

Memorandum of Agreement
between
VIRGO,
KAGRA,
and the
Laser Interferometer Gravitational Wave Observatory (LIGO)

October 2019

Purpose of agreement:

The purpose of this Memorandum of Agreement (MOA) is to establish and define a collaborative relationship between VIRGO, KAGRA and the Laser Interferometer Gravitational Wave Observatory (LIGO) to develop and exploit laser interferometry to measure and study gravitational waves.

We enter into this agreement in order to lay the groundwork for decades of world-wide collaboration. We intend to carry out the search for and analysis of gravitational waves in a spirit of teamwork, not competition. Furthermore, we remain open to participation of new partners, whenever additional data can add scientific value to the detection and study of gravitational waves. All partners in the world-wide collaboration should have a fair share in the scientific governance of the collaborative work.

Among the scientific benefits we hope to achieve from this collaboration are: better confidence in detection of signals, better duty cycle and sky coverage for searches, better estimation of the location and physical parameters of the sources, and gravitational wave studies based on the detected signals. Furthermore, we believe that the sharing of ideas will also offer additional benefits.

This MOA supersedes the MOU LIGO-M060038-v5 between VIRGO and LIGO, established in March 2019. This MOA also supersedes the MOU JGW-M1201315-v3 between KAGRA, LSC and Virgo scientific collaboration in December 2012.

Details of, and extensions to, this MOA will be provided in Attachments agreed to by LIGO, VIRGO, and KAGRA.

We refer to the joint bodies of the LIGO Scientific Collaboration (LSC), the Virgo Collaboration, and the KAGRA Collaboration as 'LVKC' in this document for brevity. The three Collaborations maintain their independent existence and may have differing (but not mutually incompatible) rules and procedures in some domains.

Parties to the agreement

1. 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 This agreement was superseded by the agreement between CNRS and INFN, founding the "European Gravitational Observatory" Consortium under Italian law (EGO), signed on 11 December 2000,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 Nikhef on July 2009, the Netherlands becoming an associate 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, the maintenance, operation and upgrade of the site infrastructure including a computing center, the performance of any research in the domain of gravitation, presenting a common interest for its members, and the promotion of the cooperation in the experimental and theoretical domain of gravitational waves in Europe. 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 currently composed of approximately 350 scientists, engineers and technicians from about 70 institutes from Belgium, France, Germany, Hungary, Italy, the Netherlands, Poland and Spain. Decisions are taken by the Virgo Steering Committee. The overall scientific exploitation of the Virgo antenna is the responsibility of the Virgo Collaboration.

In this MOA the Virgo Collaboration is represented by the Spokesperson appointed by the Virgo Steering Committee, and the EGO Consortium is represented by the director of EGO, appointed by the EGO Council.

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

The LIGO Hanford and Livingston Observatories were built under a Cooperative Agreement between the National Science Foundation (NSF) and Caltech signed in May 1992 (No. PHY9210038) and began observations in the year 2002. Advanced LIGO is an upgrade to LIGO funded by NSF under Cooperative Agreement PHY0823459 consisting of three interferometric Fabry-Perot antennas possessing 4 kilometer arm lengths, with one interferometer located at each of the LIGO Hanford and Livingston Observatories, and the third interferometer intended for installation in India upon construction of the LIGO-India Observatory. The design and construction of LIGO was carried out by the California Institute of Technology (Caltech) and the Massachusetts Institute of Technology (MIT), with contributions from member groups of the LIGO Scientific Collaboration. 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 currently composed of approximately 1300 individuals from more than 100 institutions worldwide, including scientists and engineering personnel from the LIGO Laboratory.

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 developed advanced interferometric and suspension technologies for later gravitational wave detectors, operates a detector of arm length 600 m (GEO600) near Hannover in Germany, and has made significant intellectual and material contributions to the US LIGO detectors. Gravitational wave analysis and interpretation are also significant contributions by GEO members. GEO is made up of 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 Potsdam, as well as contributors from the Universities of Birmingham, Cambridge, Cardiff, London, Portsmouth, Sheffield, Strathclyde, the West of Scotland, and the University of the Balearic Islands. The GEO Collaboration 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." The signature of the GEO Lead Scientist on this MOA 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 MOA includes GEO as well.

3. KAGRA denotes the KAGRA Collaboration.

KAGRA is a 3 kilometer laser interferometric gravitational wave antenna built at Kamioka underground site in Japan. One of its characteristic features is to be a cryogenic interferometer; the test-mass mirrors that form 3-km Fabry-Perot arm cavities are cooled down to cryogenic temperature of around 20K, so as to reduce the effect of thermal noises. Stable environment of the underground site and cryogenic technologies will be helpful to obtain fruitful sciences in the field of gravitational- wave astronomy, both in the first detection era and in the subsequent era of

gravitational wave astronomy.

