

Physical Chemistry Research

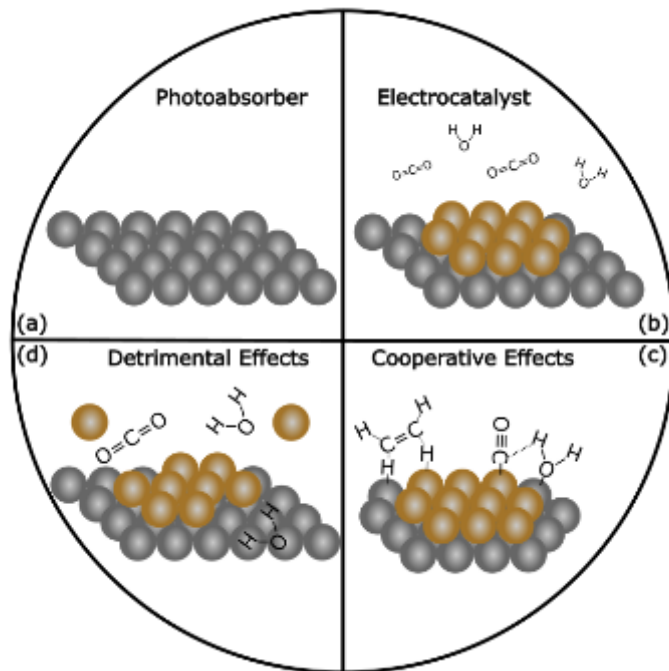
Interfacial Photochemistry

- **Dr. Jared P. Bruce**
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- Website: jpbruce.faculty.unlv.edu

Expertise

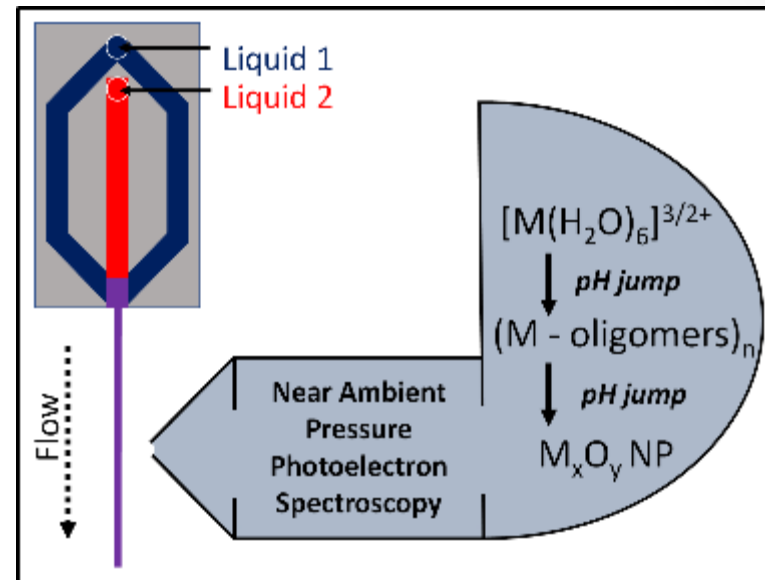
- Heterogeneous Photochemistry
- Electrocatalysis
- Photocatalysis
- Atmospheric Chemistry
- Surface Chemistry and Interfacial Characterization
- Near Ambient Pressure Photoelectron Spectroscopy

