Memorandum of Understanding between J-GEM and LIGO and VIRGO regarding follow-up observations of gravitational wave event candidates

April 5, 2014

This Memorandum of Understanding (MOU) establishes a collaborative effort among the Laser Interferometer Gravitational-Wave Observatory (LIGO) and LIGO Scientific Collaboration (LSC), the European Gravitational Observatory and Virgo Collaboration (EGO/Virgo), and Japanese Collaboration for Gravitational-Wave Electro-Magnetic Follow-up (J-GEM) in order to participate in a program to perform follow-up observations of gravitational wave (GW) candidate events with the sharing of proprietary information (see LIGO-M1300550 and VIR-0494#-13 for an overview).

The purpose of this MOU is to reference the parties involved and their relevant policies; define the appropriate data and information that is to be shared under this arrangement, and its permitted use; and establish how any publications and presentations coming out of this work will be handled. By signing this MOU, the parties agree that they understand the nature of the collaborative work, consider it to be scientifically worthwhile, and will do their best to bring it to successful completion.

A Participating groups

1. LIGO denotes hereafter the LIGO Laboratory and the LIGO Scientific Collaboration (LSC). VIRGO denotes the Virgo Collaboration and the European Gravitational Observatory (EGO) consortium. Both are described in Attachment No. 1 to this MOU.

2. J-GEM denotes Japanese Collaboration for Gravitational-Wave Electro-Magnetic Follow-up, which is described in Attachment No. 2 to this MOU.

3. PARTNERS denotes all groups that have signed an MOU with LIGO and VIRGO for the follow-up program.

B General policies and provisions

1. In entering into this MOU, the LIGO Laboratory will carry out its responsibilities following the requirements of the Cooperative Agreement with NSF.

2. The LIGO Laboratory is responsible for obtaining NSF approval of all collaborative Memoranda of Understanding with international partners, or involving NSF costs exceeding $100,000. All Memoranda of Understanding will be provided to NSF for their information.

3. Each party to this agreement continues to be responsible for all support of its staff including any expenses and travel costs associated with the activities described under this agreement.

4. This MOU does not prevent the parties from establishing other agreements on data exchange or external collaborations. The existence and general terms of any other agreements that involve the combined use of GW and follow-up data will be freely shared among the parties of this MOU.

5. This agreement is conditioned on the ability of all parties (as described in Sec. A and related attachment) to carry out observations. If the observational contribution of J-GEM to the follow-up program involves time on facilities that must be obtained through a proposal mechanism, this agreement is subject to the award of a suitable time allocation.

C Termination of this agreement

1. Data/information sharing will cease on June 1st 2017 unless continued by a new agreement.
2. Data/information sharing may cease at the request of either J-GEM, LIGO or VIRGO at any time.
3. Any data or information exchanged under the terms of this agreement (prior to its cessation), on-going analyses, and any publications or presentations using them are governed by the terms of this MOU and its attachments indefinitely, unless all of J-GEM, LIGO and VIRGO mutually agree to a change.

D Confidentiality and Appropriate Use of Data

1. All parties agree that any information or data products shared in the framework of the follow-up program shall be used only for the purposes of the collaborative work covered by this agreement.
2. All information or data exchanged (by J-GEM, LIGO or VIRGO) related to this MOU will be treated as confidential by all parties, unless it has already been made public as foreseen in Sec. F. Senior scientists should ensure that all involved persons, including students and technical staff, understand and respect the sensitive nature of the data and information exchanged.
3. All J-GEM observations that have not been triggered by LIGO/VIRGO alerts, and all LIGO/VIRGO analyses that do not make use of J-GEM observation data, are not affected by this agreement. However, any information or data exchanged in connection with such observations or analyses must be kept confidential by the recipient.
4. All parties are responsible for analyzing and interpreting their own data.
5. All parties will make certain that observations and data collected in the framework of this MOU are compatible with the above rules of confidentiality. Specifically for J-GEM, this applies to public facilities, which may not normally keep data confidential. In that case, J-GEM must impress on any observers or staff who are needed to assist that the observations and data must be kept confidential.

