

Brief Guide to Citing the LIGO–Virgo–KAGRA Collaboration

LIGO–Virgo–KAGRA Joint Editorial Board

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Scientific Motivation for the LIGO–Virgo–KAGRA Collaboration The LIGO Scientific Collaboration (LSC), the Virgo Collaboration and the KAGRA Collaboration have joined together to perform gravitational wave science using their respective ground-based Michelson interferometric detectors. Coordinated observations of the same astrophysical sources enable improved understanding of those sources, especially in localizing their directions via triangulation from different points on the Earth’s surface [1].

The Detectors In brief, the LIGO detector [2], operated by the Caltech and MIT LIGO Laboratory via a cooperative agreement with the NSF, is a pair of 4 km interferometers in Hanford, Washington and Livingston, Louisiana in the United States. The Virgo detector [3], operated by the European Gravitational Observatory and funded by INFN (Italy), CNRS (France) and Nikhef (Netherlands), is a 3 km interferometer in Cascina, Italy. The KAGRA detector [4], operated by ICRR, KEK and NAOJ and funded by MEXT (Japan), is an underground 3 km interferometer in Kamioka, Japan.

Technical details concerning these detectors may be found in the references below. In addition, the GEO 600 detector [5], operated by a consortium of German and British LSC institutions and funded by MPG (Germany) and STFC (UK), is a shorter, 600 m interferometer often used to test new technologies; it collects data when the larger detectors are being upgraded or commissioned.

LIGO is short for Laser Interferometer Gravitational-Wave Observatory. Virgo is named for the Virgo constellation, and only the first letter is capitalized. KAGRA is the name of the Large-scale Cryogenic Gravitational-Wave Telescope and written in all capital letters (taken from KAmioka and GRAVitational waves).

The Collaborations The LIGO Scientific Collaboration and Virgo collaboration have been carrying out joint analysis of available data sets and co-authoring

observational result papers since 2010. Beginning in 2021, the KAGRA Collaboration too is co-authoring observational results from the second half of the O3 run onward. When referring to the joint international collaboration, one can use the shorthand, “LIGO–Virgo–KAGRA Collaboration” or the more abbreviated “LVK Collaboration”, or still more compactly “LVK”, depending on context. Similarly, scientific results published between 2010 and 2021 may be designated concisely as “LV results”, with more recent publications containing “LVK results”. Before KAGRA joined forces with LIGO and Virgo, “LVC” was a common shorthand used for “LIGO–Virgo Collaboration”, a usage now deprecated in favor of simply “LV” when referring to older scientific publications and results.

The Observing Runs and Data Sets In certain contexts, such as in technical descriptions in scientific publications, specific detector data sets may be mentioned. For example, the first observing run of the advanced detector era (2nd-generation detectors) used LIGO detector data jointly analyzed by LSC and Virgo scientists.

For reference, the following detectors operated during the advanced detector observing runs to date:

- O1 run (Sept 2015 – Jan 2016): LIGO
- O2 run (Nov 2016 – August 2017): LIGO and (for the final month) Virgo
- O3 run (April 2019 – March 2020): LIGO and Virgo
- O3GK (April 2020): GEO and KAGRA

Future observing runs (O4 and beyond) will involve LIGO, Virgo and KAGRA detectors, to be joined eventually by a third LIGO interferometer (LIGO-Aundha) [6] near Hingoli, India, operated by IPR, IUCAA and RRCAT for the LIGO-India Scientific Collaboration (LISC).

Journal citations Journal conventions for listing authors in collaborative publications vary, but where permitted, we suggest using “F. Author *et al.* (LIGO–Virgo–KAGRA Collaboration), ...”, where “F. Author” would currently be “R. Abbott”. A compact alternative is “F. Author *et al.* (LVK Collaboration), ...”. Other alternatives include “LIGO–Virgo–KAGRA Collaboration, ...” and “LVK Collaboration, ...”.

It is **not** acceptable to refer merely to “LIGO *et al.*” (or “LSC *et al.*”) when referring to publications or results co-authored with Virgo and/or KAGRA.

References

- [1] B.P. Abbott *et al.* (LIGO–Virgo–KAGRA Collaboration), Prospects for Observing and Localizing Gravitational-Wave Transients with Advanced LIGO, Advanced Virgo and KAGRA, Living Rev.Rel. 23 (2020) 1, 3.

- [2] J. Aasi *et al.* (LIGO Scientific Collaboration), Advanced LIGO, *Class. Quantum Grav.* **32** 074001 (2015).
- [3] F. Acernese *et al.* (Virgo Collaboration), Advanced Virgo: a 2nd generation interferometric gravitational wave detector, *Class. Quantum Grav.* **32** 024001 (2015).
- [4] T. Akutsu *et al.* (KAGRA Collaboration), Overview of KAGRA: Detector design and construction history, *Prog. Theor. Exp. Phys.* **2021**, 05A101 (2021).
- [5] K L Dooley *et al.* (GEO Collaboration), GEO 600 and the GEO-HF upgrade program: successes and challenges, *Class. Quantum Grav.* **33** 075009 (2016).
- [6] B. Iyer, *et al.* (IndIGO Collaboration), LIGO-India Tech. rep. (2011), <https://dcc.ligo.org/LIGO-M1100296/public>.