Research Instrumentation

Interfacial Photochemistry

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

Expertise

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

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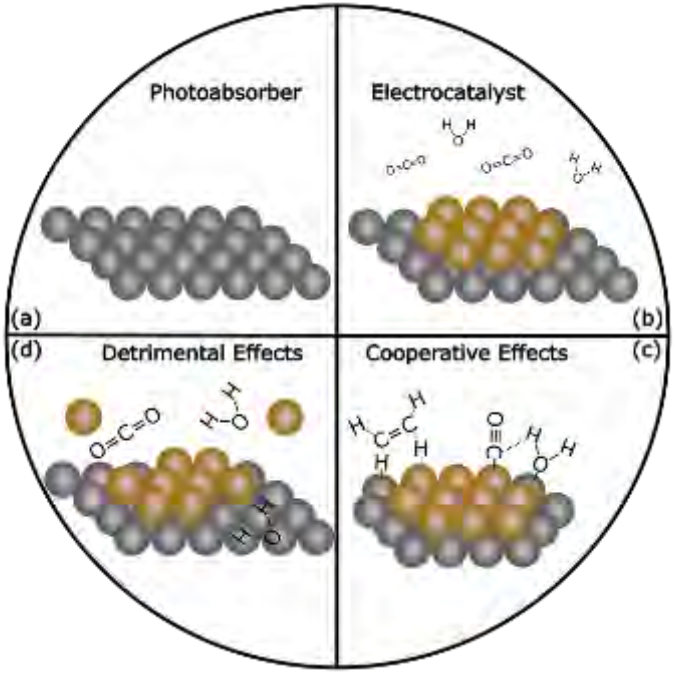
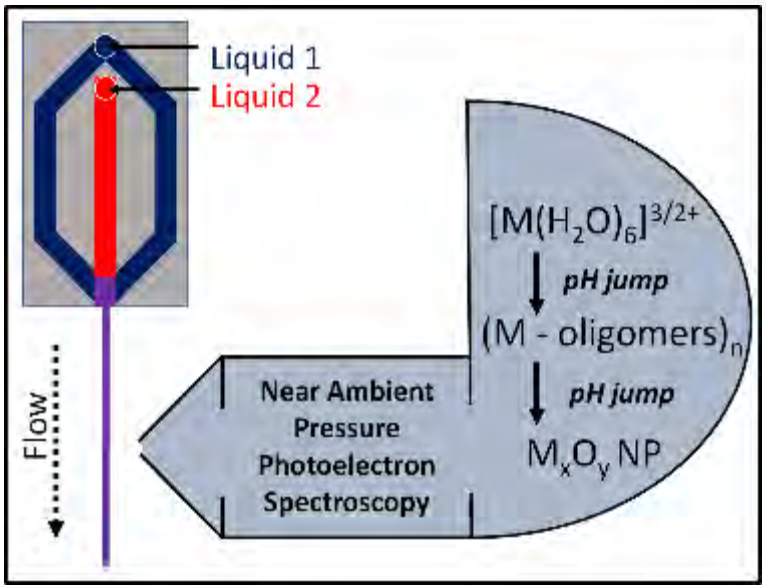
Hybrid Co-Catalyst/Photoabsorber Photochemical Interfaces



- 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 (20µm dia.) is used to investigate the liquid surface
- Microfluidic chips provide mixing chamber to induce chemical reactions

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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

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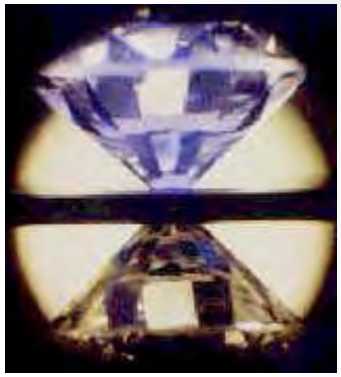
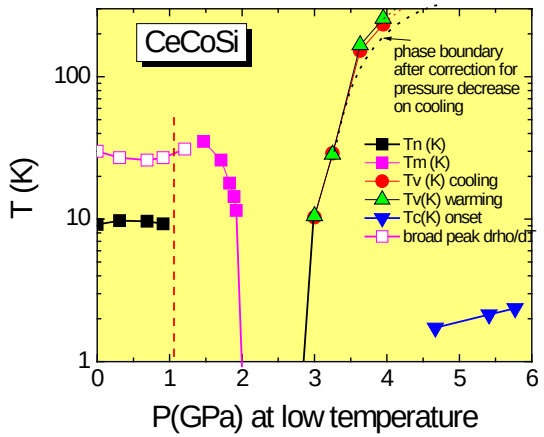
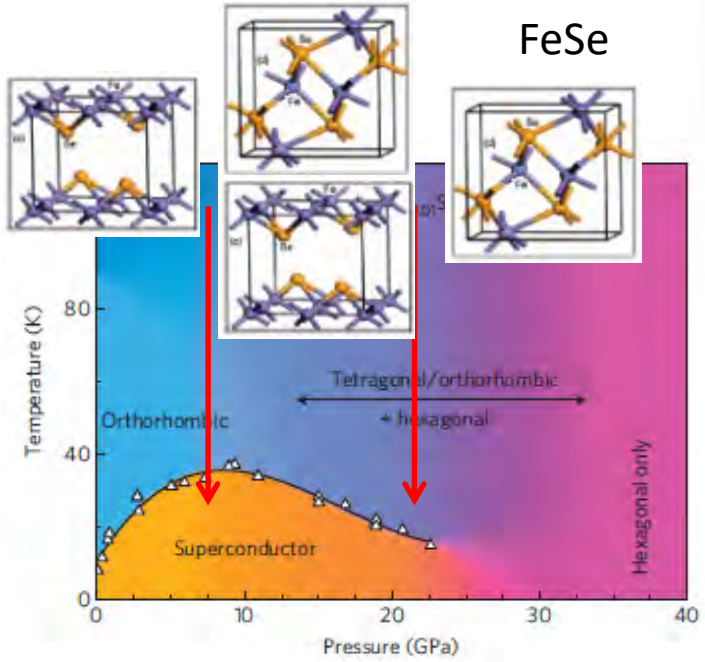
Superconductivity

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)

