

**Attachment Number A to the  
Memorandum of Understanding (LIGO-M990086-00-M)  
between the  
Cornell University Relativity Group (CURG)  
and the  
Laser Interferometer Gravitational Wave Observatory (LIGO) Laboratory  
February 15, 2000**

This Attachment A to the Memorandum of Understanding LIGO-M990086-00-M covers the role of Cornell University Relativity Group (CURG) as a Charter Member of the LIGO Scientific Collaboration (LSC) and a member of the LIGO I Development Group (LIDG). The period of performance for the activities in this Attachment is from February 15, 2000 to August 15, 2000. This period may be modified by agreement to a revision of this Attachment A.

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 Cornell University Relativity Group (CURG) and the LIGO Laboratory concerning the activities of CURG as a Collaborating Institution in the LIGO Scientific Collaboration (LSC) and in the LIGO I Development Group (LIDG), and as indicated in the Item No. 9 below.
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 Labo-

ratory, 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 - CURG 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 Item No. 9 below, 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 commitments.

The coordinates of CURG members are included in Attachment Z to the Memorandum of Understanding LIGO-M990086-00-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. LLAL Software Conventions - It is necessary that any delivered code conforms to the LLAL style as laid out in the LLAL 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. During the period February 15, 2000 to August 15, 2000, the members of CURG who will work in the LIGO I Development Group are: Eanna Flanagan, Wolfgang Tichy (Cornell 4th year graduate student), and Steve Drasco (Cornell 1st year graduate student). The following are CURG's research plans and goals for this LSC period:

a) Data Analysis for Stochastic Gravitational Waves

CURG will continue to work closely with the UTBRG group in completing the LAL coding for the standard cross-correlation statistic.

When this is completed Drasco will implement the small modifications necessary for the robust technique. The resulting code will be tested on simulated Gaussian noise and on noise from the 40-meter or from Hanford.

The paper with Joe Romano (UTBRG), and Bruce Allen and Jolien Creighton (UWMRG) deriving the optimal algorithm will be completed and submitted.

Drasco will continue his analytic exploration of data analysis methods for stochastic waves in the case when the statistical properties of the background itself is non-Gaussian (as may be produced by the superposition of signals from cosmological supernovae for example). This work is based on a Bayesian formalism that Drasco has recently mastered, and the prospects for obtaining a useful data analysis technique look very good.

b) Data Analysis for Burst Waves of Unknown Form (Blind Searches)

CURG is leading the implementation of the excess power search method.

The current LAL code has been tested only with simulated data. The code will be extended to work with prototype or Hanford data and tested.

The algorithm will be extended to a several-detector version, and the resulting algorithm will be implemented in LAL.

c) Development of Methods to Improve Waveform Templates

Tichy is in the early stages of a project relevant to sources consisting of neutron stars inspiraling into several hundred solar mass black holes, for which post-Newtonian templates will be insufficiently accurate. The essential difficulty is to evaluate the evolution of the Carter constant of the motion. Tichy is working on a method to compute the evolution of the Carter constant which was suggested by John Friedman (UWMRG). If the method pans out then it will be possible to use perturbation theory codes like that developed by Scott Hughes to compute waveforms, without necessitating the development of methods to compute local radiation forces.

d) Research Related to LIGO Facilities - Light Scattering Noise

Flanagan will complete a draft of the paper with Kip Thorne (Caltech) giving the foundational theory underlying analyses of light scattering noise in the LIGO beam tubes, and turn it over to Kip Thorne.

10. During the period February 15, 2000 to August 15, 2000, the LIGO Laboratory will share, as requested and appropriate, LIGO data of relevance to the research focus in Item No. 9 above.
11. The research effort pursuant to this Attachment A will be coordinated by E. Flanagan and Albert Lazzarini on behalf of CURG and LIGO Laboratory, respectively.
12. 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. 9, as indicated below. These resources will be in addition to the coordination effort and data to be made available per Item No. 10 above.

- a) Provide accommodations for CURG investigators while on LIGO research assignment at Caltech, and/or LIGO sites.

Approved:

Barry Barish  
Barry Barish  
LIGO Laboratory Director

Eanna Flanagan  
Eanna Flanagan  
CURG Principal Investigator

July 28, 2000  
Date

August 9, 2000  
Date

Albert Lazzarini  
Albert Lazzarini  
LIGO Laboratory Data and Computing  
Group Leader

26 June 2000  
Date