

LIGO Undergraduate Research Projects – Summer 2012 (Preliminary)

Projects at Caltech

Finding Electromagnetic Counterparts of Gravitational Wave Signals in the Transient Universe: Prospects for Advanced LIGO

Mentors: Larry Price (larryp@caltech.edu) and Steven Privitera (privitera_s@ligo.caltech.edu)

Abstract: Binary neutron star inspirals involving either another neutron star or a black hole are the most promising candidates for simultaneous gravitational-wave (GW) and electromagnetic (EM) emission. The detection of both types of emission from the same source provides a more complete picture of the underlying dynamics of the system and opens the doors to a new type of astrophysics. Success in this endeavor requires detecting the GW signal, localizing the source on the sky, and directing astronomical observatories in low-latency. The student involved in this project will join an ongoing effort to characterize the likelihood of detecting various types of EM+GW emission through an ambitious simulation campaign. Python programming will be required.

Optimal Observation Strategies for Optical Follow-up of Gravitational Wave Candidates

Mentors: Larry Price (larryp@caltech.edu) and Leo Singer (lsinger@caltech.edu)

Abstract: Optical follow-up of gravitational wave detection candidates is challenging because of the mismatch between the tens to hundreds of square degrees uncertainty in the location of gravitational wave candidates and the sub-degree fields of view of most optical telescopes. However, the advent of both large, deep survey telescopes and small, agile, robotic telescopes makes the detection of electromagnetic counterparts to binary neutron star merger an exciting possibility in Advanced LIGO. The student will investigate observational strategies for optical follow-up of gravitational wave candidates. Starting from learning about existing survey and transient astronomy methodology, the student will develop an algorithm to optimally lay out and schedule pointings of a heterogeneous network of telescopes. Specific concerns are accounting for different limiting magnitudes, slew times, and exposure times of telescopes, and light curves for different types of optical counterparts. A further goal is to minimize the total number of pointings that is required. The student will then use this algorithm to compute observing plans for a set of realistic case studies, and then assess the efficiency of a particular telescope network with respect to a large simulated population of GW triggers. This project will involve elements of astrophysics, applied mathematics, algorithms, visualization, and parallel computing. Code will be written mostly in Python.

The Gravitational Wave Signature of Pulsating Magnetars

Mentors: Peter Kalmus (peter.kalmus@ligo.org) and Christian Ott (cott@tapir.caltech.edu)

Abstract: The student will carry out non-linear general relativistic simulations of 3D pulsations of strongly magnetized neutron stars (magnetars) excited by sudden energy release in magnetar crust quakes, which may also be responsible for frequently observed soft-gamma repeater bursts in electromagnetic waves. The Caltech 3D GR code Zelmani (based on the Einstein Toolkit, <http://www.einsteintoolkit.org>) will be employed and for the first time, the simulations will make use of a realistic finite-temperature neutron star equation of state. Gravitational waves from the excited magnetar pulsations will be extracted in various ways (that complement each other) and will be fed into LIGO efforts to detect gravitational waves from bursting magnetars.

Building Confidence in the First Gravitational Wave Transient Detections in Advanced LIGO

Mentor: Alan Weinstein (ajw@caltech.edu)

Abstract: When the advanced detectors turn on in 2014-15, their sensitivity is expected to be sufficient to detect handfuls of gravitational wave transients from binary mergers, supernovae, etc. But we know from the initial detector data that the detector noise is non-stationary and non-Gaussian; there are "glitches" that can mimic the signals we look for. Often, we can tell that what we're seeing is not a real signal. But when the signals are rare and the glitches are frequent, we can be fooled. We have assembled a suite of diagnostics to help us distinguish signal from non-Gaussian noise on an event by event level, but it needs further development. This project will involve understanding the tools we have, then identifying where they can most fruitfully be improved. It will involve a lot of sophisticated computer work!

