The North American Nanohertz Observatory for Gravitational Waves

Press / Media Kit

Questions and comments should be directed to:

Dr. Elizabeth Ferrara
NANOGrav Press Officer
press@nanograv.org

NANOGrav
Physics Frontiers Center

NANOGrav
Physics Frontiers Center

NANOGrav and Pulsar Timing Array Science

What is NANOGrav?

The North American Nanohertz Observatory for Gravitational Waves (NANOGrav) is an international collaboration of astronomers dedicated to exploring the low-frequency gravitational wave universe through radio pulsar timing. NANOGrav is an NSF-funded Physics Frontiers Center, with additional funding from Canada's NSERC and CIFAR, plus the Gordon and Betty Moore Foundation.

NANOGrav has more than 190 members at over 70 partner institutions including four-year colleges, research universities, national laboratories, and radio observatories throughout North America and around the globe.

NANOGrav observes an ensemble of ultra-stable millisecond pulsars known as a pulsar timing array with the world's largest telescopes, including the Green Bank Telescope, the CHIME telescope, the Very Large Array, and (formerly) the Arecibo Telescope. NANOGrav is also a member of the International Pulsar Timing Array, which also includes the Parkes Pulsar Timing Array in Australia, the European Pulsar Timing Array, and the Indian Pulsar Timing Array.

NANOGrav uses millisecond pulsars as a network of cosmic clocks to measure invisible ripples in spacetime produced by extremely massive black holes. This transformative experiment will produce unique insights into how galaxies have grown over cosmic timescales. Our pulsar timing observations also enable many additional astrophysical experiments and applications, from stellar evolution to particle physics.

The NANOGrav website offers a wealth of information about the experiment, the science, and the collaboration. To further explore the pulsar timing array and the science it enables, we recommend the following links.

NANOGrav Website

Radio Astronomy

We observe with the largest telescopes in the world in order to probe energetic processes that are invisible to optical telescopes.

Pulsars as Cosmic Clocks

Pulsars are rapidly rotating, highly magnetic neutron stars that emit beams of radio emission, like cosmic lighthouses. They are unique laboratories for a variety of fundamental physics experiments.

Multimessenger Astrophysics

We can gain unique insights about our Universe through observations with both gravitational waves and electromagnetic waves, using telescopes on Earth and in space.

Galaxies & Supermassive Black Holes

We will gain unique insights into the history of galaxy mergers and evolution by detecting the gravitational waves produced by extremely massive pairs of black holes at the cores of merged galaxies.

Low-Frequency Gravitational Waves

Gravitational waves were predicted by general relativity and are produced by accelerating masses like black holes in binaries. Our experiment is sensitive to low-frequency gravitational waves with periods of years to decades.

Data and Software (after release)

Anyone can download the data and software used for this analysis from our website.

NANOGrav
Physics Frontiers Center

A Brief History of PTAs and NANOGrav

1960s

1970s

1980s

1990s

2000s

1967 ✦ The first radio pulsar was discovered by a team led by graduate student Jocelyn Bell-Burnell.

1975 ✦ Estabrook and Wahlquist had the idea of using spacecraft to detect low-frequency GWs, “Response of Doppler spacecraft tracking to gravitational radiation,” sparking a new way of searching for GWs.

✦ Hankins and Rickett proposed “coherent dedispersion” instrumentation to make the most precise possible TOA measurements.

1978-1979 ✦ Sazhin (1978) and Detweiler (1979) proposed the idea of using pulsars instead of spacecraft. Detweiler set the first upper limits on the amplitude of the gravitational-wave background (GWB).

1982 ✦ Backer discovered the first millisecond pulsar, PSR B1937+21.

1983 ✦ Hellings and Downs first developed the concept of a pulsar timing array (PTA) when they proposed that the cross-correlation of pulsar timing residuals could be used to search for the GWB signal. Only four pulsars were used for their first limit on the GWB.

1984 ✦ The first MSP timing program was begun at Arecibo by Taylor et al.

1990 ✦ Foster and Backer first coined the term “pulsar timing array (PTA)” and described the first PTA timing program using MSPs with the 140-ft telescope at Green Bank.

1990s ✦ Computing became fast enough to allow coherent dedispersion over ~10 MHz bandwidth. Early instruments were built for Arecibo by Berkeley, Caltech, and Princeton.

