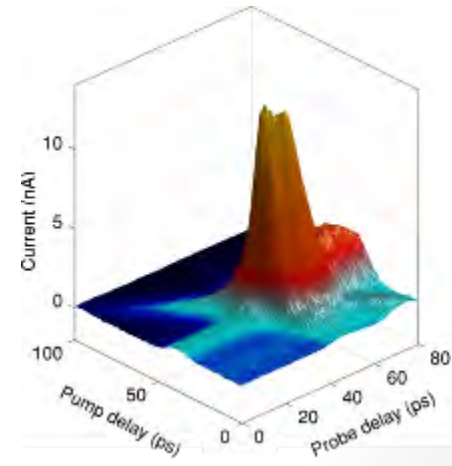
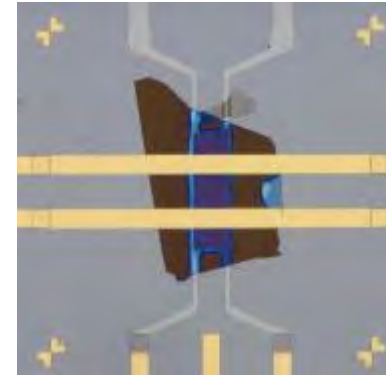
Island, J. O., et al. *Nature* **571** (2019): 85–89.

Industry-disruptive photodetectors: Ultra-sensitive phototransistors designed with 2D materials and heterostructures.



Island, J. O., et al. *Nano Letters* **15** (2015): 7853-7858.

Transient phases of driven systems: Non-equilibrium response of pumped nanomaterials below the diffraction limit.



Island – Quantum computing, quantum sensing

Journal publications:

Spin-orbit-driven band inversion in bilayer graphene by van der Waals proximity effect

J.O. Island, X. Cui, C. Lewandowski, J.Y. Khoo, E.M. Spanton, H. Zhou, D. Rhodes, J.C. Hone, T. Taniguchi, K. Watanabe, L.S. Levitov, M.P. Zaletel, A.F. Young, *Nature*, **571**, 85-89 (2019). (arXiv)

Enhanced superconductivity in atomically thin TaS₂

E. Navano-Moiatalla*, J.O. Island*, S. Manas-Valero, E. Pinilla-Cienfuegos, A. Castellanos-Gomez, J. Queieda, G. Rubio-Bollinger, L. Chirulli, J.A. Silva-Guilin, N. Agrat, G.A. Steele, F. Guinea, H.S.J. van der Zant, E. Coronado, *Nature Communications*, **15**, 7853 (2016). (arXiv)

Proximity-induced Shiba states in a molecular junction

J. O. Island, R. Gaudenzi, J. de Bruijckere, E. Burzuri, C. Franco, M. Mas-Torrent, C. Rovira, J. Veciana, T. M. Klapwijk, R. Aguado, H.S.J. van der Zant, *Physical Review Letters*, **118**, 117001 (2017). (arXiv)

TiS₃ transistors with tailored morphology and electrical properties

J.O. Island, M. Barawi, R. Biele, A. Almazan, J.M. Clamagirand, J.R. Ares, C. Sanchez, H.S.J. van der Zant, J.V. Alvarez, R. D'Agosta, I.J. Ferrer, A. Castellanos-Gomez, *Advanced Materials*, **27**, 2595 (2015). (arXiv)

Environmental instability of few-layer black phosphorus

J.O. Island, G.A. Steele, H.S.J. van der Zant, and A. Castellanos-Gomez, *2D Materials*, **2**, 011002 (2015). (arXiv)

Ultrahigh photoresponse of few-layer TiS₃ nanoribbon transistors

J.O. Island, M. Buscema, M. Barawi, J.M. Clamagirand, J.R. Ares, C. Sanchez, I.J. Ferrer, G.A. Steele, H.S. J van der Zant, and A. Castellanos-Gomez, *Advanced Optical Materials*, **2**, 641 (2014). (arXiv)

Gate controlled photocurrent generation mechanisms in high-gain In₂Se₃ phototransistors

J.O. Island*, S.I. Blanter*, M. Buscema, H.S.J. van der Zant, and A. Castellanos-Gomez, *Nano Letters*, **15**, 7853(2015). (arXiv)

Precise and reversible band gap tuning In single-layer MoSe₂ by uniaxial strain

J.O. Island, A. Kuc, E.U. Diependaal, H.S.J. van der Zant, T. Heine, and A. Castellanos-Gomez, *Nanoscale*, **8**, 2589 (2016). (arXiv)