E Data and information sharing

1. All parties will share information with all PARTNERS in the follow-up program through a dedicated communication network. LIGO and VIRGO will communicate the detected GW candidate events in the form of alerts. For each follow-up observation made by J-GEM, J-GEM will share the coordinates of the observations that have been made as soon as practical and within 12 hours of the observing time. For shared and space facilities, the intended coordinates should be shared as soon as practical and within 12 hours of the intended observing time. J-GEM is encouraged to share data analysis results in the form of a list of plausible candidates, or other relevant findings, or a non-detection statement as promptly as possible. The notices communicated by LIGO, VIRGO and all PARTNERS will include an author field, a reference number and a date to make them citable. All notices pertaining to a given event will be made publicly available when the publication of the event is released.
2. LIGO, VIRGO and J-GEM will share relevant updated information about event candidates as it becomes available.
3. LIGO and VIRGO expect to authorize a "blind injection" program. Under this program, a small number (up to 3 blind injections per run) of simulated signals may be injected into the GW interferometer data, and may lead to GW candidate alerts. No LIGO and VIRGO members (aside from the few people entrusted to carry out the program in secrecy) or J-GEM members will know that those events are not of astrophysical origin until after they have been fully vetted by LIGO and VIRGO.

F Publications and Presentations

General rules

1. Any apparent counterpart to the GW event candidate, that was identified due to the GW candidate alert, is strictly *embargoed*: it may not be published or presented prior to the public announcement or publication of the GW event candidate by LIGO and VIRGO. LIGO and VIRGO will share detailed information with all partners who observed the counterpart prior to publishing or presenting the GW event results.

2. Any publication (in any form, including peer-reviewed articles, conference proceedings, press releases, theses, and publicly-accessible electronic media) of previously unpublished results or status of the follow-up observations must be communicated in advance to LIGO, VIRGO and J-GEM for comments.

3. Proprietary information (defined in F5 and F6) may not be published or presented without the explicit consent of its owner, even if the information was shared for purposes of enabling the follow-up program. The owner of the proprietary information should be offered co-authorship or acknowledgement in exchange for including it in a publication, in accordance with usual publishing etiquette.

4. Any conflicts between the policies of the collaborations will be resolved by mutual agreement. If a conflict regards a joint paper or presentation and cannot be resolved, the joint paper or presentation may be vetoed by the LIGO Executive Director, LSC Spokesperson, Virgo Spokesperson, or J-GEM Principal Investigator.

Definition of proprietary information

5. The existence of a GW trigger, its ID, date and time are not considered as proprietary information and can be cited, accompanied by a reference to the publication or notice where that information is publicly released once the embargo has ended. The significance, skymap and other properties of the GW event candidate are the property of LIGO and VIRGO.

6. The existence of an observed counterpart (or multiple candidate counterparts) and its consistency with the GW skymap are not considered as proprietary information and can be cited, accompanied by a reference to the publication or notice where that information is publicly released once the embargo has ended. The exact location and other observed properties of any counterparts observed by J-GEM are the property of J-GEM.

Publication Cases

Results from searches of GW and presence or absence of counterparts can be published together or separately, as follows:

Publication Case 1: Separate publication of GW results and follow-up results

7. The GW results paper will be published first, and the follow-up results will be published after, or simultaneously with, the GW paper in a companion paper (or papers). The same order applies to any press releases associated with these publications. The author lists of the GW and follow-up papers will be determined independently by LIGO/VIRGO and J-GEM (and collaborators if any) respectively.

8. If a transient event detected in the follow-up observations is clearly not related to a GW event, J-GEM can request from LIGO and Virgo that these events be published without delay (while maintaining all the rules on the GW event information described above). Unless there are questions about the follow-up observation being a possible counterpart, the request is expected to be promptly approved.

Publication Case 2: Joint publication of GW results and follow-up results

9. GW and follow-up results may be jointly published in a combined paper, by mutual agreement of authorized representatives of LIGO, VIRGO, and J-GEM.

