# Memorandum of Understanding (LIGO-M050360-00-M)

# between the

# Moscow State University Relativity Group (MSURG)

# 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 Moscow State University Relativity Group (MSURG) 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 MSURG will be a member group of the LIGO Scientific Collaboration.

1. The Moscow State University Relativity Group (MSURG) consists of Professor V.B.Braginsky, who will serve as Principal Investigator for research in LIGO, and four professors and several researchers from MSU Department of Physics and also technician and post graduated students. The focus of the work done by the MSURG under this agreement will be mainly: a) to continue the researches aimed to identify and analyze different types of noises in the detector's parts and in the detector readout system, b) to explore different methods to reduce these noises, c) to propose and to analyze new topologies of the detector.

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 MSURG 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 MSURG 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 MSURG.

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. Vladimir Braginsky (MSURG) will be responsible for interaction with the designated LSC Shift Organizer with respect to the MSURG'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 MSURG and to define any resources to be provided by the LIGO Laboratory to the MSURG in support of those activities.

9. MSURG 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 MSURG members will be updated at least every six months. MSURG 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 MSURG 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 MSURG 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 MSURG at LIGO facilities shall be owned by the Moscow State 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 MSURG 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 MSURG under this Attachment will be in accordance with the policies of Moscow State University.

14. This MOU supersedes the previous MOU between the LIGO Laboratory and the MSURG (LIGO-M970084-00-M) 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:

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Barry Barish
LIGO Director

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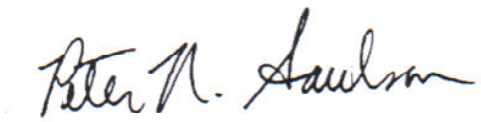
Vladimir Braginsky
Principal Investigator
MSURG



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Peter Saulson
LSC Spokesperson

# Attachment ACF to the
# Memorandum of Understanding (LIGO-M050360-00-M)
# between the
# Moscow State University Relativity Group (MSURG)
# and the
# Laser Interferometer Gravitational Wave Observatory (LIGO)
# August 15, 2005

This Attachment ACF to the Memorandum of Understanding LIGO-M050360-00-M defines the role of the Moscow State University Relativity Group (MSURG) 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 MSURG will participate in ADCDG in the following areas:

   *Interferometer Configurations* – F.Ya.Khalili and S.P.Vyatchanin are planning to continue the analysis of different new schemes of LIGO readout and topologies which has to permit to obtain the sensitivity better than SQL.

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 MSURG 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 – MSURG 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:

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| Barry Barish<br>LIGO Laboratory Director | Vladimir Braginsky<br>MSURG Principal Investigator |
| Peter Saulson<br>LSC Spokesperson | Ken Strain<br>ADCDG Leader |

# Attachment SUS to the
# Memorandum of Understanding (LIGO-M050360-00-M)
# between the
# Moscow State University Relativity Group (MSURG)
# and the
# Laser Interferometer Gravitational Wave Observatory (LIGO)
# August 15, 2005

This Attachment SUS to the Memorandum of Understanding LIGO-M050360-00-M defines the role of the Moscow State University Relativity Group (MSURG) as a Member of the LIGO Scientific Collaboration (LSC) and a member of the Isolation/Suspension/Thermal Noise Development Group (ISTNDG). The period of performance for the activities in this Attachment is from August 15, 2005 to August 15, 2006.

1. Isolation/Suspension/Thermal Noise Development Group - The Isolation/Suspension/Thermal Noise Development Group (ISTNDG) is the scientific collaboration for defining and developing future isolation and suspension improvements for use in advanced subsystems for the initial LIGO interferometers or in entirely new advanced interferometers. 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 MSURG will participate in ISTNDG in the following areas:

a) C*oating Losses* – I.A.Bilenko will implement a new installation in which:
   1. Thin tiny model of the mirror's Brownian noise will be measured, the mirror's surface will be coated with the same type of coating as it will be used in Adv. LIGO. The goal: to pinpoint the excess noise due to the coating.
   2. In the same installation the density of light (by focusing) will be managed to exceed the one in the Adv. LIGO. The goal: to observe the precursors of the laser breakdown.

b) *Suspension design for AdvLIGO* –
   1. V.P.Mitrofanov and K.V.Tokmakov will continue to improve the sensitivity and to perform the measurements of electrical charging of the mirror. The goal: to obtain the value of the short time fluctuations of the charge and thus to predict the possible mechanical action on the mirror due to AC component of Coulomb force.
   2. V.P.Mitrofanov and K.V.Tokmakov are planning to implement and to test the low noise tranquillizer which has to demonstrate the decrease of the violin mode Q (from $Q = 10^8$ to $Q = 10^6$) with the small increase of thermal noise.