Ubiquitin-mediated protein degradation

Dr. Gary Kleiger

Professor and department Chair

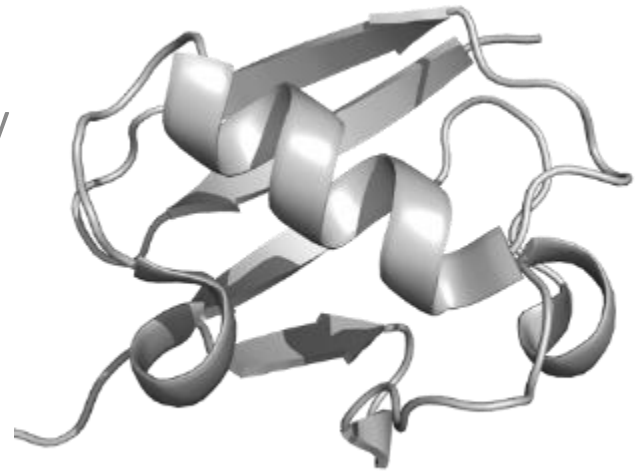
Department of Chemistry and Biochemistry

gary.kleiger@unlv.edu

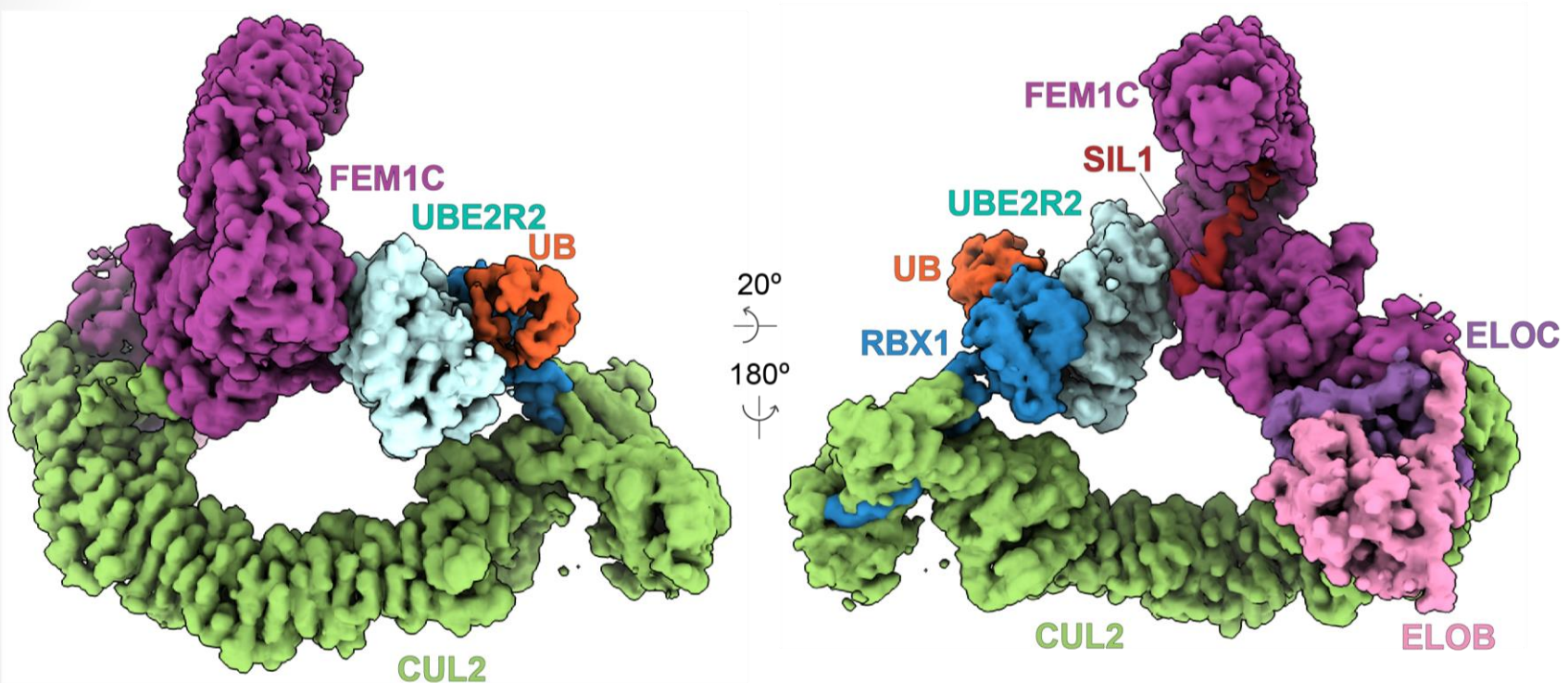
<https://kleiger.faculty.unlv.edu>

Expertise

- Structural biology
- Proteomics
- Enzyme kinetics and biophysical assays
- Cell biology

