

Attachment Number A to the
Memorandum of Understanding (LIGO-M950073-00-M)
between the
Michigan Gravity Wave Group (MGWG) in the Department of Physics of the
University of Michigan
and the
Laser Interferometer Gravitational Wave Observatory (LIGO) Laboratory
February 15, 2002

This Attachment to the Memorandum of Understanding LIGO-M950073-00-M covers the role of the Michigan Gravity Wave Group (MGWG) in the Department of Physics of the University of Michigan 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, 2002 to August 15, 2002. 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, 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 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. 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 Michigan Gravity Wave Group (MGWG) in the Department of Physics of the University of Michigan and the LIGO Laboratory concerning the activities of MGWG as a Collaborating Institution in the LIGO Scientific Collaboration (LSC) and in the LIGO I Development Group (LIDG), and as indicated in Item No. 9.

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** - MGWG 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 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-month 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 MGWG members are included in Attachment Z to the Memorandum of Understanding LIGO-M950073-00-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. **Planned Research**

Details of recent research are described in our latest progress report. To lend perspective to the specific sub items (a-j) below describing our plans for the next six months, let us first briefly summarize some of the highlights from that progress report. Following the specific sub items, we outline our plans for the six-month period starting in August 2002.

Highlights from most recent progress report:

- Gustafson has:
- Continued work on systemic noise reduction,
Assembled and tested the components of an AM-based servo control for the recycling cavity,
Devised a monitor of parasitic interferometers resulting from reflection of light back onto the mode cleaner, and
Contributed as a resident scientist at Hanford to ongoing commissioning work.

Riles has continued chairing the LSC Detector Characterization Group, devoting much time to coordinating data monitor tool software development and organizing LSC participation in engineering runs.

Chin has enhanced and delivered DMT software for defining and using operational state conditions, monitoring interferometer lock transitions, and monitoring servo instabilities. Chin has provided detailed lock segment information to the LSC on the E6 and E7 engineering runs.

Marsano has continued to refine pulsar search code as part of an analysis of fall 1999 40-meter data. Draft reports on the data cleaning and search code algorithms have been written. Monte Carlo studies of detection efficiency are underway.

Chin, Riles and Gustafson have all manned several scientific monitoring shifts during engineering runs E6 and/or E7, and continued work in the periodic sources upper limits working group.

Specific sub items of work during February 15, 2002 to August 15, 2002 are as follows:

On-site Observatory Support

- a) Gustafson and Chin will continue to investigate and reduce systemic noise in the LHO interferometers. [Ongoing work]
- b) Gustafson will continue developing an improved version of an AM based carrier-independent I+ servo. [Ongoing work]
- c) Gustafson will continue development of new controls and diagnostics. Specifically, we wish to apply to LIGO I a "lock stepper" first tried in analog at the 40 Meter for controlled in-lock stepping from one fringe to another, to allow relaxation of test mass lock positions, and possibly for calibration with one of integral fringe-wavelength steps. This is a long-term task relevant to a commissioned interferometer. In the next six months, preparation will be made to carry this out. Specifically, Gustafson and Chin will become familiar with the microprocessor digital servo software needed to implement this scheme. A first test will likely happen in the following six-month period. [Ongoing work]

d) Gustafson and Chin will continue to strongly support the LIGO I commissioning process with the goal of robust locking and running of the LIGO system, and developing the intimate LIGO IFO familiarity and expertise needed to assist in bringing the Characterized Detector performance to the effective noise level envisioned as LIGO I. [Ongoing work]

Detector Characterization

e) Riles chairs the LSC Detector Characterization Working Group. During February 15, 2002 to August 15, 2002, Riles will continue coordinating the group's efforts, together with LIGO liaison Daniel Sigg, sub group leaders Fred Raab, Jim Brau and Sam Finn, and the leaders of engineering run investigation teams. The coordination effort will include performance characterization, transient analysis, data set reduction and data set simulation. All of this work will be done in coordination with the upper limits analysis groups formed to analyze upcoming engineering run data.

Riles will continue working with LIGO Laboratory physicists, primarily John Zweizig, to facilitate efficient contributions to detector characterization by LSC members. He will also continue contributing directly to software algorithms for the on-site Data Monitor Tool in the areas of performance characterization and transient analysis (see sub items f and g).

Riles will organize LSC participation in upcoming engineering runs and data acquisition shakedowns at the Hanford and Livingston observatories in coordination with lab-designated engineering run leaders at the sites. [Ongoing work]

f) Chin will continue to add refinements to operational state condition software used in the online Data Monitor Tool (DMT), as needs arise. [Ongoing work]

g) Chin and Riles will continue to tune parameters, and add code enhancements to the lock state and servo instability monitors. [Ongoing work]

Data Analysis

h) Riles and Chin will continue implementing algorithms to discriminate between true periodic sources of gravitational radiation and instrumental artifacts. [Ongoing work]

i) Marsano will continue analysis of the 40 Meter data taken in fall 1999 by Gustafson and Steve Vass of Caltech, searching for periodic sources in known directions.

Milestone / August 15, 2002

Completion of testbed analysis and reports on software for data cleaning and searching for periodic sources of known location but unknown frequency, including estimation of statistical errors and upper limits.

j) Chin, Gustafson and Riles have joined the upper limits group to search for CW sources in the E7 and S1 data. Chin is providing the antenna pattern modulation code. Chin and Riles will provide the catalog and veto code needed to exclude known instrumental lines from consideration.

Riles, Gustafson and Chin will carry out the statistical analysis needed to set model-independent limits on CW power using multiple Fourier transforms of short data intervals. [Ongoing work]

The longer term:

We expect the six months starting in August 2002 to be quite intense as usual. Our group will continue making strong contributions in detector characterization & detector improvement, while spending increasing time on upper limits analysis of the data from the S1 Science Run. Our work will mostly be a continuation of what is described above, with increasing emphasis on the CW upper limits group search.

10. During the period February 15, 2002 to August 15, 2002, the LIGO Laboratory will share, as requested and appropriate, the LIGO data of relevance to the research topics in Item No. 9.
11. The research effort pursuant to this Attachment A will be coordinated by Richard Gustafson and Albert Lazzarini on behalf of MGWG and the 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.
 - a) Provide accommodations for MGWG investigators while on LIGO research assignment at Caltech, and/or LIGO sites.
 - b) Provide funding for off-site duty at the LIGO Hanford Observatory (LHO) site on the part of Prof. Richard Gustafson. The off-site duty is in support of the 2K LHO interferometer commissioning.

Approved:

Barry Barish
Barry Barish
LIGO Laboratory Director

2 March 04
Date

Albert Lazzarini
Albert Lazzarini
LIGO Laboratory Data and Computing
Group Leader

20 Jan 2004
Date

Ctirad Uher
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April 6, 2004
Date

Richard Gustafson
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Date