Department of Physics: Possible USRA Projects for Summer 2020

1 Computational Astrophysics of Transients and Compact Objects

My overall research direction aims at understanding the properties of astrophysical transients (supernovae, neutron star mergers, etc.) and their progenitor systems through numerical simulations. Selected students will carry out a mix of coding, analytic calculations, and data analysis depending on the details of the project and skill level. Good performance in ASTRO 320 (Stellar Astrophysics I), PHYS 234 (Intro Computational Physics) and PHYS 310/311 (Thermodynamics & Statistical Physics) will be helpful.

Contact
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2 Spin Mechanics

Join a small team building and commissioning a 'mini-LIGO' Fabry-Perot Michelson cavity interferometer, designed in this case to open a new window on magnetic resonance by detecting the miniscule mechanical (yes, mechanical!) disturbances that arise when spins flip inside a material.

The LIGO designers did such a good job in crushing the state-of-the-art for sensitive optical interferometry to detect gravitational radiation, that their technology is now enabling applications to other domains of physics and fostering a new growth industry of smaller-scale and lower-cost experiments in fundamental physics. This USRA position is an opportunity for hands-on exposure to an emerging thread of 21st century research.

Contact
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3 X-ray and/or optical/infrared observations of X-ray binaries

We have obtained a Legacy Survey using the NuSTAR X-ray telescope to observe 25 magnetic cataclysmic variables. Cataclysmic variables are binary stars where one is a white dwarf, the other a normal star; in these systems, the stars are close enough that material is pulled from the normal star to fall (accrete) onto the white dwarf. In magnetic cataclysmic variables, the white dwarf has a powerful magnetic field that channels the infalling matter to land on the magnetic poles of the white dwarf. We will obtain excellent X-ray spectral and timing information on these targets. The principal goal of the observations is to estimate the mass of the white dwarf in each system (a project led by the postdoctoral fellow Dr. Shaw), but there is a rich variety of additional information that can be obtained from the X-ray data, on the reflection of X-rays from the white dwarf surface, the obscuration of the X-rays by curtains of infalling material, and the shape of the emission beam. The student would explore this rich dataset, conduct spectral and timing analyses, and hopefully publish their results.

Contact
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4 Search for black holes and string states with the Large Hadron Collider at the CERN Laboratory in Geneva

The student will be part of the ATLAS group in the Centre for Particle Physics at the University of Alberta. The group consists of two professors, two postdoctoral fellows, three graduate students and an estimated three summer students. Our group is helping to analyze data recorded by the ATLAS experiment at the Large Hadron Collider near Geneva. My group is studying the possibility of the experiment being sensitive to higher-dimensional space beyond our common three dimensions. String theory is one possible theory that requires higher-dimensional space. For many years, string theory has guided the direction of the "theory of everything". One drawback is that it is extremely difficult to find a unique prediction of the theory that can be testable in current or future experiments. Low-scale gravity and string models based on intersecting D-branes have recently allowed a connection to be made between the theory and experiment. The student will develop the phenomenology of this theory in the context of the ATLAS experiment at the Large Hadron Collider by searching for black holes and highly-excited string states.

The student will perform the computer simulations, analyze and plot data, and present the results. She/he will also document the project and describe the significance of the results. In particular, the student will create an algorithm for searching for evidence of black holes and highly-excited string states at the Large Hadron Collider.

Contact
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5 The Dynamic Radio Universe

We are entering the era of time-domain astronomy, where repeated observations of the sky reveal the dynamic Universe are performed at many different parts of the electromagnetic spectrum. We already expect to find exciting sources like the cataclysmic ends of massive stars (supernovae and gamma-ray bursts) and transient emission from neutron star and stellar-mass black holes that steal (accrete) material from a nearby star (X-ray binaries). However, we will undoubtedly reveal unknown sources (perhaps the electromagnetic counterparts to the sources of detectable gravitational waves and astrophysical neutrinos). The Very Large Array All Sky-Survey (VLASS) is an exciting survey being performed at radio wavelengths that will be made over several years, stitching together a relatively deep image of the entire sky visible from New Mexico, where the radio array is located. Three passes will be made providing information about transients. By the summer of 2020, VLASS will have started the second of its three passes. Together, we will use data from the first epoch and incoming data from the second epoch to identify and classify transient radio sources.

Contact
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