

Gabriela González Written Testimony

“Unlocking the Secrets of the Universe: Gravitational Waves”

February 24, 2016

Mr. Chairman Smith, Ranking Member Johnson, and Members of the Committee: it is an honor to testify here on behalf of my collaborators. We thank you for your interest in gravitational wave science, and your support of the National Science Foundation funding our research in the US.

INTRODUCTION

I am Gabriela González, a professor of Physics and Astronomy at Louisiana State University, and the current spokesperson of the LIGO Scientific Collaboration.

My colleague Dr. Reitze has described the exciting science of this discovery. I will describe the role of the international LIGO Scientific Collaboration in current and future research for LIGO, and the contributions of that research to the education and training of the future scientific workforce.

THE LIGO SCIENTIFIC COLLABORATION

Our charter defines our mission: “The LIGO Scientific Collaboration (LSC) is a self-governing collaboration seeking to detect gravitational waves, use them to explore the fundamental physics of gravity, and develop gravitational wave observations as a tool of astronomical discovery. The LSC works toward this goal through research on, and development of techniques for, gravitational wave detection; and the development, commissioning and exploitation of gravitational wave detectors. No individual or group will be denied membership on any basis except scientific merit and the willingness to participate and contribute as described in this Charter.”

The LSC was formed in 1997 to exploit fully the scientific potential of the LIGO instruments then under construction, and to engage in the research and development necessary to go significantly beyond the first generation of interferometers. LIGO is composed of the LSC and the LIGO Laboratory, with significant interweaving of membership and tasks. The LSC, including the LIGO Laboratory, is the entity within LIGO that carries out LIGO’s scientific research program.

The detection of gravitational waves announced this month was the result of decades of our collaboration’s effort on many different areas:

- Experimental research on low-loss optics, seismic isolation, multiple-suspension structures, high power stabilized lasers, and much more, was the basis for the technology used in the Advanced LIGO Detectors. The current

basic research by these groups guarantees even better technology for improved detectors.

- Working with instrument science researchers in the US and abroad, the LIGO Laboratory led the construction and installation of reliable LIGO gravitational wave detectors; the project depended on the expertise and help of the broader Collaboration, including the Laboratory.
- The data calibration and data quality diagnosis use novel and clever algorithms created by the LSC members, with a monitoring effort distributed around the world.
- The search for gravitational waves hiding in the detector noise is a Big-Data analysis effort, performed by many computer codes developed by the LSC and implemented in computing clusters in many different institutions.
- The LSC manages data flow and storage for the clusters in several different physical places, including making the appropriate data open to the public, as well as producing detection alerts for the scientific community.
- Scientists in the LSC carefully characterization and interpret the gravitational wave search results, including the conclusion that our first detection was produced by the coalescence of two black holes more than a billion light years away. This effort is justly receiving interest and attention from the entire scientific community. The number and diversity of the scientists involved is one of the key elements leading to robust results.

The LSC consists of more than 1,000 scientists from 15 countries (see Fig 1). More than half the LSC members work in the US, in 22 different states (including 12 states represented by members of this Committee) and 28 different congressional districts (See Fig 2). Groups are hosted in more than 90 different academic institutions around the world; in the US, the LSC has a great diversity of colleges and universities: there are top tier private universities, large state universities, graduate universities and undergraduate colleges, and several institutions with large student population of under-represented minorities in science. Although the LSC is an international collaboration, the LIGO Laboratory and the US scientists have played a clear leading role in the scientific and leadership activities.

