FALL 2022 ASTRONOMY
UNDERGRADUATE RESEARCH OPPORTUNITIES FAIR
FRIDAY AUGUST 26TH 2-4PM
Campbell Hall 131

Join us to learn about Astrophysics/Planetary Sciences research opportunities available for Fall 2022!

ALSO:
Check out opportunities through URAP. Applications are open August 17th-29th.
AND
Apply for research funding through BPURS!
Places to look for research

- Astronomy Department, Physics Department, Space Sciences Lab (SSL), Lawrence Berkeley National Lab (SSL)
- **URAP: Undergraduate Research Apprentice Program**
  urap.berkeley.edu (deadlines: Fall Aug 29, Spring late Jan)
- Spreadsheet of research opportunities at this
  Astro Research Fair
- Spreadsheet of research opportunities at the
  Physics Research Fair
- **ULAB DeCal** (2 units, 2 semester commitment)
- Summer research programs (NSF REUs, NASA, AMNH, ...)
  “The Wild West”
  cold calls, classes, random conversations ... it’s all possible
FAQ

► When should I start?

— No unique answer, depends on the job
  — When you have time in your schedule (~10+ hr/wk)
  — Programming skills usually necessary
  — Classes that approximate research

| Labs (Astro 120, 121, 128, Physics 5BL, 5CL, 111) |
| Physics/Astro C101 (Order-of-Magnitude Physics) |
| Physics & Astronomy ULAB DeCal |

► What should be my goals in doing research?

— Aim for a deliverable (something concrete)
— Professional relationship with advisor (letters of rec)

► What if I don’t like what I am doing?
How to apply

• Details will vary. Send an email to potential advisor with:
  ▶ Statement of interest
  ▶ CV (work experience, programming experience, classes taken, ...)
  ▶ Transcript

• Research can be for:
  ▶ Credit (Astro 199, 1-2 units)
  ▶ Honors Thesis (Astro H195)
  ▶ Pay ([BPURS](#) or your supervisor’s grant)
Research Projects
Transfer students should apply!
Logistics

Requirements

- Some upper-div quantum (e.g. 137A) (though see below)
- CV, transcript(s), statement of interest by **Wednesday 8/31**
  [https://n3as.berkeley.edu/p/fa2022-apply-undergraduate/](https://n3as.berkeley.edu/p/fa2022-apply-undergraduate/)

Benefits

- **Paid** up to 10hr/week
- **Separate research/career mentors** (postdocs/profs within N3AS)
- **Transfer students** can apply for career mentorship before 137A
  (and application will automatically be resubmitted for research upon completing 137A)
Are FRBs all from young neutron stars?

Wenbin Lu  wenbinlu@berkeley.edu
Assistant Professor, Astronomy Department

\( B > 10^{14} \text{ G}, \text{“magnetar”} \)

SGR 1935+21 — a young NS

- Detected from Milky Way up to \( D \sim \text{Gpc} \)
- Likely from a NS
- One repeater in M81 (\( D = 3.6 \text{ Mpc}, \text{in globular cluster!} \))
- Total event rate \( R \gg 1 \text{ gal}^{-1} \text{ century}^{-1} \)

\( \Delta t \sim \text{ms}, F \sim \text{Jy} \)
\( N \sim 10^3, \text{many repeaters} \)

many FRBs from nearby gals
Young NSs are surrounded by supernova remnants (SNRs)

(Bailes et al. 2021)

(Kothes et al. 2018)
Young NSs are surrounded by supernova remnants (SNRs)

At $D \sim 10$ Mpc (in nearby galaxies), SNR G57.2+0.8 would have $F \sim \mu$Jy

Potentially detectable with ngVLA (few hr)

Detecting a SNR would **prove**: FRBs are indeed from young NSs

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**Diagram:**

- **G57.2+0.8**
  - $\alpha = -0.55 \pm 0.02$
  - $\alpha = -0.65 \pm 0.03$

**D ~ 8 kpc**

**Age ~ 1e4 yr**

(Kothes et al. 2018)
FRB sources with persistent radio emission (PRS)

**Milky Way** (common, least active)
- SGR1935

D ~ Gpc (rare, most active repeaters)
- FRB121102 & 190520

1 μJy → 1 mJy → 1 Jy

Crab Nebula (age = 1e3 yr)

ngVLA sensitivity
Work Plan

Goal: Searching for **SNRs** associated with **FRBs in nearby galaxies**

Todo:

✈ Literature search on SNR observations
✈ Model radio emission from SNRs and pulsar wind nebulae
✈ Provide predictions on persistent radio emission

