Message from the Chair

I am very happy to introduce you to the University at Albany Physics Department. The Department is extremely active in research, undergraduate education, and graduate education. This document gives us the opportunity to present a selection of activities in which our students and faculty take part. In recent years, we have added seven new faculty to the department. These new faculty bring expertise in diverse areas of Physics, as well as innovative approaches to undergraduate education.

Training of students, both undergraduate and graduate, is a very important part of the Department’s mission. We continue our annual PASCAL (Physics All Student Conference at ALbany) conference which provides opportunities for faculty to present an overview of their research group’s focus, and students to present short talks and posters on their research projects.

We deeply appreciate friends and alumni who have supported the Department, and I look forward to the pleasant task of updating you as new activities and discoveries unfold.

http://www.albany.edu/physics/index.shtml
https://www.facebook.com/ualbanypysics/
Undergraduate Studies:

The UAlbany Physics Department gives high priority to undergraduate education. The objective of the department is to provide students a solid foundation in both classical and modern physics. Along with courses in classical mechanics, electromagnetic theory, atomic and nuclear physics, and thermal physics, students learn modern experimental techniques, principles of quantum mechanics, and applications. Elective courses in physics and in other sciences, independent study and research with faculty members in the active research fields of the department are encouraged. Our faculty is active in research, and a variety of research opportunities exist for motivated undergraduate students. In addition to the honors program, several of our talented and motivated undergraduates have been awarded summer research fellowships at NASA (National Aeronautics and Space Administration) and NIST (National Institute of Standards and Technology).

Careers
Graduates holding the bachelor's degree in physics find employment as laboratory or theoretical research assistants in physics or engineering, high-level medical technicians, science writers and editors, computer programmers, and secondary school teachers. A bachelor's degree in physics can be an ideal background for advanced study in other sciences, engineering, and the business and medical professions. A graduate degree in physics opens a broad spectrum of opportunities in pure and applied research in academia and industry.

Special Programs
For students interested in engineering, there are available 3-2 programs with engineering colleges including Clarkson University and Rensselaer Polytechnic Institute. Students in these programs spend their first three years at this campus and the last two at the other. The tuition is at the University at Albany rate for the first three years only. Transfer into the other institution is not guaranteed and requires a minimum 3.2 grade point average. Upon successful completion of the programs, students are awarded a B.S. in Physics from the University at Albany and a B.S. in Engineering from the other institution.

Graduate Studies:

Graduate education in physics at UAlbany offers students a wide variety of research opportunities both in experimental and theoretical physics. As a part of their training, graduate students participate in research, take a wide variety of courses, and gain experience in teaching physics. All alumni of our graduate program have successful careers in academia or in industry. Prospective students are encouraged to visit the webpage describing the procedure for admission and to contact potential advisors.
Physics @ UAlbany: Introducing our faculty

The physics department consists of 17 faculty members, 2 postdocs, 44 PhD students, 9 MSc students and 130 undergraduates. We graduate about 20 BS students per year (out of 2500 in the US) and 5 PhD students (out of about 1000 nationally). In the past 3 years, 100% of our doctoral students placed in research post doctoral positions or permanent industrial jobs before graduating.

Associate Professor **Keith Earle** is the current chair of the department. His research is primarily in electron paramagnetic resonance. When he’s not too busy with administrative issues and research, he plays the bag pipes!

Assoc. Professor **Kevin Knuth** is the current associate chair of the department. His research is primarily on exoplanets and bayesian data analysis. He is also in charge of our observatory. On his free time he restores ancient Greek and Roman coins and is building his own R2D2 astromech droid!

Assoc. Professor **Jesse Ernst**’s research is primarily in particle physics. He currently has one PhD student finishing on ATLAS, and one working on LUX. In his free time he plays drums in a blues band.

Assoc. Professor **Philip Goyal**’s primary research area is information physics. He is particularly concerned with exploring how the concept of information can illuminate the foundations of quantum theory. In his spare time, he plays piano and enjoys pondering the physical basis of musical sound…

Professor **Ariel Caticha** is the former chair of the department. His research is primarily in information physics.