Distinguishing Gravitational Wave Polarizations in Continuous Waves from Spinning Neutron Stars

Mentor: Alan Weinstein (ajw@caltech.edu)

Abstract: Gravitational waves are predicted, in Einstein's General Relativity, to come in two polarizations (plus and cross). Both stretch and squeeze space transverse to the wave direction. Alternative theories predict different polarizations, some of which may stretch and squeeze space along the direction of motion. Several methods have been developed to detect such beyond-Einstein effects, but perhaps the most straightforward one makes use of continuous waves generated by spinning neutron stars such as pulsars. In this project, we will develop the method and determine the degree to which we can detect and measure beyond-Einstein polarizations (using simulated data).

Low Latency Glitch Finding and Detector Characterization for Advanced LIGO

Mentors: Alan Weinstein (ajw@caltech.edu), Jameson Rollins (jrollins@ligo.caltech.edu), and Leo Singer (lsinger@caltech.edu)

Abstract: The Initial LIGO detectors suffered from large, short-duration noise fluctuations or "glitches", due to environmental disturbances and/or instrumental instabilities. It is expected that the Advanced LIGO detectors will also be glitchy. In the past, investigation of the causes of the glitches and identifying their presence in the data was a time-consuming task, pursued days or weeks after the data were taken. For Advanced LIGO, we want to identify instrumental glitches in "real-time", using smart software looking at the data as it streams out of the detector. In this project, we will develop some of that software and test it on real data from Initial LIGO and mock data from Advanced LIGO.

Development of the Low Latency Binary Merger Detection Pipeline for Advanced LIGO

Mentors: Alan Weinstein (ajw@caltech.edu), Nick Fotopoulos (fotopoulos_n@ligo.caltech.edu)

Abstract: Advanced LIGO is under construction. Compact binary merger search pipelines are retooling to meet the challenge of more powerful and more complex detectors. In the advanced detector era, we will need powerful, efficient, automated, low-latency analysis tools in order to coordinate with electromagnetic astronomers and reach our full scientific potential. The student may be asked to contribute to diagnostics, event clustering, improved false-alarm rate estimation, network-coherent statistics, or integrating more realistic waveforms as templates. Programming experience is required.

Exploring the Signal Space of Spinning CBC Waveforms

Mentor: Nick Fotopoulos (fotopoulos_n@ligo.caltech.edu) and P. Ajith (ajith@caltech.edu)

Abstract: Real life is complicated. Powerful searches have been developed for compact binary mergers, but the best that has been published so far assumes that black holes and neutron stars are non-spinning. We have waveforms in hand that incorporate higher-order effects such as spin angular momentum, eccentricity, tidal deformability, higher harmonics, etc., but they have not been deployed as templates for search pipelines due to the difficulty in laying down a template bank and uncertainty as to how adding additional dimensions will add to the search efficiency (at fixed false-alarm rate) and computational cost. We recently developed a tool to place templates according to a stochastic algorithm that should work in an arbitrary number of dimensions. The student will integrate higher-dimensional waveforms into the stochastic placement code and explore how search efficiency and computational cost scale as we add realism. Programming experience is required.

Gamma-ray Bursts as Sources of Long-duration Gravitational Wave Signals: Prospects for the Analysis of LIGO S6/ VSR2 Data

Mentor: Alessandra Corsi (corsi_a@ligo.caltech.edu)

Abstract: Gamma-Ray bursts (GRBs), besides being among the most powerful electromagnetic explosions in the Universe, are also among the most promising astrophysical sources of gravitational waves. In the forthcoming years, ground-based GW detectors like LIGO and Virgo will reach their advanced configurations. Thanks to their improved sensitivities, these detectors are expected to answer some of the most important questions regarding the nature of GRB progenitors. Joint electromagnetic and GW studies will be crucial to this end. This project focuses on the search for long-duration (100-1000 sec) GW signals possibility associated with GRBs in the so-called "magnetar" scenario. The main scope of the project is to analyze the broadband (optical-to-X-rays) light-curves of GRBs that were triggered or followed-up by the Swift spacecraft during LIGO S6 / Virgo VSR2 runs, and establish (i) how many of these GRBs are good candidates for an associated search for GW signals using LIGO S6 / VSR2 data; (ii) what constraints can these electromagnetic observations put on the properties of the expected GW signal. Basic requirements for student: interest in both astrophysics and gravitational waves; interest in GRB data and their modeling/interpretation; interest in exploring GRB literature. Some experience with IDL programming is preferred.

