This Attachment DAT to the Memorandum of Understanding LIGO-M050270-00 defines the role of the Pennsylvania State University Relativity Group (PSURG) as a Member of the LIGO Scientific Collaboration (LSC). In particular, it addresses data analysis activities in support of the initial LIGO interferometers. The period of performance for the activities in this Attachment is from August 15, 2008 - August 14, 2009.

1. Collaboration

Together, the LIGO Laboratory and the LIGO Scientific Collaboration (LSC) are responsible for implementing and exploiting the initial LIGO detector through its science data runs. The LSC has organized the data analysis effort into search groups which coordinate analysis, review, and publication on behalf of the collaboration. LSC groups are encouraged to participate in one or more of these groups.

MOU Attachment DAT defines the contributions of each participating group to the data analysis development groups.

2. Participation

During the period August 15, 2008 - August 14, 2009, the members of PSURG will participate in the analysis of initial LIGO data in the following areas:

a. Binary Inspirals

- O'Shaughnessy will continue to work with Kalogera, Mandel and other non-LSC collaborators (C. Kim) in assembling and maintaining for the Collaboration the merger rates executive summary document. Significant improvements and extensions will be made in order to keep pace with recent theoretical work and new observations.
- Kopparapu and O'Shaughnessy will complete, incorporate into LIGO analysis interpretation, and submit for publication there study on the impact of elliptical galaxies on the LIGO merger rates.
- Higher-dimensional Waveform Templates: O'Shaughnessy, in collaboration with Valisneri and Mandel, will investigate the role of physical (quasi)symmetries
in complicating the recovery of source parameters from observed gravitational wave signals.

b. Bursts

- **BlockNormal Analysis Pipeline**: Lang, assisted by Finn, will maintain the blockNormal pipeline for use in generating triggers for later follow-up by an enhanced MaxEnt analysis.
- **MaxEnt Analysis Pipeline**: Lang, assisted by Finn, will complete the MaxEnt analysis pipeline, now underway, for astrophysically triggered sources. The MaxEnt analysis is a fully-coherent network analysis that determines the probability ratio \( \text{(signal present)/(signal absent)} \) and, for the case signal present, the probability that the supposed signal has a given duration and waveform, and the most likely waveform (i.e., the waveform and duration that maximizes the probability density). She will apply this analysis pipeline to S5 and VS1 data in the neighborhood of GRBs and SNe events.
- **S6 Triggered Analysis**: Lang, assisted by Patcyk, Bondarescu and Finn, will develop a fully automated MaxEnt triggered search pipeline. This automated pipeline will receive real-time triggers from GCN, using the general GCN trigger daemon described in section e of this attachment, retrieve and analyze LIGO (and, if possible, Virgo and GEO) data for gravitational wave events in the neighborhood of the GCN trigger, and report on its results via an abbreviated e-mail and a more detailed web page. This analysis will run 24/7 without human intervention.

c. Stochastic

Not applicable.

d. Continuous

- **Cas A**: Owen will continue collaborating with the ANU group on completing the search, and with others in the CW group on setting up similar searches.
- **Directed search targets**: Owen will continue collaborating with Penn State astronomers Sigurdsson and Eracleous on identifying promising targets for Cas A-type searches. This will include the submission of one or more papers on target lists for Cas A type searches.
- **Comb-over search**: Owen will collaborate with the University of Melbourne group on preparing the “comb-over” search for Sco X-1. This will employ Ransom’s frequency comb method, studied in a technical paper by Messenger and Woan, over a wide frequency band. The first step involves a manuscript firming up estimates of sensitivity vs computational cost for realistic conditions and comparing to astrophysical emission scenarios. Then a Melbourne student will investigate adapting existing F-statistic code for the search.
- **Owen will contribute astrophysical guidance to various searches and interpretation material to various papers as needed, including “pepping up” results for high-profile journals.
- **Astronomy liaison**: Owen will continue helping organize LIGO/neutron star meetings and getting astronomers and nuclear physicists interested in CW group activities, including soliciting sharing data.

e. Other Contributions
• Evidence-based model selection: Finn, O'Shaughnessy and (non-LSC-member) Rubbo will develop Bayesian Evidence-based methods to determine when observations justify the use of more complex models. They will apply this analysis to determine the appropriate post-Newtonian order for template bank analyses, and other LIGO analyses.