Asst. Professor **Herbert Fotso**’s research is in theoretical condensed matter.

Asst. Professor **Vivek Jain**’s research interest is in the field of experimental particle physics. He is currently on the ATLAS experiment at the Large Hadron Collider, where he is focussing on the properties of the Higgs boson. In his career, he has investigated the properties of all six quarks, and four of the six leptons!
Professor T.S. Kuan’s research is in solid-state physics and electron microscopy, currently focused on mechanical and transport properties of nm-thick films and superlattices. Besides physics, he enjoys playing the piano and reading.

Asst. Professor Alex Khmaladze’s research is in biological imaging and spectroscopy.

Professor Bill Lanford is in charge of the 4MV ion beam accelerator. He uses it to do research in solid state physics.

Asst. Professor Cecilia Levy is the newest faculty member of the department. Her research is primarily in experimental astro-particle physics in the quest for dark matter. On her free time she restores her 200 year old house, crochets and plays with her Newfoundland dogs.

Assoc. Professor Oleg Lunin is a string theorist working on studying duality between quantum gravity and strong interactions with a particular emphasis on applications to physics of black holes.

Professor Carolyn MacDonald is the director of the X-ray institute. Her research is in medical imaging. She is the author of a new textbook “An introduction to X-Ray Physics, Optics and Applications”. She enjoys kayaking with her dogs in the summer and hibernating in the winter.

Asst. Professor Jonathan Petruccelli’s research interests are computational imaging with both visible light and x-rays and efficient modeling of light propagation. He is an avid runner who can often be found on the 5K loop around campus when taking a break from research and teaching.

Asst. Professor Daniel Robbins’ research focuses on theoretical particle physics, string theory, and supersymmetry. He is interested in exploring the space of consistent possible theories, and relationships between physics and geometry.

Asst. Professor Matthew Szgydagis’ research is in experimental astro-particle physics searching for dark matter with the LUX and LZ experiments. He is the faculty advisor to our local Society of Physics Students. He is a huge Star Trek fan.

Visiting Asst. Professor Anna Sharikova’s research is in biological imaging and spectroscopy.
UAlbany string theory group consists of two faculty members, Prof. Lunin and Robbins, and five graduate students. The group pursues two main research directions:

- Establishing connections between string theory, field theories, and geometry,
- Using strings to understand black holes and strong interactions.

All three MSc and PhD alumni of the group have successful careers in scientific computing and software development, and former undergraduate students are enrolled in graduate programs at institutions like University of Illinois at Urbana-Champaign.

String Theory

What is it for?

- Constructing a quantum theory of gravity and unifying the four fundamental forces
- Analytical understanding of the strong interaction
- Getting insights into strongly coupled systems, e.g. superconductors

Condensed Matter Physics

Strongly Correlated Systems

- Encompasses some of the most technologically promising materials of our time: high temperature superconductors, heavy fermions, colossal magnetoresistive materials etc…
- Described by simple model Hamiltonians that are not amenable to solutions using standard approximations.

Because of the exponential growth of the problem with the system size, innovative methods and algorithms are essential if we are to go beyond our current understanding. Prof. Fotso’s research group develops algorithms and computer codes to study these systems in and out of equilibrium.

Quantum Information Processing and Quantum Optics

- Quantum computers, the computing paradigm of the future, will rely on controllable spin systems.
- Candidate systems that fulfill the required conditions are quantum emitters in the solid state which are susceptible to unwanted fluctuations in their environment.

Prof. Fotso’s group studies the control of these systems and the conversion of stationary-to-flying qubits that is essential for quantum networks and quantum communication.
Foundations of Inference

Foundations of inference is concerned with the mathematical tools that formalize the process of making reasonable inferences from limited information. Previous work includes improved formal derivations of probability theory (Knuth; Caticha) and its relation to the principle of maximum entropy (Caticha); and application of maximum entropy to experimental data analysis (Earle). Current work includes the investigation of different ways of quantifying information in probabilistic experiments (Goyal).

