Research Opportunities for
Physics and Astronomy Master's students

Experimental Physics

Peter Beyersdorf (not currently taking students in 2025). Research interests:

- Development of a nitrogen pumped dye laser
- Development of an optical parametric amplifier for a source for tunable mid IR radiation
- Development augmented reality classroom demonstrations and evaluating their effectiveness

Neil Switz (as of July 2025)
Biophysics/Medical diagnostics. My work involves optical techniques and devices for use in biomedical/diagnostic applications, often for so-called Neglected Tropical Diseases" – i.e. diseases that affect many people in low-income countries. For a sense of this work, and recent projects, see https://blogs.sjsu.edu/switz/ . For publications (including patents; I have significant industry experience), c.f. https://orcid.org/0000-0002-3639-4588 . Students working with me take Physics 120C and Physics 258 at the earliest opportunity for each class (note: Physics 258 is offered this fall, 2025; 120C is planned for Fall 2026) since those courses cover important background material for this sort of work. Types of projects include/have included:

- Fluorescence microscopy for biomedical/diagnostic applications
    - Design of compact, controlled high-power LED-based Kohler epifluorescence excitation and related devices for biomedical applications.
- Computational imaging techniques for resolution- and contrast-enhancement, among other imaging benefits; mainly illumination-based approaches and primarily for biomedical/diagnostic applications
- Analog circuit design:
    - Good undergraduate (and some graduate) projects. Low noise photodetector front ends for fluorescence detection (mainly advanced electronics), fast LED driver design/fabrication, etc.

→ Note: the recent US destruction of USAID and withdrawal from the WHO have dramatically impacted the projects I am engaged in. I am still evaluating how this will impact possible MS projects, but it may well limit them. Separately, projects with me will be mostly theory/calculation-based until after the (now multiply delayed) move of the experimental labs to Duncan Hall.

Chris Smallwood (as of August 2021):

Materials spectroscopy. To get a general idea of ongoing research, please visit my research website at https://smallwoodgroup.wordpress.com and my Google Scholar page. A sampling of projects for which I am actively recruiting is as follows:

- Construction and demonstration of a low-cost quadrature optical Mach-Zehnder interferometer. Seeking one student to develop software code to process imperfectly collected data (computation, experiment)
- Raman spectroscopy of quantum materials. Seeking 1–2 students to assemble a Raman spectrometer and use it to measure the properties of color centers in diamond and/or transition metal dichalcogenides (experiment).
- Fourier-transform optical interferometry. Seeking one student to outfit an optical interferometer with a motorized movable delay stage to use the interferometer to measure (as proof of principle) the coherence lengths of different kinds of optical sources and/or to measure the delay stage's cyclic error (experiment).
- Field-programmable gate array (FPGA) facilitated high-throughput data acquisition and analysis aimed at ultrafast materials spectroscopy. Seeking one student (computation).

Ramen Bahuguna (as of July 2025):

- Explain why one sees rings around traffic lights in the night. Seeking one student.

Astronomy / Astrophysics

Aaron Romanowsky (as of July 2025):

- examples of previous student projects and MS theses: https://www.sjsu.edu/people/aaron.romanowsky/students/index.html
- previous work on ultra-diffuse galaxies:
  - http://keckobservatory.org/df2-df4/
  - http://www.keckobservatory.org/anemic_galaxy/
  - https://www.keckobservatory.org/scientists_discover_massive_galaxy_made_of_99-99_percent_dark_matter/
  - https://iopscience.iop.org/article/10.3847/2515-5172/adee10
- analysis of cutting-edge new data from the Vera C. Rubin Observatory, the Euclid Space Telescope, and the Dark Energy Spectroscopic Instrument
- machine learning to discover or classify galaxies:
  - https://blog.galaxyzoo.org/2015/03/31/new-paper-galaxy-zoo-and-machine-learning/
- globular star clusters, dwarf galaxies, and dark matter in cosmological simulations:
  - http://www.tng-project.org/
- search for wandering supermassive black holes in *Hubble Space Telescope* imaging:

    - https://www.nasa.gov/feature/goddard/2023/hubble-sees-possible-runaway-black-hole-creating-a-trail-of-stars
- discovery or analysis of compact stellar systems (including supermassive black holes):
    - https://noirlab.edu/public/news/noao1503/
    - https://www.keckobservatory.org/fossil_star_clusters_reveal_their_age/
    - https://unews.utah.edu/supermassive-black-holes-found-in-two-tiny-galaxies/
    - http://chandra.si.edu/photo/2016/ngc5128/