Skills:

✈ Shocks, non-thermal particles, synchrotron emission
✈ Radio basics (angular resolution, noise, sensitivity, etc)
✈ Statistical analysis (detection rate)

Contact: wenbinlu@berkeley.edu
Detecting trace amino acid biosignatures
Searching for evidence of life: present, past and prebiotic origin

CE-LIF organic analysis technique

LIF = Laser-Induced Fluorescence

Fluorescence

Time (sec)

CE Injection
CE Separation

CE = Capillary Electrophoresis
Separation of molecules by their charge/radius

Project 1: LIF
Rebuild breadboard confocal optical detection system
- 405 nm Laser
- Photomultiplier

Project 2: CE-LIF
Operate automated voltage switching for CE
Data acquisition
Build thermal control
Confocal Laser-Induced Fluorescence Detection System


- Opportunity to Experience:
  - confocal optics optimization for high sensitivity, high resolution detection system
  - photomultiplier detector signal acquisition

- Hours: ~10hr/wk lab work. Course credit, Work-Study
  Apply: CV, brief cover letter

- Skills:
  - interests in optics, electronics, signal acquisition
  - practical, analytical, detail-oriented communicator.

- Supervisors: Anna Butterworth (SSL), Richard Mathies (Chemistry) eoa.ssl.berkeley.edu

- Contacts: Anna B butterworth@berkeley.edu
  SSL u/g coordinator: Catherine Dang catherinedang13@berkeley.edu
Software for astronomical data

Advisor: Guy Nir (Bloom lab)
guyn@berkeley.edu
Motivation

Recent discoveries in astronomy (and physics) are derived from large collaborations producing big datasets.

Being able to retrieve and process these data is fundamental to our work.

Getting a taste for how to interact with or design such software is key.
Self-lensing flares

- White dwarfs in a binary with another compact object (WD or NS or BH) can have gravitational lensing flares if the orbit is edge on.
- Flares can be very short (few seconds to hour) and not so bright (few percent).
- In large surveys it may be possible to detect them in single images.
- Over large baselines, WD-WD flares may be picked up using a periodicity search (like planet transits only positive).
- Flares are currently too rare to expect detections but limits on WD-BH could be relevant, and search methodology is applicable to LSST.
Status of self-lensing project:

- Simulation code is working.
- Need to improve some of the simulation results with realistic data.
- Paper is underway, but
- Need to process some lightcurves and verify that no flares can be identified.
- I don’t expect detections, but if we do find anything that would be really great.

Work to do:

- Lightcurve download tool needs work.
- Downloading from multiple surveys needs to be sorted out.
- Basic analysis ("single epoch flares") on a large number of exposures.
- More advanced, periodicity search, can be useful too.
Streaks

- Astronomical images show streaks from satellites, near-Earth objects, images artefacts.
- Want to remove bad data, and detect NEOs.
- Detection can be fast and efficient ([link](https://ui.adsabs.harvard.edu/abs/2018AJ....156..229N/abstract))
- Goal: develop a convolutional neural network classifier for streaks / other artefacts.
- Method: download ZTF images, use pyradon to identify streaks as training data.
- Applications: may be adapted by surveys like ZTF, LS4, LSST.
Status of streaks project:

- The streak detection tool is running, but hasn’t been tested “in real life”.
- I have never worked with neural networks so this will be a learning experience for everyone.
- The big problem is getting labeled data, but ZTF has loads of non-streak artefacts and we can easily simulate streaks.
- An end-to-end, train-on-your-own-data software package could be a great paper on its own.

Work to do:

- Download image data from ZTF (at least).
- Run pyradon and debug any issues.
- Use simple tools to separate most streaks from artefacts.
- Simulate many streaks.
- Train and test a neural net.
- Package as a ready-to-apply product.
- Benchmark and publish.
Requirements

- Proficient in python language.
- Familiar with numpy, pandas, astropy, object oriented programming.
- Familiar with git.

Expectations

- Run my code and give me feedback on it.
- Contribute code to improve my software.
- Get actual data and run real analysis on it.
- Document the results in a paper section or standalone report.

Benefits

- Learn how to download, reduce, analyze astronomical data.
- Learn to apply statistical or neural network based algorithms.
- Learn open-source best practices like git pull requests, unit testing, code review.
- Co-author a paper if/when results are published.
- Funding will be available (TBD).
Questions?

Contact: Guy Nir guyn@berkeley.edu (510) 646-7839
SSL is a world leader in space science research as well as mission and instrumentation design

With few exceptions, the majority of SSL’s funding comes from NASA

ESCAPADE Recently Announced!