• Hardware resources and services: Servers will be provided and maintained to host the following services for the LSC:
  – Collaboration Directory and Membership services, including ldap and collaboration wide mail exploders;
  – Mail services for LSC Mac users, for LSC system administrators, for LSC Registration Authorities (RAs);
  – Problem tracking systems for OSG, Directory and Membership Services;
  – LIGO Accounts Management System (LAMS);
  – The primary KDC for Kerberos authentication across the LIGO.ORG realm.

• System Administration and “Help Desk” Services
  – PSU system administrators will work with their counterparts at other institutions to insure proper integration of the resources and services described above into the LIGO Data Grid.
  – PSU system administrators will administer a secondary KDC at LIGO-CIT (and, on request, at other institutions or sites).
  – System programmer Patcyk and other PSU group members will provide “help-desk” support on a best-effort basis for the use of Matlab-compiled software for LIGO data analysis. This includes investigation of new compiler releases and maintanence of web-based documentation for LSC users.

• LIGO VO Support for OSG: PSU will continue to provide primary support for OSG usage of LIGO VO resources, continue to fulfill the responsibilities of OSG point of contact, security contact, and support center for LIGO, and handle any issues that arise for OSG users, OSG administrators and the OSG Grid Operations Center (GOC) while using LIGO facilities; regular participation in OSG Operations, OSG Integration, and OSG Support Center telecons; and representation on the LIGO Comp Comm of the LIGO VO Tier 2 site at PSU.

• LIGO VO Membership service: PSU will continue to maintain and administer the Virtual Organization Membership Service (VOMS) and LIGO Accounts Management System (LAMS) used to track users with Grid certificates approved to use LIGO Data Grid resources. Designated PSU personnel will continue to act as an Accounts Administrator to authorize users to access LDG resources.

• Collaboration and Collaborator Authentication and Authorization Initiative:
  – Menendez, assisted by Finn and Williams, will work with the Authentication and Authorization Committee to design and implement the authentication and authorization SQL and LDAP database backend infrastructure for the Collaboration.
  – Menendez, assisted by Finn and Williams, will re-implement the present “Directory Services” infrastructure as a layer of services on top of the Authentication and Authorization database backend.
  – Menendez, assisted by Finn and Williams, will add Virgo and others who have business with the LSC, into the existing authentication and authorization infrastructure.
• Certificate Authority: Designated PSU personnel will continue to act as a CA for the LIGO Data Grid, under the supervision of Warren Anderson.

• Metadata services: The PSU group will work with the UWM group to explore directions for consolidation and improvement of the metadata services currently provided on the LDG. This activity will take a view that covers enhanced LIGO and begins the process of development for the Advanced LIGO era.

• Data analysis software toolkits
  – GCN trigger daemon: Patcyk, assisted by Finn, will develop, deploy and maintain a GCN trigger daemon. The daemon will be registered with GCN and receive real-time GCN triggers. LSC data analysts will be able to register analysis jobs and conditions with the daemon. Acting on the received triggers and the conditions provided, the daemon will kick-off appropriate analysis jobs on LDG computing resources.
  – On-demand data retrieval: Patcyk, assisted by Finn, will develop, deploy and maintain an on-demand data retrieval service and associated API. This service will allow LDG programs to request FrameData without reference to its physical location, either locally on a cluster or globally across the LDG. Requested data that is anywhere available will be retrieved by the fastest available route (as determined using the Network Weather Service described below) and returned to the user program without the need for human intervention.
  – Network Weather Service: Patcyk, assisted by Finn, will develop, deploy and maintain a network weather service that will provide, via RLS, information on the network bandwidth between LDG sites. The first use of this service will be to support fast on-demand data retrieval. Koranda (UWM) has expressed an interest in participating in this activity and we welcome his involvement as permitted by his other work assignments.
  – MatApps Software Suite: Patcyk, assisted by Finn, will maintain the core infrastructure of MatApps, including the software currently used throughout the LSC to access FRAME data, to access calibration data files produced by the calibration group, and to write FRAMES from within Matlab. Over the next year work will involve identifying and centralizing core functionality required by users, improving the functionality and performance of the MatApps data discovery and retrieval services, providing functionality for control-room use. PSU will continue to assist in upgrades to the MATLAB frame-creation software to support its use by all LSC Analysis Groups.
  – Custom RDS files: Patcyk will maintain the infrastructure to produce custom RDS frames, which is now part of the MatApps package.
  – Matlab FrameBrowser: Patcyk, assisted by Finn, will develop, deploy and maintain a Matlab FrameBrowser. The browser will provide a graphical user interface view of Frame metadata, including time-spans, channels, sample rates, and other by channel and by frame annotations.