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



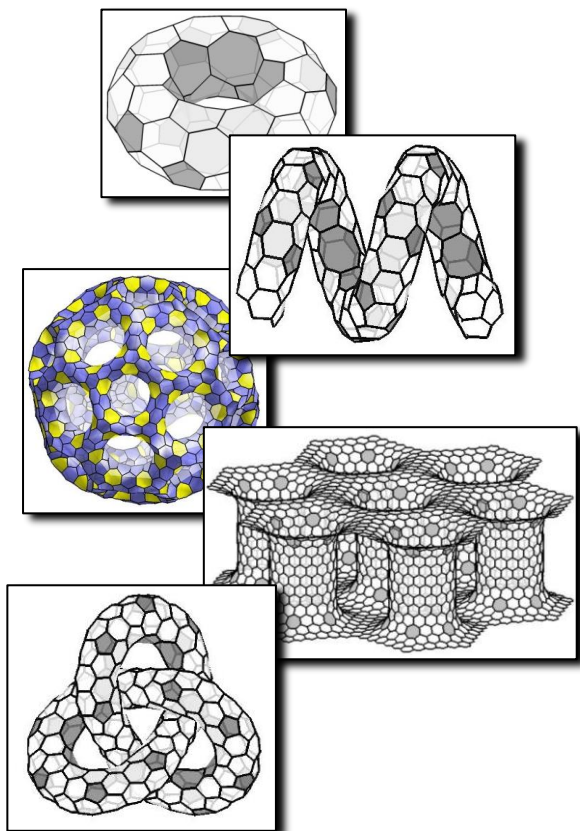
- Dynamic processes are tricky to study at the liquid surface
- A small liquid jet (20 μm dia.) is used to investigate the liquid surface
- Microfluidic chips provide mixing chamber to induce chemical reactions

Theoretical chemical physics

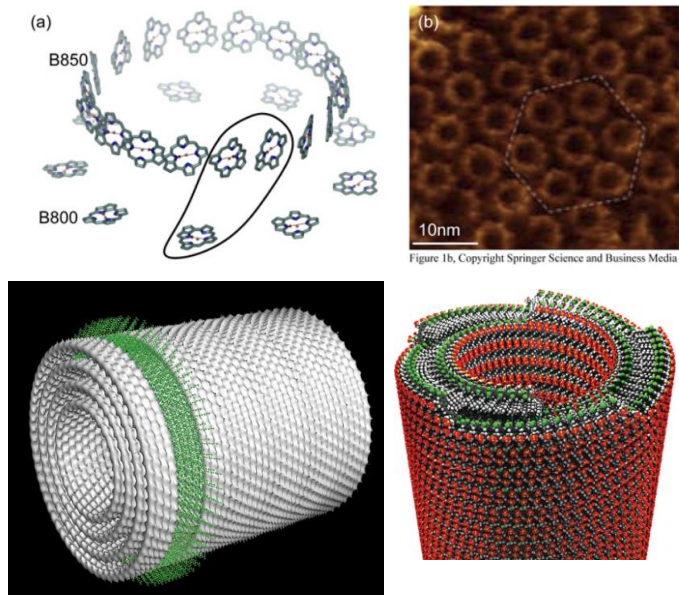
- Dr. Chern Chuang,
- Assistant Professor, Department of Chemistry and Biochemistry
- Email: chern.chuang@unlv.edu
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- Expertise
 - Open quantum system dynamics and spectroscopy
 - Photophysics and photochemistry of materials
 - Quantum transport
 - Quantum effects in biology
 - Exotic geometries and topologies of low dimensional materials