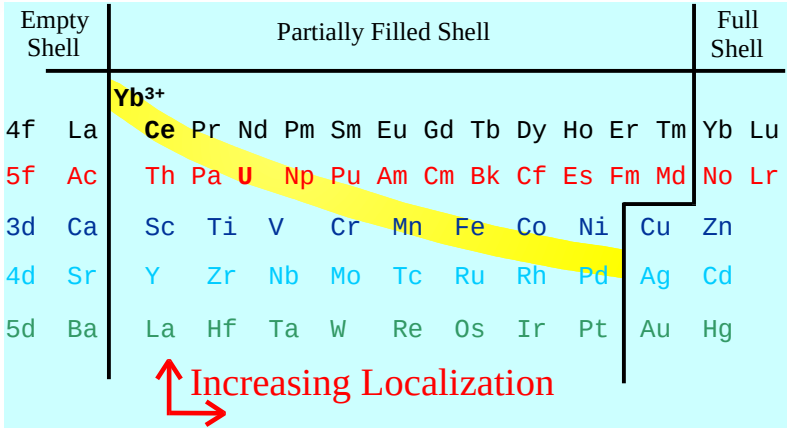






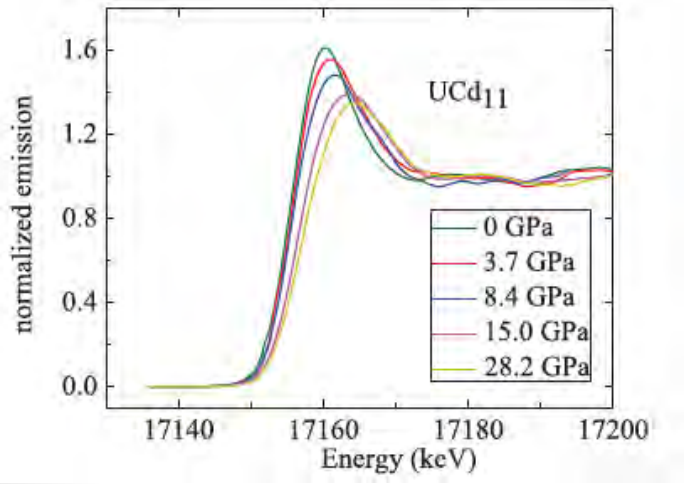
Addition of high pressure synchrotron experiments (diffraction and X-ray absorption) allows mapping of complex superconducting phase diagrams

Correlated-Electron Systems

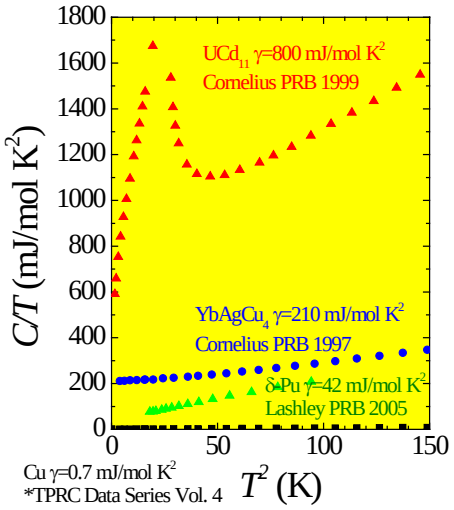


Modified periodic table

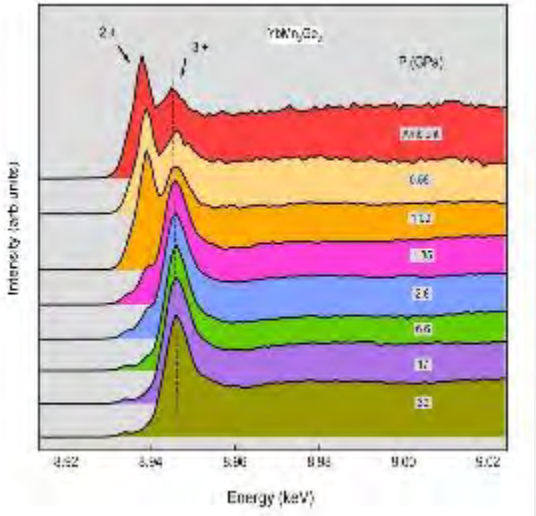
- Going from localized to delocalized electrons one often finds strong electron-electron correlations
- Correlated electron systems can yield interesting behavior: fluctuating valence, superconductivity, non-Fermi liquid, heavy fermion and many more



f-electron delocalization
X-ray absorption



Heavy fermions
Heat Capacity



Fluctuating valence
X-ray fluorescence

Art Gelis

Director, Radiochemistry Program

Actinide Separations and Recovery

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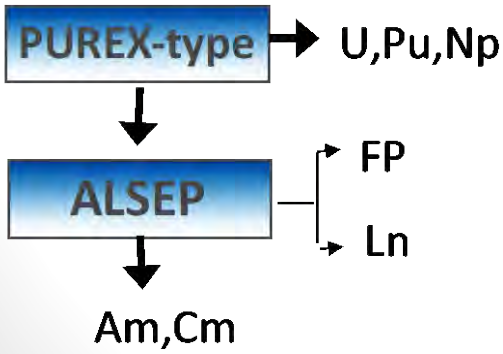
Design and Testing of Advanced Separation Processes using Additive Manufacturing

- **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 SEParation process - ALSEP, designed and tested for DOE-NE**

