VIR-0402A-15

Memorandum of Understanding between the
Relativistic Astrophysics Group of the Universitat de València
and the
Laser Interferometer Gravitational Wave Observatory (LIGO) Scientific Collaboration and VIRGO
September, 2015

This Memorandum of Understanding (MOU) establishes collaboration among the Laser Interferometer Gravitational-Wave Observatory Scientific Collaboration (LSC), the European Gravitational Observatory and Virgo Collaboration (EGO/Virgo), and the Relativistic Astrophysics Group of the Universitat de València (UV hereafter), to study classification methods for noise transients (glitches) in advanced gravitational wave detectors.

The purpose of this MOU is to reference the parties involved and their relevant policies; outline the planned work and the general timeline for it; define the appropriate data and its use that is to be shared under this arrangement; 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. Description of Participating Groups

1. The Relativistic Astrophysics Group of the Universitat de València (UV) conducts research aimed to understand the underlying physics and dynamics of some of the most representative scenarios in the fields of Relativistic Astrophysics and Cosmology. To achieve these goals the work of the group strongly relies on the analysis of the physical processes, multidimensional numerical MHD and radiative transfer simulations, and numerical relativity simulations. In particular, the group is actively focused in studying systems formed by black holes and neutron stars, which are the main targets for ground-based laser interferometers of gravitational radiation. The direct detection of these ripples in the curvature of spacetime, and the wealth of new astrophysical information that can potentially be extracted thereof, is one of the driving motivations of the current research activities of the group. Members of the group have recently started a line of research on gravitational wave data analysis through the development of total-variation-based methods for denoising and detection of gravitational waves embedded in additive Gaussian noise. Our results show that noise from gravitational wave signals can be successfully removed with our techniques, irrespective of the signal morphology or astrophysical origin. These methods can be combined with spectrograms and simultaneously with other common techniques in gravitational wave data analysis to improve the chances of detection.

The UV collaboration consists of the following members (in alphabetical order):

Pablo Cerdá-Durán, José Antonio Font Roda, José María Ibáñez Cabanell, Antonio Marquina Vila, and Alejandro Torres Forné. They are not members of LSC/Virgo.

This MOU is an agreement between these non-LSC/Virgo participants on the one hand and the LSC and Virgo on the other hand. The non-LSC members of the collaboration (i.e. the UV group) are represented by the PI representative who signs this MOU on behalf of the participating non-LSC members.

2. The Laser Interferometer Gravitational-Wave Observatory (LIGO) Laboratory is aimed at opening the field of gravitational-wave astrophysics through the direct detection of gravitational waves. LIGO detectors are using laser interferometry to measure the distortions of the space between free masses induced by passing gravitational waves. Scientists, engineers, and staff at the California Institute of Technology (CALTECH) and the Massachusetts Institute of Technology (MIT) are carrying out the operation of LIGO, and are participating in the development of Advanced LIGO and future interferometer enhancements.

LIGO is a national facility for gravitational-wave research, providing opportunities for the broader scientific community to participate in detector development, observations, and data analysis. LIGO welcomes the participation of outside scientists at any of these levels.

3. LIGO includes the LIGO Laboratory and the LIGO Scientific Collaboration (LSC). The Charter of the LIGO Scientific Collaboration 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 includes the Laboratory Directorship and the LSC Spokesperson. The German/British Collaboration for the Detection of Gravitational Waves (GEO600) is part of the LSC.

The LSC is composed of over 800 individuals from about 61 institutions worldwide, including scientists and engineering personnel from the LIGO Laboratory. It is the policy of the LSC that all LIGO participants who have earned authorship rights be included as authors on any publication reporting on LIGO and GEO observations and astrophysics results. (This does not apply to technical papers.)

3. 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 Advanced LIGO. 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 managed by the Albert Einstein Institute (AEI), Cardiff University, and Birmingham University. The project is funded in Germany by the State Government of Niedersachsen, the Max Planck Gesellschaft (MPG), and the Bundesministerium fuer Bildung und Forschung (BMBF) in Germany, and by the Science and Technology Facilities Council (STFC) in the UK.

4. 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.

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 over 200 scientists and technicians coming from CNRS and INFN laboratories and from EGO, which have signed an Agreement on 19 December 2001, as well as from 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. Publications identified as Virgo publications by their use of Virgo data (and in general according to criteria listed in the Virgo publication rules) have an author list that includes all Virgo members that have earned authorship rights.

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

B. General Policies and Provisions

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

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 travel costs associated with the activities under this agreement. Exceptional support of travel may be allowed for travel requested by that institution.

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 are scientifically related will be freely shared among the parties of this MOU.

C. Description of Planned Work

The project will test and study classification methods for noise transients (glitches) in advanced gravitational wave detectors.

D. Scope and Timeline

1. This agreement concerns data collected during aLIGO's engineering runs, which have been defined as Collaboration Open Data. It remains in place until the project has concluded, as defined by the publication of the results paper in a peer-reviewed journal or 36 months after the date of signing of this MOU.
2. Cessation of any data exchange may take place at the request of UV, LSC or VIRGO. Data exchanged under the terms of this agreement (prior to its cessation), on-going analyses of them, and any publications and presentations using them are governed by the terms of this MOU and its attachments indefinitely, unless all UV, LSC and VIRGO agree to a change. This MOU may be extended by mutual agreement between UV, LSC and VIRGO.

E. Appropriate Use of Data and Other Information

1. All parties agree that any code, data or data products received from the other parties shall be used only for the purposes of the collaborative work covered by this agreement, and shall be held confidential (unless already made public). Any public release of data would not affect the goals or terms of this project.