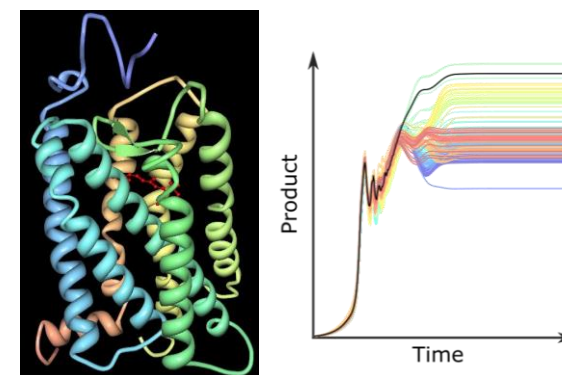
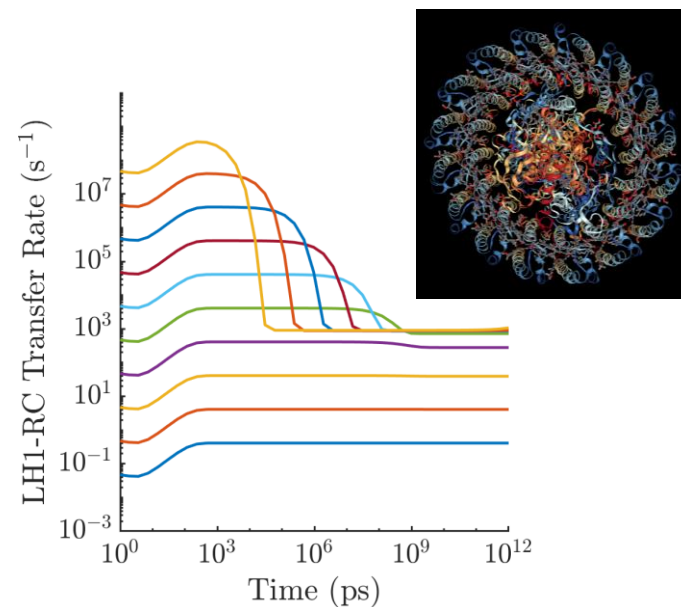
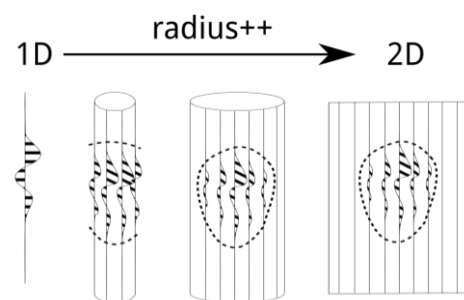
Theoretical chemical physics



Exotic low-dimensional materials



Photophysics of organic materials



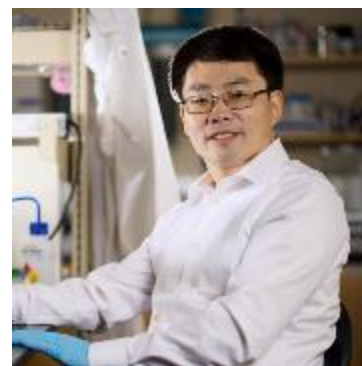
Photochemistry under environmental control

Electrochemistry for Energy Storage, Environmental Remediation, and Biomedical Applications

- **Dr. Zhange Feng**
- Assistant Professor
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Expertise

- Water and soil remediation
- Rechargeable batteries
- Electrocatalysis
- Electrosynthesis
- Electrochemical Manufacturing
- Electrical neural stimulation



A combination of electrochemistry, *in situ* spectroscopy, and theoretical calculations to study electrified interfaces

Stephen Lepp

- Professor of Astrophysics, Department of Physics and Astronomy
- Ph.D., Physics, University of Colorado, Boulder
- BPB 234, Stephen.Lepp@unlv.edu
- <http://www.physics.unlv.edu/~lepp/>

Areas of Expertise

- Astrochemistry
- Interstellar Medium
- SN1987A
- Formation of first objects in the Early Universe
- Thermal Phases in Astrophysics
- X-ray chemistry

Research Summary:

I work primarily at the intersection of Atomic and Molecular Physics with Astrophysics. Making models of astronomical environments to further our understanding of them. I have modeled: interstellar clouds, star forming regions, active galactic nuclei, SN1987A, and the Early Universe.