Rapid Follow-up Strategies for Advanced LIGO

Mentor: Roy Williams (roy.williams@ligo.org)

Abstract: Rapid electromagnetic follow-up of gravitational wave detections will be essential to fully elucidate the extreme physics behind the event. This objective of this project is to use Advanced LIGO simulation runs to optimize how event notices are interpreted and distributed to external follow-up observatories. It is part of a wider effort to develop information infrastructure for distributing rapid astronomical transients of all kinds.

Veto for Gravitational-wave Transients using Instrumental Coupling Models

Mentors: P. Ajith (ajith@caltech.edu) and Peter Kalmus (peter.kalmus@ligo.org)

Abstract: Since modern interferometric gravitational-wave detectors are highly complex instruments, the data are often plagued with a large number of noise transients (a.k.a. glitches) that are not easily distinguishable from possible GW signals. In order to perform a sensitive search for transient GW signals, it is important to identify these noise artifacts. Thus, data from many instrumental subsystems are also continuously recorded along with the "GW channel". A robust method has been developed to "veto" noise transients making use of our understanding of the coupling of different noise sources to the GW channel. Here, we check the consistency of glitches in the GW channel with those in a bilinear combination of instrumental channels, thus

establishing (with some confidence) the instrumental origin of these glitches. This method has been successfully implemented in the LIGO detector characterization. The proposed project aims to improve our understanding of various coupling mechanisms, thus further improving our ability to distinguish noise transients from real GW signals. Strong computing skills (Matlab, Python), some knowledge of statistics, and experience in data analysis (esp. Fourier techniques) are recommended. Suggested reading: Phys. Rev. D 76, 042004 (2007) [arXiv:0705.1111].

Gravitational Waves from Core-Collapse Supernovae

Mentors: Christian Ott (cott@tapir.caltech.edu), Peter Kalmus (peter.kalmus@ligo.org), and Ernazar Abdikamalov (abdik@caltech.edu)

Abstract: Gravitational waves will allow us to probe the explosion mechanism operating in the next core-collapse supernova in the galaxy. In order to interpret Advanced LIGO observations of this event and extract supernova physics, detailed predictions of the expected gravitational-wave signal are necessary and must be obtained via computer simulations. The student will work with Professor Ott and other members of the TAPIR group and LIGO laboratory on running and analyzing core-collapse supernova simulations, leading to improved predictions of the core-collapse supernova gravitational wave signature.

Comparing Numerical Relativity and Black Hole Perturbation Waveforms for Intermediate Mass Ratio Black Hole Binaries

Mentors: Christian Ott (cott@tapir.caltech.edu) and Christian Reisswig (reisswig@tapir.caltech.edu)

Abstract: Future detectors will be sensitive to signals from black hole binaries with large total masses and mass ratios. Binaries in this regime violate the requirements for both post-Newtonian techniques and black hole perturbation techniques since neither speeds nor mass ratios are small enough to be trusted as perturbation parameters. The student will work with the mentors to develop techniques for quantitative comparison of waveforms computed in independent computational frameworks, with a focus on numerical relativity waveforms versus black hole perturbation waveforms. They will explore and compare the viability of the various approximate waveforms. Such waveforms will ultimately be used to search for these systems. Comparing the different approximations will aid in determining which framework is the most suitable for developing further into extensive search pipelines.