Information Physics

Information Physics is focused on the role that information plays in our understanding of the physical world. Profs. Caticha, Goyal and Knuth explore the extent to which the laws of physics (quantum mechanics, space-time physics) might reflect the rules processing information—the broad goal is to explore the extent to which the laws of nature can be derived from informational principles.

Foundations of Quantum Theory

Foundations of quantum theory aims to explore the counter-intuitive features of quantum theory (such as non-locality), and, more generally, to unravel its implications for our conception of physical reality.

A major part of our recent work is to derive the mathematics of quantum theory from a set of physical principles. Three distinct approaches, due respectively to Caticha; to Goyal; and to Goyal & Knuth, show how informational principles lead to quantum theory. These derivations draw upon our parallel work in the foundations of inference and information theory, and provide numerous important insights into the nature of the quantum. Other ongoing work includes investigation of identical quantum particles (Goyal), derivation of the Schroedinger equation (Caticha; Goyal), investigation of the Dirac equation (Goyal; Knuth), and identification of informationally-optimal quantum measurements (Goyal).

Currently, several doctoral students work on this topic (with Caticha and Goyal), with many previous students going on to positions in academia and industry.
**Physics @ UAlbany : Research - Experiment**

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**Optics**

**Experimental Optics and Computational Imaging**

What is it?

- Applications-driven research focused on studying the properties of matter with light and x-rays.
- Includes the simulation and design of optical systems, data acquisition and data processing.
- Applications include biological imaging, medical imaging, chemistry and nondestructive inspection.

With four active members, Profs. MacDonald (x-ray optics), Petruchelli (computational imaging), Khmaladze and Sharikova (digital holography and Raman spectroscopy), specializing in different aspects of experimental optics, this is a very active field in the department. There are currently 6 graduate students and 6 undergraduates working Experimental Optics in the department. Current problems of interest include measuring cell volume to answer important biological questions, improving the diagnostic capability of mammography and the development of new imaging methodologies. Students graduating with experience in experimental or computational optics have gone on to successful careers in industry as well as academia.

**Optical modeling and simulation**

What is it?

- The development of various techniques to computationally model and simulate the behavior of light.

Professors MacDonald, Petruchelli and Fotso share an interest in optical modeling and simulation. Prof. MacDonald develops simulations of x-ray optics to aid in the design of x-ray systems, primarily for medical applications. Prof. Petruchelli is interested in tools to model the wave mechanics of light propagation more efficiently by taking advantage of the simplicity of ray tracing. Prof. Fotso is interested in the interaction of light and matter at the atomic level to study quantum information processing. There are currently 1 postdoc, 2 graduate students and 1 undergraduate student working in these areas. Students specializing in optical modeling and simulation have gone on to jobs in academia and industry.
Physics @ UAlbany: Research - Experiment (cont.)

Particle Physics

Astro-particle physics

What is it?

- Looks for new, undiscovered elementary particles of astronomical origin, such as dark matter
- Mix between particle physics, astronomy, astrophysics, cosmology, solid state physics and detector physics

The focus of Profs. Szydagis and Levy’s research groups is the search for dark matter, which is thought to make up 25% of the universe. Their research consist of simulations and data analysis for the LUX and LZ experiments, and in-situ detector development for the next generation of dark matter detectors. This versatile research gives both undergraduate and graduate students all the tools necessary for a successful career in academia or in industry. The group currently consists of one PhD student and 3 undergraduates, and is expected to double in size by the end of the year. Prof. Szydagis’ two former postdocs have now moved on. One went to industry and works in Silicon Valley, while the other continued in academia and is now an assistant professor.

High Energy Physics

Prof. Jain is the department’s tie to the Large Hadron Collider. He works on the ATLAS experiment which, alongside CMS, discovered the Higgs boson is 2012. His research group studies the coupling of the Higgs boson to third generation quarks ($b$, $t$) to understand whether the Higgs sector matches the predictions of the Standard Model, or whether it is part of a more complicated sector, as predicted by many proposed extensions to the SM. He also works on track and vertex reconstruction algorithms for the new inner tracker, which is being planned for the Phase-2 upgrade in 2024–2026. His graduate students have the opportunity to go to the LHC in Switzerland and give talks at international conferences.