KAGRA project is supported by MEXT (Ministry of Education, Culture, Sports, Science, and Technology) of Japan. KAGRA is hosted by Institute for Cosmic Ray Research (ICRR), the University of Tokyo and co-hosted by KEK and NAOJ. The KAGRA collaboration is composed of more than 360 individuals from more than 90 institutions. KAGRA membership is approved in the KAGRA collaboration meetings held three times a year.

The decisions of KAGRA management and operations are taken by the Principal Investigator, who is also the chair of the executive office (EO) of KAGRA. The decisions of scientific direction and strategy including R&D of the KAGRA collaboration are taken by the KAGRA Scientific Congress (KSC), which consists of the proportional representatives from each group. The roles of the spokesperson in this MoA will be played by the chair of the board of KSC, who is also in charge of the coordination with the other gravitational-wave research projects.

Scope of the agreement:

4. This agreement governs cooperative scientific work between VIRGO, LIGO, and KAGRA. The parties agree that all of the gravitational wave analysis work that they do will be carried out under the framework of this agreement; however, each Collaboration retains the ownership of and control over its own data. Agreements involving gravitational wave data sharing with other parties will be initiated and carried out jointly with LIGO VIRGO, and KAGRA in a spirit of teamwork.

The terms governing other forms of collaborative work with non-gravitational wave (e.g., environmental) data are not exclusive: VIRGO, KAGRA, and LIGO may each make agreements with other parties, and keep each other informed, as long as such agreements respect analysis and publication agreements established in this MOA, and they do not involve sharing of data of the other Collaboration.

5. The agreement described herein represents a scientific agreement between independent Collaborations, not a merger. Each Collaboration will maintain its own separate governance. Decisions on issues that bear on all collaborative work will be made in discussion among the leadership of the Collaborations, each acting on behalf of their own governing structures. If Collaboration leaderships cannot come to agreement on issues that bear on collaborative work covered under the terms of this agreement, each Collaboration may use its own data for its own scientific purposes. Procedures for defining and resolving conflicts are detailed in Section 25.

6. Goals for joint gravitational wave analysis (astrophysics, cosmology, fundamental physics and development of the data analysis techniques needed) will be proposed by LSC/Virgo/KAGRA Collaboration Joint Analysis Groups, will be discussed jointly by all Collaborations and will be approved by each Collaboration according to their own governing structures. The specific mechanisms for the coordination of the analysis activities are described in an Attachment to this MOA.

7. The Joint Run Planning committee is charged with strategic planning of detector upgrades, engineering runs, maintenance intervals, and observations. The specific mechanisms for the coordination of this scope are described in an Attachment to this MOA.

8. The sharing of commissioning experience and Research and Development (R&D) done by the Collaborations is encouraged, respecting all parties' publication and academic precedence rules. Joint work on commissioning may be proposed by the technical working groups to the managers of commissioning at LIGO, VIRGO, and KAGRA; the leadership of all Collaborations shall be made aware of these discussions.

9. All acquired data will be made available to all Collaborations, to be used in the framework of Joint Analysis groups. All gravitational wave analysis will be carried out under the umbrella of this agreement between LIGO, VIRGO and KAGRA; no gravitational wave analysis shall exclude members of either collaboration while this agreement remains in force.

All collaborative analysis work in the domain of gravitational waves or other messengers with entities other than LIGO, VIRGO or KAGRA will be negotiated by and carried out by the LSC, VIRGO, and KAGRA together as described in Section 3.

10. LIGO, VIRGO, and KAGRA will publicly release their data, following the procedure outlined in Attachment A to this MOA. After public release of the data, these data are also open to all LVKC members for subsequent analysis.

Coordination between VIRGO, KAGRA and LIGO

11. Scientists of LIGO, VIRGO, and KAGRA will meet regularly to exchange information on detector status and the progress of joint analysis, and to share plans for future data collection, instrument repairs, and detector enhancement. Analysis will be carried out jointly, and progress will be reported to the Collaborations regularly. The leaders of the projects will work to coordinate those plans, with the goal of optimizing the science done with the network of instruments.

12. The LSC, the Virgo Collaboration, and KAGRA Collaboration will each appoint (according to their governing structures) representatives to joint committees to coordinate detection assessment, analysis planning, run planning, computing, and editorial board, as detailed in the Attachment A to this MOA. The makeup of these committees will be decided by mutual agreement between the projects.