Supernovae Model Selection using Gravitational Wave Signals

Mentor: Peter Kalmus (peter.kalmus@ligo.org)

Abstract: The mechanism that causes supernova explosions in the collapse of massive stars is still unknown. When detected, the waveforms of gravitational waves emitted during the core collapse will carry crucial information to identify the mechanism powering the explosion. In this project, we will explore the waveform features that are most useful in this identification. We will use the promising method of principal component analysis coupled with Bayesian fitting algorithm to isolate these “robust” waveform features and use them to identify the most likely core collapse mechanism for a given waveform. We will test our algorithm on an ensemble of model waveforms injected into gravitational-wave interferometer noise and noise glitches. We will extend the method in preparation for the challenging case of a real, unknown gravitational wave signal.

Directional Gravitational Wave Search

Mentor: Peter Kalmus (peter.kalmus@ligo.org)

Abstract: Data from two or more gravitational wave detectors contain many coincident glitches: short-duration (less than a second) blips in the data. We tend to assume these are all from coincident and independent noise events in the individual detectors, but what if some of them are

actually gravitational waves? We will develop a search method that associates a sky position with each blip larger than some threshold and look for sky directions with a statistical excess of these blips. We will characterize the sensitivity of our search via simulated waveforms which model plausible astrophysical models for gravitational wave repeaters.

Studying Dynamics of Macroscopic Quantum Entanglement with Future Advanced Gravitational-Wave Detectors

Mentors: Yanbei Chen (yanbei@tapir.caltech.edu), Haixing Miao (haixing@caltech.edu), and HuanYang

Abstract: Future advanced gravitational-wave detectors will reach such high sensitivity that they possibly allows us to study quantum behaviors of the macroscopic test masses. One interesting issue, which is also of fundamental importance, is the observation of the Einstein-Podolsky-Rosen-type of quantum entanglement among macroscopic objects, for example, the kilogram-scale test masses. In this project, we will explore quantum dynamics of entanglement and study the possibility of observing it with future advanced gravitational-wave detectors or prototypes. In particular, we will theoretically evaluate the characteristic lifetime of macroscopic entangled states under thermal decoherence in realistic setups. Students who are interested in the fundamentals of quantum mechanics are welcome.

Adaptive Quantum Measurements in Future Gravitational-wave Detectors

Mentor: Yanbei Chen (yanbei@tapir.caltech.edu) Haixing Miao (haixing@caltech.edu), and HuanYang

Abstract: Advanced gravitational-wave detectors, e.g., advanced LIGO, are expected to be limited by fundamental quantum noise around the most sensitive frequency band. To further improve the detector sensitivity, various approaches based upon modifying the input or output optics of the interferometer have been proposed in the community. They usually require additional low-loss optical cavities to filter the input or the output. Such additional complexities may be avoided if a time-dependent adaptive quantum measurement is applied, e.g., the homodyne detection phase is a function of time. In this project, we will explore the possibility of using adaptive quantum measurement to reduce the quantum noise of future advanced gravitational-wave detectors. Students with a background in quantum optics are welcome.

LIGO Signals from Alternative Theories of Gravity

Mentors: Chad Galley, Anil Zenginoglu and Yanbei Chen (yanbei.chen@gmail.com)

Abstract: Once LIGO detects gravitational waves from binary black hole coalescence, we will be able to test general relativity, even for its nonlinear regime. There exists a set of alternative theories of gravity that can be tested, but so far it has been difficult to compute directly the full inspiral-merger-ringdown coalescence waveform directly from these theories, using numerical relativity. This project will explore a possible approach that can help formulate numerical strategies that will eventually lead to such waveforms.

