Attachment DAT to the

Memorandum of Understanding (LIGO-M050320-00-M)

between the

Northwestern University Gravitational Wave Astrophysics Group (NUGWAG)

and the

Laser Interferometer Gravitational Wave Observatory (LIGO)

August 15, 2005

This Attachment DAT to the Memorandum of Understanding LIGO-M050320-00-M defines the role of the Northwestern University Astrophysics Group (NUGWAG) as a Member of the LIGO Scientific Collaboration (LSC), in particular, its activities in **theoretical astrophysics and** data analysis **and interpretation** in support of the initial LIGO interferometers. The period of performance for the activities in this Attachment is from August 15, 2005 to August 15, 2006.

1. Together, the LIGO Laboratory and the LIGO Scientific Collaboration 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 the analyses, perform detailed reviews, and prepare publications on behalf of the collaboration. LSC groups are encouraged to participate in one or more of these groups. MOU Attachments define the contributions of each participating group to the data analysis groups.

2. During the period August 15, 2005 to August 15, 2006, the members of the NUGWAG Group will participate in the analysis **and interpretation** of initial LIGO data in the following areas:

   Binary Inspirals – 1) Astrophysical and astronomical guidance needed in the development of data analysis pipelines; 2) Theoretical astrophysics calculations and predictions for binary inspiral source rates and properties needed for the development of data analysis and interpretation methods; 3) Development and testing of efficient data analysis methods; 4) Review and advising services. More specifically:

   (i) Kalogera will provide advice and recommendations for signal hardware injections and Monte Carlo simulations for the determination of detection efficiencies and vetoes and upper limit caluclations. This work will be based on the most current astronomical knowledge of galaxy distribution in space, physical properties and history in binary compact object formation, as well as current astrophysical predictions and knowledge of component masses, spins, and other relevant physical properties.

   (ii) Kim and Kalogera (in collaboration with non-LSC member D. Lorimer) will continue their work on developing the first quantitative modeling of acceleration pulsar searches and their selection effects to estimate the binary inspiral rate contribution of a newly discovered double neutron star (the 4th

known in the Galactic field that will coalesce within a Hubble a time) an other future discoveries through pulsar acceleration searches. This work is expected to be completed within the year upon Kim's PhD graduation in Summer 2006.

(iii) Kim and Kalogera (in collaboration with non-LSC member D. Lorimer) will complete a publicly available web-based tool suite that will allow interested researchers to calculate inspiral rates based on binary pulsar discoveries.

(iv) O'Shaughnessy, Kalogera, and Belczynski will continue their long-term work (presented in multiple completed and future publications) on constraining population synthesis models and binary black hole inspiral rate predictions by imposing empirical constraints. New constraints to be imposed include: empirical (from pulsar observations) rate constraints from eccentric and merging pulsar binaries with white dwarf companions, empirical supernova rates of different types, and empirical constraints on neutron star kicks.

(v) O'Shaughnessy and Kalogera will address the issue of the contribution of elliptical galaxies and latent binary inspiral events to the total inspiral rate. The answer to this problem is crucial for the realistic population modeling needed for the analysis of S4 data, given the high instrument reach during S4.

(vi) O'Shaughnessy and Kalogera will contribute to the population modeling needed in data analysis and searches for spinning black hole binaries, using their published results from last year's theoretical astrophysics studies of black hole spins.

(vii) O'Shaughnessy will continue to explore the potential of genetic algorithms, as a means to more efficiently perform template inspiral searches. The expectation is that with proper tuning these methods will perform almost as reliably as a thorough study of any template bank, and compare very favorably with a conventional hierarchical search.

(viii) O'Shaughnessy will complete the investigation of using generalized templates (e.g., "spiky" templates) to detect conventionally- and poorly-modelled signals in the presence of realistic detector noise.

(ix) R. O'Shaughnessy will spend a limited amount of time developing and testing veto systems. Among others, he expects to test (i) one incorporating only the template scores themselves (i.e., the values of the overlap on various templates), in an effort to make use of the expected dependence of overlap with parameters; and (ii) one incorporating many control-channel signals, in an effort to use machine-learning and pattern-recognition algorithms to automate veto identification.

(x) Kalogera will initiate the formulation and development of strategies for the interpretation first of astrophysically interesting upper limits, and later of inspiral detections under different assumed scenaria for circumstances (one or more detections of various signal-to-noise ratios, with or without parameter estimation, etc). Such upper limits and possibly detections could become available by the Inspiral group data analysis results this coming year.

(xi) Kalogera will continue to serve as a Reviewer of the Inspiral Group analysis, publications, and presentations and as a Member of the LIGO-PAC committee.

(xii) Kalogera will continue to provide advice and perform calculations promptly when requested on issues related to source detection expectations (signal-to-noise ratios, rates, etc) as a function of future detector noise characteristics. **This really belongs more into "support for future detector design", but**

the Advanced detector template deals with real instrumentation development, so I put this here.

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 NUGWAG group members while on LIGO research assignment at any LIGO Laboratory site,
   b) Access to LIGO data in support through established LSC channels in support of this work.

4. Coordination and Reporting – NUGWAG Group will perform this research within the structures established by the LIGO Laboratory and the LSC where appropriate. In particular activities described in Item 2a) will be carried out within the LSC Inspiral Search Group, Item 2b) will be carried out within the LSC Burst Search Group, and Item 2c) will be carried out within the LSC Stochastic Search Group. 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.

5. 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.

Approved:

Barry Barish	Vassiliki Kalogera
LIGO Laboratory Director	NUGWAG Principal Investigator

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Peter Saulson
LSC Spokespoerson

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Peter Shawhan
LSC Burst Search Group Leader

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