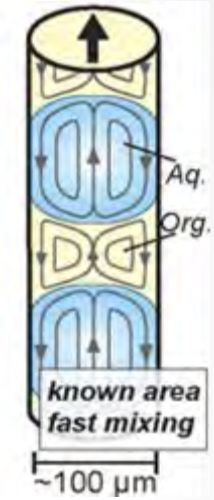


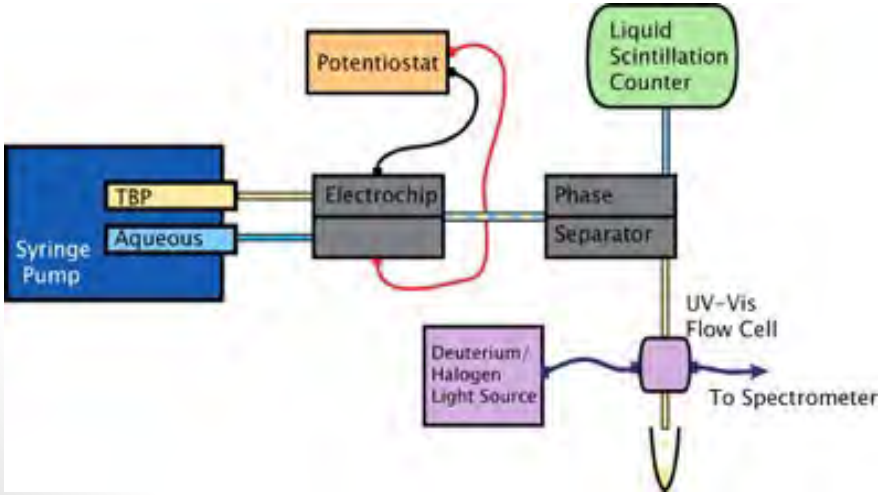
10+1 acrylic CC

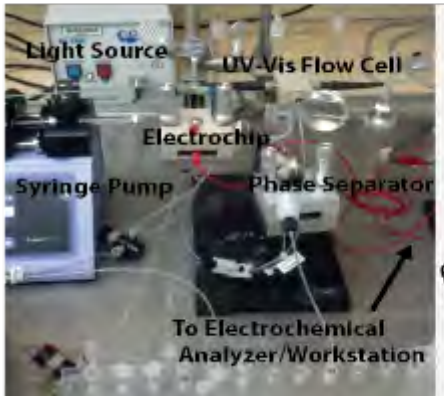
Steel CC

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**

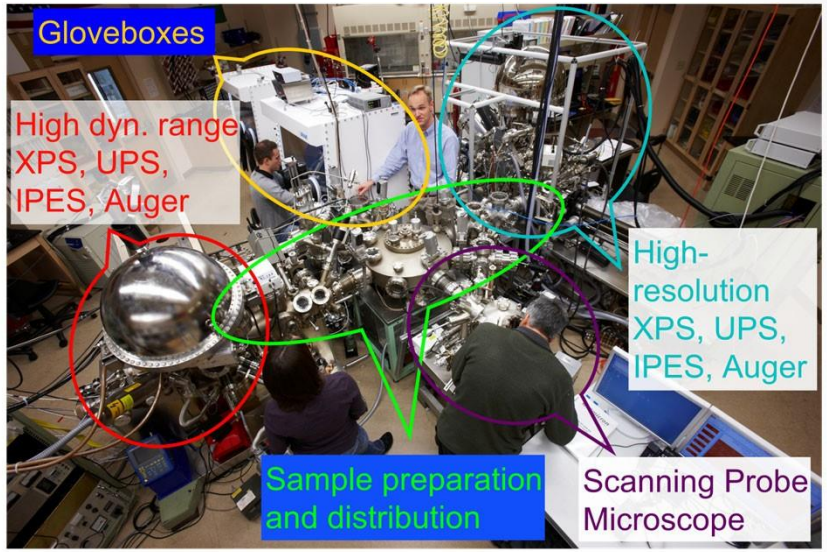






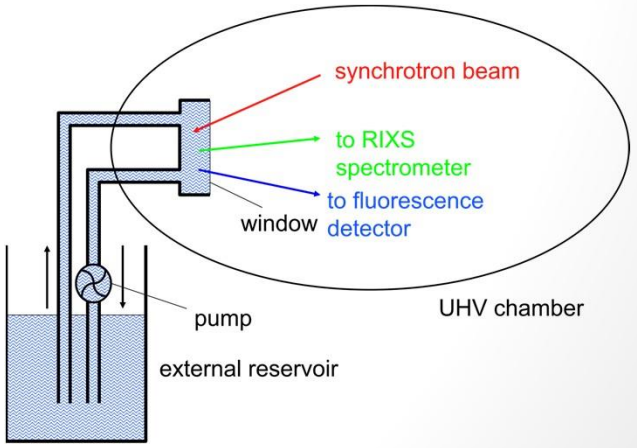
Surface and Interface Characterization of Materials for Energy Conversion

- **Dr. Clemens Heske**
- Professor
- Department of Chemistry and Biochemistry
- Email: heske@unlv.nevada.edu
- 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



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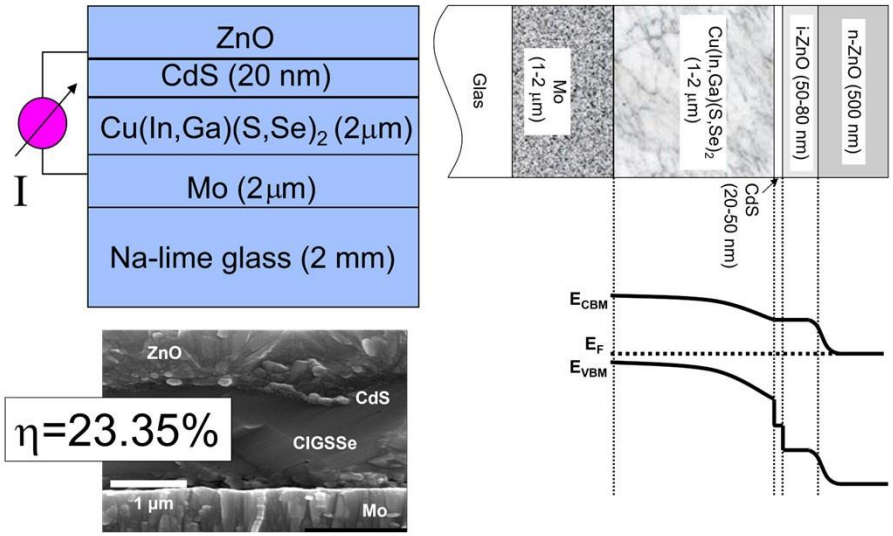
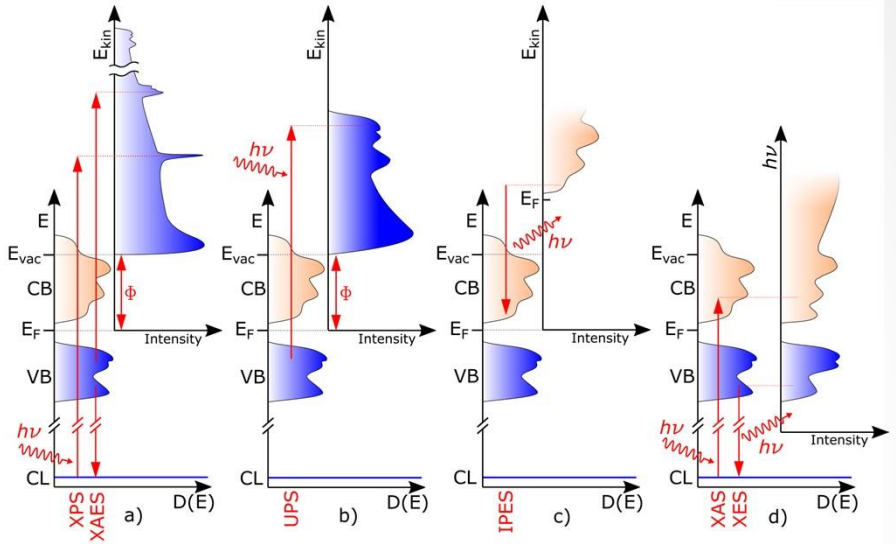
Surface and Interface Characterization of Materials for Energy Conversion

