

**Attachment Number A to the
Memorandum of Understanding (LIGO-M000234-00-M)
between the
Inter-University Centre for Astronomy and Astrophysics (IUCAA)
and the
Laser Interferometer Gravitational Wave Observatory (LIGO) Laboratory
August 15, 2003**

This Attachment A to the Memorandum of Understanding LIGO-M0000234-00-M covers the role of the Inter-University Centre for Astronomy and Astrophysics (IUCAA) as a 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 August 15, 2003 to February 15, 2004. This period may be modified by agreement to a revision of this Attachment.

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 Inter-University Centre for Astronomy and Astrophysics (IUCAA) and the LIGO Laboratory concerning the activities of IUCAA as a Collaborating Institution in the LIGO Scientific Collaboration (LSC) and in the LIGO I Development Group (LIDG), and as indicated in Items No. 8 and 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 sci-

ence 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 - IUCAA 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 in 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-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 IUCAA members are included in the Attachment Z to the Memorandum of Understanding LIGO-M000234-00-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. During the period August 15, 2003 to February 15, 2004, IUCAA Gravitational Wave Data Analysis group will focus on the following two tasks:

LIGO I Data Analysis

- a) Extended Hierarchical Search Methods for Inspiral Compact Binaries

The analytics of the extended hierarchical search algorithm has been completed and the

code has been written. The code has successfully run on simulated data. The code has been ported in the LDAS environment. The code must now be adapted to real data and it must perform on real data. For this purpose S2 data will be used. Using S2 data involves adjusting the parameters in the search schema for optimal performance. Also it has been observed during implementation that a cluster of events is generated by the presence of a signal. An optimal way of condensing this cloud of events will be tried out.

b) More efficient search

We will use Chebyshev polynomials to interpolate the maximum likelihood estimator (or its surrogate namely the match) in searching for the inspiraling binary signal. This approach has not been used so far in this context and we expect that we may need to search a given parameter space with fewer templates. This would make the search more efficient because then we would be using templates which are likely to be less statistically dependent. This work will be done in collaboration with Sam Finn.

10. During the period August 15, 2003 to February 15, 2004, the LIGO Laboratory will provide, as requested and necessary, LIGO data of relevance to the research in Item No. 9.
11. The research effort pursuant to this Attachment A will be coordinated by Sanjeev Dhurandhar and Albert Lazzarini on behalf of the IUCAA 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) Accommodations for IUCAA investigators while on LIGO research assignment at Caltech.
 - b) Funding for visits at Caltech, on the part of IUCAA investigators, as agreed.

Note:

With the goal of subsidizing LIGO funds for the IUCAA/LIGO collaboration, a joint project funded by DST of India and NSF of the US is in operation. The PIs of the project are Albert Lazzarini from LIGO Laboratory and Sanjeev Dhurandhar from IUCAA. Sam Finn, Director, Center for Gravitational Wave Physics (CGWP) at Penn State is the Co-PI. Finn has agreed to fund visits of the Indian researchers to CGWP from the CGWP funds allocated for international collaboration.

Approved:

Barry Barish

Barry Barish
LIGO Laboratory Director

26 Nov 03

Date

S. V. Dhurandhar

Sanjeev Dhurandhar
IUCAA Principal Investigator

15th December 2003

Date

Albert Lazzarini

Albert Lazzarini
LIGO Laboratory Data and Computing
Group Leader

15 Nov 2003

Date