

**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  
February 15, 2000**

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 February 15, 2000 to August 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 indicated 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 February 15, 2000 to August 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 Activities

1. Sam Finn and Soma Mukherjee will complete their technical report on the use of Kalman filters to identify and track violin modes and other stochastically excited narrow-band features in the interferometer data stream(s). The report will describe the construction of the filter, its use on simulated data sets as well as the November 1994 LIGO 40M data set, and a detailed characterization of the filter's performance. The matlab codes developed for this study will be made available to the collaboration on an PSU-maintained web page.

- S. Finn will continue to work toward implementation of the Kalman filters in the DMT. The software components needed here will be built upon those developed for the LDAS Data Conditioning API; correspondingly, progress will depend on progress of the Data Conditioning

API work.

2. S. Finn and Mijan Huq will complete their work and submit a technical report on the use of signal identification techniques for regressing environmental artifacts from the instrument data stream. The focus of this study was on 60 Hz line contamination of the November 1994 LIGO 40M data stream. The matlab codes used in this exercise will be made available to the collaboration on a PSU-maintained web page.

3. Soumya Mohanty will continue to work on the implementation of his new time-frequency stationarity test in the DMT.

4. S. Finn and Sameer Gupta will complete their study of the change in noise character of the LIGO 40M data set following the removal of instrumental and environmental artifacts (violin modes and power-main contamination). This study will report on the change in the excess noise events, the change in real detection efficiency in matched filter operations, and the change in the statistical character of the detector noise, as measured by its deviations from gaussianity.

5. S. Finn will continue to work with Edward Daw (MIT) on the software tool SimData, which accepts a detector design and, from it, generates time series of indefinite length and with the statistical characteristics of detector noise. A second release of the software, which will include whitening filters, violin modes, seismic noise, and will write frames, will take place during this period. Also during this period a technical report describing the SimData model will be completed and submitted for publication. Following this release it is anticipated that SimData will be turned over to the LIGO E2E group, who will integrate it into the E2E framework. Until then, the always current version will be maintained at <http://gravity.phys.psu.edu/~lsf/SimData>.

6. Gabriela Gonzalez will begin to develop DMT tools for correlations in the 2km LHO and 4km LLO.

#### B. Other LIGO I Development Group Activities

1. G. Gonzalez will finish developing the tuning procedure for the suspension controllers, and train operators at the sites for its use. She will also continue the work in the design team for a new design of controllers for LIGO I suspensions.

2. G. Gonzalez and Zeeno Greenwood (LATEch) will analyze the data Z. Greenwood took in LLO for amplitude of microseismic peak and correlations over 4km scale.

3. LHO Seismic Noise Correlations: G. Gonzalez and David Garrison will prepare technical report on LHO seismic noise correlations over distances -O-30m, done with measurements taken on August 98.

4. S. Finn, S. Mohanty and S. Mukherjee will continue to participate in the LIGO/TAMA

Coincidence Analysis Project. Specific tasks will depend on the direction the group takes in the analysis; however, the Penn State ERG anticipates that its responsibilities will focus on removing instrumental and environmental artifacts and the analysis of the data for intercontinental cross-correlations.

5. S. Finn will continue to coordinate the LSC team that is developing the LDAS Data Conditioning API. During this period it is expected that the digital linear filtering (PSU), digital resampling (PSU), power spectral (UTB) density and FFT (ANU) routines will be delivered and integrated into the LDAS system.
6. S. Finn, S. Gupta, M. Huq and S. Mukherjee will continue to work toward converting their new versions of the November 1994 LIGO 40M data set, which have the violin mode and power line artifacts removed, into FRAME format.
7. S. Finn will continue to serve on the LSC Software Coordination Committee, which is charged with completing LSC software standard and placing it under configuration control, coordinating the LIGO/LSC scientific software development effort, creating a controlled software repository, establishing that LSC contributed code is consistent with the LIGO/LSC Specification and Style Guide, organizing end to end tests and the mock data challenges, and operating as the LIGO/LSC software change control board.
8. S. Finn will continue to represent the LSC on the GWIC Joint Data Analysis “task force”, which is investigating the technical issues associated with joint analysis of data from the several worldwide gravitational wave detectors.
9. 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. 8 above.
10. The research effort pursuant to this Attachment A will be coordinated by Gabriela Gonzales and Albert Lazzarini on behalf of Penn State ERG and the 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 Penn State ERG investigators while on LIGO research assignment at Caltech, and/or LIGO sites.

Approved:

Barry Barish  
Barry Barish  
LIGO Laboratory Director

4-19-00  
Date

Albert Lazzarini  
Albert Lazzarini  
LIGO Staff

10 April 2000  
Date

Gabriela Gonzalez  
Gabriela Gonzalez  
ERG Principal Investigator

3/17/00  
Date

Lee Samuel Finn  
Lee Samuel Finn  
ERG Principal Investigator

3/17/00  
Date