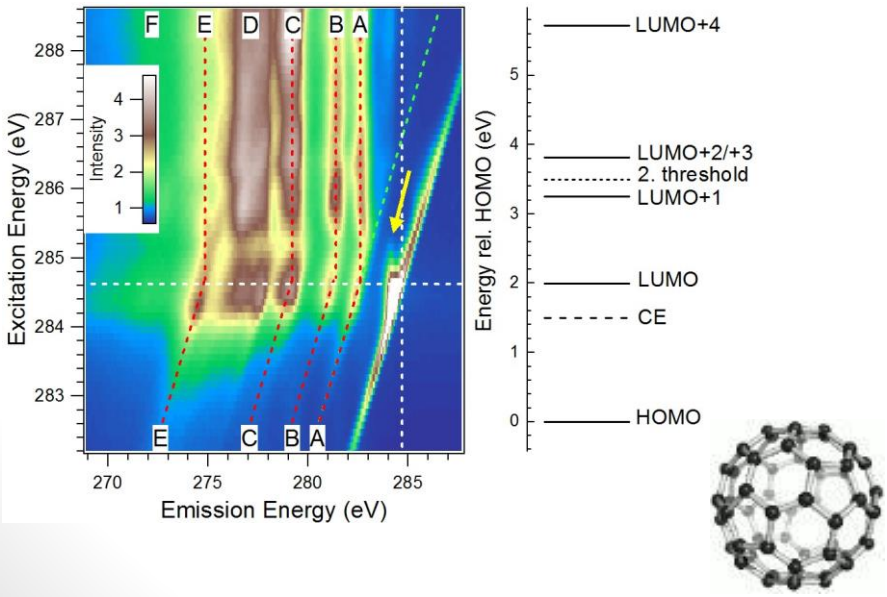
Cu(In,Ga)(S,Se)$_2$ Thin-Film PV Device



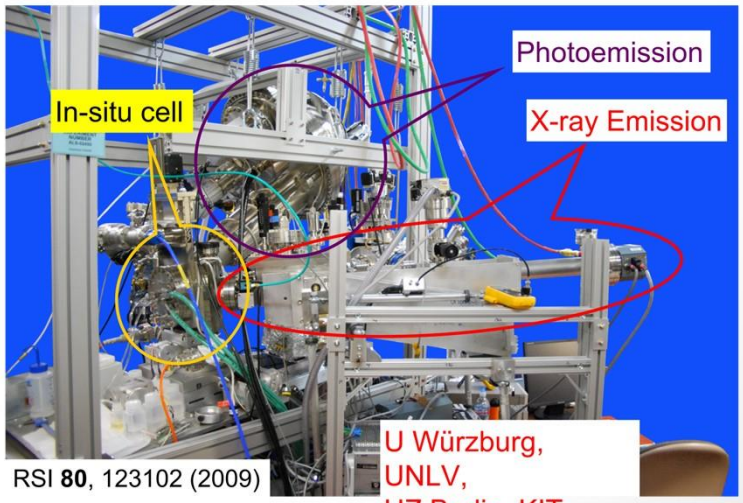
Method development



Electronic structure of C_{60}



SALSA: Solid And Liquid Spectroscopic Analysis



RSI **80**, 123102 (2009)

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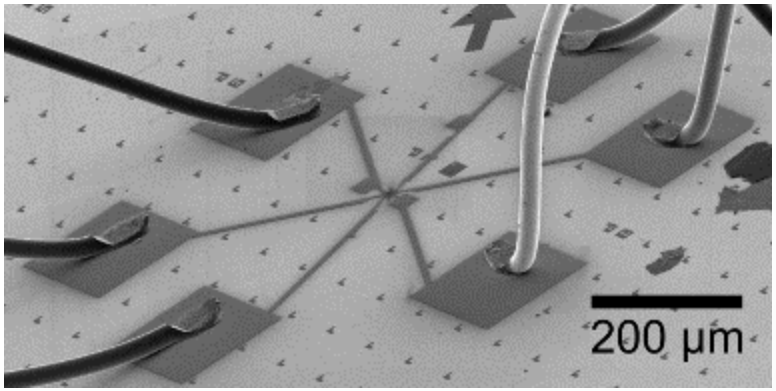
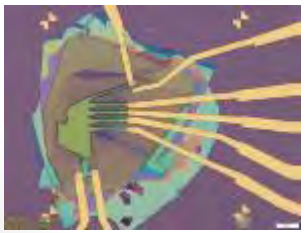
Island – Quantum computing, quantum sensing

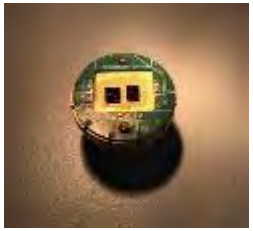
The Nanoscale Physics Group @ UNLV

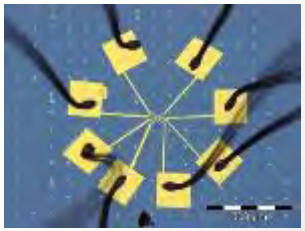
Areas of Research

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







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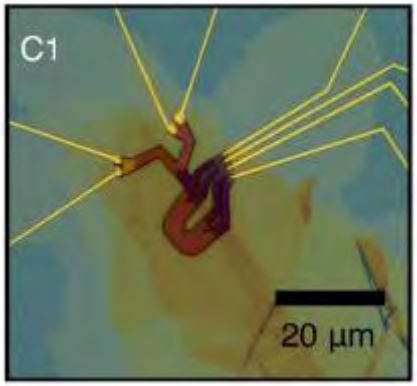
Island's Lab website

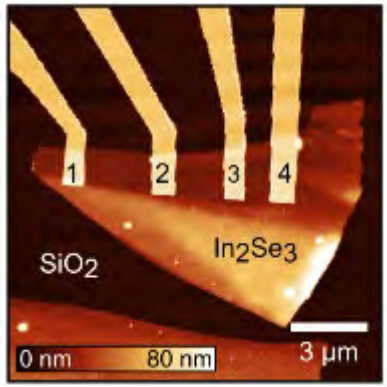
Island – Quantum computing, quantum sensing

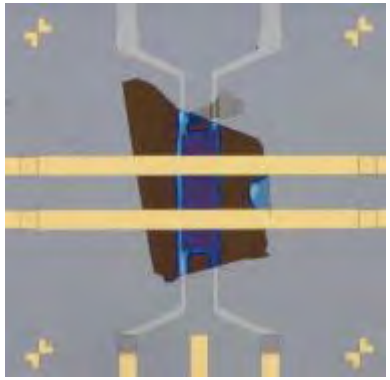
Quantum computing: Topological phases for fault-tolerant, universal quantum computing.

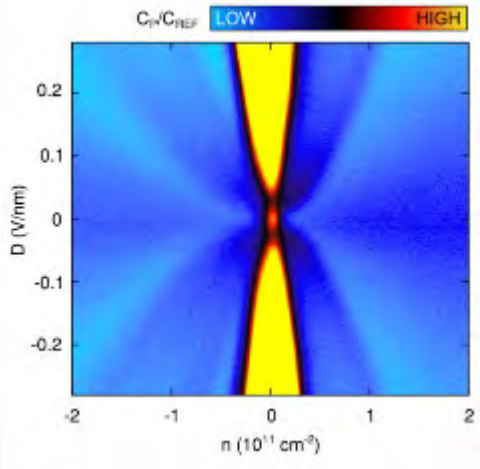
Industry-disruptive photodetectors: Ultra-sensitive phototransistors designed with 2D materials and heterostructures.

