

Memorandum of Understanding (LIGO- M050306-00-M)
between the
National Astronomical Observatory of Japan TAMA (NAOJ-TAMA)
and the
Laser Interferometer Gravitational Wave Observatory (LIGO)
August 15, 2005

The purpose of this Memorandum of Understanding (MOU) is to establish and define a collaborative relationship between the National Astronomical Observatory of Japan TAMA Group (NAOJ-TAMA) and the Laser Interferometer Gravitational-Wave Observatory (LIGO). Both parties to this agreement share the broad goals of developing the instruments and techniques for detecting and studying gravitational waves, and subsequently using them as an astrophysical probe. Under this MOU, the NAOJ-TAMA Group will be a member group of the LIGO Scientific Collaboration.

1. The National Astronomical Observatory of Japan TAMA (NAOJ-TAMA) consists of Associate Professor Seiji Kawamura, who will serve as Principal Investigator for research in LIGO, and one professor, one post doctoral fellow, and three graduate students. The focus of the work done by the NAOJ-TAMA Group under this agreement will be to develop the advanced interferometer configuration for Advanced LIGO.
2. LIGO comprises two parts: the LIGO Laboratory and the LIGO Scientific Collaboration. These two entities report to the LIGO Directorate, consisting of the LIGO Director, the LIGO Scientific Collaboration Spokesperson, and the LIGO Laboratory Deputy Director. The design and construction of the LIGO Observatories were carried out by California Institute of Technology (Caltech) and the Massachusetts Institute of Technology (MIT) under a Cooperative Agreement between the National Science Foundation (NSF) and Caltech. The LIGO Oversight Committee supervises the realization of LIGO.
 - A. The LIGO Laboratory is responsible for the operation of the LIGO Observatories, the development and implementation of future detector systems, and participates in all aspects of the research with the LIGO detectors. LIGO is a system of three interferometric Fabry-Perot antennas, two of them 4 kilometers long and the third one 2 kilometers long, aimed at the simultaneous detection of gravitational waves in the frequency range 40-6000 Hz. LIGO Observatories are located in Hanford, Washington and

in Livingston Parish, Louisiana (USA) and began observations in the year 2002. The LIGO Laboratory is funded through a Cooperative Agreement between the National Science Foundation and Caltech, with the portion of the LIGO Laboratory at MIT funded through a subcontract from Caltech.

- B. The LIGO Scientific Collaboration (LSC) is organized as a separate entity from the LIGO Laboratory. It includes scientists from the LIGO Laboratory, and those from collaborating institutions, and has its own governance and leadership (which includes the LSC Spokesperson as a member of the LIGO Directorate). The Collaboration ensures equal scientific opportunity for individual participants and institutions. It organizes the research, publications, and all other scientific activities. The Collaboration reports to the LIGO 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 Program Advisory Committee. The organization of the LSC and its governance are defined in its Charter.
3. As a member group of the LSC, the NAOJ-TAMA Group will participate in the governance of the LSC and in setting its policies and procedures, as defined in the LSC charter. Similarly, it agrees to abide by the policies and procedures adopted by the LSC and posted on its website (<http://www.ligo.org/policies.html>), concerning publication, data access, software standards, and so on.
 4. Membership in more than one collaboration active in the same area of research may present complications. Members of the LSC contemplating joining other gravitational wave collaborations or participating in data analysis efforts with collaborations outside a framework established by the LSC should inform and consult with LSC and the LIGO Laboratory to ensure that no conflicts of interest exist.
 5. The LSC is the primary advocate of interferometric gravitational wave research in the U.S. To function effectively in this role, it needs to be informed in advance about major new initiatives. The NAOJ-TAMA Group agrees to inform the LSC of any major new proposals related to LIGO to be submitted to the NSF, and to consult with the LSC concerning the best approach to support the overall LIGO program. The final decision about the scope of any such proposal shall remain the prerogative of the NAOJ-TAMA Group.
 6. LSC Service Functions - Participation in the LSC brings with it responsibility for service functions to support the overall effort in achieving high detector sensitivity and high data quality. In particular, each LSC group is expected to assist in the staffing of scientific monitoring shifts during organized data runs. The staffing of these shifts is notable for both its importance and the travel burden it places on scientists. This burden makes an equitable shift allocation mechanism necessary.

A nominal guideline is that each LSC group should staff a fraction of the shifts

comparable to its FTE fraction devoted to LSC activities. Seiji Kawamura (NAOJ-TAMA Group) will be responsible for interaction with the designated LSC Shift Organizer with respect to the ABC Group's Service Function commitments.