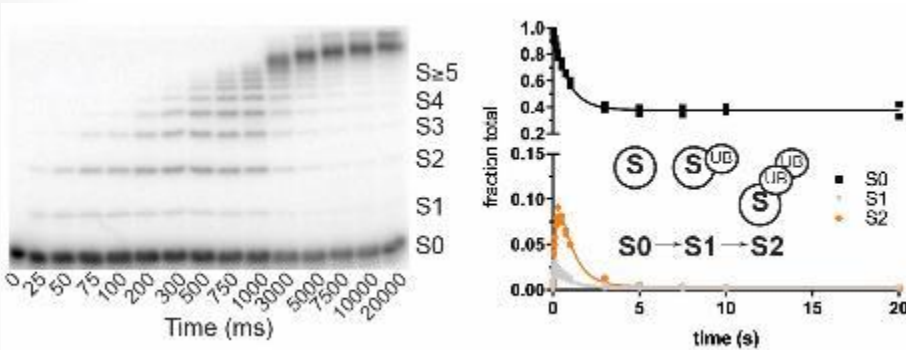


Determining the structures of enzymes that promote protein degradation by cryo-EM.

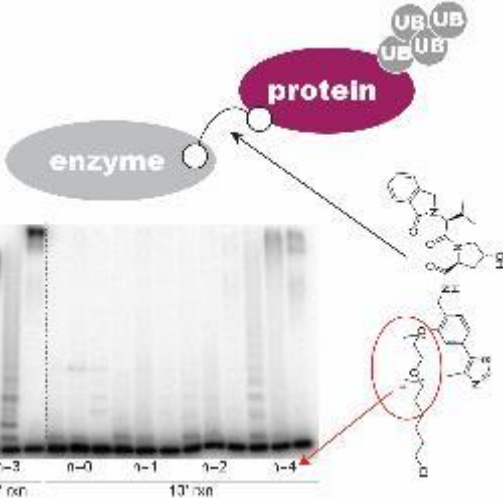
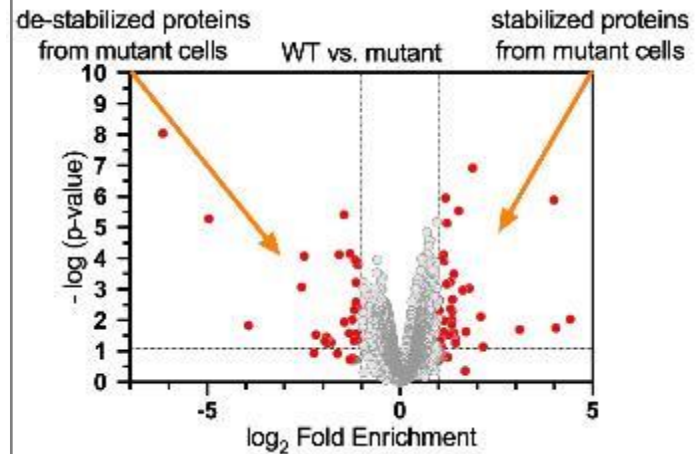


Uncovering how the enzymes that promote protein degradation function in human cells.

Kinetics help us understand how enzymes select protein targets for modification with ubiquitin.



High-resolution mass-spectrometry tells us how mutations in enzymes that lead to human disease affect the stabilities of key human cellular proteins.



Small molecule inducers of protein degradation can be used to treat human disease. We study the mechanism of how they function both in test tubes and cells.

Novel chemistry and biology using highly ionizing radiation

Michael Pravica, Ph.D.

Professor of Physics

Department of Physics and Astronomy

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Expertise:

Useful Hard X-ray photochemistry

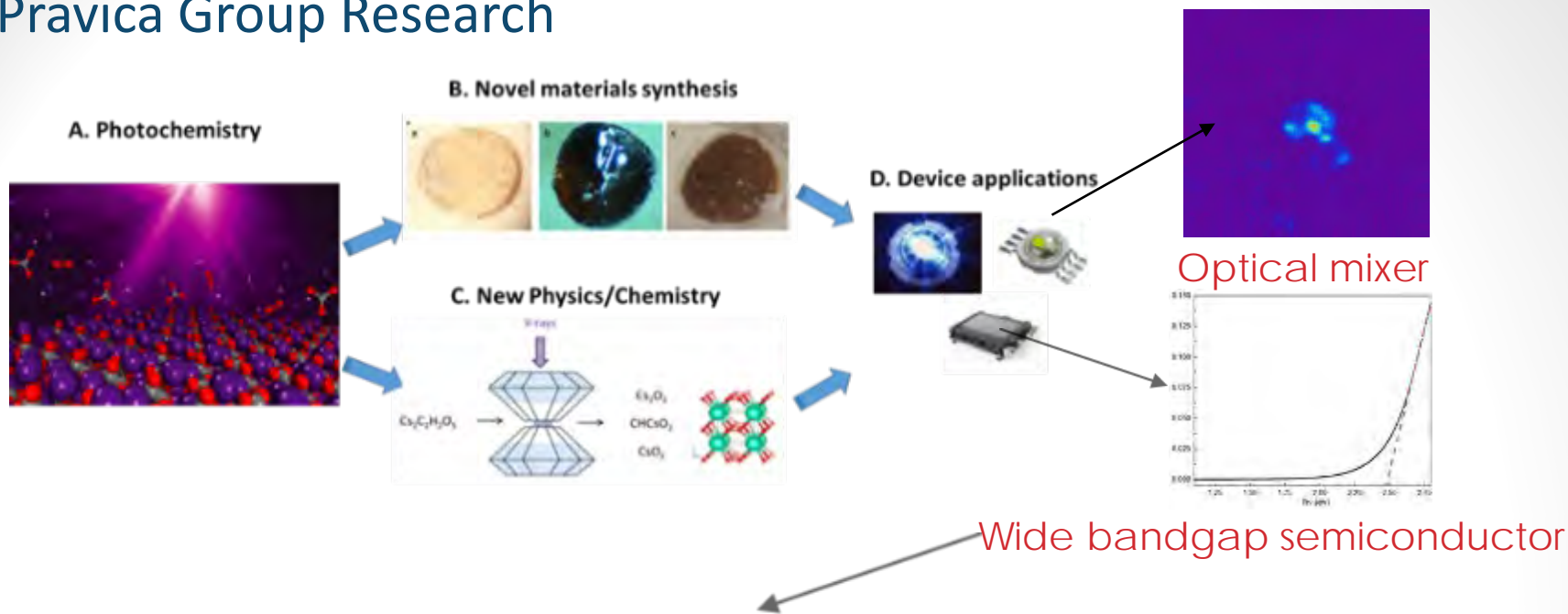
High pressure

Spectroscopy

Ion Beam Nuclear Transmutation Doping

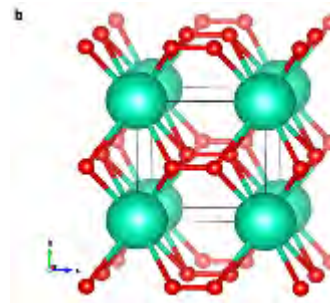
High quality synthesis of vaccines using tuned hard x-rays

Pravica Group Research



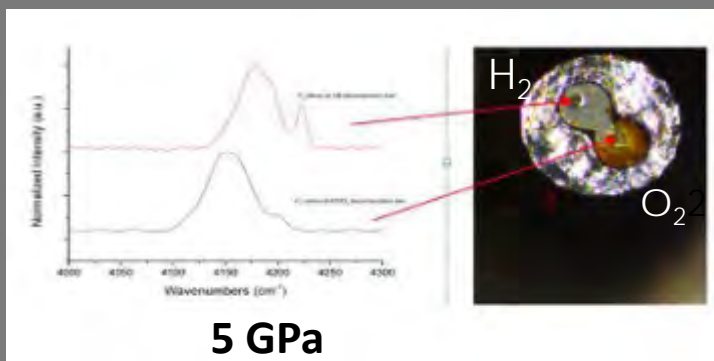
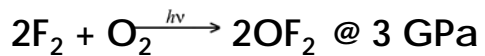
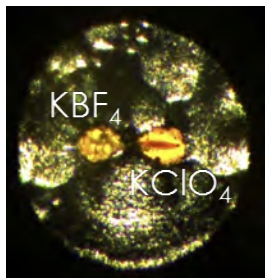
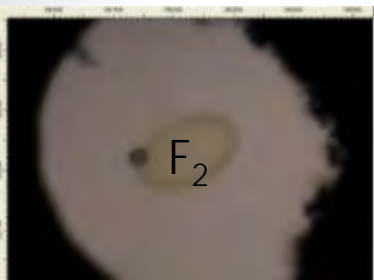
Radiation-hardened sensors/direct energy conversion devices for EXTREME CONDITIONS or tuned solar materials

Useful hard x-ray photochemistry



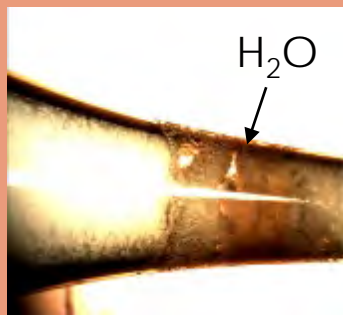
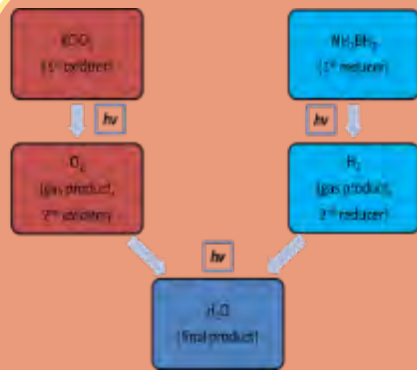
Novel structures of known materials produced With hard x-rays and high pressure (e.g. CsO₂)