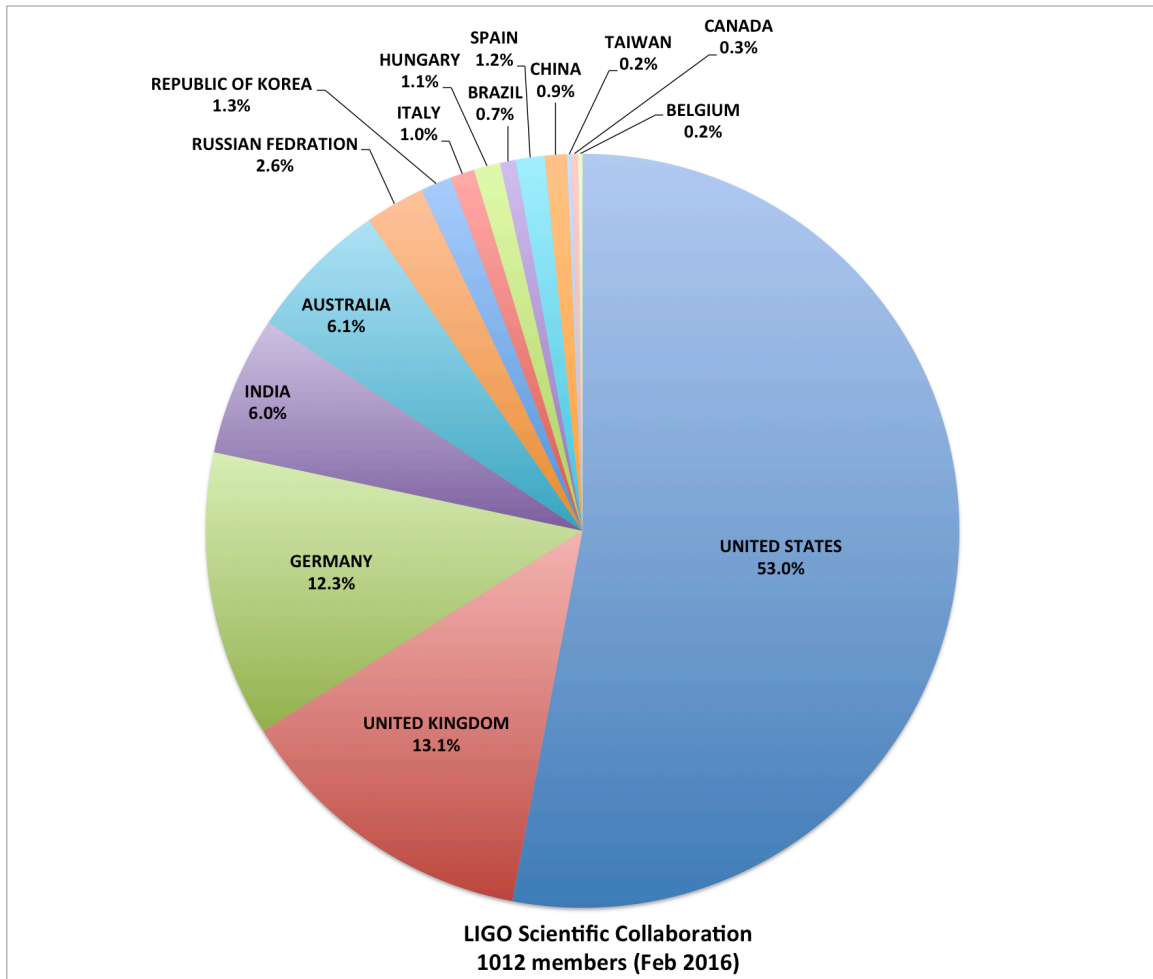


Figure 1: Membership distribution among countries in the LSC

Within the US, the very large majority of the financial support for research comes from the NSF. Groups outside of the US are supported by their national funding agencies. Our collaboration does not pool financial resources though – we agree to work together in scientific activities, sharing intellectual and human resources in “working groups” dedicated to different topics. Each group seeks funding for their research based on the merits of the research done in that group. The US funds the LIGO Laboratory with a Cooperative agreement, but also funds the basic research in the many other groups through the competitive NSF research grant system, guaranteeing the quality of the funded activities.

We are a democratic organization: we elect leaders of our working groups, and we elect the spokesperson, or leader, of the collaboration. I have the honor of occupying today this position – Prof Rainier Weiss from MIT, Prof Peter Saulson from Syracuse University and Prof David Reitze from University of Florida were my predecessors.

LIGO has fostered effective relationships to other gravitational-wave collaborations, like the European Virgo Collaboration, our closest partner. We share fully in the

science, data, computing, and technology with Virgo – we author papers together, including the recent paper describing the first observation of gravitational waves - this paper has more than 1,000 authors. The Japanese KAGRA collaboration is expected to form just as close a relationship once their instrument begins operating a few years from now. Just last week, the government of India approved a LIGO-India project to build an Observatory to house a third LIGO detector; the many LSC members in India and the LIGO Laboratory were critical to this development effort.