Groups making extensive contributions to the LSC in other service efforts that involve a substantial travel burden may request a reduction in their nominal share of shift staffing. Those efforts can include:

- Commissioning and instrument improvement
 - Participation in on-site detector characterization investigations
 - Development/operation of analysis software/hardware infrastructure and validation of analysis software that requires travel away from the home institution.
7. Each party to this agreement continues to be responsible for all support of its staff including travel costs associated with the activities under this agreement. Exceptional support of travel by the other institution may be allowed for travel requested by that institution.
 8. Attachments to this MOU will be prepared annually to define the specific activities and responsibilities of the NAOJ-TAMA Group and to define any resources to be provided by the LIGO Laboratory to the NAOJ-TAMA Group in support of those activities.
 9. NAOJ-TAMA Group will provide an annual status report on its activities in support of LIGO. The report will consist of a summary status on research by topic as indicated in the Attachments for that period 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 by each member of the group. The report will be due one month before the close of the period of performance under the Attachments in question.
 10. The LSC will review the progress report against the Attachments from the previous year and assess the Attachments for the up-coming year annually, under its established procedure, and recommend acceptance or rejection of each Attachment by the LIGO Director and the LSC Spokesperson.
 11. A list of NAOJ-TAMA Group members will be updated at least every six months. NAOJ-TAMA Group members and appropriate contact information will be provided in electronic form as Attachment Z to this Memorandum of Understanding. In cases where individuals who leave the group have had access to LIGO data and this access should be terminated, the NAOJ-TAMA Group Principal Investigator is responsible for timely notification to the Directorate and to the computing committee so access may be revoked.
 12. The LIGO Laboratory is responsible for obtaining NSF approval of collaborative Memoranda of Understanding where required. All Memoranda of Understanding will be provided to NSF for their information.

13. The rights to intellectual property developed under this Attachment using LIGO Laboratory resources will be subject to the National Science Foundation Grant Policy as indicated in Section 730, Intellectual Property.
- A. In the event a patentable invention is conceived or first actually reduced to practice during the work of a member(s) of the NAOJ-TAMA Group at LIGO Laboratory facilities, he/she will:
 - i) make prompt disclosure of the invention to the Director of the LIGO Laboratory; and
 - ii) cooperate with LIGO Laboratory and supply all information and execute all papers including invention reports, records of invention, patent applications and powers of attorney, necessary and proper to fulfill the obligations of the LIGO Laboratory to the U.S. Government sponsor.
 - B. The ownership of inventions conceived solely by members of the NAOJ-TAMA Group at LIGO facilities shall be owned by the National Astronomical Observatory of Japan University, although the LIGO Laboratory shall be granted a license to use such invention for noncommercial research purposes at LIGO facilities. Inventions that are conceived by both members of the NAOJ-TAMA Group and LIGO Laboratory staff as part of the LIGO project shall be jointly owned and any income from commercial licensing shall be shared in proportion to the number of joint inventors from each institution.

In all other regards, the rights to intellectual property developed by members of the NAOJ-TAMA Group under this Attachment will be in accordance with the policies of National Astronomical Observatory of Japan University.

14. This MOU supersedes the previous MOU between the LIGO Laboratory and the NAOJ-TAMA group (LIGO-M990031-00) and its amendments and attachments. This MOU will remain in force until the parties mutually agree to terminate it, or until it is terminated in accordance with LSC procedures.

Approved:

Barry Barish
LIGO Director

Seiji Kawamura
Principal Investigator
NAOJ-TAMA Group

Peter Saulson
LSC Spokesperson

**Attachment ACF to the
Memorandum of Understanding (LIGO- M050306-00-M)
between the
National Astronomical Observatory of Japan TAMA (NAOJ-TAMA)
and the
Laser Interferometer Gravitational Wave Observatory (LIGO)
August 15, 2005**

This Attachment ACF to the Memorandum of Understanding LIGO-M050306-00-M defines the role of the National Astronomical Observatory of Japan TAMA (NAOJ-TAMA) as a Member of the LIGO Scientific Collaboration (LSC) and a member of the Advanced Detector Configurations Development Group (ADCDG). The period of performance for the activities in this Attachment is from August 15, 2005 to August 15, 2006.

1. Advanced Detector Configurations Development Group - The Advanced Detector Configurations Development Group (ADCDG) is the scientific collaboration for defining and developing entirely new advanced interferometers. It is expected that this development group will pursue research in dual recycling, resonant sideband extraction, Sagnac interferometers, systems with non-transmitting optics and other advanced configurations. MOU Attachments define the roles and responsibilities of groups in this development group.
2. During the period August 15, 2005 to August 15, 2006, the members of NAOJ-TAMA Group will participate in ADCDG in the following areas:

a) The 4-m suspended-mirror RSE interferometer

F. Kawazoe, K. Kokeyama, S. Sato, and S. Kawamura will demonstrate the new signal extraction method in the 4-m suspended RSE interferometer at NAOJ. This signal extraction method, which would be a backup method for Advanced LIGO interferometer, uses two modulations: one phase modulation and one amplitude modulation. The phase modulation sidebands will transmit through the Michelson interferometer because of the Michelson asymmetry, while the amplitude modulation sidebands will be completely reflected back because of the Michelson asymmetry. This contrast of the behavior between the two sets of the sidebands makes it possible to extract most effectively the length signal of the signal extraction cavity. We will start with building the Mach-Zender interferometer for the double modulation without producing the sidebands of the sidebands. Then we will try to lock the central part of the RSE interferometer and will proceed to the whole interferometer.

b) Homodyne detection experiment

S. Sakata, S. Sato, and S. Kawamura will investigate the possibility of making very light mirror (less than 1 mg) in order to make it possible to observe the radiation pressure effect, thus the ponderomotive squeezing effect without employing an extremely high power laser

nor a cavity of extremely high finesse. As soon as we obtain a conceptual design of the mirror, we will develop the mirror as well as its suspension system. We will then install them into the existing interferometer. We also will develop the interferometer control scheme for the simple Michelson interferometer with the homodyne detection. We will try it in the real set-up.

c) The 40m RSE prototype at Caltech

S. Kawamura will visit Caltech for two months in summer of 2006 to work on the 40m prototype. He will work on either characterization of the RSE interferometer, DC readout, or output mode cleaner, whichever is the most important research topic at that time.