High Pressure Fluorine Chemistry



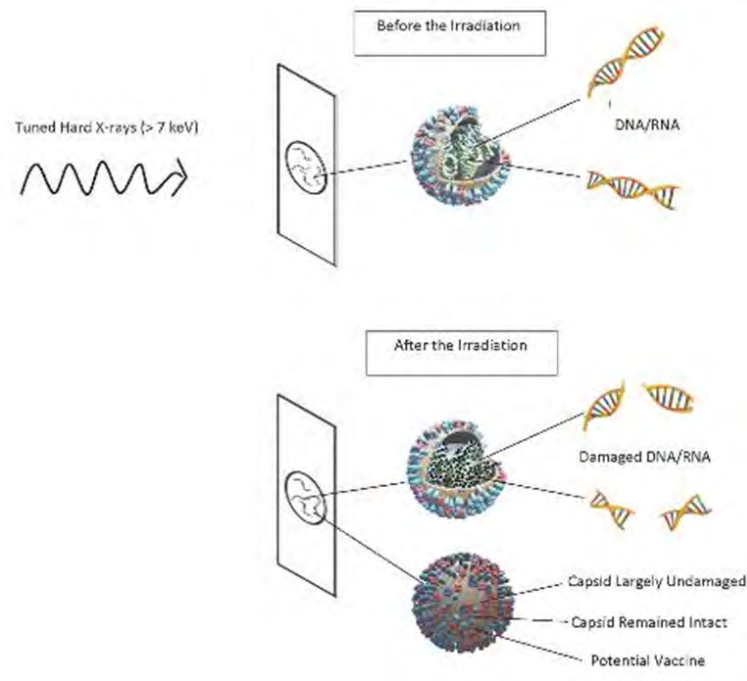
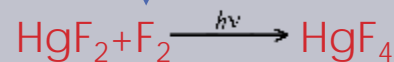
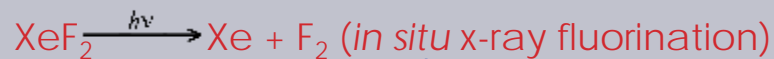
5 GPa

Molecular mixtures at high pressure



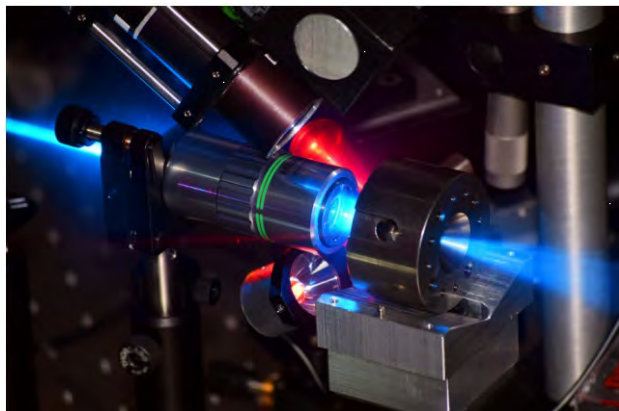
X-ray induced combustion

Inner shell chemistry at high pressure

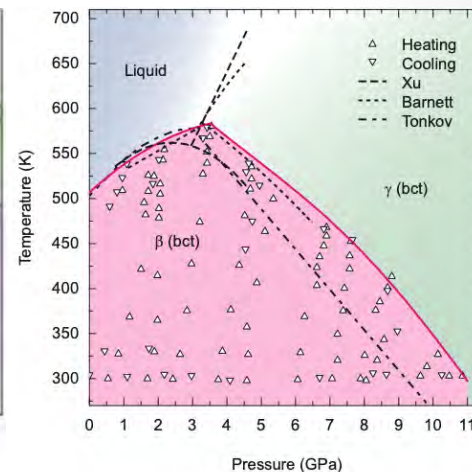
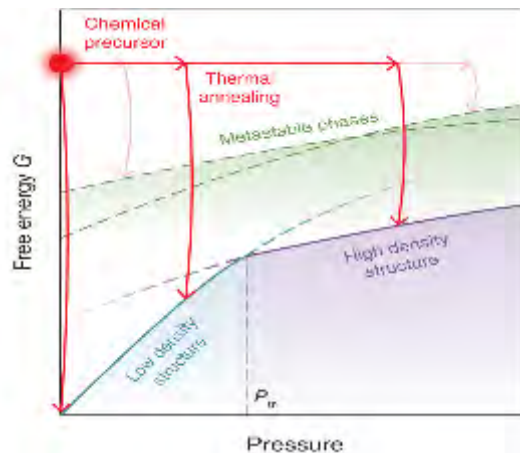


Using tuned hard x-rays to damage viruses to create high quality vaccines by targeting specific molecular groups/bonds that resonantly absorb x-ray energy leading to decomposition chemistry.