Spin Configurations of Binary Black Holes

Mentors: Emanuele Berti, Ajith Parameswaran (ajith@caltech.edu) and Yanbei Chen (yanbei.chen@gmail.com)

Abstract: This project will study the possibility distribution of the spin configuration of binary black holes, when they enter LIGO's detection band. In particular, whether the spins are more likely to be aligned or nearly aligned, due to possible spin-spin interaction (taking into account newly available, higher post-Newtonian correction terms), and possible interaction with the environment. Result of this project will affect our estimate on the complexity of binary black-hole data analysis.

Image Distortion near Black Holes

Mentors: Mark Scheel (scheel@tapir.caltech.edu) and Nick Taylor

Abstract: One of the most promising sources of gravitational waves for potential detection by LIGO is the inspiral and merger of two black holes. In an effort to aid LIGO data analysis, the Caltech-Cornell SXS collaboration is numerically solving Einstein's equations for a number of such binary black hole systems with varying mass ratios and spins. A novel way to visualize the structure of such a numerical solution would be to produce images of a distorted background in the vicinity of the black holes. This would involve following photons through the spacetime to produce a pixel map from the background to the image at the observer's location. Because light rays passing near a black hole can be bent by large angles, the entire sky would have to be used as a background image. In the literature and on the web, one can find images of a distorted stellar background in the vicinity of a single black hole, produced by ray-tracing through an analytical solution to Einstein's equations. We will do a similar thing using instead the full numerical solution to Einstein's equations for a binary black hole system. Additionally, if producing a single image is not too computationally expensive, we will make movies of the inspiral, merger, and ringdown. This would not only provide potential insight into the structure of spacetime near the black holes, but would also make for fascinating images and movies by themselves. These would be useful for public outreach activities, appealing to funding agencies, and attracting future students and researchers.

Investigating Crackle Noise in Metal Blades

Mentors: Eric Quintero (ericq@caltech.edu), Jan Harms (harms_j@ligo.caltech.edu), and Rana Adhikari (rana@caltech.edu)

Abstract: Material defects can lead to nonlinear internal dynamics in any type of material – for example, metal blades that will be used as part of the seismic isolation system for the Advanced LIGO detectors. Blade motion at low frequencies can convert into high frequency motion, possibly making the system susceptible to random noise known as “crackle” noise. Since the conversion parameters will depend on material properties and details of the manufacturing process, a detailed investigation of crackle noise can provide information to further mitigate noise in seismic isolation systems, and more generally reduce unwanted nonlinear dynamics of metal blades. The student will work on a laser interferometer experiment to measure crackle noise in metal blades. The goal is to characterize various blade samples and relate measured crackle noise to material properties, and infer the impact that this noise source has on the Advanced LIGO suspension systems. The student will become familiar with feedback systems and the technique of locking an interferometer, which are fundamental concepts relevant for LIGO, and interferometry as a whole.

Low Noise Seismic Sensing for Adaptive Filter Networks

Mentors: Jenne Driggers (driggers_j@ligo.caltech.edu) and Rana Adhikari (rana@caltech.edu)

Abstract: LIGO detectors are extremely sensitive to low frequency seismic motion. At the 40m Prototype Interferometer we test new noise cancellation techniques to reduce seismic noise in the detectors. This technology will be applied to the Advanced LIGO detectors to improve low frequency sensitivity to astrophysical events. In order to maximize our noise cancellation, we must utilize low noise readout electronics to maintain the integrity of the seismometer data. The student will determine noise requirements for a seismometer box which is compatible with multiple seismometers used in LIGO (e.g. Guralp CMG-40T, Streckeisen STS-2, Trillium T-240). The student will design, build and characterize the readout box before installing and testing it with the seismic sensors. General laboratory skills, with an emphasis on electronics, are recommended.