✦ Multiple upper limits were set on the GWB using small numbers of MSPs — e.g., Stinebring, Ryba, and Taylor (1990) and Kaspi, Ryba, and Taylor (1994).

1997 ✦ The Arecibo Gregorian dome upgrade was completed.

2000 ✦ The Green Bank Telescope came online.

2003 ✦ Jaffe and Backer demonstrated that detection of GWs from super-massive black hole binaries through PTAs was a worthwhile and achievable goal.

early 2000s ✦ Various groups around the world began PTA timing programs in earnest, with the Parkes PTA established in 2006, the European PTA in 2006, and NANOGrav in 2007. NANOGrav was formed at a meeting at NRAO in Charlottesville, VA, with strong encouragement from then-NRAO-director Fred Lo.

2004 ✦ Berkeley, Bryn Mawr and UBC built the 100-MHz ASP and GASP coherent-dedispersion instruments for Arecibo and Green Bank, respectively, allowing high enough timing precision to enable a truly sensitive search for gravitational waves.

2008 ✦ At a meeting at Arecibo, Andrea Lommen first coined the term “International Pulsar Timing Array (IPTA)”, and the IPTA collaboration was born.

A Brief History of PTAs and NANOGrav - Continued

2010s

2010
- NANOGrav received its first award as a collaboration from the NSF from the PIRE (Partnerships for International Research and Education) program for $6.5M.
- NANOGrav began using the advanced GUPPI pulsar timing instrument at the Green Bank Telescope.

2012
- NANOGrav began using the advanced PUPPI pulsar timing instrument at Arecibo.

2013
- NANOGrav released its first dataset and GWB limit, based on five years of data on 17 pulsars.

2015
- NANOGrav became a Physics Frontiers Center with a $17.3M award from the NSF. This award was co-funded by the PHYS and AST divisions.

2015-2016
- NANOGrav released its nine-year dataset, with 37 pulsars, and the associated GWB upper limit, along with other papers.

2016
- The IPTA released its first dataset, with 48 MSPs, along with the first upper limit on the GWB set using IPTA data.

2018
- NANOGrav released its 11-year dataset, with 45 pulsars, and the associated upper limit on the GWB, along with other papers.

2019
- The IPTA published its second data release, with 65 pulsars.
- CHIME began collecting data to include with NANOGrav observations.

2020s

2020
- NANOGrav released its 12.5-yr dataset, with 47 pulsars, and the associated upper limit on the GWB, along with other papers. The collaboration reported the detection of a common noise process consistent with a GWB.
- Preliminary analysis showed the first sign of the spatial correlations expected from a GWB in NANOGrav data.
- The Arecibo Telescope collapsed.

2021
- Both the EPTA and the PPTA reported the detection of a common process consistent with that detected by NANOGrav in their most recent datasets.
- NANOGrav received another $17M award from the Physics Frontiers Center program, again co-funded by the PHYS and AST divisions.

2022
- The IPTA reported the detection of a similar common process as seen in the NANOGrav 12.5-yr data in combined PTA data.

2023
- NANOGrav releases its 15-yr dataset, with 68 pulsars, and associated GWB and other papers. NANOGrav reports evidence for the spatial correlations that are the hallmark of an astrophysical GWB.

NANOGrav
Physics Frontiers Center

About NANOGrav: The Telescopes

NANOGrav uses world-class radio telescopes to observe a suite of pulsars using precise timing. Three major observatories have provided data for NANOGrav's 15-year data set.

The Arecibo Telescope - Puerto Rico

For decades, the NSF's iconic 305-m diameter Arecibo telescope in Puerto Rico was the largest and most sensitive radio telescope in the world. That sensitivity, from 300 MHz to over 2 GHz, made it one of the very best instruments for pulsar science, as evidenced by the hundreds of pulsars discovered with Arecibo data, and the amazing scientific results, including a Nobel Prize in Physics for the discovery of binary pulsars which allowed for the study of gravitational wave emission. Nineteen of the pulsars that NANOGrav currently monitors were initially found with Arecibo. While Arecibo was limited to seeing only about 30% of the total sky, its unparalleled sensitivity meant that for those pulsars that it could see, nothing could measure them better. The Arecibo telescope collapsed on December 1, 2020. Its legacy lives on in NANOGrav's data, as approximately one half of our gravitational wave sensitivity comes from our Arecibo observations.