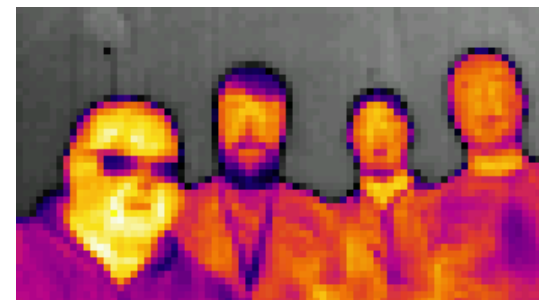
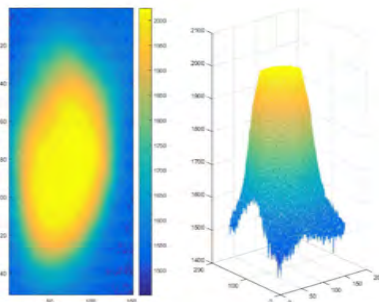
Salamat Group – Collaboration with MSTS



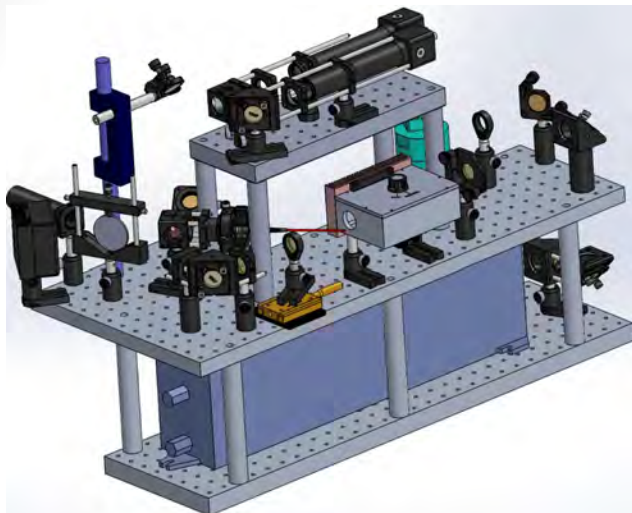
Metrology – accurate mapping of P, V, T



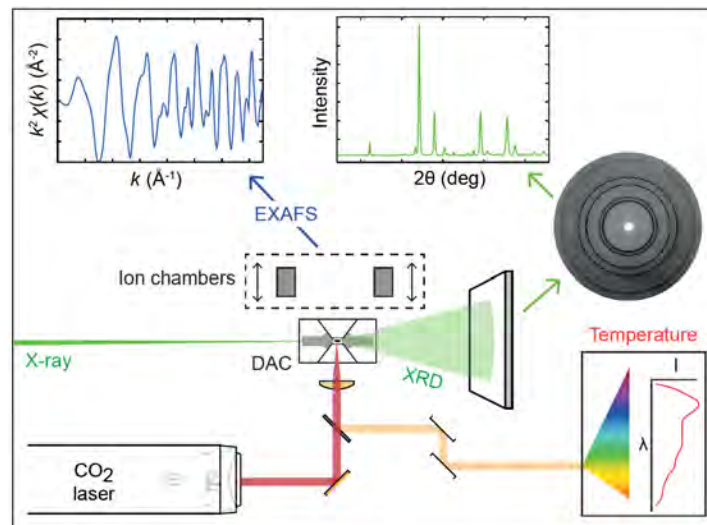
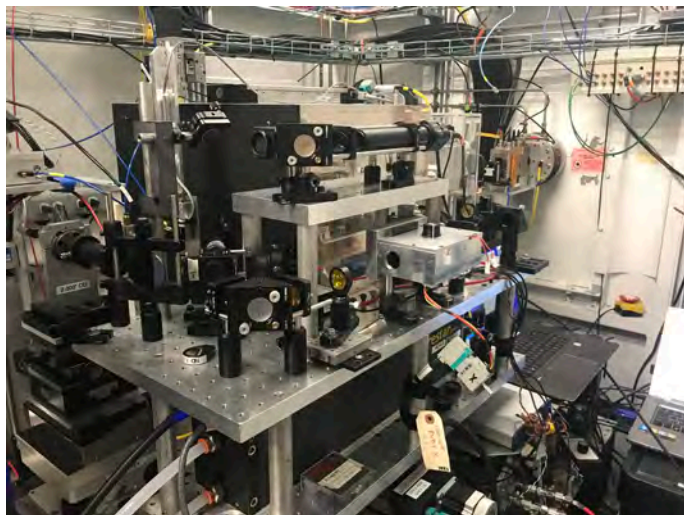
High temperature modelling – understanding emissivity under extreme conditions



Warm dense matter – probed using EXAFS



- Development of a CO₂ laser heating
- Direct heating of non-metallic systems in a DAC
- First HTHP EXAFS measurements of insulators
- In situ and post heating measurements
- Determining absolute temperature from X-ray spectroscopy



