

Attachment ACF to the
Memorandum of Understanding (LIGO-M 050292 -00-M)
between the
Caltech Relativity Theory Group (CaRT)
and the
Laser Interferometer Gravitational Wave Observatory (LIGO)
August 15, 2006

This Attachment ACF to the Memorandum of Understanding LIGO-M 050292 -00-M defines the role of the **Caltech Relativity Theory Group** 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, 2006 to August 15, 2007.

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, 2006 to August 15, 2007, the members of **CaRT** will participate in ADCDG in the following areas:

a) Interferometer Configurations

1. Intracavity Readout Configurations for LIGO-III: Chao Li and perhaps others, in collaboration with Yanbei Chen's group (AEI) and perhaps Vladimir Braginsky's group (MSURG), expect to explore intracavity readout configurations for LIGO-III.

c) Other Contributions

1. Testing Quantum Theory for Macroscopic Systems Using Future LIGO Interferometers: Members of CaRT (Chao Li, Yasushi Mino [who will likely have moved to Japan], Mike Boyle, Curt Cutler, Ilya Mandel and Kip Thorne) will continue their collaboration with Yanbei Chen's group (AEI) on the conceptual design of experiments that LIGO could perform to test the fundamental concepts of quantum mechanics for macroscopic systems. This research will also give us a deeper understanding of quantum measurement theory for LIGO interferometers.

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,
 - b) Access to LIGO data through established LSC channels in support of this work.
 - c) Not Applicable

4. Coordination and Reporting -

CaRT 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.

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:

Jay Marx
LIGO Laboratory Director

Kip S. Thorne
Principal Investigator
Caltech Relativity Theory Group

Peter Saulson
LSC Spokesperson

Attachment DAT to the
Memorandum of Understanding (LIGO-M 050292 -00-M)
between the
Caltech Relativity Theory Group (CaRT)
and the
Laser Interferometer Gravitational Wave Observatory (LIGO)
August 15, 2006

This Attachment DAT to the Memorandum of Understanding LIGO-M 050292 -00-M defines the role of the **Caltech Relativity Theory Group** as a Member of the LIGO Scientific Collaboration (LSC), in particular, its activities in data analysis in support of the initial LIGO interferometers. The period of performance for the activities in this Attachment is from August 15, 2006 to August 15, 2007.

1. 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 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, 2006 to August 15, 2007, the members of **CaRT** will participate in the analysis of initial LIGO data in the following areas:

a) Binary Inspirals

1. BCV2 Template-Based Search for Spinning Binaries. Vallisneri, together with Jones and Sathyprakash (Cardiff), Buonanno (UMD), and Owen (PSU), will take part in the writing of the S3 spinning-BBH search paper, performed using BCV2 templates.
2. PBCV Template-Based Search. In collaboration with several other members of IULGROUP, Vallisneri will take part in the development of searches based on the quasiphsical PBCV templates, either used alone or as a follow up to a BCV2 search. In collaboration with Pan, Buonanno, and Chen, Vallisneri will also complete the characterization of parameter estimation prospects in spinning solar-mass BH binaries.
3. Stochastic Methods for Template Placement. In collaboration with Brown (CaRT and LIGO Lab-Caltech), Vallisneri will continue the development of general template-placement methods based on stochastic principles, with a special attention to developing tools for PBCV-template-based searches.
4. Extreme Mass Ratio Inspirals (EMRIs). Duncan Brown (CaRT and LIGO Lab-Caltech) and Fazi (LIGO Lab-Caltech) will continue their development of templates for LIGO's EMRI searches. Brown, Li and Mandel will continue their scoping of the science that can be extracted from LIGO's EMRI searches and how to extract it. These researchers and collaborators will complete and submit a paper for Physical Review Letters on foundations for and scoping out of LIGO's EMRI searches.

d) Continuous

1. LALBarycenter Routines: Cutler, plans some improvements to the LALBarycenter LAL routines, which he wrote some time ago. These routines currently barycenter the data to within around 2-3 microsec; the improvements should decrease this error by about a factor of 2. Also, with Rejean Dupuis (CaRT and LIGO Lab-Caltech), Cutler intends to document some tests of LALBarycenter based on comparisons to TEMPO. And Cutler intends to finish a 30-page document explaining how LALBarycenter works.