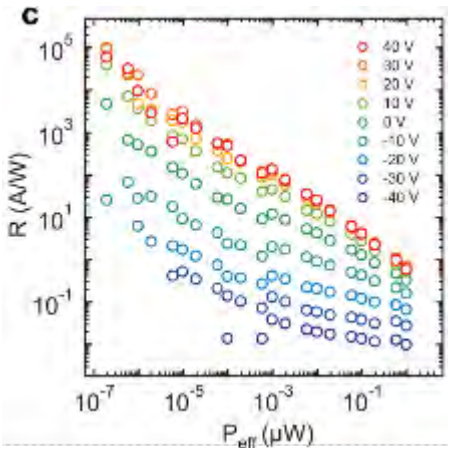
Transient phases of driven systems: Non-equilibrium response of pumped nanomaterials below the diffraction limit.

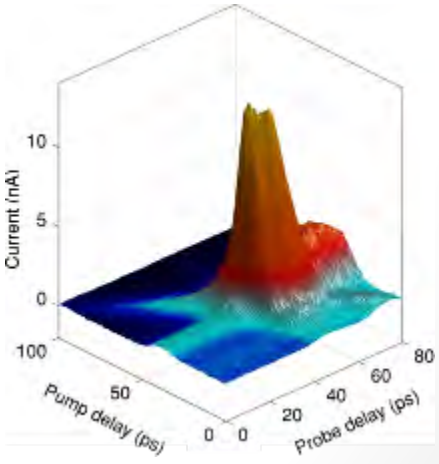












Island, J. O., et al. *Nature* **571** (2019): 85–89.

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

Island's Lab website

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. Chirolli, 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)

T1S3 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)

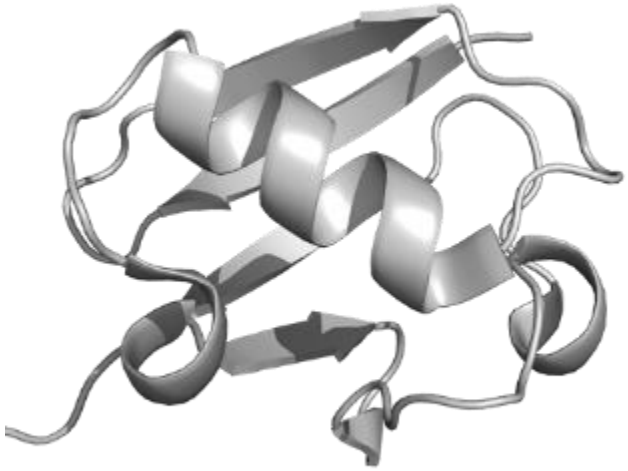
Gate controlled photocurrent generation mechanisms in high-gain ln2Se3 phototransistors
J.O. Island*, S.I. Blanter*, M. Buscema, H.S.J. van der Zant, and A. Castellanos-Gomez, Nano Letters, **15**, 7853(2015). (arXiv)

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)

Island's Lab website

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

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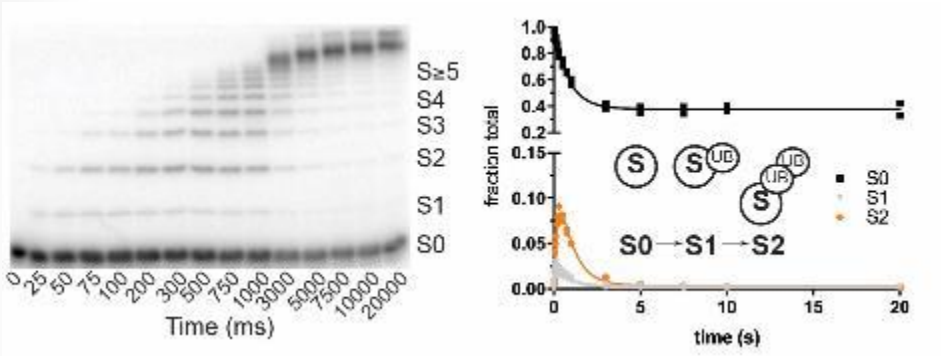
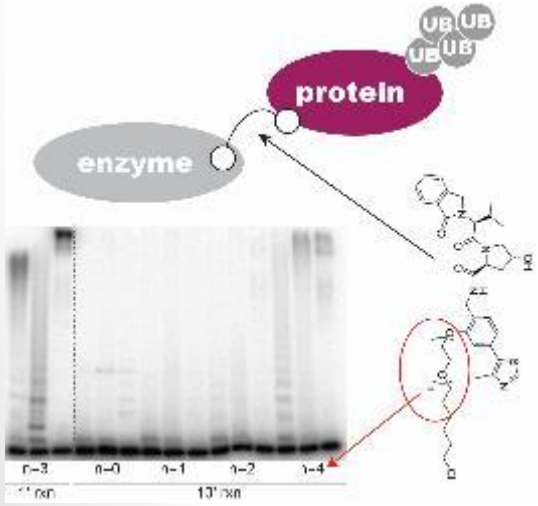
Uncovering how the enzymes that promote protein degradation function in human cells.

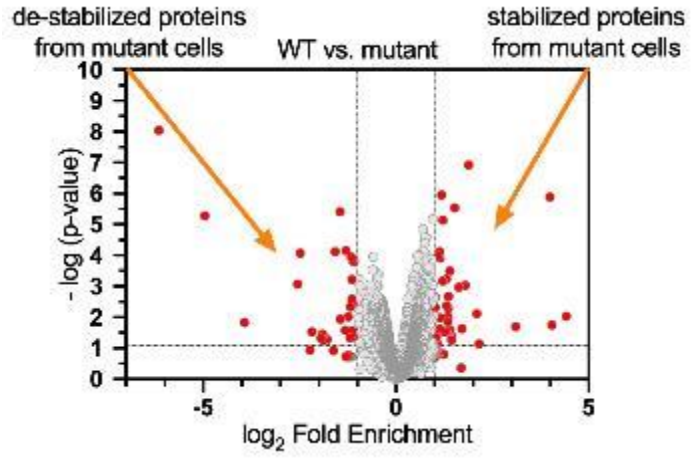
Kinetics help us understand how enzymes select protein targets for modification with ubiquitin.





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.