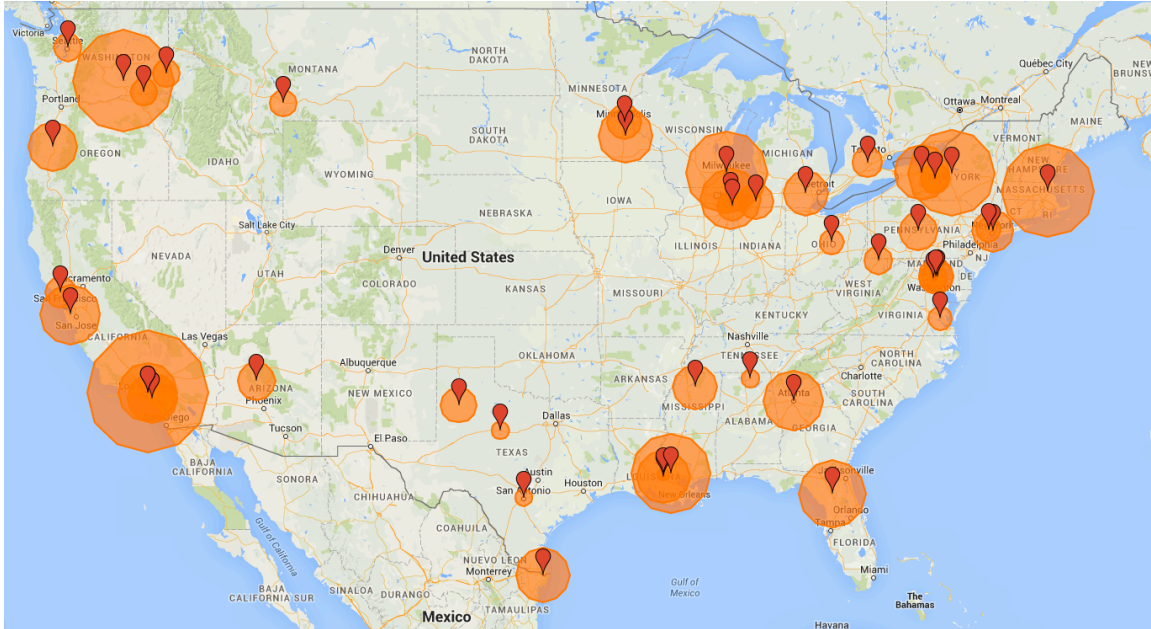


Figure 2: LIGO Scientific Collaboration groups in the US. [Created using Google maps].

LIGO TRAINS THE SCIENTIFIC WORKFORCE

LIGO, with its scientific success now recognized worldwide, has grown the field of gravitational wave science through education and training of the next generation of researchers. The LSC, including university-based graduate students and postdocs, has fostered innovation in all aspects of the field, from experimental research for future detectors to the astrophysical interpretation of the results. The institutional diversity of the LSC means that in addition to students from the top-tier universities, LIGO is also involving first-generation college students from our nation's public regional universities, some with a large fraction of under-represented minorities in science.

The LSC and the LIGO Laboratory take very seriously their educational responsibilities, and work closely together on these issues. As displayed in Fig. 3, more than half of the LSC'S members are young investigators, either postdocs or students. Currently, there are 255 graduate students, 107 undergraduate students and 172 postdoctoral scholars in the LSC (see Figure 3). About half of the graduate students (119) and most of the undergraduate students (79) are in US institutions.

This strong contingent of postdocs and students receives training in forefront science and technology; many of them will take on leadership roles in the future of gravitational-wave and other science areas as well as in industry.