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,
 - b) Access to LIGO data through established LSC channels in support of this work.
 - c) Not Applicable

4. Coordination and Reporting -

CaRT 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, Item 2c) will be carried out within the LSC Stochastic Search Group and Item 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 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:

Jay Marx
LIGO Laboratory Director

Kip S. Thorne
Principal Investigator
Caltech Relativity Theory Group

Peter Saulson
LSC Spokesperson

Attachment OPT to the
Memorandum of Understanding (LIGO-M 050292 -00-M)
between the
Caltech Relativity Theory Group (CaRT)
and the
Laser Interferometer Gravitational Wave Observatory (LIGO)
August 15, 2006

This Attachment OPT to the Memorandum of Understanding LIGO-M 050292 -00-M defines the role of the **Caltech Relativity Theory Group** as a Member of the LIGO Scientific Collaboration (LSC) and a member of the Optics Development Group (ODG). The period of performance for the activities in this Attachment is from August 15, 2006 to August 15, 2007.

1. Optics Development Group - The Optics Development Group (ODG) is the scientific collaboration for defining and developing instruments in optics 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, 2006 to August 15, 2007, the members of **CaRT** will participate in ODG in the following areas:

b) Other Contributions

1. Light Scattering in the LIGO Beam Tubes and Design of the Baffles that Control it: Thorne and Lazzarini (LIGO Lab-Caltech) will produce a LIGO technical report on Lazzarini's foundations and Thorne's computations of Advanced-LIGO light-scattering noise in the LIGO beam tubes. Thorne will complete his revision of his long Phys Rev paper with Eanna Flanagan (Cornell) to include the two-component BRDF's of initial LIGO mirrors. Thorne and Flanagan hope to submit that long-delayed paper during the coming year.

2. Parametric Instability in Advanced LIGO: Savov will complete his analysis of the influence of low-finesse optical modes on the parametric instability in Advanced LIGO.

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,
- b) Access to LIGO data through established LSC channels in support of this work.
- c) Not Applicable

4. Coordination and Reporting -

CaRT 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 Optics Development Working 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.

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:

Jay Marx
LIGO Laboratory Director

Kip S. Thorne
Principal Investigator
Caltech Relativity Theory Group

Peter Saulson
LSC Spokesperson

**Attachment Number Z to the
Memorandum of Understanding (LIGO-M **050292** -00-M)**

between the

Caltech Relativity Theory Group

(CaRT)

and the

Laser Interferometer Gravitational Wave Observatory (LIGO) Laboratory

This Attachment to the Memorandum of Understanding LIGO-M **050292** -00-M lists the coordinates of members of the **Caltech Relativity Theory Group** 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, 2006 to August 15, 2007. This period may be modified by agreement to a revision of this Attachment. This list may be extended by agreement to a revision of this Attachment.

Principal Investigator

First Name: **Kip S.**

Last Name: **Thorne**

Affiliation: **Caltech**

Address: **130-33 Caltech**

City: **Pasadena**

State: **CA**

Zip Code: **91125**

Country: **United States**

Primary Email: **kip@tapir.caltech.edu**

Job Title: **Feynman Prof of Theor Phys**

Secondary Email:

Phone Number: **626 395 4598**

Fax Number: **626 796 5675**

Begin Date: **Aug 15, 2006**

End Date: **Aug 15, 2007**

Research FTE: **50 %**

LIGO FTE: **25 %**

AdvLIGO FTE: **25 %**

Author on LSC papers:

LSC Council Delegate?

Member #2

Select this box if the contact information of this member is the same as that of the Principal Investigator.

First Name: **Curt**

Last Name: **Cutler**

Affiliation: **Caltech and JPL**

Address: **169-237 Jet Propulsion Laboratory, 4800 Oak Grove Drive**

City: **Pasadena**

State: **CA**

Zip Code: **91109**

Country: **United States**

Primary Email: **Curt.J.Culter@JPL.NASA.gov**

Job Title: **Sr Faculty Associate, Caltech**

Secondary Email: **culter@tapir.caltech.edu**

Phone Number: **(818) 393-3251**

Fax Number:

Begin Date: **Aug 15, 2006**

End Date: **Aug 15, 2007**

Research FTE **80** %

LIGO FTE **15** %

AdvLIGO FTE %

Author on LSC papers:

LSC Council Delegate?

Member #3

Select this box if the contact information of this member is the same as that of the Principal Investigator.

First Name: **Michele**

Last Name: **Vallisneri**

Affiliation: **Caltech and JPL**

Address: **169-237 Jet Propulsion Laboratory, 4800 Oak Grove Drive**

City: **Pasadena**

State: **CA**

Zip Code: **91109**

Country: **United States**

Primary Email: **vallis@caltech.edu**

Job Title: **Research Scientist, JPL**

Secondary Email:

Phone Number: **818 393 7634**

Fax Number: **603 506 6524**

Begin Date: **August 15, 2006**

End Date: **August 15, 2007**

Research FTE **75** %

LIGO FTE **25** %

AdvLIGO FTE %

Author on LSC papers:

LSC Council Delegate?