Machine Learning to Reduce Noise in Gravitational Wave Detectors

Mentors: Jenne Driggers (driggers_j@ligo.caltech.edu), Den Martynov (martynov_d@ligo.caltech.edu), and Rana Adhikari (rana@caltech.edu)

Abstract: Future GW detectors will use machine learning techniques to improve strain sensitivity and operation stability. One possible application of machine learning is to control an online adaptive filter. This digital instrument is used at LIGO to subtract seismic noise measured by seismometers and accelerometers from the gravitational wave channel. Seismic noise cancellation depends on the various parameters of the filter such as adaptation rate, leaking factor, number of noise witness channels, filter length, etc. The algorithm will need to control the parameters depending on the conditions of the environment. The student will program the machine learning code to use past data to determine future behavior or the adaptive filtering system. Knowledge of computer science, basic understanding of digital filtering and general laboratory skills are recommended.

Real-time Calibration of Gravitational-wave Strain

Mentors: Jameson Rollins (jrollins@ligo.caltech.edu), Rana Adhikari (rana@caltech.edu)

Abstract: Precise calibration of gravitational wave detectors is very important for extracting the most science from the data. To extract the maximum information from astrophysical explosions interferometer length and strain calibration will be done in real-time in the digital control system. This will be particularly important for the very low latency data analysis pipelines that will attempt to quickly identify gravitational wave candidate events, reconstruct their source positions on the sky, and notify follow-up telescopes. At the LIGO 40m prototype laboratory we will be prototyping real-time calibration methods on one of the 40m suspended arm cavities. The student will gain experience with interferometer control systems, calibration concepts, and working with real-time digital control and data acquisition systems. General laboratory skills including electronics and computing are recommended.

Real-time Simulation of a Suspended Cavity with the Advanced LIGO Digital Controls System

Mentors: Jameson Rollins (jrollins@ligo.caltech.edu) and Rana Adhikari (rana@caltech.edu)

Abstract: Simulations are a powerful tool for understanding complex systems. Regarding interferometers, simulations can help us understand how to best design the control systems, as well as help us understand and characterize all possible noise sources. The new advanced LIGO digital control system allows us to make real-time time-domain simulations of the interferometer that can interact directly with the interferometer controls. We will be building a simulation of a single 40m optical cavity, including suspensions, actuation, readout, and all noise sources. Computing skills are required.

Detector Characterization Tools for Interferometer Commissioners

Mentors: Jameson Rollins (jrollins@ligo.caltech.edu), Josh Smith, and Rana Adhikari (rana@caltech.edu)

Abstract: Interferometric gravitational wave detectors are incredibly complicated beasts. Making them work properly is a very challenging task. Commissioners (the scientists who work on the detectors) have to process large amounts of information to gain subtle insights into how the detector is behaving. The goal of this project is to figure out how to distill the massive amount of information being extracted from the detector into useful, digestible bits that can be presented to commissioners. This will require understanding intricacies of the detector, sophisticated analysis of data from many different channels, and elegant data representation techniques. General laboratory, modeling, and particularly computing skill are recommended.

Thermal Noise in Ultra-Stable Fabry-Perot Cavities

Mentors: Tara Chalermongsak (chalermongsak_t@ligo.caltech.edu) and Rana Adhikari (rana@caltech.edu)

Abstract: Brownian thermal noise from silica/tantala dielectric coatings on mirrors is a limiting noise source in LIGO at the most sensitive band (50-300 Hz). However, the theoretical calculation of coating noise at such frequency has yet to be verified. We aim to use ultra stable dual Fabry-Perot cavities in order to measure the coating noise. In this experiment, the student will learn how to suppress various technical noise sources (e.g. ambient thermal fluctuations, seismic noise, light absorption) by employing a feedback control system. General laboratory skill in optical physics is required.

Cryogenic Silicon Fabry-Perot Cavities: Laser Stabilization with sub-Hertz Linewidth

Mentors: David Yeaton-Massey (dmassey@ligo.caltech.edu) and Rana Adhikari (rana@caltech.edu)

Abstract: Fabry-Perot cavities with exceptional length stability are essential tools in the frequency stabilization of lasers for precision spectroscopy, optical atomic clocks, quantum optics experiments, and interferometric gravitational wave detectors. The stability of the cavity is ultimately limited by a multitude of noise sources, including thermal noise of the mirror coatings, vibration-induced elastic deformation, laser power fluctuations, and temperature fluctuations of the cavity itself. In this project, we will be pushing towards the theoretical limitations on the performance of a pair of 4 inch silicon cavities at cryogenic temperatures (120K), and investigating whatever noise sources limit us.

