

**Memorandum of Understanding (LIGO-M0900311, VIR-0109A-10)**

**between the**

**IceCube Collaboration**

**and the**

**Laser Interferometer Gravitational Wave Observatory (LIGO) Scientific Collaboration**

**and**

**VIRGO**

**November 28, 2009**

This Memorandum of Understanding (MOU) establishes collaboration among the Laser Interferometer Gravitational-Wave Observatory and its associated scientific collaboration (LSC), the European Gravitational Observatory and Virgo Collaboration (EGO/Virgo), and the High-Energy Neutrino telescope operated by the IceCube Collaboration (IceCube), to perform a joint research program for coincident cosmic sources of gravitational waves (GW) and high-energy neutrino (HEN) events.

1. The IceCube Collaboration is an organization of scientists pursuing a research program to study high-energy neutrinos from cosmic sources. The Collaboration uses the IceCube Observatory at the National Science Foundation (NSF) Amundsen-Scott South Pole Station for this research program. The IceCube Observatory consists of a surface array, IceTop, and a deep ice array IceCube, which includes an inner detector, DeepCore. When completed, the instrumented volume in the ice will reach approximately  $1 \text{ km}^3$ , with an array of over 5000 digital optical modules monitoring for the Cherenkov light emitted by relativistic charged particles passing through the ice. The Host Institution for the IceCube project is the University of Wisconsin-Madison (UW), under the terms of Cooperative Agreements with the NSF<sup>1</sup>. The IceCube Collaboration is composed of approximately 250 individuals from 34 institutions worldwide. In this MOU the IceCube Collaboration is represented by the Principal Investigator, the Director of the Observatory, and the Spokesperson.
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

---

<sup>1</sup> Cooperative Agreement Nos. ANT-0236449, dated August 2002, and ANT-0639286, dated April 2007, between the National Science Foundation, Washington D.C. 20550 and the University of Wisconsin-Madison, Madison, WI 53715

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.

Caltech has prime responsibility for the LIGO Project under the terms of a Cooperative Agreement<sup>2</sup> with the NSF. 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.

LIGO includes the LIGO Laboratory and the LIGO Scientific Collaboration (LSC). The Charter of the LIGO Scientific Collaboration (LSC) 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 approximately 750 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 scientific publication arising from the analysis of LIGO data.

LIGO holds several bi-lateral data exchange agreements with other gravitational wave detector and data analysis groups. With the exception of the parties covered in this agreement, access of data or any other information from non-LIGO detectors is not covered by this agreement.

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.

---

<sup>2</sup> Cooperative Agreement No. PHY-0107417 between the National Science Foundation, Washington D.C. 20550 and the California Institute of Technology, Pasadena, CA 91125, dated October 2001

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 approximately 200 scientists and technicians coming mainly from CNRS and INFN laboratories and from EGO, which have signed an Agreement on 19 December 2001. 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 spokesman appointed by the Virgo steering committee and the EGO Consortium by the director of EGO appointed by the EGO council.

5. Attachment No.1 to this Memorandum of Understanding defines the terms and conditions governing the joint analysis of LIGO, VIRGO and IceCube data collected during LIGO's S5 science run (covering the period from November 4, 2005 through September 30, 2007) and S6 science run (covering the period from July 7, 2009 through December 31, 2010), Virgo's VSR1 science run (covering the period from May 18, 2007 through September 30, 2007) and VSR2 science run (covering the period from July 7, 2009 through December 31, 2010), and IceCube's 22-string science run (covering the period from May 31, 2007 through April 4, 2008) and IceCube's 59-string and 77-string science runs covering the period from May 20, 2009 through December 31, 2010).
6. In entering into this Memorandum of Understanding, the LIGO Laboratory will carry out its responsibilities following the requirements of the Cooperative Agreement.
7. 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.
8. 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.

9. 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.
10. Cessation of any data exchange may take place at the request of either IceCube, 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 IceCube, LSC and VIRGO agree to a change. This MOU may be extended by mutual agreement between IceCube, LSC and VIRGO.

---

Jay Marx  
LIGO Laboratory Executive Director

---

Date

---

Francis Halzen  
IceCube Observatory Principal Investigator

---

Date

---

Albert Lazzarini  
LIGO Laboratory Deputy Director

---

Date

---

James Yeck  
IceCube Observatory Director

---

Date

---

David Reitze  
LSC Spokesperson

---

Date

---

Thomas Gaisser  
IceCube Collaboration Spokesperson

---

Date

---

Jacques Colas  
Director of EGO

---

Date

---

Francesco Fidecaro  
Virgo Spokesperson

---

Date

---

Bernard Schutz  
GEO 600 Principal Investigator for Data Analysis

---

Date