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



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Novel chemistry and biology using highly ionizing radiation

Michael Pravica, Ph.D.
Professor of Physics
Department of Physics and Astronomy
Phone: (702)895-1723
Email: michael.Pravica@unlv.edu

Expertise:
Useful Hard X-ray photochemistry
High pressure
Spectroscopy
Ion Beam Nuclear Transmutation Doping
High quality synthesis of vaccines using tuned hard x-rays

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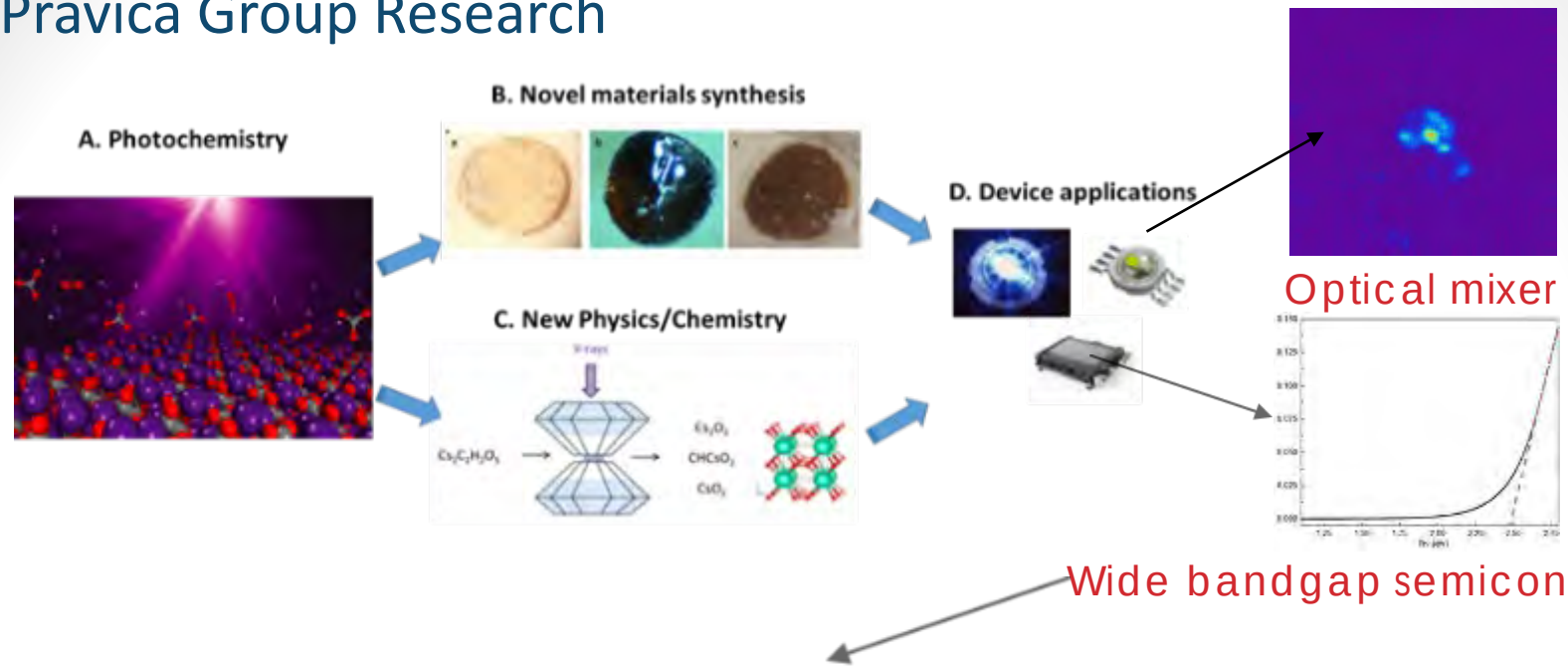
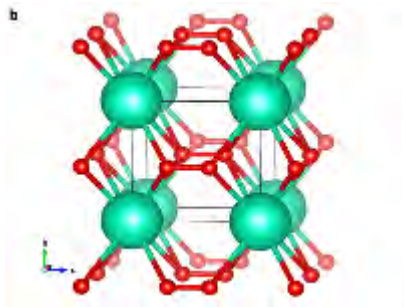
Pravica Group Research



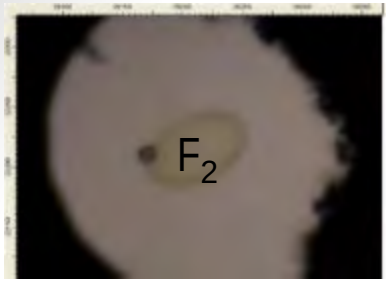
Radiation-hardened sensors/direct energy conversion devices for EXTREME CONDITIONS or tuned solar materials

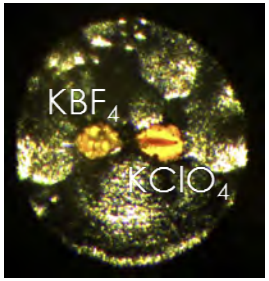
Useful hard x-ray photochemistry



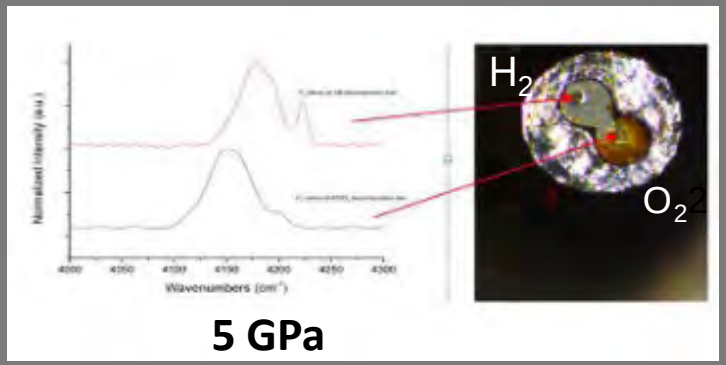
Novel structures of known materials produced With hard x-rays and high pressure (e.g. CsO_2)