Prof. Ernst links astro-particle and high energy physics by currently working with an ATLAS and a LUX PhD student to understand how the combination of information theory and machine learning can be used to improve measurement sensitivity on both ATLAS and LUX.
Exoplanets

Prof. Knuth’s research group is focused on carefully modeling photometric phenomena, such as reflected and refracted light, thermal emissions, and relativistic effects, such as Doppler beaming. Their models are carefully tested on real exoplanets using data from the Kepler Space Telescope. By employing Bayesian model testing they can select the most probable models based on the data, which leads to a better understanding of the physics of exoplanets. The group consists of two graduate and one undergraduate students, and has graduated one PhD student and three MSc students.

Biophysics

Electron paramagnetic resonance is used to study the structure and dynamics of a wide range of materials and systems, for example, it is used to assess water penetration in cell membranes.

Prof. Earle’s research group develops high field EPR instruments to study structure and dynamics. The sensitivity of high field EPR to small changes in local environment can be used to probe subtle changes in the electrochemical environment of a spin label. He also develops modern line shape analysis methods for further insights, making both theory and experiment important components of his work. His former students have all had success both in industry and academia.

Material Physics

The major theme of Prof. Kuan's research program is to study the structure and behavior of solids with a few layers of atoms (thin films). His group is interested in the wetting, morphology, viscous flow, strain relaxation, carrier localization, and scattering at surface and interface of the layer. His former students have moved on to prestigious institutions like MIT and BNL, or are working for renowned companies like Intel.

Prof. Lanford's research harnesses the 4MV ion beam accelerator located on the Albany campus, which offers unique capabilities for material physics.
Postdoctoral Fellows

Laila Hassan (Prof. MacDonald's group):
Our group has been developing a novel x-ray imaging technique which could greatly improve discrimination for early breast cancer detection and differentiates between materials for security scanning and rapid non-destructive analysis. I have developed an efficient Matlab code to model the system, including absorption, scattering and diffraction interactions to test a wide range of applications. Recently we started collaborating with Medical Physics Department at Cork University Hospital in Ireland to identify the material composition of metallic implants in a clinical setting. Working as a post doc in UAlbany is a great opportunity since it provides me with all the necessary resources needed for research. Also, living here in the capital region is a plus for my family. It has numerous family activities and entertainments.

Graduate Students

Stewart Swift (Prof. Jain's group):
I work in the ATLAS Collaboration on location at CERN. The physics I'm investigating is centered around the measurement of the top-yukawa coupling by direct searches. I'm working to provide a differential cross-section measurement of tt+bb, which will improve our ability to tune Monte Carlo and constrain the irreducible tt+bb background which effects ttH (H->bb). We want to measure this coupling directly with ttH to remove any loops. If the coupling deviates from the standard model it could provide insight into what is beyond the standard model. I'm also involved in the phase-2 upgrade of the ATLAS inner tracker. The work initially involved investigating the robustness of the inner tracker. I have since moved on to developing a new dedicated algorithm to reconstruct photon conversions. I've found that the department is effective in cultivating an environment that is conducive to productivity and success. Feedback I've received from faculty relating to my work has been invaluable.
I have lived in France for nearly a year. This has allowed me to work closely with ATLAS experts (of which there are many). I've also been able to attend workshops as well as a conference in Crete. Visiting Crete, which is a beautiful island with interesting culture, is definitely one of my favorite perks.
Pedro Pessoa (Prof. Caticha’s group):
I chose UAlbany for my PhD because I was really interested in the research in entropy, information and statistical physics held here, and I have found a superb environment to keep up with my studies.

Now, my research is focused on the role of entropy in renormalization - a set of techniques which find application in many fields of Physics, such as critical phenomena and quantum field theory. This summer, I presented my most recent paper on an international conference held in São Paulo, Brazil.

