Crackling Noise in Blade Springs
Vanessa Acon
Mentors: Rana Adhikari, Tara Chalermsongsak, Alastair Heptonstall, Mingyuan Huang, and Seiji Kawamura

Crackling noise arises in various physical systems, implying a nonlinear conversion of energy from slow changing external conditions into discrete 'crackling' events at higher frequencies. The mirrors in Advanced LIGO are suspended with a series of blade springs and mechanical flexures. At the sensitivity levels of Advanced LIGO, we are concerned with any noise in that suspension system, in this case with crackling noise in the blade springs. Our goal is to measure and characterize this crackling noise and determine its relevance to LIGO measurements. To do so, we construct a low-noise table-top Michelson interferometer with blade springs such that when they are driven in unison, any change in the output signal will be due to crackling. In order to extract a crackling signal on the order of the sensitivity of LIGO itself, we demodulate the signal using a "chopping" technique. Currently we have measured characteristic values for the blade springs, designed the low-noise Michelson apparatus, designed and simulated the chopping technique, and calculated an initial noise budget for the experiment. Subsequent work will be to continue to improve the low-noise design, complete the low-noise apparatus assembly, and collect crackling noise data. We can then derive the characteristic coefficients telling us the relationship between crackling and driving force, and compare our data with the current LIGO noise budget to see if crackling will pose a significant source of noise for LIGO measurements.

Gravitational Radiation From Compact Binaries in the Massive Brans-Dicke Theory of Gravity
Justin A. Alsing
Mentors: Emanuele Berti and Yanbei Chen

Most high-energy physics extensions to General Relativity predict the existence of scalar fields. For this reason, the investigation of gravitational radiation in scalar-tensor theories may provide important insights into high-energy modifications of Einstein's theory.

We have computed the scalar and tensor contributions to the gravitational radiation from compact binary systems in the massive Brans-Dicke theory, and used recent observations of radiation damping in mixed binary systems to put stringent bounds on the parameters of the theory. The calculation divides neatly into four sections; the field equations of the massive Brans-Dicke theory are obtained, and linearized in the weak-field limit. Post-Newtonian expressions for the scalar and tensor fields are then derived from the resulting field equations. Using these results, the post-Newtonian equations of motion and the periastron shift of compact binaries are derived. The scalar and tensor gravitational waveforms are then obtained by solving the linearized field equations, and using these results together with those obtained in previous stages of the calculation we have derived an expression for the gravitational radiation damping of compact binary systems. Finally, with the result for the radiation damping in hand, we have used recent observations of radiation damping in mixed binary systems to put tight bounds on the parameters of the theory.

Study of Fundamental Quantum Noise in Advanced Gravitational-Wave Detectors
Anthony Bartolotta
Mentors: Yanbei Chen and Haixing Miao

Gravitational waves are weak phenomena; therefore, the effectiveness of laser interferometer gravitational wave detectors is very susceptible to noises present in the system. The ultimate limit on the effectiveness of the detector is noise produced by quantum effects. There are two primary sources of this quantum noise, the shot noise and the radiation pressure noise. Shot noise is decreased as the laser power is increased; however, this increases the radiation pressure noise. As such, these two sources of quantum noise, if not correlated, result in the Standard Quantum Limit. Advanced gravitational-wave detector schemes are designed to surpass the Standard Quantum Limit at their most sensitive detection band; of these proposed configurations, we have been considering the local readout scheme. The local readout scheme operates by measuring the local motion of the test mass with an auxiliary carrier light. The investigation of this scheme began with an analysis of Fabry-Perot cavities. This was expanded upon with an analysis of coupled Fabry-Perot cavities. This analysis was done by determining the transfer functions of each component and using MatLab to numerically determine the total transfer function. This provided the framework for analyzing the local readout detection scheme.

Real-Time Decision-Making for Gravitational Wave Detection
Christopher M. Biwer with Nick Fotopolous, Larry Price, and Leo Singer
Mentors: Alan Weinstein and Roy Williams

We have designed a real-time coincidence detector, a program that searches notifications of recent astrophysical observations for coincident events, that can be connected to the LIGO low-latency pipeline. The principle objectives were to determine time, and spatial models for gamma-ray bursts, and then implement methods to identify these coincidences in real-time using the existing advanced LIGO prototype infrastructure. The primary functions of the coincidence detector are to query remote databases, decide if any coincidences exist, and publish notifications; a modular design was implemented to allow easy manipulation, and addition of new models. Time coincidences are found by searching time windows that encompass the range of expected time delays between different messengers. Coincidences in space are determined by computing the likelihood ratio statistic for shared areas of the sky. Subsequent analysis of trial runs, and injected coincidences were conducted to evaluate performance.