Thermal-lensing Modeling and Control in 2nd and 3rd Generation GW Detectors

Mentors: Aidan Brooks (aidanfbrooks@me.com) and Rijuparna Chakraborty (rijuparna_chakraborty@yahoo.co.in)

Abstract: Absorption-induced non-spherical thermal lensing in the optics of 2nd and 3rd generation interferometers will diminish the overall performance of these devices. In Advanced LIGO, a thermal compensation system (TCS) is employed to correct thermal lensing. For both 2nd and 3rd generation devices, we must model and understand the 2D thermal lenses in conjunction with our correction system and we must develop a system to determine the optimum compensation to apply. Modeling and strong computing skills are recommended.

Projects at the LIGO Hanford Site

Advanced LIGO Installation and Commissioning

Mentors: Dale Ingram (ingram_d@ligo-wa.caltech.edu), Daniel Sigg (sigg_d@ligo.caltech.edu), and LHO science staff

Abstract: LIGO Hanford (LHO) will offer projects to four students for the summer of 2012. All of the projects will focus on the installation and commissioning of Advanced LIGO subsystems. The focus of each project will grow clearer as the summer approaches. In the meantime, prospective student participants can count on a significant instrumentation emphasis at LHO, with potential opportunities related to electronics, detector controls, environmental sensing and more. LHO scientists will serve as the key mentors, but participants can expect to work extensively with teams of Advanced LIGO installation and commissioning personnel.

Matlab Tools For Analysis Of LIGO Trend Data

Mentors: Greg Mendell (gmendell@ligo-wa.caltech.edu) and Rick Savage (richard.savage@ligo.org)

Abstract: Quick investigations of trends, statistics, and the spectral analysis of long periods of LIGO data requires several steps that we would like to improve and streamline. The project will be to further develop tools we have used for gathering this data and analyzing it in Matlab.

Python and other scripting languages may also be used, and a GUI or web interface to these tools could also be developed. The tools will be applied to look for interesting features in some of the auxiliary channels from LIGO's last science run.

Projects at the LIGO Livingston Site

Education and Public Outreach in LIGO

Mentor: William Katzman (wkatzman@ligo-la.caltech.edu)

Abstract: The LIGO Science Education Center seeks to utilize the laboratory and enthusiasm generated by gravitational wave research in order to inspire and educate students and the general public. In this project the student will engage in general outreach activities targeted towards the public and teachers and work on one or more of the following projects: 1) Develop a classroom apparatus & lesson to better get across the idea of relative motion. 2) Work on re-vamping an exhibit to increase visitor interactions around the exhibit.

Investigating Electromagnetic Interference in the Control Electronics of the Advanced LIGO Detectors

Mentor: Joseph Betzwieser (jbetzwieser@ligo-la.caltech.edu)

Abstract: The advanced LIGO interferometers are currently being constructed and installed in Hanford, Washington and Livingston, Louisiana. These detectors are extremely complex with large electronic infrastructures necessary for their control. In this project the student will investigate how sensitive the installed electronics are to cross talk between systems as well as external sources of electromagnetic fields. The project will require both experimental and analytical skills.

Development of Techniques for Advanced Gravitational-wave Detectors

Mentor: Valery Frolov (vfrolov@ligo-la.caltech.edu)

Abstract: The LIGO lab is in the process of upgrading the interferometers to achieve higher sensitivity to gravitational wave signals. The students will work on characterization of optics with low scatter and developing techniques to use scattered light for beam position monitoring. Both experimental and analytical skills will be utilized.