2. Access to collaboration web sites and/or mailing lists may be granted to facilitate working together. Any information exchanged related to this MOU concerning UV, LIGO, Virgo should be treated as confidential unless it has already been made public. 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.

F. Publications and Presentations

1. LIGO, Virgo, and UV will cooperate on any publication of scientific results resulting from the collaborative work described in this agreement. Any intention to publish (in any form, including peer-reviewed articles, conference proceedings, and theses) results or status of the LSC-VIRGO-UV joint analysis must be communicated and approved in advance.

2. Publication or other presentation of results related to the collaborative work will follow the usual principles for scientific credit and authorship. Any joint paper(s) or presentation(s) will be guided by the publication policies of all the participating collaborations for authorship, internal review, and approvals4. In particular, *any publication from* UV *research that contains results derived from the use of LIGO or VIRGO data* will include all LIGO-VIRGO- UV collaboration members as authors. The author list will have one block for LIGO/ Virgo authors and a separate block for members of the UV project who are not members of the LIGO or Virgo collaborations; or, if journal rules allow only a single block, then the collaboration affiliations of all authors will be indicated in a suitable way. The list of non-LIGO/VIRGO-UV authors will be alphabetical. 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 collaborations in presenting the joint work. Technical papers that do not use LIGO-VIRGO data may have limited author lists. Authorship of these papers will be determined by the UV collaboration and standard LSC-Virgo publication policies.

The publication rules are available in the following documents: LSC [http://www.ligo.caltech.edu/docs/T/ T010168-03/], VIRGO [VIR-0560A-09 https://tds.ego-gw.it/ql/?c=6872 and VIR-0559A-09 https://tds.ego-gw.it/ ql/?c=6871].

3. All members of the UV, LSC and VIRGO collaborations will be given the opportunity to read and comment upon any scientific publications resulting from this collaborative work before their submission to any public archive or to a journal.

4. Any conflicts between the policies of the collaborations will be resolved by mutual agreement. If a conflict cannot be resolved, the LIGO Executive Director, LSC Spokesperson, Virgo Spokesperson, and the PI of the UV group may veto the joint paper or presentation.

5. After publication of a joint paper, all members of the UV, LIGO and Virgo collaborations will be able to present the results publicly following the prevailing policies of all collaborations. All such presentations of the joint work must give credit to the UV, LIGO and Virgo collaborations.

_____ Date

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José A. Font
UV PI Representative

September 23rd, 2015____ Date

Fulvio Ricci
Virgo Spokesperson

_____ Date

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Gabriela Gonzalez
LSC Spokesperson

Group Name: Relativistic Astrophysics Group of the Universitat de València
Group PI name: José Antonio Font Roda
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Names and email address of group members participating in LIGO-VIRRGO-UV joint project:

Alejandro Torres-Forné (alejandro.torres@uv.es)

Antonio Marquina Vila (antonio.marquina@uv.es)

José María Ibáñez Cabanell (jose.m.ibanez@uv.es)

We agree to abide by collaboration policies stated in the UV Collaboration Memorandum of Understanding:

(Signature of Group PI).

Attachment to the Collaboration Memorandum of Understanding for non-LSC/Virgo groups participating in the project: Glitch-classification (temporary name for the project)

The project will test and study classification methods for noise transients (glitches) in advanced gravitational wave detectors. The main three classification methods currently implemented in the data analysis pipelines are an adaptation of LALInference Burst (LIB), a Principal Component Analysis for Transients (PCAT), and a Wavelet Detection Filter with a Machine Learning classification procedure (WDF-ML). PCAT is already running daily at the aLIGO detector sites and LIB is currently running on the Livingston GW channel only. Lots of whistle glitches have been found in the aLIGO engineering runs ER6 and ER7 data. In particular the project will study how the various classification methods perform when using ER data from multiple auxiliary channels. The participation of the members of the UV group Torres-Forné and Font will focus on the use of the WDF-ML method developed by Elena Cuoco (EGO, INFN-PISA) along with providing help on the corresponding data analysis. The use of the total-variation-based denoising methods developed by members of the UV collaboration Torres-Forné, Marquina, Font, and Ibáñez, is deferred to a later stage of the project, as these methods are currently in a developing stage.

The primary result of the project will be a scientific paper where the classification methods have been applied on real data (open collaboration data), using auxiliary monitoring channels where there are classes of identified glitches.

This work represents an update of a first paper done on MDC data : "Classification methods for noise transients in advanced gravitational-wave detectors" , J.Powell, D. Trifirò, E. Cuoco, M.Cavaglia, Ik S. Heng , submitted to Classical Quantum Gravity .

It will be developed in collaboration with Jade Powell and Ik Siong Heng, from Glasgow University, with (Elena Cuoco EGO,INFN, Pisa), Giancarlo Cella (INFN, Pisa),Daniele Trifirò (Pisa University) and Marco Cavaglià (Missisipi University).

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Notes:

1. This project is not intended to unduly interfere with the other scientific activities of the Relativistic Astrophysics Group of the Universitat de València and of the LSC-VIRGO collaborations. No detection (or upper limit) statements will be pursued by the project.
2. The following Frame/LIGOLW data sets will be created for use in the project:

    (a) ER6 data

    (b) MDC data

5. The members of the UV collaboration, who are not members of the LSC-Virgo collaborations, will have access to all data sets to be analyzed within the project.
6. Final analysis and interpretation will be a cooperative undertaking between all participants in the project, using existing analysis tools and techniques where appropriate, with the exact division of tasks to be determined by mutual agreement.