10. Any joint paper(s) or presentation(s) will be guided by the publication policies of all the participating collaborations for authorship, internal review, and approvals. The list of J-GEM authors will be established according to J-GEM rules and preferences. The author list will have one block for LIGO and VIRGO authors and a separate block for J-GEM authors; or, if journal rules allow only a single block, then the collaboration affiliations of all authors will be indicated in a suitable way. Whenever an individual author listing is not allowed (e.g. for conference proceedings), the contributing author will clearly identify the fact that he/she represents all parties of this agreement in presenting the joint work. For the first publication presenting any given LIGO/VIRGO event, the author list will start with the block of LIGO and VIRGO authors.

11. If the follow-up data analysis is crucial for verifying or interpreting the GW event, LIGO and VIRGO may require to review the analysis of the follow-up data which will be shared with the LIGO, and J-GEM team may require to review the analysis of the GW data, as a condition for publishing a joint paper.

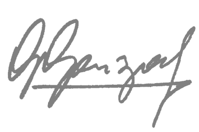
Michitoshi Yoshida
Team Leader of Japanese Collaboration for Gravitational-Wave Electro-Magnetic Follow-up

Signature

Date

Gabriela Gonzalez
LSC Spokesperson

Signature



Date April 5, 2014

David Reitze
Director of LIGO Laboratory

Signature

Date April 5, 2014

Bernard Schutz
GEO 600 Principal Investigator for Data Analysis

Signature

Date April 5, 2014

Jean-Yves Vinet
Virgo Spokesperson

Signature

Date April 5, 2014

Federico Ferrini
Director of EGO

Signature

Date April 5, 2014

Attachment No. 1 — Definitions of LIGO and VIRGO

1. LIGO denotes hereafter the LIGO Laboratory and the LIGO Scientific Collaboration (LSC).

   LIGO was built under a Cooperative Agreement between the National Science Foundation (NSF) and Caltech signed in May 1992 (No. PHY9210038). LIGO is a system of three interferometric Fabry-Perot antennas possessing 4 kilometer arm lengths, aimed at the simultaneous detection of gravitational waves in the frequency range 10-6000 Hz. LIGO observatories have been built in Hanford, Washington and in Livingston Parish, Louisiana (USA) and began observations in the year 2002. The design and construction of LIGO was carried out by the California Institute of Technology (Caltech) and the Massachusetts Institute of Technology (MIT). Caltech and MIT jointly operate LIGO Laboratory for the NSF under a Cooperative Agreement between NSF and Caltech, with MIT participating through subaward from Caltech. The LIGO Oversight Committee supervises the realization and exploitation of LIGO.

   The LSC is composed of approximately 900 individuals from more than 70 institutions worldwide, including scientists and engineering personnel from the LIGO Laboratory. LSC membership includes all of the scientists and engineers in the GEO project. These scientists and engineers have the same rights and privileges as any other LSC members with regard to the provisions of this MOU.

   The LSC Charter establishes the functions, organizational structure and responsibilities of the LSC as well as its role in the research of the LIGO Laboratory, and the release of scientific results. The LIGO leadership consists of a Directorate that includes the LIGO Executive Director, the LIGO Laboratory Deputy Director, and the LSC Spokesperson. The LSC Collaboration Council, with proportional representation from each group, votes on issues of importance to the collaboration, and elects the Spokesperson.

   The German/British Collaboration for the Detection of Gravitational Waves (GEO) has built a detector of arm length 600m (GEO600) near Hannover in Germany, with the purposes of joining in a worldwide search for gravitational radiation from astronomical sources and of developing advanced interferometric and suspension technologies for later gravitational wave detectors. The design, construction and operation of the GEO600 system is being carried out by scientists and technologists at the University of Hannover, the University of Glasgow, and the Max Planck Institute for Gravitational Physics (Albert Einstein Institute) in Hannover and Golm. Data acquisition and analysis are carried out by the Albert Einstein Institute (AEI), Cardiff University, the University of Glasgow and Birmingham University. The project is funded in Germany by the State Government of Niedersachsen, the Max Planck Gesellschaft (MPG), and the Bundesministerium für Bildung und Forschung (BMBF) in Germany, and by the Science and Technologies Facilities Council (STFC) in the UK.

