Attachment Number A to the Memorandum of Understanding (LIGO-M970063-00-M) between the Northwestern University Theoretical Relativity Group (NUTRG) and the Laser Interferometer Gravitational Wave Observatory (LIGO) Laboratory

August 15, 1997

This Attachment to the Memorandum of Understanding LIGO-L970063-00-M covers the role of NUTRG 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, 1997 to February 15, 1998. This period may be modified by agreement to a revision of this Attachment.

1. LIGO Scientific Collaboration - The LIGO Scientific Collaboration will be organized as a separate organization from the LIGO Laboratory. It will include scientists from the LIGO Laboratory, and those from collaborating institutions, and will have 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 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 will commence on March 1, 1997 and will end following the first full meeting of the Collaboration at which the Collaboration Council will assume its role. We expect that this transition will occur within six months. Membership in the Collaboration during this charter period will be initiated by proposal to the LIGO Laboratory Directorate.

   Following the charter period proposals will be evaluated through the Collaboration Council. With Collaboration approval, 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 Northwestern University Theoretical Relativity Group (NUTRG) and the LIGO Laboratory concerning the activities noted below, under provision 8, of NUTRG as a Collaborating Institution in the LIGO Scientific Collaboration (LSC) and in the LIGO I Development Group (L1DG).

4. LIGO I Development Group - The LIGO I Development Group will be 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 - NUTRG will provide a summary report of progress, monthly, by e-mail to the Collaboration Council and to the LIGO Laboratory Director. NUTRG will submit a complete report on its activities every six months, supply an updated List of Collaborators, and a plan of activities for the next six months. This report should be submitted one month before the updated attachment will take effect.

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

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. During the period August 15, 1997 - February 15, 1998, NUTRG , led by Prof. L.S. Finn, will include as collaborators Soumya Mohanty, Soma Mukherjee, and Joseph Romano. From August 15 - August 31, only Finn will participate in the effort described below. Starting September 1, Finn and his group will be in residence with the LIGO project at Caltech for one year. Each member of Finn's research group will work primarily on one of these projects in collaboration with appropriate LIGO personnel; Finn will supervise their progress while working on projects of his own, also in collaboration with LIGO project personnel.

   The work for LIGO 1 will consist of:

   a.) Monte Carlo simulations for data analysis. Characterizing the performance of data analysis algorithms requires testing on data whose content is known. Mohanty will work to develop a data simulator for use in testing analysis software. The simulator will be integrated into the existing LIGO end-to-end simulation model. The simulated data stream will include both signal and noise components. On the noise side, the data stream will include Gaussian, non-Gaussian and non-stationary noise sources. The character of the non-Gaussian and non-stationary noise sources will be drawn from investigations of the data records from existing interferometers. On the signal side, injection of both deterministic and stochastic signals drawn from anticipated astrophysical sources. Mohanty will take the lead in working with LIGO project personnel in this effort.

b.) Characterization of non-Gaussian and non-stationary noise sources. Gaussian noise arising from fundamental processes, e.g., LASER shot noise or thermal noise can generally be anticipated and characterized, a priori. Consequently, the analysis of data generally begins by assuming that the signal is additively superposed with Gaussian-stationary noise. Non-Gaussian and non-stationary noise sources generally are the result of processes that are not well understood and are difficult to anticipate or characterize; nevertheless, data analysis must recognize and accommodate the presence of these noise sources. Working with data from existing gravitational-wave detectors (both interferometric and acoustic), we will work to develop tools that can be used for identifying and characterizing non-Gaussian and non-stationary noise in the LIGO data stream. Efforts in this direction are part of an ongoing effort within the LIGO project. We are not proposing to start a new or independent effort in this area; rather, we are proposing to integrate our own expertise into the existing effort within the LIGO project. Mukherjee has been studying techniques for identifying and characterizing non-Gaussian and non-Stationary noise sources using the 100-hour Glasgow-Munich data run and will take the lead on this project.

c.) Stochastic signal detection. Allen has implemented a prototype data analysis for stochastic signals based on the work of Michelson, Christensen and Flanagan. This analysis derives from the perspective of Frequentist data analysis, which focuses on the characterization of decision rules based on ad hoc measures of the data. Bayesian data analysis offers a different perspective on data analysis, which focuses on an assessment of the probability of signal presence in a particular data stream. Finn has described the Bayesian data analysis for stochastic signal data analysis and proposes to develop a prototype analogous to Allen's with the goal of a comparative analysis of the performance of these two prototypes on simulated LIGO data. Romano, who worked with Allen on the development of the Frequentist stochastic signal data analysis prototype, will be primarily responsible for developing the Bayesian analysis prototype.

d.) Data analysis for generic impulsive burst events. Burst sources of gravitational radiation with detectable intensity generally result in the destruction of the source. On very general grounds we expect the waveform of the final burst of radiation emerging from such a source to have the character of an exponentially damped sinusoid (this is certainly true of anticipated burst sources like binary coalescence, black hole formation, and gravitational core collapse). Finn will work to implement an analysis prototype for the detection and characterization of these generic burst events.

e.) Data analysis for multi-detector receivers. The output of the several LIGO interferometers can be analyzed individually, as distinct gravitational-wave receivers acting in isolation, or coherently, as part of a larger, logical gravitational-wave receiver. Analysis of the data stream from a multi-detector receiver, as opposed to separate analyses of an equal number of isolated single-detector receivers, requires more sophisticated data handling and analysis techniques; however, the marginal gain in instrument sensitivity and extractable science is enormous. Finn will develop his analysis prototype for generic burst events into an analysis prototype for generic burst events in a multiple-detector receiver.

f.) Data stream management and analysis. There are a number of decisions regarding the management of the LIGO data stream yet to be made: for example, what pre-processing of the data stream will take place on-site, at Hanford and Livingston? ; what will be archived on site, and for how long?; what kinds of data analysis will be carried out on-line at the sites?; what fraction of the data stream will be forwarded off-site for archiving and analysis? Will data forwarded off-site be streamed or batched? If batched, what will be the delivery frequency and format: e.g., hourly by high speed data link, daily by tape, etc.? The answers to these questions are affected by the physics associated with the anticipated sources, e.g., the gravitational-wave signals associated with stellar core collapse will arrive several hours before any associated supernova becomes visible; consequently, timely identification of core collapse gravitational-waves is critical) and have implications for the for the personnel and computing power needed at each site. Finn will work with the LIGO project personnel currently investigating these issues to help define the criteria by which these decisions are to be made and, where appropriate, help make those decisions.

Approved:

Barry Barish
LIGO Laboratory Director

Aug 13, 1997
Date

Lee Samuel Finn
NUTRG Principal Investigator

5 Sept 1997
Date