LSC Six-Month Progress Report

LIGO-M030053-00-M

Organization Carleton College Relativity Group (CCRG)
Report Date February 15, 2003

Attachment A / LIGO I

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 Parameter Estimation

a) Pulsar Signals: Prof. Nelson Christensen and Carleton student Ben Saks are working on the development of a Metropolis-Hastings algorithm (a MCMC technique) in order to detect and estimate parameters for gravity wave signals from periodic sources (such as pulsars). This work is being done in collaboration with Graham Woan and Rejean Dupois of Glasgow, and Renate Meyer of Auckland. The continuous waves upper limit group recently conducted a time-domain signal search based on a Bayesian approach. This is a search for a signal from a pulsar where the source location and pulsar rotation frequency are known. We are modifying this approach in order to estimate all four parameters; gravity wave amplitude, polarization, pulsar rotation inclination angle and phase. The code has been written and presently being tested. The advantage of a MCMC method is that it is efficient for a large parameter number. If our initial results are successful we will expand the technique to first try to identify signals from sources where the location is known but the signal frequency is not (such as SN1987A).

b) Binary Inspiral Parameter Estimation: Christensen and Carleton student Adam Libson are working on the development of a Metropolis-Hastings program for binary inspiral signal detection and parameter estimation. 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. Our initial results have been written up for publication, and will be submitted for publication; see Figure 1 below. This initial program can find events and estimate the signal parameters in the simplest sense; 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. The work is presently being extended in order to search for signals created by binary black hole inspiral events. For this research we are using signals and templates created in collaboration with B.S. Sathyaprakash of Cardiff.

2. Detector Characterization for LIGO S1 Run and S2 Preparation.

a) 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), Prof. Adrian Ottewill (University College Dublin), and Dr. Dennis Ugolini (Caltech) also collaborate on this work.

b) The sub-group examined data from the LIGO S1 scientific run. We computed numerous correlations between interferometer control channels and environmental monitors in order to decipher sources of noise. Numerous correlations were observed, as well as a few places where LIGO noise was coherently coupled at differing frequencies. Preliminary results of the correlation analysis we presented during detector characterization group telecons, with the results posted on the web: see S1 Correlations at http://physics.carleton.edu/Faculty/Nelson/S1Corr/S1Corr.htm

c) The DMT program, CorrMon, was tuned up (in collaboration with Adrian Ottewill) during E9, and we are now preparing for the upcoming S2 run.

d) Intersite correlations are also being studied, in collaboration with Robert Schofield of Oregon. We have been looking at correlations between the LSC-AS_Q channels at the LLO and LLO sites; some correlations have actually been found. In addition, we are analyzing data from coil magnetometers at the two sites. Correlations between magnetometer data at LLO and LHO have been observed. Correlations between AS_Q data at one site and magnetometer data at another have also been observed. These results have been reported during detector characterization telecons, and passed to the stochastic upper limit group though e-mails. The results are posted on the web: Intersite S1 http://physics.carleton.edu/Faculty/Nelson/InterS1/InterCorrelations.htm

3. Staffing Shifts for LIGO Scientific Runs

Christensen worked shifts during S1 at LLO. He will also be staffing shifts during S2.

4. Inspiral Upper Limit Group

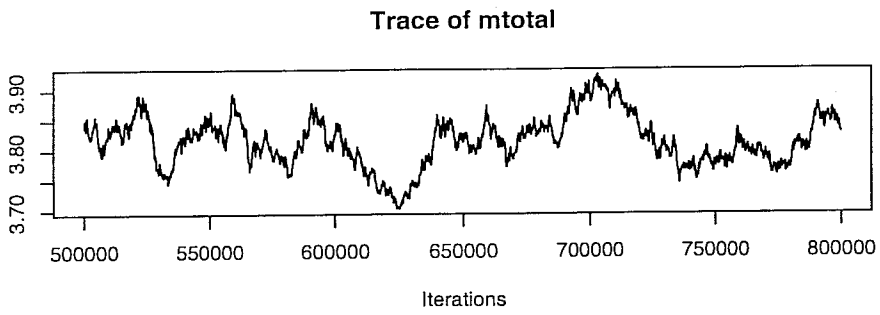
Christensen is an active member in two of the LSC groups dedicated to using LIGO data to set upper limits on astrophysical sources. One of these is the Inspiral Upper Limit (IUL) Group, and especially the IUL Detector Characterization Sub-Group. Christensen spends much time contributing to this detector characterization sub-group, and is working with many other LSC members on this effort. Carleton undergraduate Carl Ebeling has contributed significantly to this research task as well. The sub-group has conducted extensive studies on numerous environmental monitor channels in order to quantify when environmental events influence the quality of the interferometer output data. We developed code in order to present veto flags for the data. We spent significant amounts of time analyzing data from various interferometer control signals in order to develop potential veto flags for spurious inspiral-like events in the AS_Q data. Calculations and plots were made to display the veto efficiency verses dead-time for potential vetoes. The results were presented to the IUL group, and also posted on the web:

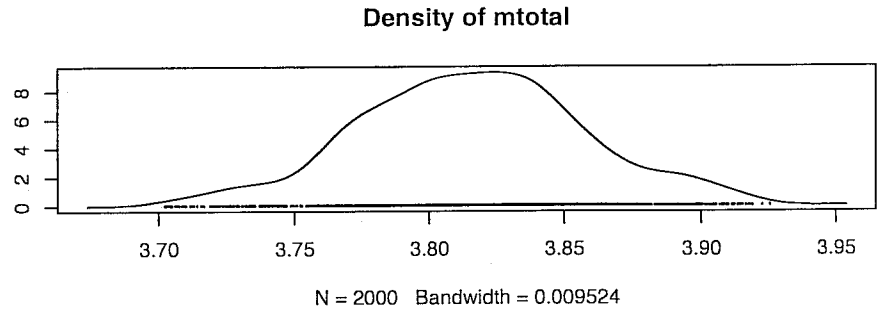
S1 vetoes http://physics.carleton.edu/Faculty/Nelson/S1vetoes/S1vetoes.htm

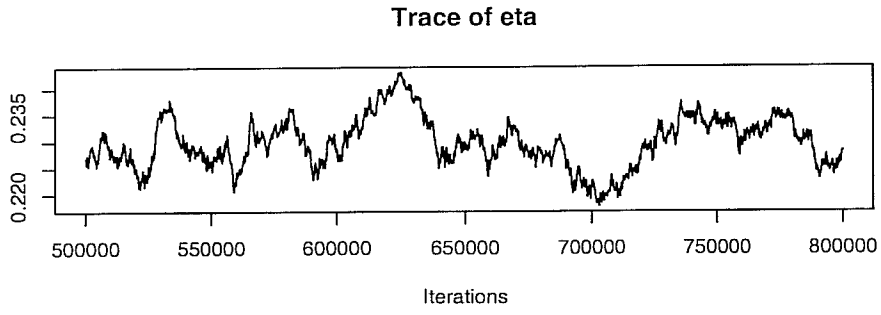
5. Stochastic Background Upper Limit Group

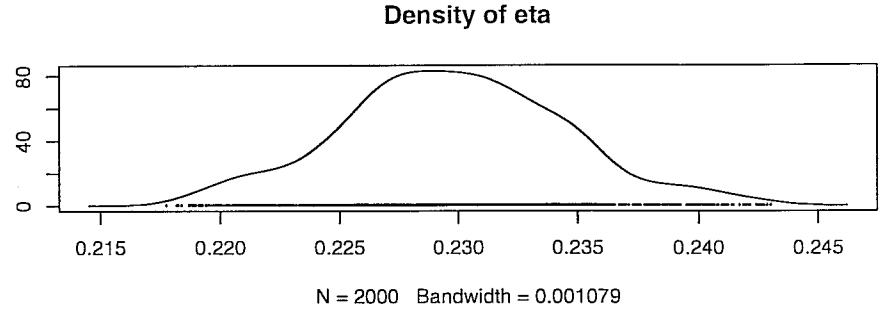
Christensen is a member of the LSC's Stochastic Background Upper Limit Group. The core of this effort has been in studying intersite correlations. This work was discussed above.

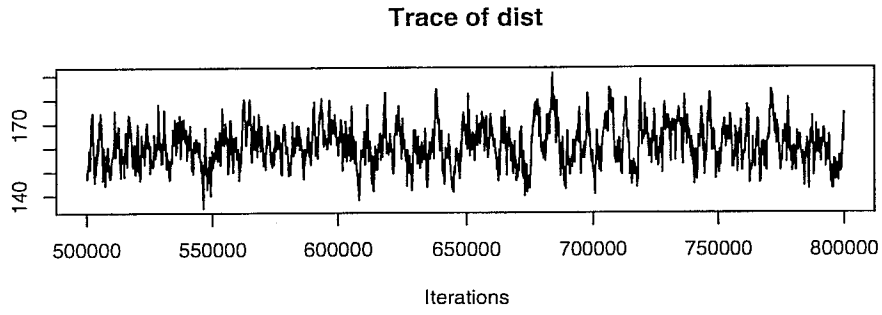
Figure 1: The trace plots and kernel densities for the parameters m_1 = 1.4 solar mass (SM), m_2 = 2.4 SM, $m_t = m_1 + m_2$ = 3.8 SM, $\eta = m_1 * m_2 / (m_1 + m_2)^2$ = 0.233, distance D, and phase, generated from the MH routine with SNR=14.