Properties of Neutron Stars, Their Pulsational Modes, and Gravitational Wave Emission
Iryna Butsky
Mentors: Christian Ott and Jeff Kaplan

In this project, we investigate the different proposed equations of state (EOS) for neutron stars. We create mass - radius plots of the different EOS, along with constraints to find if any are inconsistent with theory or observation. Using the Spectral Einstein Code (SpEC), we evolve a spherical neutron star model to observe the oscillations in central density. Performing a Fourier transform on these oscillations allows us to extract the pulsational frequencies which are perturbed with a quadrupole perturbation. The theoretical f-mode frequencies are then obtained using perturbation theory.

Ultra-Stable Fabry-Perot Cavities for Coating Thermal Noise Characterization
Raphael Cervantes
Mentors: Frank Seifert, Rana Adhikari, and Tara Chalemsongsak

The performance of high-precision optical interferometric experiments is compromised by many noise sources. One of these noise sources is the coating thermal noise. The characterization of the coating thermal noise limit in various coatings could be used to verify the current theoretical model and to help minimize it for future experiments. Currently, the reference cavity noise experiment aims to use a small table-top setup with a fast turn around for measuring the coating thermal noise. The experiment consists locking a laser to a reference Fabry-Perot cavity using Pound-Drever-Hall locking. The same laser is sent to another cavity and the difference in frequencies between the output beams is measured, and thus the length fluctuations of the cavity are characterized. Although there are other noise sources, they will be minimized so that the coating thermal noise is dominant in the frequency region of interest. Cavity mirrors with different coatings can then be tested to characterize the fluctuations caused by various coating materials and/or designs.

Third-Generation Gravitational Wave Detector Placement
Michael Coughlin
Mentor: Jan Harms

One of the most immediate challenges associated with third-generation gravitational wave detectors is to select site candidates. There are numerous factors that must be taken into consideration, including surface topography, seismicity, population density and many more. The project analyzes a number of US-wide data sets, including seismic, wind, topography, and geology, as well as seismic data from around the world. The combination of these data sets indicates the suitability of possible site locations. Other analyses with the seismic data include tracking seismic noise levels at various frequencies over large periods of time as well as microseismic peak correlation in various locations.

Probing Strong-Field Gravity: Constraining the Number of Gravitational Wave Polarizations
Bryant Garcia
Mentors: Larry Price and Stephen Privitera

General Relativity predicts only two tensorial gravitational wave polarizations. More general theories, however, contain up to six independent polarizations. Observations of these four non-tensorial polarizations could severely constrain alternative theories of gravity and provide a unique strong-field test for GR. As the 2^{nd} generation gravitational wave detectors, advanced LIGO and VIRGO, come online, we expect to begin compiling a list of known GW signals. We present a model selection analysis for constraining the number polarizations present in the gravitational field. We investigate the possibility of detecting these alternate polarizations using the next generation of gravitational wave detectors.

Investigation of Noise in Photodiodes Meant for a Gravitational Wave Interferometer
Matthew S. Gilmer
Mentors: Valery Frolov and Chris Guido

This research focuses on the isolation of excess noise in photodiodes from other noise sources through noise cancellation techniques. The noise spectra from two photodiodes were simultaneously monitored; a beam splitter facilitated the investigation by allowing the same laser source to be incident on the two detectors at once. The research includes the use of a feedback system and several other noise reduction techniques. These were performed for many different photodiodes. The experiment was done in a clean room, the Optics Lab at the LIGO Livingston Observatory. Data was taken and analyzed in the context of the 4km Gravitational Wave Interferometer to be used in the upcoming project, Advanced LIGO.

Spin Effects in the Gravitational-Wave Memory for Quasi-Circular Inspiralling Compact Objects
Xinyi Guo
Mentors: Marc Favata and Yanbei Chen

The gravitational-wave memory effect is a time-varying but non-oscillatory contribution to the gravitational-wave amplitude. When a gravitational-wave with memory passes through an ideal detector, it will cause a permanent displacement of the test masses. The nonlinear form of the memory arises from the gravitational waves produced by previously emitted gravitational waves, and is present in virtually all gravitational-wave sources. It is also known to affect the gravitational-waveform at leading order despite the fact that it originates from higher-order interactions. Thus understanding the memory is important for building our accurate knowledge of the gravitational-waveforms in order to probe the nonlinearity of general relativity. Previous calculations of the memory have only considered non-spinning binaries. However, most compact binaries have spinning components; these spins will significantly modulate the gravitational-wave amplitude and phase. We studied the effect on the memory from the spin-orbit interaction and calculated the corrections to the memory waveform through 1.5 post-Newtonian (PN) order. We found that the spin correction starts to enter at 1PN order and can contribute a ~20% correction to the memory.