3. 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. 2, as indicated below.
 - a) Research accommodations for NAOJ-TAMA group members while on LIGO research assignment at any LIGO Laboratory site,
 - b) Access to LIGO data through established LSC channels in support of this work.
4. Coordination and Reporting – NAOJ-TAMA Group will perform this research within the structures established by the LIGO Laboratory and the LSC where appropriate. In particular activities described in Item 2 will be carried out within the Advanced Detector Configurations Development Group of the LSC. Coordination will include keeping the Group leaders informed of activities and plans, reporting to the group at meetings and telecons, and through technical documents submitted to the LIGO Document Control Center.

In addition, an annual report will be submitted with the update to this Attachment, giving a summary status on research by topic as indicated in Item No. 2, 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. This Attachment will be updated at least annually with a plan of activities for the succeeding on-year period. These documents will be due one month before the close of the period of performance under this Attachment.

Approved:

Barry Barish
LIGO Laboratory Director

Seiji Kawamura
NAOJ-TAMA Principal Investigator

Peter Saulson
LSC Spokesperson

Ken Strain
ADCDG Leader

**Attachment Z to the
Memorandum of Understanding (LIGO-M050306-00-M)
between the
National Astronomical Observatory of Japan TAMA (NAOJ-TAMA)
and the
Laser Interferometer Gravitational Wave Observatory (LIGO)
Laboratory
August 15, 2005**

This Attachment to the Memorandum of Understanding LIGO-M050306-00-M lists the coordinates of the members of the National Astronomical Observatory of Japan TAMA (NAOJ-TAMA) who will participate in the LIGO Scientific Collaboration (LSC) as members of LIGO Development Groups. The period of performance for the activities in this Attachment is from **August 15, 2005 to August 15, 2006**. This period may be modified by agreement to a revision of this Attachment.

Name	Address	Contact Info.	FTE 2/05 to 8/05	Est. FTE 8/05 to 2/06	Authorship
Kawamura, Seiji Faculty	National, Astronomical Observatory of Japan 2-21-1 Osawa, Mitaka, Tokyo, 181-8588, Japan	seiji.kawamura@nao.ac.jp Tel. 81-422-34-3618 Fax 81-422-34-3793	50%	50%	Y
Fujimoto, Masa- Katsu Faculty	National Astronomical Observatory of Japan 2-21-1 Osawa, Mitaka, Tokyo, 181-8588, Japan	fujimoto.masa- katsu@nao.ac.jp Tel. 81-422-34-3622 Fax 81-422-34-3793	5%	5%	N
Sato, Shuichi Post Doctoral Fellow	National, Astronomical Observatory of Japan 2-21-1 Osawa, Mitaka, Tokyo, 181-8588, Japan	sato.shuichi@nao.ac.jp Tel. 81-422-34-3662 Fax 81-422-34-3793	50%	50%	Y
Kawazoe, Fumiko Grad Student	National, Astronomical Observatory of Japan 2-21-1 Osawa, Mitaka, Tokyo, 181-8588, Japan	kawazoe@gravity.mtk.na o.ac.jp Tel. 81-422-34-3625 Fax 81-422-34-3793	100%	100%	Y
Sakata, Shihori Grad Student	National, Astronomical Observatory of Japan 2-21-1 Osawa, Mitaka, Tokyo, 181-8588, Japan	shihori.sakata@nao.ac.jp Tel. 81-422-34-3662 Fax 81-422-34-3793	100%	100%	Y

Kokeyama, Keiko Grad Student	National, Astronomical Observatory of Japan 2-21-1 Osawa, Mitaka, Tokyo, 181-8588, Japan	enterprise@gravity.mtk.na o.ac.jp Tel. 81-422-34-3625 Fax 81-422-34-3793	100%	50%	Y
Somiya, Kentaro Post Doctoral Fellow Moved to Max Planck Institut in Germany on Apr, 1, 2005	National Astronomical Observatory of Japan 2-21-1 Osawa, Mitaka, Tokyo, 181-8588, Japan	somiya@hagi.k.u- tokyo.ac.jp Tel. 81-422-34-3622 Fax 81-422-34-3793 (2/15/05 to 3/31/05)	80% (until 3/31/05)		

Approved:

Barry Barish
LIGO Laboratory Director

Seiji Kawamura
NAOJ-TAMA Principal Investigator

Peter Saulson
LSC Spokesperson