Publications

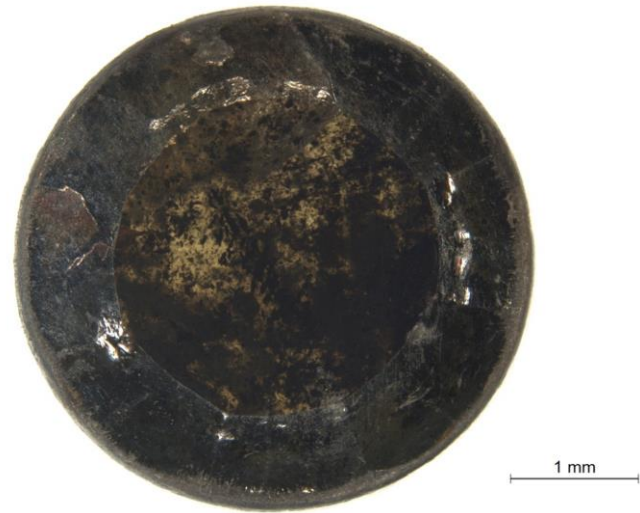
- (1) D. Smith, D. Sneed, N. Dasenbrock-Gammon, E. Snider, G. A. Smith, C. Childs, J. S. Pigott, N. Velisavljevic, C. Park, K. V. Lawler, R. P Dias, A. Salamat*, Anomalous Conductivity in the Rutile Structure Driven by Local Disorder [The Journal of Physical Chemistry Letters 10 18 5351-5356 \(2019\)](#)
- (2) J. Kearney M. Grauzinyte D. Smith A. Gulans D. Sneed C. Childs, J. Hinton C. Park J. S. Smith, E. Kim, S. D. S. Fitch, A. L. Hector, C. J. Pickard J. A. Flores-Livas, A. Salamat*, Pressure tuneable visible range band gap in the ionic spinel tin nitride [Angewandte Chemie International Edition, 57, 11623-11628 \(2018\)](#)
- (3) C. Childs, K. V. Lawler, A. L. Hector, S. Petitgirard, O. Noked, J. S. Smith, D. Daisenberger, L. Bezacier, M. Jura, C. J Pickard, A. Salamat*, Covalency is Frustrating: $\text{La}_2\text{Sn}_2\text{O}_7$ and the Nature of Bonding in Pyrochlores under High Pressure Temperature Conditions [Inorganic chemistry, 57, 15051-15061, \(2018\)](#)
- (4) D. Smith, K. V. Lawler, M. Martinez-Canales, A. W. Daykin, Z. Fussell, G. A. Smith, C. Childs, J. S. Smith, C. J. Pickard, and A. Salamat*, Postaragonite phases of CaCO_3 at lower mantle pressures [Physical Review M 2, 013605 \(2018\)](#)
- (5) D. Smith, J. S. Smith, C. Childs, E. Rod, R. Hrubciak, G. Shen, A. Salamat*, A CO_2 laser heating system for in situ high pressure-temperature experiments at HPCAT [Review of Scientific Instruments 89, 083901 \(2018\)](#)
- (6) R. Briggs, D. Daisenberger, O. T. Lord, A. Salamat, E. Bailey, M. J. Walter, P. F. McMillan*, High-pressure melting behavior of tin up to 105 GPa [Physical Review B 95, 054102 \(2017\)](#)
- (7) M. Zaghoo, A. Salamat, I. F. Silvera*, A first order phase transition to metallic hydrogen. [Physical Review B 93, 155128 \(2016\)](#)
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Research Oliver Tschauner

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Expertise

- Crystallography.
- Mineralogy.
- Physics and Chemistry at high pressure.
- Dynamic compression.



Natural diamond with CO₂ inclusions
at a pressure of 20000
atmospheres

Selected Publications

- ♦ Discovery of davemaoite, CaSiO_3 -perovskite as a mineral from the lower mantle. O. Tschauner, S. Huang, S. Yang, M. Humayun, W. Liu, S. N. Gilbert Corder, H. A. Bechtel, J. Tischler, G. R. Rossman, **Science** 374, 891-894 (2021).
- ♦ Ice-VII inclusions in diamonds – evidence for aqueous fluid in the Earth’s deep mantle O. Tschauner, S. Huang, E. Greenberg, V.B. Prakapenka, C. Ma, G. R. Rossman, A.H. Shen, M. Newville, A. Lanzirotti, K. Tait, **Science** 359, Issue: 6380, 1136 (2018) 10.1126/science.aao3030.
- ♦ Discovery of Bridgmanite – the most abundant mineral in Earth, in a shocked meteorite, O. Tschauner, C. Ma, J. Beckett, C. Prescher, V. Prakapenka, G. Rossman, **Science** 346, 1100 (2014), DOI: 10.1126/science.1259369
- ♦ Is merrillite shock-transformed whitlockite? Implications for the water budget of Mars, C. Adcock, O. Tschauner, E. Hausrath, A. Udry, Y. Cai, S.N. Luo, **Nature Communications** 8, Article Number: 14667 (2017).
- ♦ Tissintite ($\text{Ca, Na, } \square$) AlSi_2O_6 , a Highly Defective, Shock-Induced, High-Pressure Pyroxene in the Tissint Martian Meteorite. Chi Ma, Oliver Tschauner, John Beckett, Yang Liu, George Rossman, Kirill Zuravlev, Vasili Prakapenka, Przemyslaw Dera and Lawrence A. Taylor, **Earth Planet. Sci. Lett.** 422, 194-205 (2015).
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- ♦ Tschauner, O., Ma, C. (2023). Discovering High-Pressure and High-Temperature Minerals. In: Bindi, L., Cruciani, G. (eds) **Celebrating the International Year of Mineralogy. Springer Mineralogy.** Springer, Cham. https://doi.org/10.1007/978-3-031-28805-0_8