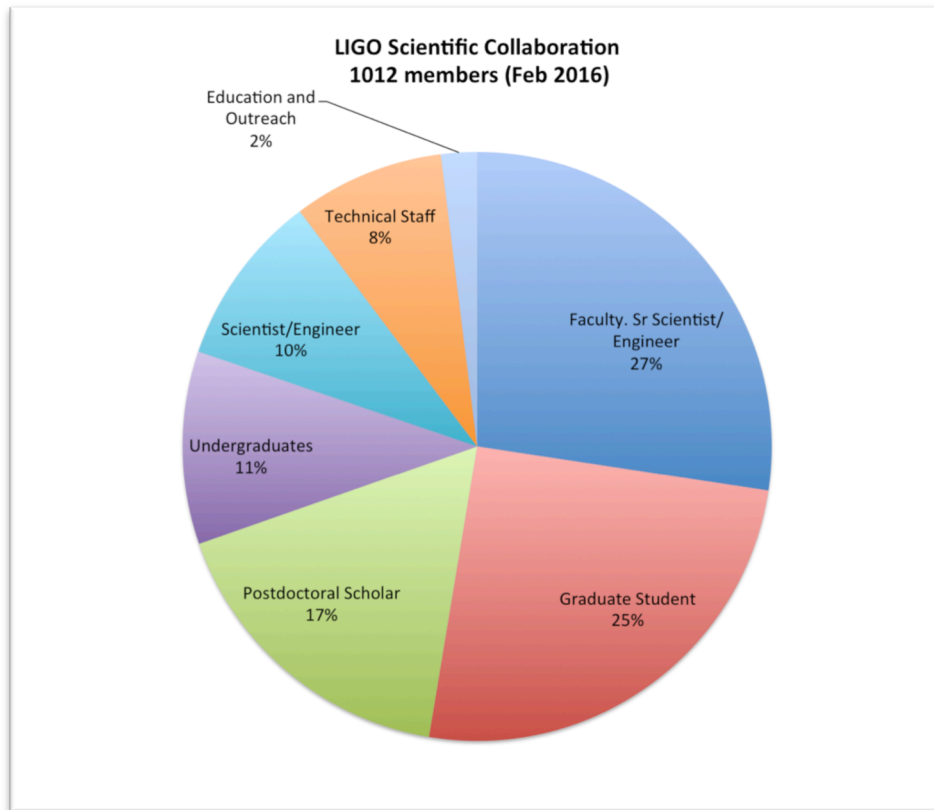


Figure 3: Positions of LSC members

The LSC is strongly committed to train a diverse workforce: We pledge to provide a welcoming, inclusive environment to talented individuals regardless of characteristics such as, but not limited to, physical ability, race, ethnicity, gender, sexual orientation, economic status, or personal religious practices, and to support the professional growth of all collaboration members. The LSC has a LIGO Academic Affairs Council (LAAC), responsible for overseeing and documenting the LSC's activities in representing and protecting the interests of students and postdocs. The LAAC is also responsible for providing education and training activities for new students and postdocs in the LSC.

Undergraduates contribute to the LSC's research program. Undergraduates conduct research with LIGO Laboratory and LSC groups in a number of different ways. Undergraduate researchers come from both primarily undergraduate institutions (for example, liberal arts colleges) as well as from large universities. Individual researchers at graduate institutions often supervise undergraduates throughout the academic year and the summer; much of this support (in the US) comes from NSF grants to individual researchers. Additional undergraduates not included in Fig. 3

are involved with LIGO through participation in summer Research Experience for Undergraduates (REU) programs at many LSC member institutions.

The small fraction shown in Figure 3 for K-12 Education and Outreach is the number of people solely dedicated to those activities. However, Education and Outreach constitute important parts of the LSC's activities, and many members of the collaboration dedicate a significant fraction of their time to this effort. LIGO has spent many years informing the general public about our science, and we have also prepared intensely in the last few months material, activities and talks to explain the significance of the first observation of gravitational waves. The public's reception to our discovery has been extremely positive and intense: last Saturday, almost 1,300 people visited the LIGO Science Education Center at the LIGO Livingston Observatory (also funded by NSF) to see where the science is done, and meet some of the scientists who do it. The local as well as the national coverage presented the broad spectrum of scientists working on this field – there are many local heroes to celebrate.

The broadness and openness of the collaboration research provides an important learning and education environment for all the young people. Thanks to this, the hundreds of people who received training in the LSC are now important contributors not just to higher education in academia, national laboratories and high school science education, but also to cutting-edge industry in the US. An incomplete list of companies employing LSC graduates are: the human genomics industry, US health care industry, bio-medical information, oil industry, Microsoft, Google, Boeing, Space-X, Northrop Grumman, Synaptics, Celestron, Luminit, Cytotec Engineered Materials, GE Global Research, Geneva Trading, Seagate.

CONCLUSION

The LSC will continue working hard on its mission to understand the Universe better through the newly opened gravitational wave window. We are very proud about the result of our work being not just amazing astrophysical results, but also pushing the technology frontiers and contributing to progress of society with a broadly educated and efficient workforce for academia and industry.