Measuring the Vibration Isolation of the Suspended Tip-Tilt Mirrors in the LIGO 40m Prototype
Nicole L. Ing
Mentors: Koji Arai, Rana Adhikari, and Jameson Graef Rollins

The Tip-Tilt (TT) mirrors are used in the LIGO 40m prototype to geometrically fold the power recycling cavities. We will evaluate the effectiveness of the Tip-Tilt suspension in reducing vibration isolation by injecting horizontal and vertical motion and measuring the relative displacement between the mirror and the suspension frame. Since current plans for Advanced LIGO include the use of a similar type of Tip-Tilt suspensions, our evaluation of will be useful for the Advanced LIGO design.

Advanced LIGO Output Mode Cleaner Piezo Actuator Noise
Brian J. Koopman
Mentors: Valera Frolov and Ryan DeRosa

The Laser Interferometer Gravitational Wave Observatory (LIGO) in Livingston, Louisiana was built with the intention of one day detecting gravitational waves caused by cosmological events such as binary inspiral and supernovae. The interferometer is a 4km long Fabry-Perot Michelson interferometer. The readout of the interferometer is located in the Output Mode Cleaner (OMC), within which a piezo actuator is attached to one of the mirrors. The piezo actuator can introduce a new source of noise to the interferometer readout, a noise that we currently know little about. By utilizing a small Michelson interferometer with two piezo actuators, one in each arm, this source of noise can be studied.
By driving the two piezo actuators in common mode, keeping the differential arm length the same, a peak in the amplitude spectral density can be created at 1Hz. This creates harmonic peaks at higher frequencies. When the 1 Hz peak is suppressed by locking signal the harmonics remain, demonstrating a phenomenon known as up conversion. Understanding this upconversion will lead to understanding how much noise the piezo actuators present in the differential arm (DARM) readout.

Testing General Relativity Using Gravitational Waves From Spinning Neutron Stars
Christina Lee
Mentor: Alan Weinstein

The direct detection of a gravitational wave with the Advanced LIGO detectors provides the opportunity to measure departures from General Relativity. These departures can arise in the speed of the gravitational wave, existence of alternate polarizations, and parity violation. To measure these, I simulated a single detector measurement of a continuous gravitational wave from a well defined pulsar source, for example the Crab pulsar, due to an asymmetry in the moment of inertia. The Doppler frequency modulation allows determination of the speed to a part in 10^{-6} for a signal with a sufficiently high signal to noise ratio. If the speed differs by much more than this value, the signal extraction technique no longer works. I also measured the ability to distinguish two additional polarizations, the breathing and longitudinal, from the standard plus and cross. If in propagation one polarization handedness is enhanced and the other suppressed due to parity violation it would result in an anomalous measurement of the inclination angle of the neutron star spin with respect to the line of sight, which is known from X-ray observations.

Modeling the Advanced-LIGO Response to Gravitational Waves and Calibration
Benjamin C. Li
Mentor: Alan Weinstein

The response of the Advanced LIGO detectors (currently under construction) to gravitational waves depends in a complex way on the optical configuration of the laser interferometer at the heart of the detector. This can change due to intentional and unintentional changes to the configuration parameters. Precise calibration of that response, required for optimal extraction of information about the gravitational wave source, will require us to carefully monitor and understand those configuration parameters. This project aims to identify the most important parameters and the best methods for measuring them. This will be done through careful modeling and simulation, using existing Matlab-based software.

Investigating Gravitational Waves From the Ringdown of Accreting Black Holes
Ryan C. Lynch
Mentor: Gregory Mendell

The characteristic strain produced by black hole ringdowns is well-known, taking the form of a damped sinusoid. The frequency of oscillation of this strain function is dependent upon the inverse of the source's mass, and therefore it should decrease over time as the source black hole accretes mass. Currently, the data pipelines used to conduct match-filtered searches for ringdowns implement static-mass templates: templates with constant frequencies. Here, signal templates are designed with dynamically changing mass to account for mass accretion, allowing the expected frequency of oscillation in strain to vary over time. Simulations are also run to search for ringdowns over single and multiple detectors, using both static-mass and dynamic-mass templates. By comparing the results of these searches, it is clear that while mass accretion does make static-mass templates less efficient than dynamic-mass ones, this difference is only significant in cases of extremely high accretion rates that greatly exceed the Eddington limit. Thus, static-mass templates should be capable of detecting black hole ringdowns as they are currently understood.