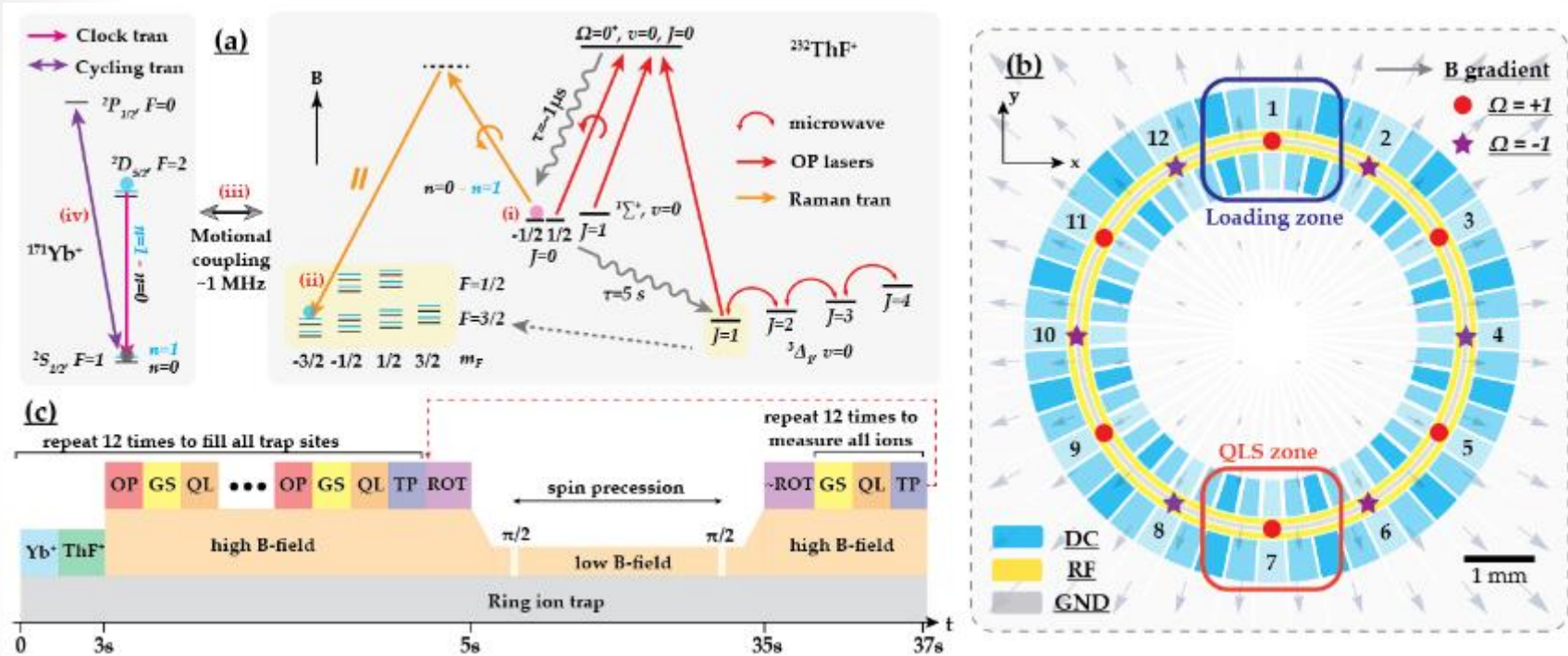
Zhou Lab – Experimental AMO physics

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Research projects

- Explore new physics beyond the Standard Model by precision measurements using quantum logically controlled molecular ions
- Precision metrology and spectroscopy using optical frequency combs
- Quantum transducer – link ion trap and superconducting quantum computers
- Experimental astrochemistry – cold ion-radical collisions

Search for T, P -odd symmetry violation



- On-chip Quantum sensors
- Entanglement between atomic ions and molecular ions
- Scalability and multiplexing measurements
- New table-top platform to investigate nuclear physics