Quantum Information and Quantum Control of Chemical Reactions

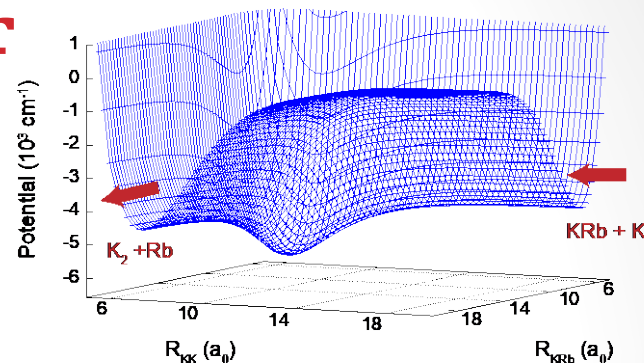
Balakrishnan Naduvalath

Department of Chemistry & Biochemistry,
UNLV

Areas of Expertise

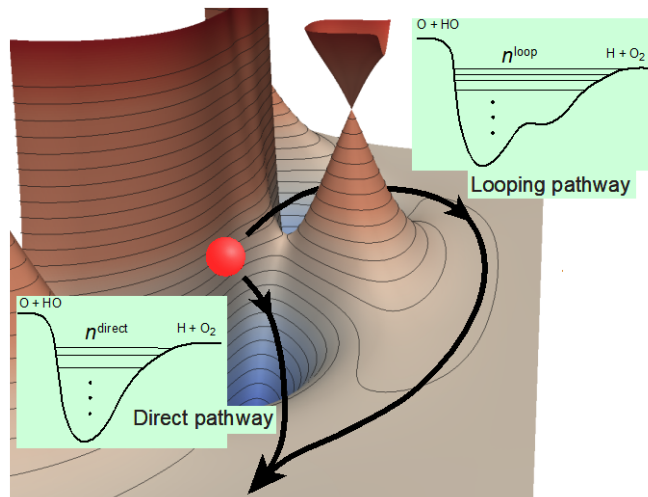
- Ultracold Molecules
- Ultracold Quantum Engineered Chemistry
- Quantum control of chemical reactions
- Geometric phase effect in chemistry
- Stereodynamic control of chemical reactions

\$\$\$: NSF, DOD, NASA



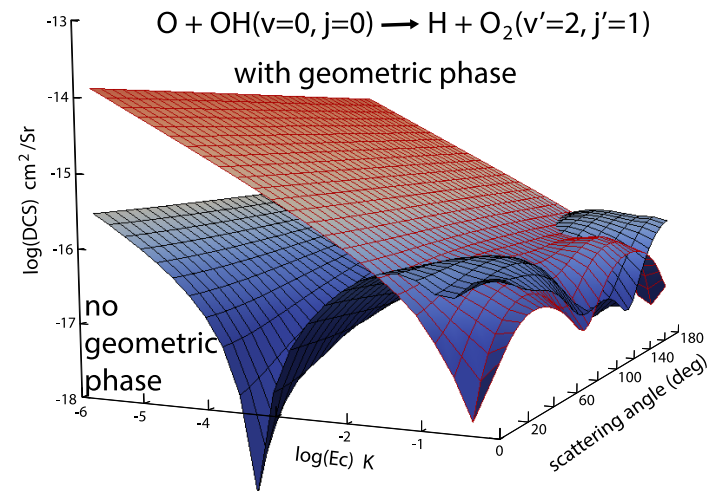
Chemical reaction pathway in ultracold K+KRb collisions. Quantum engineered KRb molecules have been prepared at 300 nK. Ultracold polar molecules such as KRb are potential candidates for quantum computing and quantum information processing.

Controlling reaction outcome through quantum interference



Right panel: The nature of the interference can be controlled by including “geometric phase”. In the image on the right, inclusion of the geometric phase enhances the reactivity. The geometric phase (that correctly describes the sign of the wave function near a conical intersection with an excited electronic state) acts as a “quantum switch” (Hazra, Balakrishnan, and Kendrick, *J. Phys. A* **119**, 12291 (2015))

Left panel: Two paths for a chemical reaction. These two paths can interfere constructively or destructively, maximizing or minimizing the reaction rate. This quantum effect becomes magnified in the ultracold regime (Kendrick, Hazra, and Balakrishnan, *Nature Comm.* **6**, 7918 (2015)).