High Pressure Fluorine Chemistry





$$2F_2 + O_2 \xrightarrow{h\nu} 2OF_2 \ @\ 3\ GPa$$



5 GPa

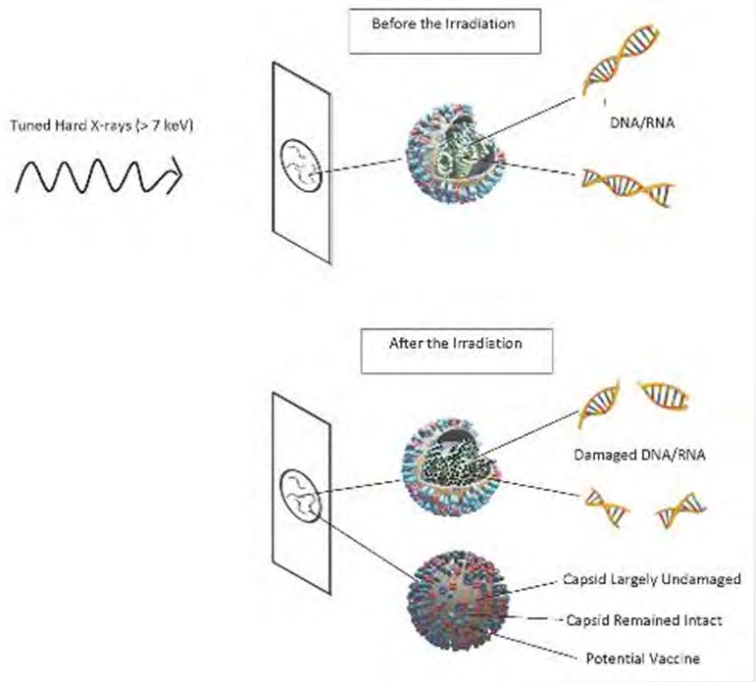
Molecular mixtures at high pressure

X-ray induced combustion

Inner shell chemistry at high pressure

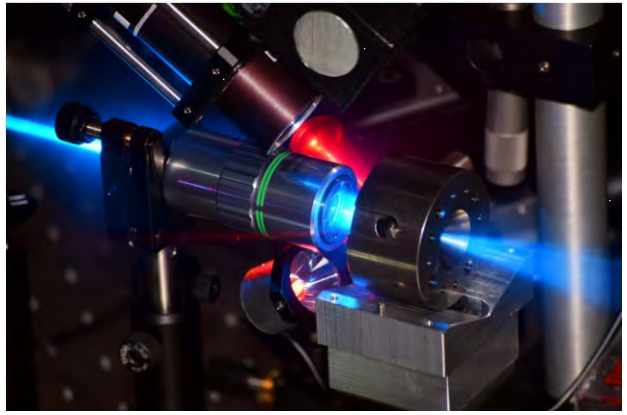
$$XeF_2 \xrightarrow{h\nu} Xe + F_2 \text{ (}\textit{in situ}\text{ x-ray fluorination)}$$

$$HgF_2 + F_2 \xrightarrow{h\nu} HgF_4$$

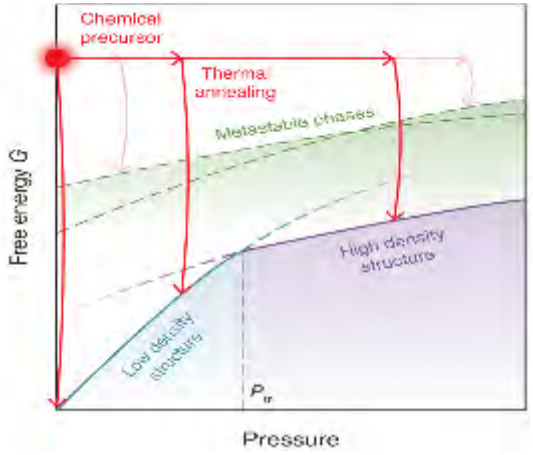


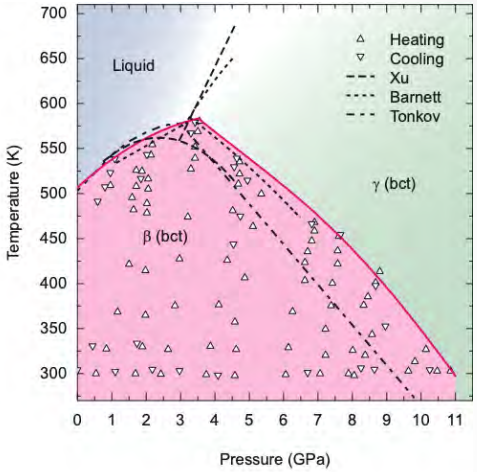
Using tuned hard x-rays to damage viruses to create high quality vaccines by targeting specific molecular groups/bonds that resonantly absorb x-ray energy leading to decomposition chemistry.

Salamat Group – Collaboration with MSTS

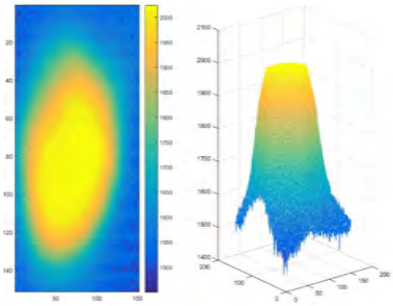


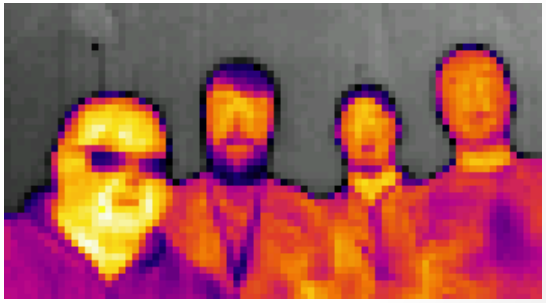
Metrology – accurate mapping of P, V, T





High temperature modelling – understanding emissivity under extreme conditions





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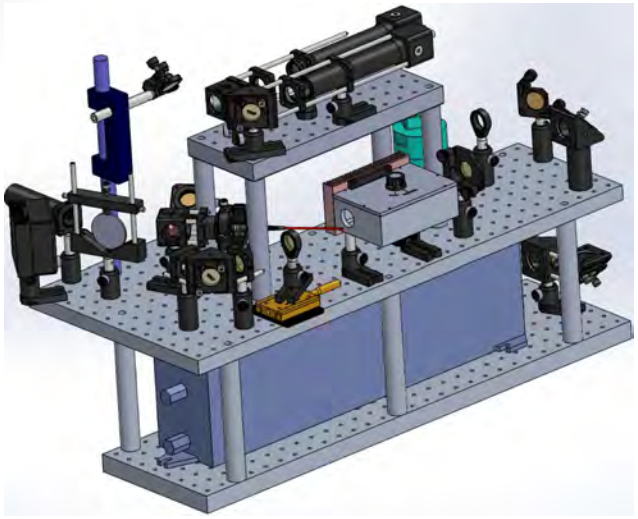
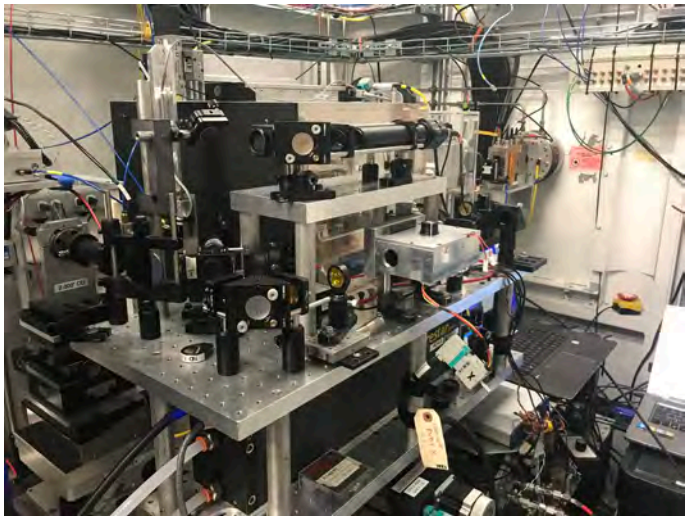
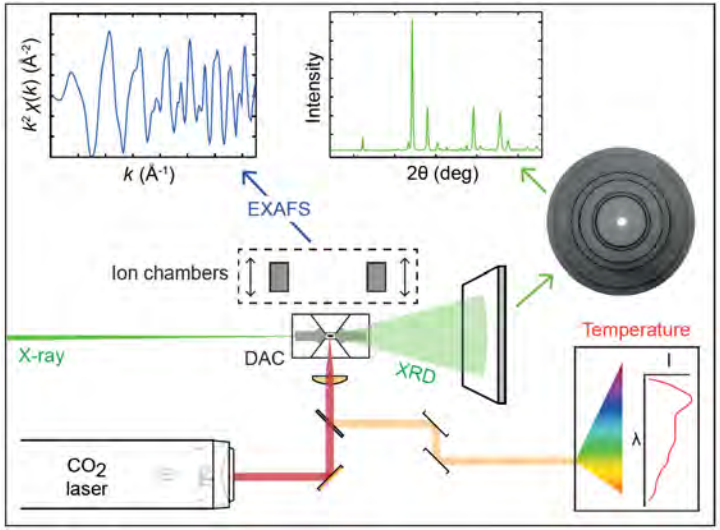
Warm dense matter – probed using EXAFS



