

**Attachment Number A to the
Memorandum of Understanding (LIGO-M970058-00-M)
between the
Experimental Relativity Group (ERG) of the Pennsylvania State University
and the
Laser Interferometer Gravitational Wave Observatory (LIGO) Laboratory
August 15, 1999**

This Attachment to the Memorandum of Understanding LIGO-M970058-00-M covers the role of ERG 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, 1999 to February 15, 2000. This period may be modified by agreement to a revision of this Attachment.

1. LIGO Scientific Collaboration - The LIGO Scientific 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, physics publications, and talks announcing new 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 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 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 Experimental Relativity Group (ERG) of the Pennsylvania State University and the LIGO Laboratory concerning the activities of ERG as a Collaborating Institution in the LIGO Scientific Collaboration (LSC) and in the LIGO I Development Group (L1DG), and as noted in Item No. 8 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 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, during the first two years following its collection, through formal collaboration within the LIGO I Development Group.

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 - ERG 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. 8 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 duties.

The coordinates of ERG members are included in Attachment Z to the Memorandum of Understanding LIGO-M970058-00-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. This paragraph describes the work planned by the Penn State Relativity Group during the period August 15, 1999 to February 15, 2000. It is organized in sub-paragraphs whose headings describe how those activities relate to the LIGO Science Collaboration development groups.

A. Detector Characterization Development Group Activities:

1. Kalman Filter Development: Lee Finn and Soma Mukherjee will continue developing the Kalman Filtering techniques for the monitoring violin and other moderate to high Q modes of the detector subsystem.

A technical report, describing the method, an implementation, and the results of tests of its effectiveness will be completed.

The implementation in the LIGO Laboratory Data Monitoring Tool will be initiated.

2. System Identification for Artifact Regression: L. Finn, and Mijan Huq will produce a

technical report describing the use of system identification techniques to regress power-main and other environmental artifacts from the gravitational wave channel, an implementation in Matlab for power-main features, and the results of tests of its effectiveness on LIGO 40M prototype data.

3. Stationary Test / LIGO Data Monitoring: Soumya Mohanty will produce a technical report describing a new stationarity test for use in monitoring LIGO data, an implementation, and the results of tests of its effectiveness on LIGO Hanford Observatory (LHO) seismic data.
4. Stationary Properties / LIGO 40M Data: L. Finn and Sameer Gupta will study statistical properties of LIGO 40M data before and after several stages of conditioning: with no conditioning, following removal of violin mode resonances using Kalman filtering, and following removal of power-main features using regression techniques.
5. Simulated Data Sets: L. Finn will continue to chair the Detector Characterization subgroup assigned to develop simulated time series for LIGO noise. The first release of this software package will include all the principle noise sources (shot, radiation pressure, thermal and seismic). The second release will add violin modes, the ability to write data as frames.
6. LIGO I Suspensions / Diagnosis and Characterization: Gabriela Gonzalez will collect LHO seismic data with the goal of beginning to diagnose/characterize the LIGO I suspensions, seismic isolation and LHO seismic activity.
7. LIGO 40M data Set / Data Mining Technique: L. Finn will supervise University of Western Ontario collaborators C. Ling, R. Valluri, and D. Fielder, in an examination of the LIGO 40M data set using data mining tools. The immediate goal of this exercise is to see if data mining techniques can be used to identify the signature of an interferometer in danger of going out of lock.

B. Other LIGO I Development Group Activities

1. LHO Mode Cleaner: G. Gonzalez will participate in the commissioning of the LHO mode cleaner.
2. Gravity Gradient Studies: G. Gonzalez will collaborate with LATech and University of Oregon on gravity gradient studies.
3. LHO Seismic Noise Correlations: G. Gonzalez, Gaurav Khanna and David Garrison will analyze data and prepare technical report on LHO seismic noise correlations over distances ~0-30m, done with measurements taken on August 98.
4. LIGO/LSC Noise Characterization/Coincidence Analysis Program: L. Finn, S. Mohanty and S. Mukherjee will participate in the LIGO/LSC Noise Characterization/Coincidence Analysis program, which is being organized by the LIGO Laboratory.

Activities and responsibilities will depend on the directions taken by the group.

- 5. LLAL Development: L. Finn will work with Albert Lazzarini and Kent Blackburn (LIGO Laboratory staff) on LLAL design and software verification and validation issues.
- 6. LDAS /API: L. Finn will undertake coding tasks for LDAS data conditioning API.
- 7. November 1994 LIGO 40M Data Set: L. Finn, S. Mukherjee and M. Huq will produce new versions of the November 1994 LIGO 40M data set which have the violin mode and power line artifacts removed. These new data will be made available to the LIGO Laboratory and, on approval by the LIGO Laboratory, to other members of the LSC Collaboration.
- 9. During the period August 15, 1999 to February 15, 2000, the LIGO Laboratory will share as requested and appropriate the LIGO data of relevance to the research focus in Item No. 8 above.
- 10. The research effort pursuant to this Attachment A will be coordinated by Gabriela Gonzales and Albert Lazzarini on behalf of ERG and LIGO Laboratory, respectively.
- 11. 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. 8, as indicated below. These resources will be in addition to the coordination effort and data to be made available per Item No. 9 above.
 - a) Provide accommodations for investigators in Item No. 8 above while on research assignment on LIGO at Caltech and/or at LHO and LIGO Livingston Observatory (LSU) sites.

Approved:

Barry C Barish
 Barry Barish
 LIGO Laboratory Director

Dec 2, 1999
 Date

Albert Lazzarini
 Albert Lazzarini
 LIGO Staff

28 Nov 1999
 Date

Gabriela Gonzalez
 Gabriela Gonzalez
 ERG Principal Investigator

12/15/99
 Date

Lee Samuel Finn
 Lee Samuel Finn
 ERG Principal Investigator

12/16/99
 Date