- Twin satellites dubbed “Blue” and “Gold” to study Mars’ ionosphere and magnetic field
- Follow along and learn more at ssl.berkeley.edu
SSL Undergraduate Opportunities Include:

- Research
- Instrument Design/Build
- Education and Public Outreach
- Project Management

Stay informed!

ssl.berkeley.edu/students/undergraduate
Current SSL Undergrad Opportunities

Most SSL research opportunities are offered via URAP – The deadline to apply for Fall 2022 is August 29th, 9 AM!

Find out more and apply now at urap.berkeley.edu

Space Sciences Laboratory

Andreas Zoglauer, Staff Researcher
(2) The COSI gamma-ray telescope: Improving the data-analysis pipeline with machine learning (Open)
(3) Building the GAPS Antarctic Balloon Payload to Probe Dark Matter Using Galactic Particle Signatures (Open)

Christopher Chaston, Research Physicist
(1) 'Turbulent field topology and particle scattering in the Solar Corona' (Open)
(2) 'Relativistic electron scattering in electromagnetic turbulence' (Open)
(3) 'Energy Transport, Conversion and Dissipation in Earth’s Magnetotail' (Open)
(4) 'Flow tracing through the auroral acceleration region' (Open)

Thomas Immel, Research Physicist
(1) Analysis of NASA ICON data from Earth orbit (Open)

Juan Carlos Martinez Oliveros, Research Physicist
(1) The Background and Transient Observer (BTO) for the Compton Spectrometer and Imager (COSI) (Open)

Tony Mercer, Aerospace Engineer
(1) Solar Probe SWEAP and MAVEN PF spacecraft instrument operations and analysis (Open)

Raul Monsalve
(1) Techniques in Radio Cosmology Instrumentation (Full- no new appr needed)

Mitsuo Oka, Associate Research Physicist
(1) High-Energy Particles at Shocks in Space (Full- no new appr needed)
(2) Visualization and selection of data from NASA’s MMS mission (Open)

Oswald Siegmund, Research Physicist
(1) Photon Counting Detector Technology (Open)
Current Undergrad Opportunities

There are also occasional direct hires, internships, and other arrangements, such as:

**Title:** Detection of extraterrestrial biosignatures on icy moons and analysis of prebiotic trace organics in primitive carbonaceous meteorites.
**Description:** Build a brassbound Confocal Laser-Induced Fluorescence Detection system. Opportunity to experience (1) confocal optics design and optimization for high sensitivity, high resolution detection system; (2) photomultiplier detector signal acquisition, and (3) temperature control design and implementation
**Contact:** Anna Butterworth (butterworth@berkeley.edu)

**Title:** Detailed X-ray/optical/UV/NIR study of a candidate black hole ultracompact X-ray binary (BH UCXB)
**Description:** The main work for this project is to study an intermediate brightness persistent X-ray binary by combining dedicated NuSTAR, XMM-Newton, and NICER data as well as an in-depth archival analysis. UCXBs are especially interesting for future lower frequency gravitational wave observations.
**Contact:** John Tomsick (jtomwick@berkeley.edu)

**Title:** Studies of Galactic NuSTAR serendipitous sources
**Description:** With major improvements in high-energy X-ray sensitivity, NuSTAR has been discovering large numbers of 3-24 keV sources, uncovering sources where extreme physics is occurring. Our group is using the recently updated 80-month catalog to study the Galactic NuSTAR serendipitous sources.
**Contact:** Ben Coughenour (coughenour@berkeley.edu)
Current Undergrad Opportunities

There are also occasional direct hires, internships, and other arrangements, such as:

**Title:** Radial diffusion in the Earth's radiation belts.
**Description:** This work is focused on analyzing a large data set, to look for possible correlations with various indicators of "space weather". This is a great opportunity to develop coding skills!
**Contact:** Solene Lejosne (solene@berkeley.edu)

**Title:** Analysis of data from NASA's Ionospheric Connection Explorer (ICON) mission
**Description:** The main focus of this project is to better understand the sources of "space weather" in the plasma environment near the Earth. Python experience is required.
**Contact:** Brian Harding (bharding@ssl.berkeley.edu)

Remember, stay informed!

ssl.berkeley.edu/students/undergraduate
Signatures of Eccentric Protoplanetary Disks

Astro Undergraduate Research Fair
August 26, 2022

J. J. Zanazzi
Planet Formation

Protoplanetary Disks: gas and dust orbiting young stars

Eventually form planetary systems

J. J. Zanazzi
Substructures Reveal Planets

Structured protoplanetary disks detected (e.g. Andrews+ 2018)