13. The separate LSC, Virgo Collaboration, and KAGRA Collaboration Program Committees, responsible in each Collaboration to define the scope of efforts of that Collaboration, will coordinate to form compatible programs and scope. Similarly, the Diversity and Education and Public Outreach Committees of the three collaborations will coordinate.

Organization of joint gravitational wave analysis:

14. All analysis activities on proprietary data, their documentation, and the software used for such activities will be open to all members of the LSC, Virgo Collaborations, and KAGRA Collaboration in a spirit of cooperation, open access, full disclosure and full transparency with the goal of best exploiting the full scientific potential of the data.

Gravitational wave analysis projects and activities will be organized in joint Analysis Groups, comprising members of the LSC, the Virgo Collaboration, and KAGRA Collaboration. Every analysis project shall be affiliated with at least one of the Analysis Groups.

Participation in the Analysis Groups will be open to all members of the three collaborations. Instrument and detector characterization experts will be encouraged to be active members of all Analysis Groups and Review Committees, to ensure appropriate use and interpretation of the data.

The organization and operation of the Analysis Groups are detailed in Attachment A to this MOA.

Review and publication of observational results:

15. Analysis Review Chairs will be attached to each Analysis Group. They will be responsible for ensuring that detailed technical review of analysis results is carried out and vetting the scientific validity of claims made in talks and papers. The organization and operation of the Analysis Review process are described in Attachment A to this MOA.

All data and their interpretation will be held strictly within the membership of the Collaborations until the review processes outlined below are complete and the three Collaborations have given their permission for public release. No discussion of results or pre-prints shall take place with scientists who are not members of the Collaborations or with members of the media, until the leaderships of the Collaborations have approved the release of the information; this holds for all papers, whether LVKC papers (see sections 16 and 17) or short author list (with a fraction of LVKC members and possibly non-LVKC authors), and all talks, interviews, and other public dissemination of results. Willful dissemination of information in contradiction of these rules may be a basis for expulsion from the Collaboration in question.

16. Author lists of those eligible to sign Observational Results papers are to be separately established according to the rules of each Collaboration, and maintained by them. All papers authored by all eligible VIRGO, KAGRA and LIGO authors will be published with one single alphabetical list of authors, referred to as "The LIGO Scientific Collaboration, the Virgo Collaboration, and the KAGRA Collaboration".

17. Once full-authorship Observational results have been published and relevant snippets of data made public, analyses on the public data may be undertaken by individuals and smaller groups with authorship as desired while following the publication rules adopted by LIGO, VIRGO, and KAGRA. LVKC publication rules must be followed when co-authoring with non-LVKC persons on subjects within the scope of the Programs laid out by the LVKC; LVKC members must inform non-LVKC colleagues of these rules in a timely way.

Organization of collaborative instrumentation science research

18. We encourage open sharing of technical information by all possible means among LVKC members, whether related to commissioning of present interferometers, or R&D on detector upgrades or on future interferometers. We encourage visits (both short-term and long-term) of scientists to the observatories and/or to the campus research facilities of the other project. We also encourage specific joint research and development projects whenever feasible. The leadership of LIGO, VIRGO, and KAGRA shall be informed of all collaborative work; depending on the nature of the work, it may require an Attachment to the MOA be negotiated if significant commitments are required.

Meetings of instrument science working groups of one Collaboration will be open to members of the other Collaboration. In addition, periodic joint collaboration-wide meetings will be held, to facilitate the exchange of knowledge and ideas. Documentation of technical developments will be made available to all Collaborations.

A joint review process will be established for joint instrument science, technical, and R&D papers to ensure fairness to authors, recognition of prior background knowledge, the quality of papers, and timely publication. All publications and presentations which come about due to the work of the joint collaborative effort or from sharing of ideas in the context of the joint collaboration shall be submitted to the joint review process, whether or not authorship includes members from the three Collaborations. A final version shall be circulated to the three Collaborations before submission.

Further details of the joint instrumentation research is given in Attachment A to this MOA.

Code of conduct

19. The LIGO, Virgo, and KAGRA Collaborations strive for workplaces free from discrimination and harassment. It is the policy of the three Collaborations that all members will conduct themselves in a professional manner that is welcoming to all participants and free from any form of discrimination, harassment, or retaliation. Members will treat each other with respect and consideration to create a collegial, inclusive, and professional environment. Creating a supportive environment to enable scientific discourse is the responsibility of all members.

The LVKC also shall not tolerate instances of scientific misconduct, which is characterized by any of fabrication, falsification, or plagiarism in proposing or performing research in the LVKC.