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 PSURG group members while on LIGO research assignment at any LIGO Laboratory site.

    Not Applicable

b. Access to LIGO data through established LSC channels in support of this work.

    Not Applicable

4. Coordination and Reporting

PSURG will perform research within the structures established by the LIGO Laboratory and the LSC where appropriate.

In particular, with reference to activities described above:

2a will be carried out within the LSC Inspiral Search Group.

2b will be carried out within the LSC Burst Search Group.

2c will be carried out within the LSC Stochastic Search Group.

2d will be carried out within the LSC Continuous Waves search Group.

This includes 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 one-year period. These documents will be due one month before the close of the period of performance under this Attachment.

5. Computer Code

All computer code delivered to the LSC under this Attachment must be developed in consultation with the LSC Data Analysis Software Working Group (DASWG) and archived, documented and reviewed as determined by that group.
Attachment OPS to the
Memorandum of Understanding LIGO-M050270-00
between the Pennsylvania State University Relativity Group (PSURG) and the
Laser Interferometer Gravitational Wave Observatory (LIGO)

For The Period
August 15, 2008 - August 14, 2009

This Attachment OPS to the Memorandum of Understanding LIGO-M050270-00 defines the role of the Pennsylvania State University Relativity Group (PSURG) as a Member of the LIGO Scientific Collaboration (LSC) in the areas of detector commissioning, detector characterization, and operations support in the initial LIGO interferometers. The period of performance for the activities in this Attachment is from August 15, 2008 - August 14, 2009.

1. Collaboration

Together, the LIGO Laboratory and the LIGO Scientific Collaboration (LSC) are responsible for implementing and exploiting the initial LIGO detector through its science data runs. LSC groups are encouraged to contribute to the commissioning, characterization, and operation of the LIGO detectors, as members of working groups established by the LIGO Laboratory and the LSC.

2. Participation

During the period August 15, 2008 - August 14, 2009, the members of PSURG will participate in the initial LIGO detector research program in the following areas:

a. Detector Commissioning

   Not Applicable

b. Detector Characterization

   Not Applicable

c. Detector Operations

   Thorne will work on a release of MatApps utilities for installation in the control rooms for use with the MATLAB-based mDV package of online analysis tools. (See also DAT.)

d. Other Contributions

   Not Applicable
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 PSURG group members while on LIGO research assignment at any LIGO Laboratory site.

      Not Applicable

   b. Access to LIGO data through established LSC channels in support of this work.

      Not Applicable

4. Coordination and Reporting

PSURG will perform research within the structures established by the LIGO Laboratory and the LSC where appropriate. In particular, with reference to activities described above:

   2a will be carried out in coordination with the LIGO Laboratory Commissioning Leader.

   2b will be carried out within the Detector Characterization Working Group of the LSC.

   2c will be carried out in coordination with the LHO or LLO Site Head.

This includes 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 one-year period. These documents will be due one month before the close of the period of performance under this Attachment.

5. Computer Code

All computer code delivered to the LSC under this Attachment must be developed in consultation with the LSC Data Analysis Software Working Group (DASWG) and archived, documented and reviewed as determined by that group.
Attachment OUT to the
Memorandum of Understanding LIGO-M050270-00
between the Pennsylvania State University Relativity Group (PSURG)
and the
Laser Interferometer Gravitational Wave Observatory (LIGO)

For The Period
August 15, 2008 - August 14, 2009

This Attachment OUT to the Memorandum of Understanding LIGO-M050270-00 defines the role of the Pennsylvania State University Relativity Group (PSURG) as a Member of the LIGO Scientific Collaboration (LSC) in support of Education and Outreach to the broader community. The period of performance for the activities in this Attachment is from August 15, 2008 - August 14, 2009.