Member #4

Select this box if the contact information of this member is the same as that of the Principal Investigator.

First Name: **Mike**

Last Name: **Boyle**

Affiliation: **Caltech**

Address: **130-33 Caltech**

City: **Pasadena**

State: **CA**

Zip Code: **91125**

Country: **United States**

Primary Email: **boyle@caltech.edu**

Job Title: **graduate student**

Secondary Email:

Phone Number: **626 395 8650**

Fax Number: **626 796 5675**

Begin Date: **August 15, 2006**

End Date: **August 15, 2007**

Research FTE **100** %

LIGO FTE %

AdvLIGO FTE **5** %

Author on LSC papers:

LSC Council Delegate?

Member #5

Select this box if the contact information of this member is the same as that of the Principal Investigator.

First Name: **Chao**

Last Name: **Li**

Affiliation: **Caltech**

Address: **130-33 Caltech**

City: **Pasadena**

State: **CA**

Zip Code: **91125**

Country: **United States**

Primary Email: **lichao@caltech.edu**

Job Title: **Graduate Student**

Secondary Email:

Phone Number: **626 395 8651**

Fax Number: **626 796 5675**

Begin Date: **Aug 15, 2006**

End Date: **Aug 15, 2007**

Research FTE **100** %

LIGO FTE **10** %

AdvLIGO FTE **20** %

Author on LSC papers:

LSC Council Delegate?

Member #6

Select this box if the contact information of this member is the same as that of the Principal Investigator.

First Name: **Ilya**

Last Name: **Mandel**

Affiliation: **Caltech**

Address: **130-33 Caltech**

City: **Pasadena**

State: **CA**

Zip Code: **91125**

Country: **United States**

Primary Email: **ilya@caltech.edu**

Job Title: **Graduate Student**

Secondary Email:

Phone Number: **626 395 8655**

Fax Number: **626 796 5675**

Begin Date: **Aug 15, 2006**

End Date: **Aug 15, 2007**

Research FTE **100 %**

LIGO FTE **10 %**

AdvLIGO FTE **5 %**

Author on LSC papers:

LSC Council Delegate?

Member #7

Select this box if the contact information of this member is the same as that of the Principal Investigator.

First Name: **Pavlin**

Last Name: **Savov**

Affiliation: **Caltech**

Address: **130-33 Caltech**

City: **Pasadena**

State: **CA**

Zip Code: **91125**

Country: **United States**

Primary Email: **pavlin@caltech.edu**

Job Title: **Graduate Student**

Secondary Email:

Phone Number: **626 395 2151**

Fax Number: **626 796 5675**

Begin Date: **Aug 15, 2006**

End Date: **Aug 15, 2007**

Research FTE **100 %**

LIGO FTE **%**

AdvLIGO FTE **50 %**

Author on LSC papers:

LSC Council Delegate?

Member #8

Select this box if the contact information of this member is the same as that of the Principal Investigator.

First Name: **Pan**

Last Name: **Yi**

Affiliation: **Is leaving CaRT in August and moving to Buonanno's group at U Maryland.**

Address:

City:

State:

Zip Code:

Country:

Primary Email:

Job Title:

Secondary Email:

Phone Number:

Fax Number:

Begin Date:

End Date:

Research FTE %

LIGO FTE %

AdvLIGO FTE %

Author on LSC papers:

LSC Council Delegate?

Member #9

Select this box if the contact information of this member is the same as that of the Principal Investigator.

First Name:

Last Name:

Affiliation:

Address:

City:

State:

Zip Code:

Country:

Primary Email:

Job Title:

Secondary Email:

Phone Number:

Fax Number:

Begin Date:

End Date:

Research FTE %

LIGO FTE %

AdvLIGO FTE %

Author on LSC papers:

LSC Council Delegate?

Member #10

Select this box if the contact information of this member is the same as that of the Principal Investigator.

First Name:

Last Name:

Affiliation:

Address:

City:

State:

Zip Code:

Country:

Primary Email:

Job Title:

Secondary Email:

Phone Number:

Fax Number:

Begin Date:

End Date:

Research FTE %

LIGO FTE %

AdvLIGO FTE %

Author on LSC papers: LSC Council Delegate? **Authorship:****Thorne****Vallisneri****Yi****Scientific Collaboration Council Delegate(s):****Thorne**

Approved:

Jay Marx

LIGO Laboratory Director

Principal Investigator(s)

Caltech Relativity Theory Group

Peter Saulson

LSC Spokesperson