LSC Six-Month Progress

LIGO-M020328-00-M

Organization Carleton College Relativity Group (CCRG)

Report Date August 15, 2002

We have been extremely busy with LIGO related research. Carleton College is an active member of the LIGO Scientific Collaboration (LSC), and our research is coordinated with the LIGO Laboratory and the full LSC through memoranda of understanding. A description of our activities is presented below.

1) Demonstration of the Markov chain Monte Carlo (MCMC) technique for binary inspiral parameter estimation.

Prof. Nelson Christensen and Carleton student Adam Libson are working on the development of a Metropolis-Hastings program. This program is designed to take LIGO data and search for a gravity wave signal from the inspiral of a pair of compact objects (neutron stars, black holes). The goal is to develop a MCMC routine that operates within the LIGO-LSC Algorithm Library (LAL). The core of the inspiral event program comes from the LAL program “findchirp”, developed by Duncan Brown and Prof. Patrick Brady (University of Wisconsin, Milwaukee). We have written our routine so that it will call findchirp. This is important because as new and higher order templates are developed then they will automatically be incorporated and used through findchirp. The program does run, and can be used to find events and estimate the signal parameters (masses of the two binary stars, amplitude of the signal). We continue to work on the code in order to optimize and quantify its performance and efficiency. We are presently writing up the results for publication. Integration of this MCMC routine into the LAL system will occur in the coming months. We are also working with Dr. Massimo Tinto (of Caltech and JPL) and graduate student Hua Fang (Caltech) in order to investigate the efficiency of the Metropolis-Hastings routine as a search tool for binary inspiral events. Presently we are creating signals with the LAL routine inject, and detecting them with out Metropolis-Hastings modification of LAL routine findchirp.

2) Detector Characterization for LIGO E7 Engineering run and S1 Preparation.

Nelson Christensen is part of a LIGO detector characterization investigation led by Prof. Keith Riles (Dept. of Physics, University of Michigan). Nelson Christensen is the leader of a sub-group investigating correlations between LIGO interferometer signals and signals from environmental monitors. Russ Bainer and Carl Ebeling (Carleton undergraduates), and Prof. Adrian Ottewill (University College Dublin), Dr. Steve Penn (Syracuse University) and Dr. Dennis Ugolini (Caltech) also collaborate on this work.

The sub-group examined data from the LIGO E7 engineering run. We are now preparing for the upcoming S1 run. We computed numerous correlations between interferometer control channels and environmental monitors in order to decipher sources of noise. In addition, we also used higher order statistics, namely the bicoherence, in order to look for non-linear up-conversion of noise in the interferometer output. Numerous correlations were observed, as well as a few places where LIGO noise was coherently coupled at differing frequencies. Our group continues to scrutinize the LIGO data for deleterious noise correlations.

In July Nelson Christensen and Carleton student Carl Ebeling spent a week at the Hanford site. We were planning to attend S1, but when that was cancelled we came anyway so that we could get a number of the software systems tested and running. We conducted correlation studies using CorrMon. Also, we worked with Steve Penn on bicoherence, and used it to examine a number of channels. Finally, we worked on veto identification software that can be used by the inspiral and burst groups. All of this work is intended to be applied to the upcoming S1 run.

3) Inspiral Upper Limit Group

Nelson Christensen is an active member in two of the LSC's groups dedicated to using LIGO data to set upper limits on astrophysical sources. One of these is the Inspiral Upper Limit (IUL) Group. Christensen is concentrating his efforts in two specific sub-group activities.

a) IUL Detector Characterization Sub-Group

Nelson Christensen is the leader of the Detector Characterization Sub-Group, and is working with seven other LSC members on this effort. The sub-group conducted extensive studies on numerous environmental monitor channels in order to quantify when environmental events influence the quality of the interferometer output data. We are charged with developing code in order to present veto flags for the data. The E7 engineering run acquired much data over the span of December 2001 through January 2002. The IUL group just finished writing its report on the E7 analysis, and Christensen contributed to the detector characterization and veto sections. At Carleton College, Christensen and student Carl Ebeling have spent much time going through the "LOWNOISE" data collected at LLO in July. We are collaborating with Peter Shawhan on the development of software that helps to identify possible veto channels for the inspiral group during S1. We have thrown ourselves at the LOWNOISE data. We are using absGlitch to examine glitches in the AS_Q channel, as well as other interferometer control and PEM channels. Results from this effort are posted at http://physics.carleton.edu/Faculty/Nelson/LOWNOISE/LOWNOISE.htm

b) Multiple Interferometers and Statistics Sub-Groups

Nelson Christensen is also a member of the Multiple Interferometers and Statistics Sub-Group. His primary responsibility will be to develop a Metropolis-Hastings MCMC code in order to estimate parameters and produce summary statistics for events recorded by the binary inspiral template search. This work is explained above. The extension of the Metropolis-Hastings code to accommodate data from multiple interferometers, and hence to estimate additional parameter values (source location on the sky, gravity wave polarization) is in progress. The code is not yet complete, but is one of our primary research efforts. We are collaborating with Prof. Sukanta Bose (Washington State University) on the multiple interferometer parameter estimation effort.

4) Stochastic Background Upper Limit Group

Nelson Christensen is a member of the LSC's Stochastic Background Upper Limit Group. Christensen is part of the detector characterization effort, with the goal being to identify possible sources of correlated noise between the two LIGO detector sites. This correlation effort makes use of correlation code already being used in the other correlation studies. Nelson Christensen is working with Peter Fritschel (M.I.T.) and Mike Landry (LIGO-Hanford) on this effort. We are concentrating our search on seismic, magnetic and voltage line noise.

There is much overlap in interest between the Keith Riles detector characterization group and the Upper Limit detector characterization sub-groups. As such, Nelson Christensen is working in close consultation with a number of LSC members on detector characterization.