1. Education and Outreach

As a frontier physics effort, LIGO offers a unique opportunity to inspire interest in science among students and to educate the broader community. The LIGO Laboratory supports a broad program of education and outreach to take advantage of these opportunities. Activities to attract and educate visitors take place at both Observatories, as well as the development of educational materials for use there and elsewhere.

The LIGO Laboratory is building a Science Education Center at the Livingston Observatory, and is participating with local partners to make it a vehicle for science education throughout the region. LSC groups are invited to participate in these activities, and to suggest others, with the goal of leveraging activities to make a greater impact.

This MOU Attachments defines the role and responsibilities of groups in this development group.

2. Participation

During the period August 15, 2008 - August 14, 2009, the members of PSURG will participate in in LDG in the following areas:

a. Educational Materials Developed

   Not Applicable

b. Other Contributions

   - All PSURG members will continue to engage in opportunistic outreach activities.
   - PSU will continue to maintain a mirror site that serves Einstein@Home data.
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 PSURG group members while on LIGO research assignment at any LIGO Laboratory site.

   Not Applicable

b. Access to LIGO data through established LSC channels in support of this work.

   Not Applicable

4. Coordination and Reporting

PSURG will perform 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 with the LIGO Observatories Educational and Outreach Leaders. This includes 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 one-year period. These documents will be due one month before the close of the period of performance under this Attachment.

5. Computer Code

All computer code delivered to the LSC under this Attachment must be developed in consultation with the LSC Data Analysis Software Working Group (DASWG) and archived, documented and reviewed as determined by that group.
Jay Marx
LIGO Laboratory Director

Lee Samuel Finn
Principal Investigator(s)
PSURG

David Reitze
LSC Spokesperson
Attachment Z to the Memorandum of Understanding LIGO-M050270-00 between the Pennsylvania State University Relativity Group (PSURG) and the Laser Interferometer Gravitational Wave Observatory (LIGO) for the period August 15, 2008 - August 14, 2009.

This Attachment Z to the Memorandum of Understanding LIGO-M050270-00 lists the members of Pennsylvania State University Relativity Group (PSURG) participating in LIGO Scientific Collaboration (LSC) development group activities in support of the initial LIGO interferometers. The period of performance for these activities is from August 15, 2008 - August 14, 2009.

Faculty:

The Faculty category includes all “faculty rank” LSC members. This includes professorial appointments, research faculty appointments, teaching faculty appointments, lecturer and reader appointments, and similar appointments, and visiting appointments in all these categories.

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systems administrator or programmer, technician, and similar appointments, and visiting appointments in all these categories.

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Undergraduate Students:

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              State: PA
              Postal Code: 16801
              Country: USA
Administrative Staff:

The Administrative Staff category allows the listing of administrative aides and other staff members who perform essential support services in or for LSC member groups, but are not involved in the LIGO Scientific Collaborations engineering or scientific work. Personnel who are involved in the LSC’s scientific or engineering work, including computer system administration and programming, should be listed under other categories. Personnel listed as Administrative Staff may be designated as a point of contact or proxy, but do not appear as authors on LSC publications, do not count toward a group’s council delegate allocation, may not serve as council delegates, and do not increase a group’s shift obligation.

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Forwarding: lsfinn+bbk@psu.edu

FTE Commitment:

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Total FTE: 11.25

Roles:

Principal Investigators: Finn, Lee Samuel

Membership Point-Of-Contact: Finn, Lee Samuel

Group PIO/Press Coordinator: Kennedy, Barbara

Proxies: Williams, Hannah

Author Eligible | Council Delegates
---|---
Finn, Lee Samuel | Finn, Lee Samuel

PSURG Attachment Z  Generated: September 9, 2008  Page 4 of 5
Author Eligible
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Desai, Shantanu
Kopparapu, Ravi Kumar
O'Shaughnessy, Richard
Thorne, Keith
Minelli, Jeffrey
Williams, Hannah

Council Delegates
Owen, Benjamin

Approvals:

Jay Marx
LIGO Laboratory Director

Lee Samuel Finn
Principal Investigator(s)
PSURG

David Reitze
LSC Spokesperson