Thomas Madura (as of August 2022)

- 3D Printing for astrophysical data visualization and astronomy education for students with blindness/visual impairments

  See e.g.
    - https://www.nasa.gov/content/goddard/astronomers-bring-the-third-dimension-to-a-doomed-stars-outburst
    - http://www.sciencemag.org/news/2015/01/3d-printer-recreates-bizarre-star-system
- Data analysis of surveys/assessments on the effectiveness of 3D prints to teach astronomy to students with blindness/visual impairments and interest them in pursuing an education and/or a career in science, technology, engineering, or math (STEM).
- 3D computational astrophysics - hydrodynamics, radiative transfer theory, mock observations, numerous codes and methods

  See e.g.
  https://science.nasa.gov/science-news/science-at-nasa/2015/05jan_etacarina

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Physics Education Research

Cassandra Paul (as of July 2025):

Physics Education Research (PER). My research relates to the teaching of physics and other science disciplines, and how institutional teaching and learning structures or policies impact student success:

- Researching the impact of undergraduate Learning Assistants in the College of Science (in collaboration with Dr. Gina Quan) (Paid research opportunities here)
- Working to understand student experiences in Physics and other STEM fields at SJSU as they relate to issues of equity and inclusion
- Researching how the changes made to Physics 2a impact student success as measured by fail, drop, withdraw rates in physics 2a, retention in the major and other quantitative metrics
- Investigating methods of assigning course grades (grade scales, partial credit, extra credit, curving etc.) in physics, and their impact on students

Gina Quan (as of July 2025):
Physics Education Research (PER). My research broadly understands the processes of physics teaching and learning, and is embedded in the highly collaborative SJSUPER group. Here are some sample projects:

- Understanding how to support students of color transferring from community college to four-year universities
- Researching the impacts of Learning Assistants on undergraduate teaching (paid opportunities available, in collaboration with Dr. Cassandra Paul)

Brianne Gutmann (as of August 2022):
I do physics education research (PER) and will be working on and/or thinking about:

- A project about how science, policy, society, and ethics are taught in physics classrooms, to determine factors that affect students and faculty in having conversations and reasoning about ethics, science and society. The project could include curriculum development, interviews, and/or video analysis.
- A project about online adaptive learning tools (i.e. adaptive homework) in different contexts; understanding strengths and limitations of the system for different content, skills, and students
- Thinking about: applications of queer theory to STEM education; interested in understanding the experiences of queer students in physics and higher education, as well as how critical theories can be useful in those contexts
- Thinking about: community building and student leadership as ways to build better culture in physics and STEM

Quantum Information Systems / Quantum Foundations

Hilary Hurst (as of August 2025):
Please note that Dr. Hurst is not taking research students until January 2026.
My research group in quantum computing and quantum information is focused on understanding better quantum control pathways. I study how quantum systems interact with noisy, imperfect environments and weak quantum measurement. I have a mix of numerical (i.e. lots of coding) and analytical (math and model-building) projects available theoretically modeling quantum gasses, magnetic materials, and superconducting quantum circuits, which are the building blocks of today's quantum computers. For more information please visit my website: hhurst.github.io. Available research topics are are listed below (most can be tailored to graduate or undergraduate level):

- Quantum measurement and simulation: Weak measurement induced phases in 1d atomic systems and understanding wavefunction collapse in highly entangled systems. Mostly simulation, some analytical work as well. Follow up to this work.
- Quantum computing: Simulation of open quantum systems using quantum computers.
- Quantum gases: Efficient numerical simulation of stochastic Gross-Pitaevskii equations in 1D and 2D
    - numerical methods, high-performance computing, and parallelization
- Quantum gases: Domain formation in spin-½ quantum gases under weak measurement
    - mostly numerical, some analytical. Follow up to this work.
- Quantum gases: Optimized feedback cooling for interacting bosonic atoms using novel signal filtering techniques
    - Mostly numerical, some analytical. Follow up to this work.