Identifying Correlated Detector Noise Contaminating Searches for Stochastic Gravitational Wave Backgrounds
Gabriella Martini
Mentors: Nick Fotopoulos and Alan Weinstein

The Stochastic Gravitational Wave Background (SGWB) is the undetected gravitational radiation counterpart to the cosmic microwave background radiations (CMBR). The theoretically most sensitive SGWB searches involve co-located pairs of detectors, like the LIGO Hanford interferometers. Unfortunately these detectors are immersed in a common noisy environment which induces correlations in the data that can mimic that of an SGWB. Much of the correlation can be identified and removed using data by cross-correlating physical environment monitors (PEMs) such as seismometers, voltmeters, etc. with the gravitational wave channels. In the past, stochastic searches have employed crude approximations of the environmental contamination to avoid the computational heavy-lifting involved in the complete calculation. This project analyzes the full NxN cross-coherence matrix for the improved calculation of the environmental contribution to detector correlation. Preliminary results show that clustering algorithms identify a block structure amongst the PEM coherences and indicate the possibility of a significant reduction in computation.

Optical Gyroscopes for the LIGO Gravitational Wave Detectors
Zoe L. Masters
Mentors: Rana Adhikari, Alastair Heptonstall, and W. Zach Korth

Seismic isolation of the mirrors in the LIGO detectors can improve the detectors' performance at low frequencies. Because seismometers confuse rotation with horizontal motion, however, optical gyroscopes will be added to the advanced LIGO detectors to measure rotation alone. The goal of this project is to improve electronics and reduce mechanical noise in a laser-based optical gyroscope operating on the Sagnac principle and locked using the Pound-Drever-Hall technique. Specific improvements include a new circuit board containing generic filters for use in the locking system, prototype tests and simulations of a possible thermal stabilization method, and tests of the gyroscope's current functionality.

An Optical Follower Servo for the LIGO Photon Calibrators
Rolf Minton
Mentors: Richard Savage and Paul Schwinnberg

The LIGO Photon Calibrator currently uses a power modulated auxiliary laser to induce periodic displacements of the 40 kg end test masses on the order of 10^{-18} m via radiation pressure. The *optical follower* servo reduces unwanted modulation harmonics, lowers relative power noise, and significantly increases the usable fraction of the auxiliary laser power. The response of the servo actuator, an acousto-optic modulator, saturates by a factor of 30 over the range of injected laser power modulations desired. Modeling and lab measurements indicate that variable gain in the servo electronics can compensate for this actuator's saturation. A prototype servo amplifier has been constructed and tested. The experimental results are presented and discussed.

Diagnosis of the 40m Prototype Interferometer With Auxiliary Laser-Beam Injection
Sonali Mohapatra
Mentors: Rana Adhikari and Suresh Doravari

The aim of this project is the deterministic locking and characterization of the arms of the LIGO 40m prototype interferometer. In order to obtain low-loss high-reflectance mirrors, LIGO uses dielectric coatings on the test masses. The Pound-Drever-Hall technique is employed to lock the laser to the cavity or vice-versa. The high sensitivity of the PDH lock limits its linear range which makes it difficult to bring the cavity into resonance with the laser. As a solution to this problem, this report describes an auxiliary-beat lock (green or IR) to give us a much broader linear range. This enables us to smoothly change the cavity length and thus lock the laser to the cavity by obtaining a resonance. The 532 nm green laser light is obtained by frequency doubling of the 1064nm NdYAG auxiliary laser. This frequency doubled green beam from the AUX laser has been previously used to obtain a green-beat lock between the Pre-Stabilized-Laser and the AUX laser. We use the IR beam from the AUX laser, before it is frequency doubled and obtain an IR beat lock. The frequency noise of the IR-beat lock and the Green-Beat lock are compared.

