Attachment Number A to the Memorandum of Understanding (LIGO-M000125-00-M) between the Carleton College Relativity Group (CCRG) and the Laser Interferometer Gravitational Wave Observatory (LIGO) Laboratory

August 15, 2003

This Attachment A to the Memorandum of Understanding LIGO-M0000125-00-M covers the role of the Carleton College Relativity Group (CCRG) as a Charter Member of the LIGO Scientific Collaboration (LSC) and a member of the LIGO I Development Group (L1DG). The period of performance for the activities in this Attachment is from August 15, 2003 to February 15, 2004. This period may be modified by agreement to a revision of this Attachment.

1. LIGO Scientific Collaboration - The LIGO Scientific Collaboration (Collaboration) is organized as a separate organization from the LIGO Laboratory. It includes scientists from the LIGO Laboratory, and those from collaborating institutions, and has its own leadership and governance. The Collaboration will ensure equal scientific opportunity for individual participants and institutions. It will organize the research, publications, and all other scientific activities. The Collaboration will report to the Laboratory Directorate for final approval of its research program, technical work, observational physics publications, and talks announcing new observations and physics results. This will be done through regular semi-annual reports to the Directorate and its PAC.

2. Charter Membership - An initial period for formation of the Charter group of institutions in the LIGO Scientific Collaboration commenced on March 1, 1997 and ended following the first full meeting of the Collaboration at which the Collaboration Council assumed its role.

   Following the charter period, proposals will be evaluated and approved, as appropriate, through the Collaboration Council. An MOU with the LIGO Laboratory, including Attachments defining specific work, will be required for any participating institutions.

3. This document is an agreement between the Carleton College Relativity Group (CCRG) and the LIGO Laboratory concerning the activities of CCRG as a Collaborating Institution in the LIGO Scientific Collaboration (LSC) and in the LIGO I Development Group (L1DG), and as indicated in Items No. 8, 9, and 10.

4. LIGO I Development Group - The LIGO I Development Group is the scientific collaboration for implementing and exploiting the initial LIGO detector and physics through the initial science data run. Only groups who establish a specific Attachment approved by the LIGO Laboratory, which defines a sufficient contribution and participation in LIGO I development,

implementation or data analysis will be part of this initial LIGO data run and science. Participation in future data runs and science that follow LIGO I will be possible for other groups, with guidelines to be determined by the LIGO Scientific Collaboration. It is anticipated that LIGO I data will only be made available through formal collaboration within the LIGO I Development Group during the first two years following its collection.

The general guideline for institutional membership in the LIGO I Development Group is that the contribution per collaborator of any new group to the design, construction, and implementation of the initial LIGO detector and to the first data run be comparable to that of the LIGO Laboratory scientists.

5. Report of Progress - CCRG will provide a status report on its activities in support of LIGO every six months. The report will consist of: a) a summary status on research by topic as indicated in Item No. 10 including progress against the milestones if any, significant accomplishments such as new insights/discoveries or publications, issues of concern if any, and an indication of invested time, b) updated List of Collaborators, and c) a plan of activities for the succeeding six-monthly period. The report will be due one month before the close of the period of performance under the Attachment in question.

6. Term of Membership - The Membership will be renewed every six months upon evidence of satisfactory performance of agreed upon duties.

   The coordinates of CCRG members are included in the Attachment Z to the Memorandum of Understanding LIGO-M000125-00-M.

7. Intellectual Property Rights - The rights to intellectual property developed under this Attachment will be subject to the National Science Foundation Grant Policy as indicated in Section 730, Intellectual Property.

8. LAL Software Conventions - It is necessary that any delivered code conforms to the LAL style as laid out in the LAL specification T990030. This includes: 1) coding style, headers, etc.; 2) use of function calls, etc.; 3) organization of software in the directory structures indicated in the document; 4) inclusion of test codes and validation tests to enable users to verify successful installation of implementation; and 5) documentation and users manuals (html or pdf) to enable users to understand and adopt code.

9. LSC Service Functions - Participation in LIGO I brings with it responsibility for service functions to support the overall effort in achieving high detector sensitivity and high data quality. In particular, each LIGO I group is expected to assist in the staffing of scientific monitoring shifts during organized data runs. The staffing of these shifts is notable for both its importance and the travel burden it places on scientists. This burden makes an equitable shift allocation mechanism necessary.

