Summary of the Gravitational Waves 2010 Workshop

The field of gravitational waves has flourished over the past two decades. The first-generation interferometer-based gravitational-wave detectors have reached design sensitivities and have collected years of excellent data. Future generations of detectors, with substantial improvements in sensitivity, are being designed and built. At the same time, recent advances in numerical relativity have made big strides in understanding the expected waveforms from compact binary mergers, which are among the most promising signals to be detected by gravitational-wave detectors. Other astrophysical and cosmological models of gravitational-wave sources are also being developed. Hence, the Gravitational Waves 2010 Workshop which took place in October 2010, was both very timely and exciting - it brought together theorists and experimentalists representing very different parts of the field, and it generated a number of stimulating discussions.

The Workshop started with a session on cosmological models of gravitational-wave sources. **Alessandra Buonanno** discussed how measurements of the stochastic gravitational-wave background can be used to constrain the equation of state in the very early universe, and **Jean-Phillip Uzan** summarized a variety of tests of general relativity ranging from very short (sub-millimeter) to very large (astrophysical) scales. **Jean-Francois Dufaux** and **Jerome Martin** discussed how gravitational-wave observations can be used to probe reheating and preheating phases of inflationary models, while **Chiara Caprini** and **Daniel Chung** presented the possible signatures of phase transitions in the CMB and gravitational-wave observations.

The workshop continued with a session on the current terrestrial interferometer-based detectors. **Nergis Mavalvala**, a recent recipient of the prestigious MacArthur award, started the session with a beautiful talk on the status of LIGO, with emphasis on methods for surpassing one of the major obstacles in future detectors, the standard quantum noise limit. **Marie Anne Bizouard** and **Harald Lueck** followed, discussing the current status and plans for the Virgo and GEO600 detectors respectively.

The first day closed with a session on numerical relativity. **Manuella Campaneli** summarized the recent breakthroughs in the field of numerical relativity, and showed several captivating movies of simulated binary black-hole mergers. **Pablo Laguna** discussed the exciting possibility of detecting binary black-hole mergers with multiple messengers: gravitational and electromagnetic waves. The day concluded with a very stimulating talk by **Franz Pretorius**, who discussed the possibility of using parameterized post-Einsteinian extension of expected waveforms to identify possible departures from general relativity.

The second day revisited cosmology models. **Jun'ichi Yokoyama** discussed the amplification of vacuum fluctuations in the early universe, and **Richard Easther** presented the possibility of resonant amplification of the stochastic gravitational-wave background during the preheating phase of inflation, which could potentially be within reach of the next-generation of detectors. **Craig Hogan** discussed holographic noise, which arises in some string theory models of physics at highest energy scales. He proposed the possibility of using gravitational-wave detectors to measure the holographic noise, which could be a unique way to probe string theory models. This proposition generated very interesting “hallway” discussions with the experimentalists present at the workshop.

The following session focused on terrestrial gravitational wave detectors. **Shinji Miyoki** discussed the status and plans for the recently funded new detector LCGT in Japan, **Andrea Lommen** described how gravitational waves could be detected using millisecond pulsar timing measurements, and **Jens Gundlach** discussed how torsion balances are used to probe gravity at short distance scales and how they could complement the gravitational-wave detectors. **Mark Kasevich** presented the very promising new technology, atom interferometry, which has already found applications in developing gravimeters and gravity gradiometers, and has good potential to yield gravitational wave detectors as well. This presentation generated “hallway” discussions with experts on traditional interferometry techniques, allowing a number of experiences and ideas to be shared.

The last session of the day focused on astrophysical models of gravitational waves. **Christian Ott** discussed the possible gravitational-wave signatures generated during the collapse of massive stars, **David Merritt** described similar signatures produced by extreme mass ratio inspirals (EMRIs), and **Chris Fryer** presented predictions for rates of mergers of binary neutron star and/or black hole systems.

The second day ended with a dinner on the Centennial Showboat, where an evening lecture was given by **Rai Weiss** of MIT, suitably titled "We have a good chance to make the centennial". Rai Weiss gave an inspiring anecdotal overview of the history associated with the introduction of General Relativity by Albert Einstein in 1916, and stated his expectation that gravitational wave detectors will "make the centennial" and detect first gravitational waves by 2016. He also summarized the major obstacles faced by the experiments today.

The third day of the Workshop started with sessions on the future gravitational-wave detectors. **Guido Mueller** and **Michele Vallisneri** gave an overview of the instrument status and science targets of the satellite-based LISA detector, and **Masaki Ando** discussed the Japanese satellite-based DECIGO project. **B. Sathyaprakash** presented a number of science targets to be pursued by the third-generation ground-based detectors and **Harald Lueck**, the principal investigator of the European Einstein Telescope project, discussed the status and findings of this design study. **Jan Harms** presented a study of the underground environment and discussed its advantages for gravitational-wave detectors.

The Workshop ended with sessions on recent results from gravitational wave searches performed using data from ground-based detectors LIGO and Virgo. **Peter Shawhan** summarized the searches for transients of arbitrary waveforms, **Duncan Brown** discussed searches for compact binary coalescences, **Xavier Siemens** presented results from the searches for cosmic string signatures in gravitational waves, and **Stefan Ballmer** summarized the searches for stochastic gravitational-wave signals. **Szabi Marka** discussed the emerging concept of multi-messenger astronomy – using gravitational wave signals along with electromagnetic or neutrino observations to study a variety of astrophysical objects. **Jolien Creighton** investigated what can be learned about neutron star structure using binary inspiral gravitational wave observations, and **Warren Anderson** discussed statistical subtleties associated with gravitational-wave searches.

During and after the workshop, many participants expressed their excitement with the breadth and depth of the science discussed at the workshop and their appreciation for the opportunity to participate. **Rai Weiss**, one of the leaders of the field, commented that "*this workshop was the most interesting one I have gone to for many years*". In summary, this was a very productive and strongly interactive workshop.

For more information please visit the workshop webpage at: http://www.ftpi.umn.edu/workshops/2009-2010/gw2010/index.html.