The Code of Conduct document [LIGO-M1900037/VIR-0222-19/JGW-M1707082](#) is the defining document for the LSC, Virgo Collaboration and the KAGRA Collaboration, respectively. Each Collaboration may write a more detailed interpretation or provide additional measures, but all internal documents must be consistent with the Code of Conduct above.

Coordination with governing bodies and sponsors:

20. Each party to this MOA continues to be responsible for obtaining all resources, and for all support of its staff including travel costs associated with the activities under this MOA. Exceptional support of travel by the other party may be allowed for travel requested by that party.

21. In order to preserve the intellectual property rights of their respective institutions and sponsors, the Virgo Collaboration Spokesperson, the EGO Director, the LSC Spokesperson, the LIGO Executive Director, the KAGRA Principal Investigator, and the KSC Spokesperson will promptly inform each other of any invention resulting from joint actions which might lead to intellectual property rights. Each of them will be responsible to further notify their respective governing bodies as well as relevant institutions and sponsors from their Collaboration with any possible interest in those intellectual property rights.

22. The LIGO Laboratory is responsible for obtaining NSF approval of collaborative Memoranda of Agreement where required. All attachments will be provided to NSF for their information.

23. The Virgo Spokesperson and the EGO Director are responsible for obtaining the EGO Council approval of collaborative Memoranda of Agreement. All attachments will be provided to EGO Council for its information.

24. The KSC Spokesperson is responsible for obtaining the necessary approvals from the KAGRA Collaboration of the collaborative Memoranda of Agreement.

Conflict resolution:

25. The LSC, Virgo Collaboration, and KAGRA Collaboration will make every effort to come to agreement on issues bearing on collaborative work covered under this agreement. In the event that a conflict between the three collaborations cannot be resolved in good faith through discussions between Collaborations' governing bodies, each Collaboration may act independently using their own data. Neither Collaboration shall impede the work of the other Collaboration. The Collaborations will continue joint activities on projects that are not affected by the conflict.

Such conflicts, were they to arise, include but are not limited to issues related to publication or presentation of gravitational wave analysis or instrument science results or discoveries, access to

LIGO, VIRGO, or KAGRA data from non-collaboration members, selection of data for analyses, or use of data by collaboration members. In the event of conflict, the Collaboration moving forward with the non-collaborative activity will continue to share information on the progress of that project with the other Collaboration. In general, the other Collaboration is welcome to participate in corresponding working group meetings.

As stated in Section 3, agreements involving gravitational wave data sharing with other parties will be initiated and carried out jointly with LIGO, VIRGO, and KAGRA, in a spirit of teamwork. However, if one Collaboration establishes an agreement with a third party involving the use of its own data, the other Collaborations maintains the right to access and use those data. The Collaborations will share information on arrangements made with third parties including those in conflict.

Term of agreement:

26. This agreement will come into force after approval by the Collaborations' governing bodies, endorsement by NSF and the EGO Council, and conditions in the "Letter of Intent for KAGRA to Join the O3 Run" (L1900363-v1, VIR-0909A-19, JGW-M1910813) are satisfied. It covers collaborative work beginning on the date the agreement has been signed by all parties and lasting until 30 September 2023. It may be amended or extended by mutual agreement between LIGO, VIRGO, and KAGRA. Cessation of any data exchange may take place at the request of either LIGO, VIRGO or KAGRA. Data collected under the terms of this agreement (prior to its cessation), on-going analysis of them, and any publications and presentations using them are governed by the terms of this MOA and its attachments indefinitely, unless all LIGO, VIRGO, and KAGRA agree to a change.

Approved:

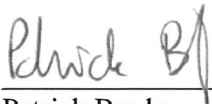
 4 OCT 2019

David Reitze Date
LIGO Executive Director and LIGO Principal Investigator



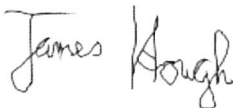
27-Sep-2019

Albert Lazzarini Date
LIGO Laboratory Deputy Director



27 September 2019

Patrick Brady Date
LSC Spokesperson




27 September 2019

James Hough Date
GEO Representative

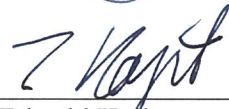


30-Sep-2019

Stavros Katsanevas Date
Director of EGO

 Oct. 4, 2019

Jo van den Brand Date
Virgo Collaboration Spokesperson



Oct. 4, 2019

Takaaki Kajita Date
KAGRA Principal Investigator



Oct 4, 2019

Hisaaki Shinkai Date
KSC Board Chair