   The agreement LIGO-M040357-00-M (dated November 5, 2004) between LIGO and GEO states, "All such agreements to share data with external projects will be made jointly by LIGO/LSC and GEO leadership, with the goal that, wherever it makes scientific sense, provisions for sharing data will treat data from LIGO and GEO equivalently." Thus, this agreement applies equally to data from any of the three LIGO interferometers and to data from the GEO 600 interferometer. The signature of the GEO600 Principal Investigator for Data Analysis on this MOU is in accord with LIGO-M040357-00-M and constitutes their endorsement of this collaboration.

   By virtue of this agreement, the term LIGO as used in this MOU includes GEO as well.

2. VIRGO denotes the Virgo Collaboration and the European Gravitational Observatory (EGO) consortium.

   CNRS and INFN signed an agreement on 27 June 1994 concerning the realization of a three kilometer Fabry-Perot interferometric antenna aimed at the detection of gravitational waves in the frequency range 10-10 000 Hz, named Virgo, located at Cascina, Italy. This agreement was superseded by the Agreement between CNRS and INFN, founding the "European Gravitational Observatory" Consortium under Italian law (EGO), signed on 11 December 2000, completed by the agreement signed with the Nikhef on July 2009, the Netherlands becoming an associated member.

The main purpose of EGO is to ensure the end of the construction of the Virgo antenna, its commissioning, its operation and its upgrade, as well as to promote an open co-operation in R&D. The Consortium is supervised by the EGO Council. The implementation of the above is performed via the involvement of the Virgo Collaboration in the framework of the Memorandum of Agreement between the Virgo Collaboration and EGO Consortium, signed on 20 November 2002.

The Virgo collaboration is composed of approximately 200 scientists and technicians coming mainly from CNRS and INFN laboratories, which have signed an Agreement on 19 December 2001, as well as from EGO, the Netherlands, Poland and Hungary. Decisions are taken by its steering committee. The overall scientific exploitation of the Virgo antenna is under the responsibility of the Virgo Collaboration

In this MOU the Virgo collaboration is represented by the spokesperson appointed by the Virgo steering committee and the EGO Consortium by the director of EGO appointed by the EGO council.

Attachment No. 2 — Definition of J-GEM

LIGO-Virgo Event Follow-up Program

This form will be attached to the Memorandum of Understanding.

Full name of the partner project:
Japanese Collaboration for Gravitational-Wave Electro-Magnetic Follow-up Observation

Abbreviated name:
J-GEM

Project web site (if available):
not yet available

Name, institution, email and title[1] of the leader(s) (who will sign the MOU):
Michitoshi Yoshida, Hiroshima University, yoshidam@hiroshima-u.ac.jp, Team Leader of J-GEM

Name, institution, email, and phone numbers of the liaison with LVC:
Michitoshi Yoshida, Hiroshima University, yoshidam@hiroshima-u.ac.jp, +81-82-424-7371

List of associated members (name, institution and email):
- Kouji Ohta, Kyoto University, ohta@kusastro.kyoto-u.ac.jp
- Kentaro Motohara, University of Tokyo, kmotohara@ioa.s.u-tokyo.ac.jp
- Mamoru Doi, University of Tokyo, doi@ioa.s.u-tokyo.ac.jp
- Tomoki Morokuma, University of Tokyo, tmorokuma@ioa.s.u-tokyo.ac.jp
- Kenshi Yanagisawa, National Astronomical Observatory of Japan (NAOJ), yanagi@oao.nao.ac.jp
- Masaomi Tanaka, NAOJ, masaomi.tanaka@nao.ac.jp
- Koji S. Kawabata, Hiroshima University, kawabtkj@hiroshima-u.ac.jp
- Takahiro Nagayama, Nagoya University, nagayama@z.phys.nagoya-u.ac.jp
- Fumio Abe, Nagoya University, abe@stelab.nagoya-u.ac.jp
- Kenta Fujisawa, Yamaguchi University, kenta@yamaguchi-u.ac.jp
- Nobuyuki Kawai, Tokyo Institute of Technology (TITech), nkawai@phys.titech.ac.jp