Ehsan Khatami (as of May 2024)

- Quantum many-body simulations
    - Check out a recent work by my student Jacob: https://arxiv.org/abs/2101.12721
    - We also collaborate with experimentalists from time to time and do numerical calculations for them. For example, for recent works see arXiv:2310.03267 (quantum dot arrays in Si) and https://arxiv.org/pdf/2308.12269.pdf (fermionic atoms in an optical lattice).
- Machine learning applications in quantum many-body physics

    Here are two early studies my graduate students did in this field:
    - See the popular summary of https://link.aps.org/doi/10.1103/PhysRevX.7.031038
    - and check out https://arxiv.org/abs/1708.03350. Also check out this Physics Girl video.
    - This is an example of a relatively recent work: https://journals.aps.org/prresearch/abstract/10.1103/PhysRevResearch.7.013122
    - And this one is by a graduate student of mine: arXiv:2310.03267
- Numerical methods in condensed matter physics

    Mostly developing or refining algorithms, parallel structuring and high-performance computing
    - Here is one of the main methods I use: https://arxiv.org/abs/1207.3366
    - Here is a study my high school student did a few years ago: https://arxiv.org/abs/1810.06202

Local computational resources: Spartan high-performance computing cluster: http://spartan01.sjsu.edu/ (need to be on SJSU VPN).

Ken Wharton (as of May 2024):

Quantum Foundations. Specifically, trying to better understand what quantum theory is telling us about what nature might be doing when we're not looking.

- Funded(?) Graduate Research Project: Local Weak Values as Hidden Variables in Quantum Gates
- Undergraduate/Graduate projects: 1) Classical-oscillator-based hidden variable models for qubits. 2) Survey of causality and causal-models as used in classical physics (paper for American Journal of Physics)

Theoretical Physics

Curtis Asplund (as of August 2025):
I'm a theoretical physicist. My main research area is in theoretical high energy physics. A couple of things I'm currently interested in are quantities known as entanglement entropy and complexity in quantum systems. These have the potential to help us answer some questions about black holes, but are also interesting in their own right and may help explain phenomena in certain laboratory systems (e.g., ultracold atoms). This year, I am looking to work with both undergraduate and master's students. If you have coding experience (equivalent to a 1 semester course or more) in Mathematica, Python, R or C++, then I have some projects in mind that involve numerical simulations of evolving systems in which we can study the development of complexity and/or entanglement. For students who have taken a quantum mechanics course and who are interested in doing calculations in quantum systems, we can study the dynamics of entanglement and complexity in some models, and possibly also work on developing the theory of these quantities. I am also organizing a directed reading/independent study of quantum field theory in Fall 2025. Please contact me if interested in this.

Other scholarly interests:
I'm a member of the The Physicists Coalition for Nuclear Threat Reduction, which "works to reduce the threats from nuclear weapons by mobilizing advocacy within the physical sciences communities in the United States and internationally." If you'd be interested in a research project related to nuclear weapons policy, please let me know.

Kassahun Betre (as of August 2023):
I am broadly interested in quantum gravity; the attempt to merge Einstein's geometric description of spacetime with the quantum mechanical view of microscopic objects. In particular, I am interested in approaches in which geometric description of spacetime emerges from quantum systems described without any reference to background space (called background independent quantum systems). Classically, we think of spacetime as an infinitely divisible continuum. But efforts to merge Einstein's General theory of Relativity with Quantum Mechanics indicate that this is only a large-scale property that ceases to be the case if one zooms in below the Planck length – similar to the way that water appears to us as a continuum but if we look at it at the molecular level it becomes granular. How should we model spacetime at the

sub-Planckian length scale? I study ways in which both the description and the dynamics of spacetime can be modeled using discrete combinatorial objects such as graphs and simplicial complexes combined with statistical mechanics. There are three aspects to this approach:

- Mathematics -- What are the appropriate discrete structures and what are the properties which translate to the geometric notions of dimension, length area, volume, curvature, etc at the macroscopic scale? Also, what are algebraic characterizations of combinatorial objects such as simple graphs and simplicial complexes?
- Physics -- What is the mechanism by which a discretized geometric space can emerge from combinatorial microscopic systems? Here, we rely on statistical mechanics and condensed matter approaches.
- Simulation -- Since exact solutions cannot be worked out, we use Monte-Carlo simulations to study the low energy states of the models.

Students interested in working with me can participate in any one of the above three areas depending on their interests. I am taking new masters and undergraduate students in the Fall of 2023.

In addition to my own research interest, we have a growing and thriving High Energy Physics program at SJSU which includes myself, Dr. Asplund, and masters and undergraduate students. We have recently been awarded funding by the Department of Energy to establish a traineeship program in High Energy Physics in which up to 3 trainees each year will get the opportunity to do cutting edge, full-time paid summer research at SLAC National Laboratory. Students interested in pursuing a career or PhD in High Energy Physics and want to participate in the traineeship program should contact me or Dr. Asplund.