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 MSURG 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 – MSURG 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 Isolation/Suspension/Thermal Noise 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:

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| _____ | _____ |
| Barry Barish<br>LIGO Laboratory Director | Vladimir Braginsky<br>MSURG Principal Investigator |
| _____ | _____ |
| Peter Saulson<br>LSC Spokesperson | Joseph Giaime<br>ISTNDG Leader |

# Attachment Number Z to the
# Memorandum of Understanding (LIGO-M050360-00-M)
# between the
# Moscow State University Relativity Group (MSURG)
# And the
# Laser Interferometer Gravitational Wave Observatory (LIGO)
# August 15, 2005

This Attachment to the Memorandum of Understanding LIGO-M050360-00-M lists the members of MSURG group who will participate in the LIGO Scientific Collaboration (LSC). The period of performance for the activities in this Attachment is from August 15, 2005 to February 15, 2006. This period may be modified by agreement to a revision of this Attachment.

| Name | Address | E-mail | Phone Nos. | Begin Date End Date | FTE fraction | | Qualifies for authorship |
|---|---|---|---|---|---|---|---|
| | | | | | Upcoming year | Previous year | |
| Braginsky Vladimir, Faculty | Department of Physics, Moscow State University, Moscow 119992 Russia | brag@ hbar.phys. msu.ru | 07-095-147-6225 Fax: 07-095-932-8820 | Aug.15, 2005 Feb.15, 2006 | 80% | 80% | Yes |
| Mitrofanov Valery, Faculty | Department of Physics, Moscow State University, Moscow 119992 Russia | mitr@ hbar.phys. msu.ru | 07-095-939-3783 Fax: 07-095-932-8820 | Aug.15, 2005 Feb.15, 2006 | 60% | 60% | Yes |
| Vyatchanin, Sergey Faculty | Department of Physics, Moscow State University, Moscow 119992 Russia | SVyatcha nin@ phys. msu.ru | 07-095-939-4428 Fax: 07-095-932-8820 | Aug.15, 2005 Feb.15, 2006 | 60% | 60% | Yes |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Khalili Farid Faculty | Department of Physics, Moscow State University, Moscow 119992 Russia | farid@ hbar.phys. msu.ru | 07-095-939-1224 Fax: 07-095-932-8820 | Aug.15, 2005 Feb.15, 2006 | 60% | 60% | Yes |
| Bilenko Igor Faculty | Department of Physics, Moscow State University, Moscow 119992 Russia | igor@ hbar.phys. msu.ru | 07-095-939-4034 Fax: 07-095-932-8820 | Aug.15, 2005 Feb.15, 2006 | 60% | 60% | Yes |
| Tokmakov Kirill Faculty | Department of Physics, Moscow State University, Moscow 119992 Russia | kirill@ hbar.phys. msu.ru | 07-095-939-3783 Fax: 07-095-932-8820 | Aug.15, 2005 Feb.15, 2006 | 60% | 60% | Yes |
| Apalkov Viktor Technician | Department of Physics, Moscow State University, Moscow 119992 Russia | N/A | N/A | Aug.15, 2005 Feb.15, 2006 | 50% | 50% | No |
| Danilishin Stefan Faculty | Department of Physics, Moscow State University, Moscow 119992 Russia | stefan@ hbar.phys. msu.ru | 07-095-939-1224 Fax: 07-095-932-8820 | Aug.15, 2005 Feb.15, 2006 | 30% | 30% | No |
| Strigin Sergey Faculty | Department of Physics, Moscow State University, Moscow 119992 Russia | strigin@ hbar.phys. msu.ru | 07-095-939-4428 Fax: 07-095-932-8820 | Aug.15, 2005 Feb.15, 2006 | 30% | 30% | No |
| Prokhorov Leonid Grad. student | Department of Physics, Moscow State University, Moscow 119992 Russia | N/A | N/A | Aug.15, 2005 Feb.15, 2006 | 50% | 50% | No |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Lazebny V.I. Grad. student | Department of Physics, Moscow State University, Moscow 119992 Russia | N/A | N/A | Aug.15, 2005 Feb.15, 2006 | 50% | 50% | No |

Scientific Collaboration Council Delegates: Vladimir Braginsky and Valery Mitrofanov

Approved:

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Barry Barish
LIGO Director

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Vladimir Braginsky
Principal Investigator
MSURG

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Peter Saulson
LSC Spokesperson