- Development of a CO_2 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)

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(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: $La_2Sn_2O_7$ and the Nature of Bonding in Pyrochlores under High Pressure Temperature Conditions Inorganic chemistry, 57, 15051-15061, (2018)

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(5) D. Smith, J. S. Smith, C. Childs, E. Rod, R. Hrubiak, 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)

(8) A. Salamat*, R. Fischer, R. Briggs, M. I. McMahon, S. Petitgirard, In situ synchrotron X-ray diffraction in the laser heated diamond anvil cell: melting phenomena and synthesis of new materials. Coordination Chemistry Reviews 277-278, 15 (2014)

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Research Oliver Tschauner

- **Dr. Oliver Tschauner**
- Professor of Research
- Department Geoscience
- Email: oliver.Tschauner@unlv.edu
- Website: https://geoscience.unlv.edu/people/department-faculty/oliver-tschauner/

Natural diamond with CO_2 inclusions at a pressure of 20000 atmospheres

Expertise

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

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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
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- Tissintite (Ca, Na, □) $AlSi_2O_6$, 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, Przemyslav Dera and Lawrence A. Taylor, **Earth Planet. Sci. Lett.** 422,194-205 (2015).
- Ahrensite, gamma-Fe_2SiO_4, a new shock-metamorphic mineral from the Tissint meteorite: Implications for the Tissint shock event on Mars. Ma, C. ; Tschauner, O.; Beckett, J.R.; Liu, Y.; Rossman, G.R.; Sinogeikin, S.V.; Smith, J.S.; Taylor, L.A. **Geochim. Cosmochim. Acta** 184, 240-256 (2016). DOI: 10.1016/j.gca.2016.04.042
- 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

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Zhou Lab – Experimental AMO physics

- **Dr. Yan Zhou**
- Assistant Professor
- Department of Physics and Astronomy
- Email: yan.zhou@unlv.edu
- Website: https://www.physics.unlv.edu/~yanzhou/index.html

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

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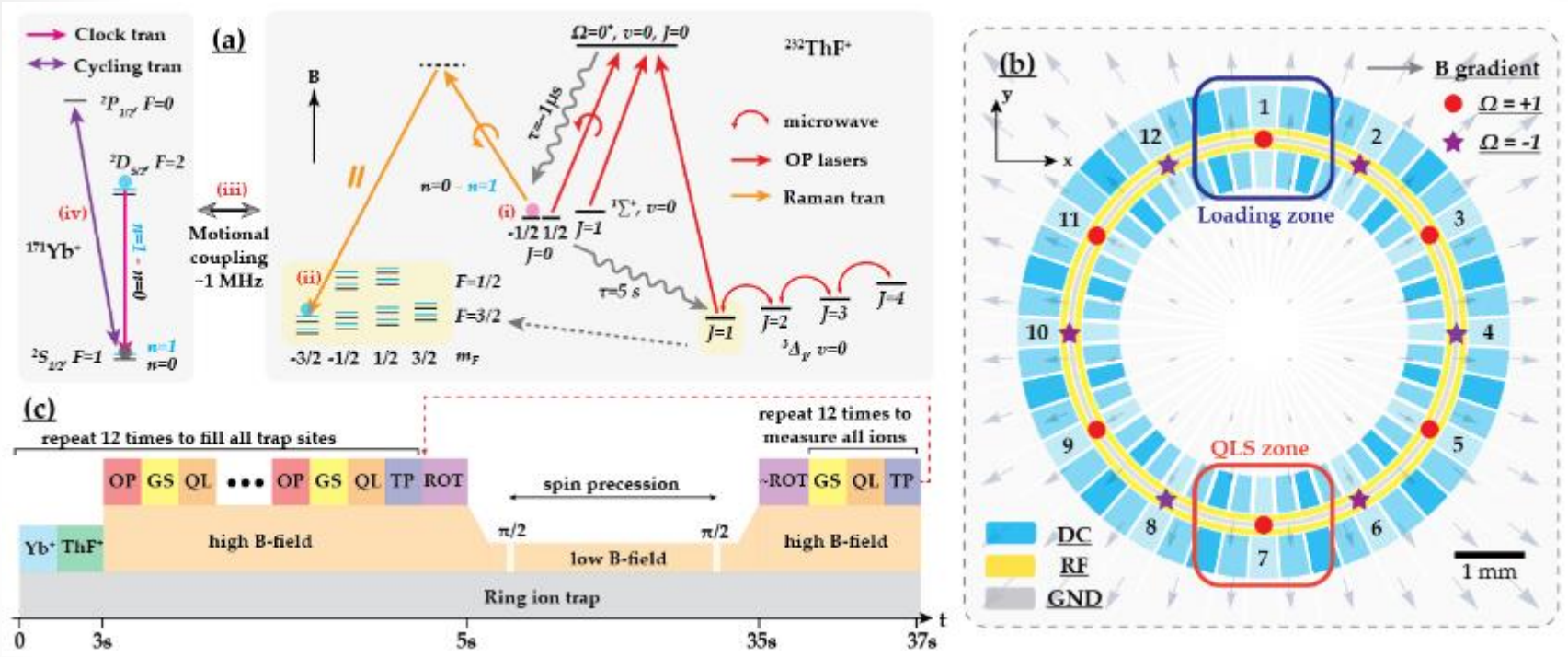
Search for *T,P*-odd symmetry violation



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

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