Exploration of the Latest Numeric-Relativity-Inspired Waveforms for Compact Binary Coalescence
Jessie Otradovec
Mentors: L. Santamaría, P. Ajith, and A. Weinstein

Coalescing compact binaries are among the most promising sources of gravitational waves (GWs), which makes them a particularly interesting problem for GW astrophysics. The signature of these systems encodes a great deal of information about their parameters: masses, spins, orbital angular momentum and sky position. Although there is no analytically exact solution of such systems in full General Relativity, recent breakthroughs in Numerical Relativity have allowed the computation of handfuls of waveforms at the late stages of the binary coalescence (near the merger and ringdown) for multiple points in the parameter space. Together with post-Newtonian methods and black hole perturbation theory, it is now possible to construct waveforms for the full coalescence process. In turn, these waveforms are used in search algorithms and parameter estimation in GW data analysis. This study seeks to validate different waveform families by comparing the overlap, normalized difference in signal-to-noise ratio (SNR) and chi-square. In addition, visual inspection for expected behavior is performed. Preliminary findings document differences in conventions, and ~6%-15% maximum disagreements in SNR. Additionally, worse agreement is found at smaller symmetric mass ratios. Some unexpected behavior of the generic-spin approximant family has also been discovered.

A New Magnetar Gravitational Wave Search: GW Stacking Using Timing Information From Electromagnetic Light Curves
Bryance Oyang
Mentor: Peter Kalmus

Soft gamma repeaters (SGR) are thought to be magnetars, young neutron stars with extremely strong magnetic fields (10^{14}-10^{15} Gauss). These objects sporadically release large bursts of soft gamma rays when energy in the magnetar's magnetic field is released by crustal deformation and fracture. This could excite non-radial modes (f-modes) on the magnetar, which would emit gravitational waves (GW). This project expands a database of bursts' light curves collected by satellites and uses the information collected to run a search for GWs in LIGO data. Since we expect the GWs and the gamma rays to arrive in our solar system at roughly the same time, we find the start times of each burst from the light curves. Then we run a "stacking" search for GWs in LIGO data, where we combine time-frequency tilings of LIGO data at the times of each burst for hundreds of bursts. Stacking dramatically improves the sensitivity for GWs under the assumption that the frequencies of the GWs are the same from burst to burst.

Prototyping Adaptive Feed-Forward Seismic Noise Cancellation at the 40m Interferometer
Ishwita Saikia
Mentors: Rana Adhikari and Jenne Driggers

Advanced LIGO is an upcoming upgrade to the LIGO Project, which we expect to be able to detect gravitational waves with frequencies as low as 10 Hz. At such low frequencies the detectors will encounter seismic noise, displacement noise which moves the mirrors (present in the detectors) and thus changes the path length. This noise is due to the ground motion that occurs by volcanic/seismic activity, ocean tides, human activities, etc. This project is intended to reduce seismic noise at the 40m Prototype Interferometer with the help of online adaptive filtering. The technology developed in the 40m laboratory will be applied in Advanced LIGO.

Extracting Information About the Central Engine of Core Collapse Supernovae Using Gravitational Wave Signals
James H. C. Scargill
Mentor: Peter Kalmus

The complete and detailed mechanism which governs the core collapse in certain supernova explosions is unknown. Different possible mechanisms will cause different waveforms of gravitational radiation to be emitted, and thus information on the mechanism can be deduced from the received waveform. This project will develop existing ways in which this information can be extracted. Principal component analysis can be used to identify key waveform features from a library of known waveforms; Bayesian statistical techniques can then be used to analyse a new waveform (modelled as received by the detector, i.e. with noise) in terms of these principal components. Current algorithms can be improved by considering the coherent response of multiple detectors, which would give higher accuracy and durability in model selection and parameter estimation, as well as extra polarisation and sky-location information. This in turn will allow quantitative comparison to previous algorithms. Having developed such an algorithm, we will then test it on new waveforms to determine its efficacy in distinguishing the various mechanisms which govern core collapse, as the signal-to-noise ratio is reduced, in order to know what science could be done with gravitational waves in the event of a (galactic) supernova.

Thermal Coupling in Cryogenic Fabry-Pérot Cavities
Jennifer Schloss
Mentor: David Yeaton-Massey

The measurement of extremely weak signals such as gravitational waves requires highly sensitive detectors with exceptionally low noise levels. In an effort to reduce the contribution of thermal noise due to Brownian motion and fundamental temperature fluctuations, cryogenic Fabry-Pérot reference cavities are being built. To improve the temperature-stability of these cavities, it is useful to understand the couplings of outside temperature fluctuations to the cavity interior. Conductive and radiative heat transfer through cryogenic and ambient-temperature cavities was modeled using FEA simulation software. Room-temperature simulation output was compared with an equivalent experimental measurement. The level of agreement provides an indication of the extent to which the model cryogenic cavity simulations predict the thermal couplings in the physical cryogenic cavities.