Jennifer Carter (Prof. Knuth’s group):
I am researching exoplanet characterization using Bayesian data analysis techniques including Nested Sampling. Currently, I am focused on refining the model used to characterize the reflected light of an exoplanet. This refinement will take into account the finite angular size of a host star and is useful for extremely close-in exoplanets for which the standard Lambertian model is not a sufficient approximation.

While at UAlbany I have enjoyed teaching a variety of courses and attending four conferences, including the 2014 and 2016 sessions of the Sagan Exoplanet Summer Workshop. For the 2017 New York Celebration of Women in Computing (NYCWiC) conference I had the pleasure of working with two undergrads to produce a poster. In my spare time, I enjoy brewing beer and playing a variety of video games with my boyfriend. We also enjoy playing hide and seek with our cat, Boo, and running outside with our four dogs.
Undergraduate Students

Collin Wilson (Prof. Szydagis’s group):
I spent the past summer trying to create a superheated (heated to above 100 degrees Celsius at atmospheric pressure) water device capable of detecting radiation, by rapidly bubbling when the radiation interacts with the water molecules. By filtering out background radiation, a system similar to the one I attempted to build could be applied towards detecting dark matter, as any particle passing through it with enough energy should interact with the water enough to trigger spontaneous bubbling. I was unfortunately unable to build a system that demonstrated statistically significant radioactive sensitivity, although I am hopeful that I have narrowed down the potentially successful system setup enough that my successors may have an easier path towards success. As a part of my research, I had the opportunity to attend a workshop at MIT that hosted talks and presentations from several prestigious experimentalists, including Professor Szydagis, who gave a talk on my research as well as the research of another student. Entering the event, I was very afraid that my lack of results and the relative simplicity of my research would feel out of place at a workshop hosted by such an esteemed university, but Professor Szydagis’ presentation did not seem at all out of place and was actually very well received by the conference attendees. My experience at this workshop helped me realize that you don’t need to be some otherworldly genius in order to belong in physics, and that a career in physics is actually quite accessible as long as you have a passion for it and are willing to put in the requisite work.

Chris Li (Prof. Jain’s group):
Between January and August of 2017, I conducted research with Professor Jain, who is a member of the ATLAS Collaboration, and Professor Petruccelli, who does research in optics. I enjoyed applying, for the first time, what I learned in class to a real-life problem—a problem which didn’t have an answer in the back of a textbook but rather, one which no one had solved yet. I was able to give a talk about my research at the Physics Department conference, PASCAL, and presented a poster at the university-wide conference for undergraduate research. After finishing that project, I became a member of Professor Petruccelli’s lab, and now work on lab-related projects in optimization.
Lecturers

Dr. Robert Schmitz  
Physics instructor and undergraduate lab coordinator. He has an unusually large collection of video games!

Dr. Shamshad Ahmad

Dr. Eric Woods

Administrative & Technical

David Liguori, Support Technician
David is involved with all things technical in the department including undergraduate and research lab equipment, computer software, computer hardware and a/v presentation systems. He enjoys working with students. In his own words: “jack of all trades, master of none”.

Ben Rekemeyer, Administrative Manager
I have been with the UAlbany since 2012 working as a Graduate Assistant, Resident Director, and Apartment Coordinator with Residential Life. I have a Bachelor’s Degree in Business Administration from SUNY Cobleskill and a Master’s Degree in Education Administration and Policy Studies from UAlbany. In an effort to broaden my skill set I made the switch from Student Affairs to the Physics Department in August of 2017. I’m a huge professional wrestling fan and have been to five Wrestlemanias, traveling all over the country to places such as Miami, New Orleans, NYC, Orlando, Philly, Dallas, and San Antonio to see live shows.

Paul Labate, Office Assistant:
Paul is the go to person for students that have any questions relating to the department. Paul is very knowledgeable about the Physics curriculum and is always happy to guide students to exactly where they need to go. Every week he makes sure that everything is set up for our department’s guest speakers, helps faculty members adjust courses as needed, and helps students make sure they get into all of the right classes. If you’re ever walking through the Physics building and have some extra time on your hands make sure to stop in and say hi.