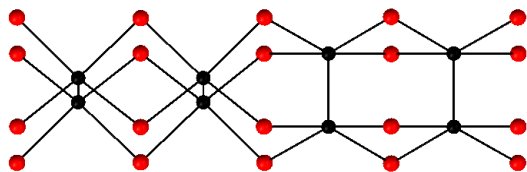
References

- P. G. Jambrina, J. F. E. Croft, H. Guo, M. Brouard, N. Balakrishnan, and F. J. Aoiz, Stereodynamical control of a quantum scattering resonance in cold molecular collisions, *Phys. Rev. Lett.* **123**, 043401 (2019).
- J. F. E. Croft and N. Balakrishnan, Controlling rotational quenching rates in cold molecular collisions, *J. Chem. Phys.* **150**, 164302 (2019).
- K. Hilsabeck, J. Meiser, M. Sneha, N. Balakrishnan, and R. N. Zare, Photon Catalysis of Deuterium iodide photodissociation, *Phys. Chem. Chem. Phys.* **21**, 14195 (2019).
- J. F. E. Croft, N. Balakrishnan, M. Huang, and H. Guo, Unrevealing the stereodynamics of cold controlled HD-H₂ collisions, *Phys. Rev. Lett.* **121**, 113401 (2018). (**Editor's choice**).
- J. F. E. Croft, C. Makrides, M. Li, A. Petrov, B. K. Kendrick, N. Balakrishnan, and S. Kotochigova, Universality and chaoticity in ultracold K+KRb chemical reactions, *Nature Comm.* **8**, 15897 (2017).
- N. Balakrishnan, Perspective: Ultracold molecules and the dawn of cold controlled chemistry, *J. Chem. Phys.* **145**, 150901 (2016).
- B. K. Kendrick, J. Hazra, and N. Balakrishnan, The Geometric Phase Appears in the Ultracold Hydrogen Exchange Reaction, *Phys. Rev. Lett.* **115**, 153201 (2015).
- B. K. Kendrick, J. Hazra, and N. Balakrishnan, The Geometric Phase Controls Ultracold Chemistry, *Nature Communications* **6**, 7918 (2015).

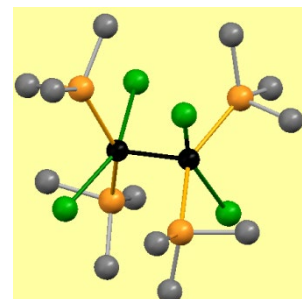
→ Synthetic and coordination chemistry

Technetium binary and ternary halide compounds

Compounds with multiple metal-metal bonds



TcCl_2 : a unique structure-type



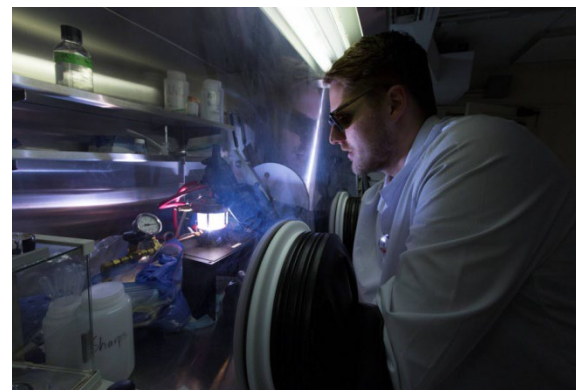
$\text{Tc}_2\text{Cl}_4(\text{PMe}_3)_4$

→ Chemistry relevant to remediation and fuel cycle applications

Separation, vitrification, and waste forms (alloys)



Demonstration of the separation of uranium from technetium for fuel cycle application