Directional Gravitational Wave Search
Clio Sleator
Mentor: Peter Kalmus

Ground-based observatories such as LIGO are expected to directly detect gravitational waves (GWs), which will begin the age of gravitational wave astronomy. The search methods depend on the astrophysical sources of GWs. Some sources (specifically violent events in the universe), such as core-collapse supernovae, neutron star collapse, merging compact binaries, star-quakes, pulsar glitches, and cosmic string cusps, are thought to make bursts of GWs that last less than 1*s*. As detector glitches look like burst signals, it is difficult to determine the difference between them. In this project, a search method will be developed that looks for sky directions with a statistical excess of triggers. Upon finding such a sky direction, it should be easier to determine whether the glitches seen in the data are only glitches or if they are actually GW signals. In order to find a sky direction with a statistical excess of triggers, we will have to calculate the sky direction of each event using time-of-flight triangulation and plot these sky directions onto skymaps. Using simulated signals will help to characterize the search.

Optimal Telescope Tilings for Electromagnetic Followup of Gravitational Wave Events
Antony J. Speranza
Mentors: Larry R. Price and Leo Singer

With the enhanced detection capabilities of Advanced LIGO, the prospect of multi-messenger astronomy has become an exciting means for investigating some of the most violent events in the universe. Gravitational wave detectors are inherently omnidirectional, while EM telescopes can image only small portions of the sky at one time. In order to make a joint observation of a GW event and an EM counterpart, we need an efficient method for determining EM telescope tilings that most effectively image the probable sky location of the source, as determined by the GW detector. For the single telescope case, this can be viewed as a convolution of the telescope's field of view with the source location skymap. We discuss an algorithm for efficiently computing tilings for a single telescope, and explore optimization techniques for quickly determining tilings that maximize the detection probability when multiple telescopes are involved. For both cases, we characterize the detection efficiency as a function of tiling resolution using a network of EM telescopes that will likely be available during upcoming scientific runs with aLIGO. The efficiency gains for the multiple telescope algorithms makes a case for coordinated tilings across the entire EM telescope network.

Characterization of Noise in Driven Cantilever Blade Springs
Larisa Thorne
Mentors: Rana Adhikari and Alastair Heptonstall

In the search for gravitational waves, detection is difficult to all but the most accurate and sensitive devices. Among the myriad of noises that could affect device readings is the "crackling" noise in driven blade springs, characterization of which is crucial to determining its status as a limiting factor in the shape of the LIGO noise curve, and ultimately detection and measurement of gravitational waves.

Crackling noises are characteristic of systems which are subject to an outside driving force, and which respond in a series of discrete and abrupt jumps. Part of the crackling noise effect is due to some sort of hysteresis in the system. This is logical, considering that the excess energy lost due to hysteresis causes (nonlinear) energy upconversion in the blade springs which is transitioning from slow driving force applied into the crackling noise at higher frequencies.

Simulations can only offer so much information. In order to comprehend the underpinnings of the crackling, an actual experiment must be run. A downscaled Michelson interferometer must be constructed to quantify the crackling noise. This noise should be revealed in the output signal (after it has been demodulated via a 'chopping' technique) when the cantilever blade springs are driven in unison by magnetic actuators, and the set-up has either been adjusted to its lowest noise level (we will use vacuum tanks and seismic isolation stacks to accomplish this) or all other sources of noise are known and accounted for. Once the crackling noise has been identified, it will be possible to determine if it will limit future gravitational wave detection in advanced LIGO (aLIGO).

Study of PowerFlux Response to Continuous Wave Signals of Non-Standard Form and Locations of Potential Sources in the Milky Way Galaxy
Gregory E. Vansuch
Mentor: Vladimir Dergachev

We present results on the robustness of the PowerFlux algorithm to injected signals with various parameters, in particular the speed and period of a gravitational wave, as well as the ability of the algorithm to reconstruct parameters from simulations. We will also describe potential locations of continuous gravitational radiation from various star clusters and the arms of the Milky Way Galaxy.

Implementing Digital Control for Quad-Maglev Suspension
Yi Xie
Mentors: Haixing Miao and Rana Adhikari

Low-frequency seismic noise prevents us from detecting gravitational waves from many interesting astrophysical sources. The maglev suspension system is decided to create a soft suspension by using a specially designed magnetic field. And the digital control system produces feedback control force to make the balance come true.