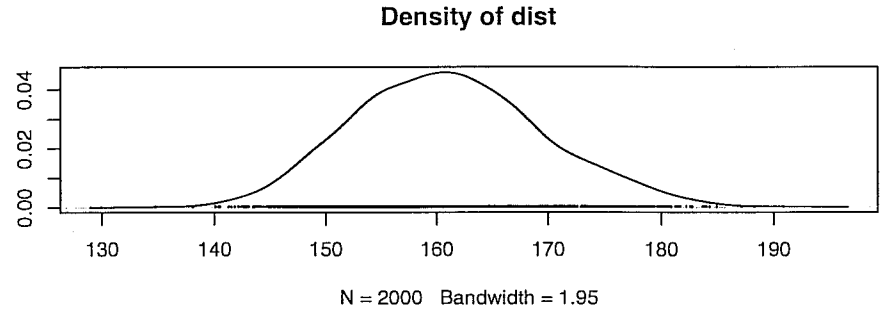

Trace of mtotal
3.70
3.80
3.90
500000
550000
600000
650000
700000
750000
800000
Iterations

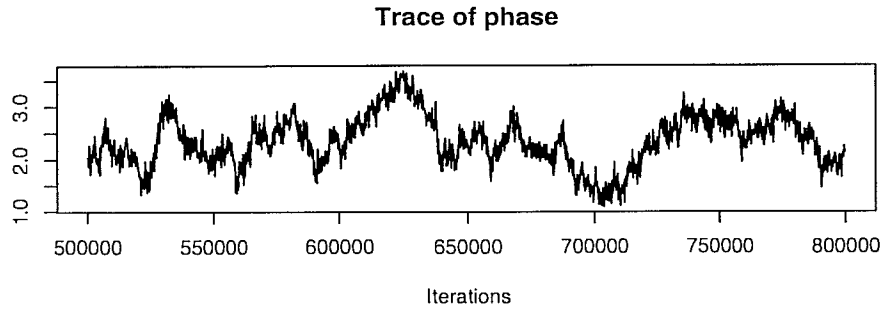

Density of mtotal
0
2
4
6
8
3.70
3.75
3.80
3.85
3.90
3.95
N = 2000 Bandwidth = 0.009524

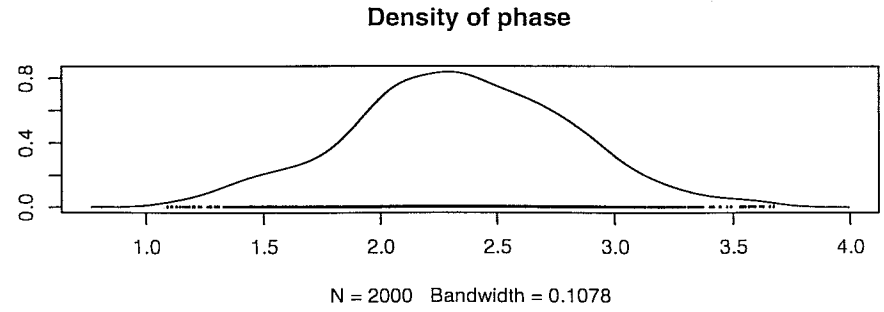

Trace of eta
0.220
0.235
500000
550000
600000
650000
700000
750000
800000
Iterations


Density of eta
0
40
80
0.215
0.220
0.225
0.230
0.235
0.240
0.245
N = 2000 Bandwidth = 0.001079


Trace of dist
140
170
500000
550000
600000
650000
700000
750000
800000
Iterations


Density of dist
0.00
0.02
0.04
130
140
150
160
170
180
190
N = 2000 Bandwidth = 1.95


Trace of phase
1.0
2.0
3.0
500000
550000
600000
650000
700000
750000
800000
Iterations


Density of phase
0.0
0.4
0.8
1.0
1.5
2.0
2.5
3.0
3.5
4.0
N = 2000 Bandwidth = 0.1078