Gaps likely from planets (e.g. Lin & Papaloizou 1986; Fung & Chiang 2016; Choksi & Chiang 2022)

J. J. Zanazzi
Substructures Reveal Planets

Structured protoplanetary disks detected (e.g. Andrews+ 2018)

Gaps likely from planets (e.g. Lin & Papaloizou 1986; Fung & Chiang 2016; Choksi & Chiang 2022)

Any other planet-caused substructures? J. J. Zanazzi
Observations of Eccentric Protoplanetary Disks

MWC 758: First detection of eccentric disk cavity \((\text{Dong+ 2018})\)
\[ e \approx 0.1 \]

Other Eccentric Protoplanetary Disks:
GW Ori \((\text{Bi+ 2020; Kraus+ 2020})\): \[ e \approx 0.21 \]
HD 98800 \((\text{Kennedy+ 2019})\): \[ e \approx 0.03 \]
Eccentric Planets Excite Eccentric Disks

Massive planets carve gaps \Rightarrow \text{Planet orbit and disk eccentric}

(e.g. Kley & Dirksen 2006; Dunhil+ 2013; Farris+ 2014; Duffel & Chiang 2015; Teyssandier & Ogilvie 2017)

Eccentric Disk \Rightarrow Eccentric Planet?

J. J. Zanazzi
Project: Signatures of Eccentric Disks

Project Goals:

Temperature and velocity in eccentric disk

Emission from eccentric protoplanetary disk using RadMC-3D

(Dullemond 2012; Williams & Best 2014)

J. J. Zanazzi
How to Apply

Preferred Coursework:
- Advanced Mechanics
- Thermodynamics

Coding experience
- Python (highly desired)
- Fortran (not necessary)

Application
- Curriculum Vitae
- Transcript
- Cover Letter

Send to jzanazzi@cita.utoronto.ca

J. J. Zanazzi
Undergraduate Laboratory at Berkeley (ULAB) - Physics and Astronomy

Instagram: @ulab.phys.astrowebsite: www.ulab.berkeley.edu
Email: physics@ulab.berkeley.edu

- Introduction to research for students with little-to-no research experience
- 2 unit, 2 semester DeCal
- Learn intro to python, statistics, Latex, how to read papers, how to apply to research
- Conduct research project in group of 5-6 students under an experienced undergraduate mentor
- Students go on to get positions working with faculty after taking ULAB
- Present work at end-of-year symposium
- About half and half physics and astro projects

Previous projects:
- Cosmic Ray Predictions With a Homemade Muon Detector
- Observing and Obtaining a Light Curve from a Potential Transiting Exoplanet
- Measuring Cosmic Distances using Gravitational Waves
- Simulating Scattering Processes in TGFs Using Monte Carlo Methods
- Determining Hubble's Constant From Time Delays in Lensed Quasars
Research projects available in the Moving Universe Lab (PI: Lu)

Project 1: Improve adaptive optics at Keck telescope.

Work with Matthew Freeman, Sean Terry (UCB postdoc)
Research projects available in the Moving Universe Lab (PI: Lu)

Project 2: The Galactic Center

Work with Anna Pusack (UCB grad) and UCLA group
Research projects available in the Moving Universe Lab (PI: Lu)

Project 3: Black Hole Lensing

Gravitational Microlensing by Black Hole

The two microlensed images appear as a single brightened star

Work with Casey Lam, Natasha Abrams (UCB grads)
Research projects available in the Moving Universe Lab (PI: Lu)

**Student Expectations:**
- coding experience is helpful (not required*)… coding curiosity is a must
- Keck AO Upgrades: interest in hands-on work or in instrument simulations
- Star Clusters, Galactic Center: interest in data analysis
- Black Hole Hunt: *only experienced coders, independent workers*

- >= 10 hrs per week minimum to be effective

**Interested?**

- Send your CV/resume and unofficial transcript to jlu.astro@berkeley.edu
- or apply to URAP

- Indicate your project interest/preference

- Talk to me and other members of my group (https://jluastro.atlassian.net/wiki/spaces/MULab/overview)

*Recent undergrads that have worked with me:* Shrihan Agarwal, Ningyuan Xu, Niranjan Bhatia, Eden McEwen, Sam Rose, Ruoyi Yin, Matt Ortiz, Jesus Martinez, Carissa Lewis, Kingsley Ehrich, Ryota Inagaki, Natasha Abrams (Harvard), Theo Pedapolu, Grace Jung, Blake Dreschsler