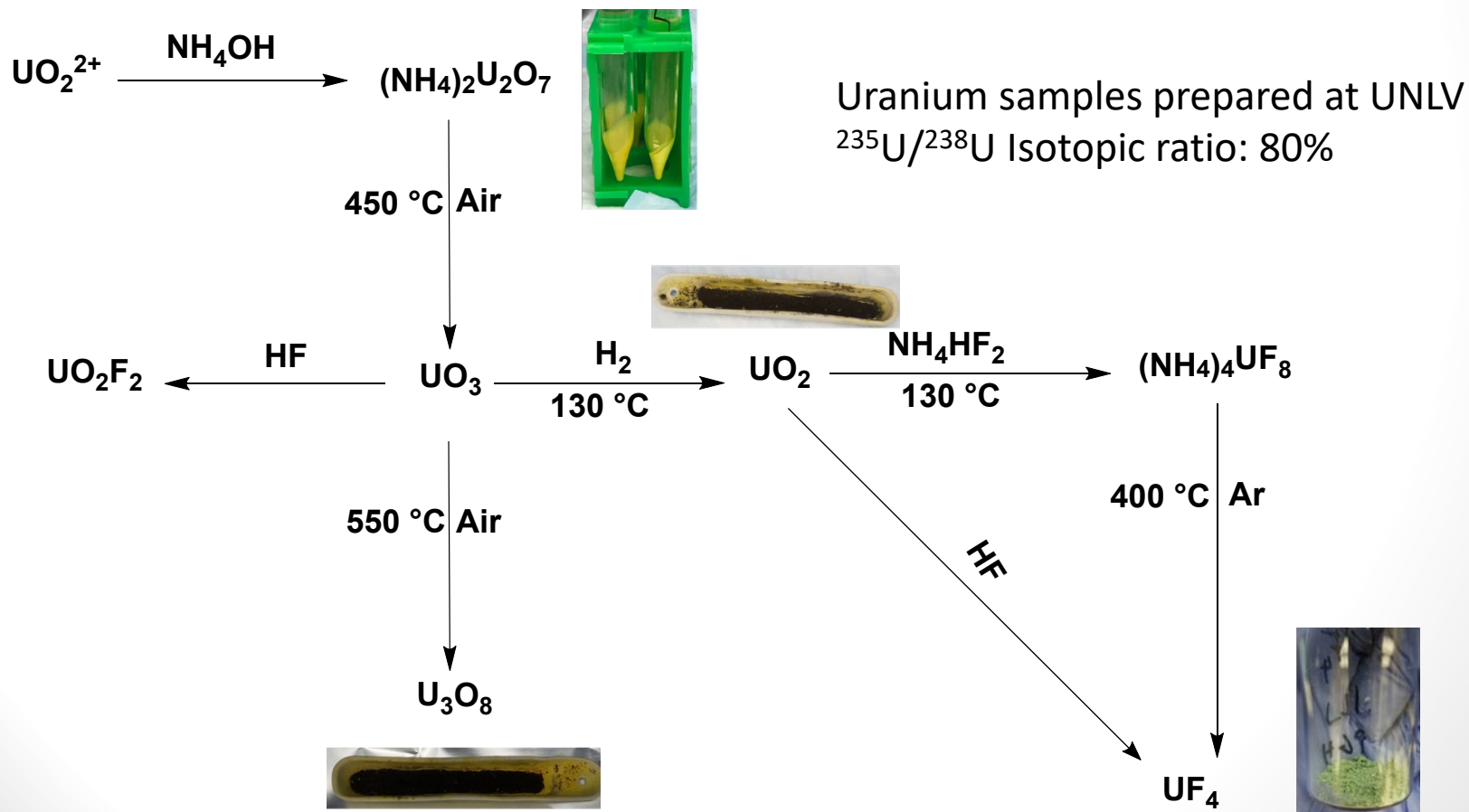


Preparation of U-Tc alloys by arc melting

→ Collaborative work relevant to nuclear forensics

Analysis of Uranium Isotopic Ratios by Thermal Ionization Mass Spectrometry (TIMS)

- Uranium compounds found throughout the fuel cycle (UO_2 , U_3O_8 , UF_4) prepared at UNLV
- $^{235}\text{U}/^{238}\text{U}$ isotopic ratio measurements using TIMS at LANL



Colloidal Quantum Dots: Single-Photon Emitters & Sensor Materials

SWIR colloidal quantum dots for LIDAR

- **Dr. Tian Qiao**
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Expertise

- Synthesis of Colloidal Quantum Dots
- Optical Spectroscopy
- Single Photon Emitters
- Shortwave IR Emitters

On-demand synthesis of colloidal quantum dots

