Attachment DAT to the Memorandum of Understanding LIGO-M050292-00 between the Caltech Relativity Group (CaRT) and the Laser Interferometer Gravitational Wave Observatory (LIGO)

For The Period

August 15, 2008 - August 14, 2009

This Attachment DAT to the Memorandum of Understanding LIGO-M050292-00 defines the role of the Caltech Relativity Group (CaRT) as a Member of the LIGO Scientific Collaboration (LSC). In particular, it addresses data analysis activitites 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 CaRT will participate in the analysis of initial LIGO data in the following areas:

a. Binary Inspirals

   (a) Spinning black-hole binary search.
   Fazi, Chen and Vallisneri will collaborate with Brown (SUERG) to complete the development of the PTF (”Physical Template Family” a.k.a. PBCV) search for spinning black-hole binary inspiral signals. Specifically, they will formulate a template placement strategy using the “directed stochastic” techniques developed by Vallisneri and Manca (see item 2 below). They will also examine Fazi’s existing and yet-to-be-produced results to determine how best the PTF search can be used in the CBC pipeline (as a stand-alone search or as a hierarchical follow-up to a non-spinning template bank).

(b) "Directed stochastic" template-placement algorithms.
Vallisneri and Manca will complete a technical article on the use of computational geometry to produce "directed" stochastic template banks modulated by the local density of signals in source-parameter space. They will produce prototype LAL code to create such banks for the signal families currently implemented in LAL.

(c) Nonspinning black-hole binary search in 2nd year of S5 and in S6.
Vallisneri will complete the analysis of one month of S5 data in the context of the search for low-mass inspiral signals, and will participate in the compilation of results for the entire S5 span, in collaboration with many in the CBC group. He will also participate in the development and testing of the CBC search pipeline for use as an online search in S6.

(d) Improvements to intermediate data handling in LAL.
In collaboration with Kipp Cannon (LIGO Lab CIT), Vallisneri will work on improving the handling of XML files in LAL, and specifically of the inspiral and injection tables used by the CBC search pipeline. On the basis of the prior planning of Cannon and Fairhurst (Cardiff), Vallisneri will collaborate in implementing the use of "coinc tables" to represent event coincidences in the pipeline.

(e) Application of Numerical Relativity into LIGO Data Analysis
Ajith will develop LAL/LALApps-based pipelines for injecting 1) phenomenological inspiral+merger+ring down (IMR) waveforms containing higher harmonics from non-spinning binaries and 2) leading harmonics waveforms from spinning binaries with no precession. These phenomenological waveforms will be constructed based on the formalism proposed by Ajith, Chen and collaborators. He and Chen, in collaboration with WSU scientists, will also work on constructing a template bank in LAL/LALApps for the non-spinning phenomenological IMR waveforms.
Boyle will continue his collaboration with Syracuse scientists in using numerical-relativity information to improve efficiency of SPA templates.

(f) Symmetries and degeneracies in parameter estimation.
In collaboration with Ilya Mandel (Northwestern) and Richard O'Shaughnessy (PSU), Vallisneri will investigate the role of physical (quasi)symmetries in complicating the recovery of source parameters from measured gravitational-wave signals. The idea is to develop techniques to identify such global symmetries from the equations of motion, gravitational-wave generation and propagation. Vallisneri plans also to continue investigating the reliability of the Fisher-matrix formalism in predicting parameter-estimation accuracy; following up on his analytic work [Phys. Rev. D 77, 042001 (2008)], he plans numerical studies comparing Fisher-matrix and Markov-Chain Monte Carlo results.

(g) Use of effective-field–theory techniques for inspiral signal computations.
In collaboration with Ira Rothstein (CMU) and Rafael Porto (UCSB), Vallisneri and Manca will investigate the use of results from effective-field–theory computations (as pioneered by Yale's Goldberger) in increasing the accuracy of the signals used in LSC searches, with a special attention to spinning systems. Where possible and useful, Vallisneri and Manca will implement newly computed terms to the LAL waveform-generation code, and investigate their impact.

(h) Use of FPUs to accelerate search codes.
Linqing Wen is going to work with collaborators at UWA and Caltech LIGO Lab

to develop GPU-accelerated search pipelines that exploit the data-parallelism of graphical processors.

(i) LIGO IMRIs
Cutler plans to study parameter estimation accuracy for LIGO IMRIs for which larger BH is rapidly rotating. He would also like to estimate systematic errors if ones template waveforms are only accurate to lowest nontrivial order in the radiation reaction force.

(j) Parameter Estimation for spinning BH mergers
Cutler will use the MCMC code — currently being developed for LISAs MLDCs — to calculate parameter-estimation accuracy for LIGO mergers as well, for case when both bodies are spinning.

b. Bursts

Linqing Wen is going to (1) work with UWA researchers and student and the Caltech LIGO group to develop GPU-accelerated search pipelines using the data-parallelism of the GPUs, (2) collaborate with Yanbei Chen and other Caltech scientists to further investigate the angular resolutions of a network of GW detectors and its efficiency in identifying electromagnetic counterparts of GW events.

c. Stochastic

.

d. Continuous

Cutler plans to investigate further how worthwhile it would be to develop a CW search for the most recent SNe, assuming they spin down extremely fast — on timescale of days to months. This would be analogous to searching for GW bursts from close by SNe, except these bursts would be nearly continuous and much longer than the the bursts one normally thinks of. In any given year, the nearest SN might be roughly 10Mpc away. A rough estimate suggested that a reasonable search might be run on Einstein@Home.

e. 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 CaRT 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

CaRT 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.

Jay Marx
LIGO Laboratory Director

Yanbei Chen
Principal Investigator(s)
CaRT

David Reitze
LSC Spokesperson