   A nominal guideline is that each LIGO I group should staff a fraction of the shifts comparable to its FTE fraction devoted to LIGO I activities. An eight hour shift is assumed. The current count of FTE in the Collaboration is XX (not including GEO FTE). The (name of group) has ZZ FTE's associated with LIGO I and is expected to staff x.x% of the scientific monitoring shifts during this MOU period.

Each LIGO I group will assign a representative who will be responsible for interaction with the designated LSC Shift Organizer (currently Keith riles of Michigan Univ.) with respect to the group's Service Function commitments.

Groups making extensive contributions to the LSC in other service efforts that involve a substantial travel burden may request a reduction in their nominal share of shift staffing. Those efforts can include:

1) Commissioning and instrument improvement

2) Participation in on-site detector characterization investigations

3) Development/operation of analysis software/hardware infrastructure and validation of analysis software that requires travel away from the home institution.

10. During the period August 15, 2003 to February 15, 2004, Professor Nelson Christensen and up to three undergraduate students will continue research in the areas of data analysis algorithm development and coding, and R&D related to the LIGO facilities. The following are CCRG's research goals for the six-month period under this agreement:

Detector Characterization

a) Christensen and the Carleton College students will continue focusing on detector characterization issues. We will continue to measure and report on correlations measured between interferometer and environmental channels. Nonlinear upconversions will also be studied through measurements of the bicoherence. We will also participate in investigations into the interferometer performance that will allow us to create viable veto triggers for the inspiral event search. Finally, we will also carry on with the extraction of correlated environmental signal between the LIGO interferometer sites as part of our participation in the stochastic background upper limits group.

LIGO I Data Analysis

b) Statistics and Parameter Estimation for Binary Inspiral Searches

The development of the Metropolis-Hastings code will be completed, and the code will be installed within LIGO's LAL computing system. The final installation will occur after its testing on hardware injected signals. We will continue with development of similar code with Sukanta Bose (of Washington State Univ.) for the multiple detector problem. We will also continue to work on extending the capabilities of the code to account for spin of the masses.

c) Statistics and Parameter Estimation for Continuous Wave Signals

Will work on the development of a Metropolis-Hastings for signal detection and parameter estimation for gravity wave signals from periodic sources (such as pulsars). This work is being done in collaboration with Graham Woan and Rejean Dupois (of Univ. of Glasgow). As part of our effort in the continuous wave group we will conduct a search for a signal (with unknown frequency and frequency derivative) from the remnant of SN1987A. The

Metropolis-Hastings code will also supplement the time-domain search for sources of known location and frequency components by searching the frequency and frequency-derivative parameter space in a near vicinity to the values derived from radio observations.

LSC Service Functions

d) The CCRG team agrees to staff .8% of the science monitoring shifts in support of engineering and scientific running of LIGO detectors.

Nelson Christensen will be responsible for the coordination of commitments, on the part of CCRG, in support of the LSC Service Functions with the designated LSC Shift Organizer.

11. During the period August 15, 2003 to February 15, 2004, the LIGO Laboratory will provide, as requested and necessary, LIGO data of relevance to the research topics in Item No. 10.

12. The research effort pursuant to this Attachment A will be coordinated by Nelson Christensen, Albert Lazzarini and Keith Riles on behalf of CCRG, the LIGO Laboratory and the LSC, respectively.

13. Resource Sharing: The LIGO Laboratory will contribute resources including allocation of appropriate scientific and engineering personnel, research facilities and funding in support of the effort in Item No. 10, as indicated below.

a) Accommodations for CCRG investigators while on LIGO research assignment at Caltech, and /or LIGO sites.

Approved:

Barry Barish
LIGO Laboratory Director
15 Dec 03
Date

Nelson Christensen
CCRG Principal Investigator
Date

Albert Lazzarini
LIGO Laboratory Data and Computing Group Leader
25 Nov 2003
Date

Irene Pekowsky for K. Riles
Keith Riles
LSC Shift Organizer
12-17-03
Date