List one or more published papers as examples of your work, preferably relevant to this kind of project:
- “Radioactively Powered Emission from Black Hole-Neutron Star Mergers”, Tanaka, M., Hotokezaka, K. et al. ApJ, 780, 31, 2014
- “Radiative Transfer Simulations of Neutron Star Merger Ejecta”, Tanaka, M. & Hotokezaka, K., ApJ, 775, 113, 2013
- “A Luminous and Fast-expanding Type Ib Supernova SN 2012au”, Takaki, K., Kawabata, K.~S., Yamanaka, M., et al., ApJL, 772, L17, 2013
- “GRB 091208B: First Detection of the Optical Polarization in Early Forward Shock

1 Can be Principal Investigator of XXXXX, Director of XXXXX, XXXXX Spokesperson, Leader of XXXXX team, etc

Emission of a Gamma-Ray Burst Afterglow", Uehara, T., Toma, K., Kawabata, K.~S., et al., ApJL, 752, L6, 2012
- "Optical behavior of GRB 061121 around its X-Ray shallow decay phase", Uehara, T., Kawabata, K.~S., Yoshida, M., et al., A&A, 526, 92, 2011

What telescope(s) / instruments do you plan to use (name(s), plus journal ref(s), web site(s), or description):

1. Katana Telescope, http://hasc.hiroshima-u.ac.jp/telescope/kanatatel-e.html, 1.5m optical-infrared telescope of Hiroshima University. Location: Higashi-Hiroshima Observatory, Japan
   Instruments: HOWPol – optical imaging polarimeter and spectrograph. FOV=15'φ
   HONIR – optical and near-infrared imaging spectrograph. FOV=10x10 $arcmin^2$
2. Mini-TAO Telescope, http://www.s.u-tokyo.ac.jp/en/press/2009/15.html, 1m optical-infrared telescope of University of Tokyo. Location: Tokyo Atacama Observatory (TAO), Chile
   Instruments ANIR – Near-infrared camera. FOV=5x5 $arcmin^2$
3. Kiso Schmidt Telescope, http://www.ioa.s.u-tokyo.ac.jp/kisohp/OVERVIEW/overview_e.html, 1.05m Schmidt telescope of University of Tokyo. Location: Kiso Observatory, Japan
   Instrument: KWFC – optical wide-field camera. FOV=2.2x2.2 deg^2
   CMOS camera – optical wide-field imager (under development). FOV=6x6 deg^2
4. OAO-WFC, http://ads.nao.ac.jp/abs/2008AIPC.1000..596Y, 0.9m infrared telescope of NAOJ. Location: Okayama Astrophysical Observatory (OAO), Japan
   Instrument: Wide field near-infrared camera. FOV=0.92x0.92 deg^2
5. MITSuME Telescopes, http://ads.nao.ac.jp/abs/2005NCimC..28..755K, 0.5m optical telescopes of NAOJ and TITech. Locations: OAO and Akeno Observatory, Japan
   Instrument: Optical three-color simultaneous camera. FOV=0.5x0.5 deg^2
6. IRSF, http://www.z.phys.nagoya-u.ac.jp/~irsf/index_e.html, 1.4m infrared telescope of Nagoya University. Location: South African Astronomical Observatory, South Africa
   Instrument: SIRIUS – near-infrared three-color simultaneous imager. FOV=7.7x7.7 $arcmin^2$
7. Yamaguchi 32m Radio Telescope, http://www2.nict.go.jp/aeri/sts/stmg/ivstdc/news_21/pdf/fujisawa.pdf, 32m radio telescope of Yamaguchi University. Location: Yamaguchi University, Japan
   Instruments: 6.7 GHz, 8 GHz, 22 GHz radio receivers
8. Kyoto 3.8m Telescope, http://www.kusastro.kyoto-u.ac.jp/psmt/index.html (in Japanese), 3.8m optical-infrared telescope of Kyoto University. Location: OAO, Japan. This telescope is under construction. First light is scheduled to be in 2015.
   Instruments: Optical imaging spectrograph with integral field spectroscopy unit (IFU) (under development). FOV=15x15 $arcsec^2$ (IFU FOV)
9. HinOTORI Telescope, http://home.hiroshima-u.ac.jp/~youtsumi/Tibet/, 0.5m optical telescope of Hiroshima University. Location: Tibet, China. This telescope is under construction. The first light will be in 2015.
   Instrument: Optical three-color simultaneous camera. FOV=0.45x0.45 deg^2
10. MOA-II, http://www.phys.canterbury.ac.nz/moa/moa_telescope.html, 1.8m optical telescope of MOA collaboration. Location: Mt. John Observatory, New Zealand
    Instrument: Optical wide-field camera. FOV=1.5x1.5 deg^2
11. Subaru Telescope, http://www.naoj.org/, 8.2m optical infrared telescope of NAOJ, Location: Mauna Kea, Hawaii, USA.

What is your access to the telescope(s) or facilities? (e.g. do you own them; own a share of their time; have been awarded a time allocation; will propose for time; etc.)

Telescope #1 - #9: we own them.
Telescope #10: we own a share of their time.
Telescope #11: we will propose for time.

How do you plan to use them for this project?

We are now developing a multi-site observation network for searching for electro-magnetic counterpart of gravitational wave transient using the above telescopes. We are funded for this project by Ministry of Education, Culture, Sports, Science and Technology in Japan until the end of March 2019. Communication system between the facilities and detailed observation strategy are now under development.

We utilize this network for LIGO/Virgo GW search. The basic strategy is very simple: first, we try to detect optical-infrared transients in high probability area of GW skymap using wide-field telescopes, #3, #4, and #7. These telescopes have field-of-view wider than 1 square-degree. In the same time, we use telescopes #2, #5, #6, and #10 for surveying peripheral region of the best area or second probable region of the skymap. In this search, we plan to weight the observation regions using nearby galaxy catalog, however, the details of the strategy are still under consideration. After picked up transient candidates, we follow up the objects using other telescopes. If we detect a clear signal, we do spectroscopic follow-up using telescopes #1, #8, and #11, and radio observation with telescope #9.

How promptly do you expect to be able to have results?

It depends on the nature of the transients. We can deliver initial results of each observation within 1 day, probably, within a few hours, by using the pipeline data reduction systems installed at each observatory/institute.

Have you used these telescopes / instruments before?

Yes.

How will you evaluate the significance of any apparent counterpart you find? That is, how will you quantify the false coincidence probability?

It is very difficult to say the identification process in detail at present, because we do not know the spectrum and time variability of the EM counterpart of a GW source. We are thus planning the following basic strategy for counterpart identification.

The basic transient identification process after prompt follow-up observation is as follows:

1. Subtract reference image from object image and detect point sources, if some reference image (in archival data of wide-field survey such as SDSS, 2MASS, Pan-STARRS, etc., or past observation frames by our telescopes) is available. We have developed pipeline software for transient discovery, which performs standard data reduction, image subtraction, and transient finding automatically. This system has been used for supernova survey with Kiso Schmidt Telescope/KWFC for 2 years, resulting in the discovery of about 50 supernova candidates (and 9 confirmed IAU supernovae) so far.
2. If there is no reference image available, detect all the point sources in the object image.
3. Do catalog matching and select uncatalogued point sources.
4. Exclude moving objects by checking the motions of the candidate sources using multiple exposure data and checking known asteroid data.

5. Select rapidly decaying candidates using multiple exposure data and multi-sites observation data. Then we will check the coincidence between the positions of the candidates and galaxy locations using nearby galaxy catalog. We also will check high-energy satellite alert. -> send the candidates' information to LVC ad orphan short gamma-ray burst like events.
6. Keep other transient candidates for next day observation. Make follow-up observation for candidate objects at least for 3 nights. Try to find newly brightening and decaying objects. -> macro-nova candidates. If we identify such kind of candidates, continue observation for longer time and watch their time variability.
7. If we identify macro-nova like transients, we send the candidates information to LVC.