Credit: Arecibo Observatory, a facility of the NSF

Arecibo Observatory Website

The Green Bank Telescope (GBT) - West Virginia

The NSF's 100-m diameter GBT, in West Virginia, is the largest human-made movable object on land. And that huge size plus its steerability is why it has been so important for pulsar observations over the past two decades. Because it can see more than 80% of the total sky, the GBT provided the best data possible on dozens of millisecond pulsars that Arecibo couldn't observe. The combination of fantastic sky coverage and excellent sensitivity, enhanced by the surrounding National Radio Quiet Zone, lets the GBT contribute about half of our gravitational wave sensitivity. 16 of the pulsars that NANOGrav currently monitors were discovered there, through a series of sensitive pulsar surveys over the years.

Currently, the Gordon and Betty Moore Foundation funds most of NANOGrav's ongoing observations of 72 pulsars with the GBT.

Photo Credit: Jay Young for Green Bank Observatory

Green Bank Observatory Website

NANOGrav
Physics Frontiers Center

About NANOGrav: The Telescopes

NANOGrav uses world-class radio telescopes to observe a suite of pulsars using precise timing. Three major observatories have provided data for NANOGrav's 15-year data set.

The Very Large Array (VLA) - New Mexico

The NSF also funds the iconic Y-shaped array of 27 25-meter diameter dishes in New Mexico. The VLA is usually used to make radio images via interferometry, but the combined collecting area of its dishes, its broad radio frequency coverage, and its ability to see far into the Southern sky, make it a key instrument for NANOGrav pulsar timing, as 15 pulsars need those capabilities. The 15-year data release is the first to include VLA measurements, but it will not be the last. In combination with the CHIME telescope in Canada, the VLA is helping to offset the loss of the Arecibo telescope in our regular observations.

Photo Credit: NRAO/AUI/NSF

Very Large Array Website

The Canadian Hydrogen Intensity Mapping Experiment (CHIME) - British Columbia

CHIME, a set of 4 fixed cylindrical reflectors that operates as a transit telescope, is run by a consortium of universities led by the University of British Columbia, McGill University, and the University of Toronto. CHIME operates at low radio frequencies and was originally designed to map the distribution of Hydrogen gas in the early Universe. Software manipulation of the incoming data stream can allow the telescope to "point" anywhere within its large field of view; this feature is used to detect the still-mysterious Fast Radio Bursts and also to time up to 10 pulsars simultaneously. CHIME provides daily observations of all the Northern NANOGrav pulsars, and, along with the VLA, is helping to offset the loss of the Arecibo telescope in our regular observations. CHIME/Pulsar data will be included in future NANOGrav data releases.

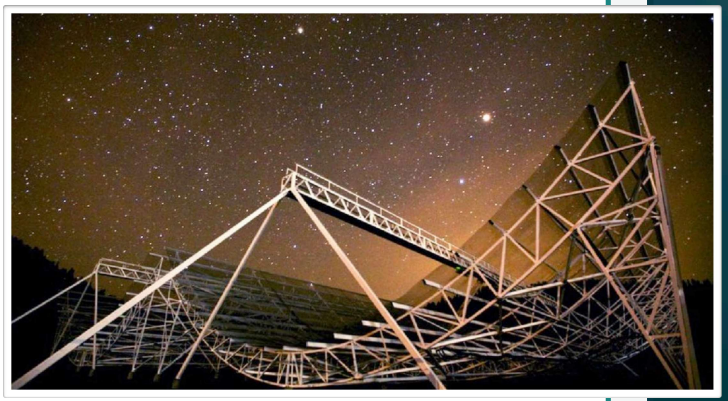


Photo: Courtesy of CHIME

CHIME Website

NANOGrav
Physics Frontiers Center

About NANOGrav: The Pulsar Timing Array

Over the last two decades, NANOGrav has regularly added more pulsars to the array. We have shown that our sensitivity to gravitational waves increases as the number of pulsars grows, expanding our detector.

Pulsar Searches

Finding pulsars, like finding a needle in a haystack, requires painstaking and methodical work. Many of the pulsars that have been added to the array over the last decade were discovered through the Green Bank telescope, as well as the Pulsar Arecibo L-band Feed Array survey at Arecibo and other pulsar search programs.

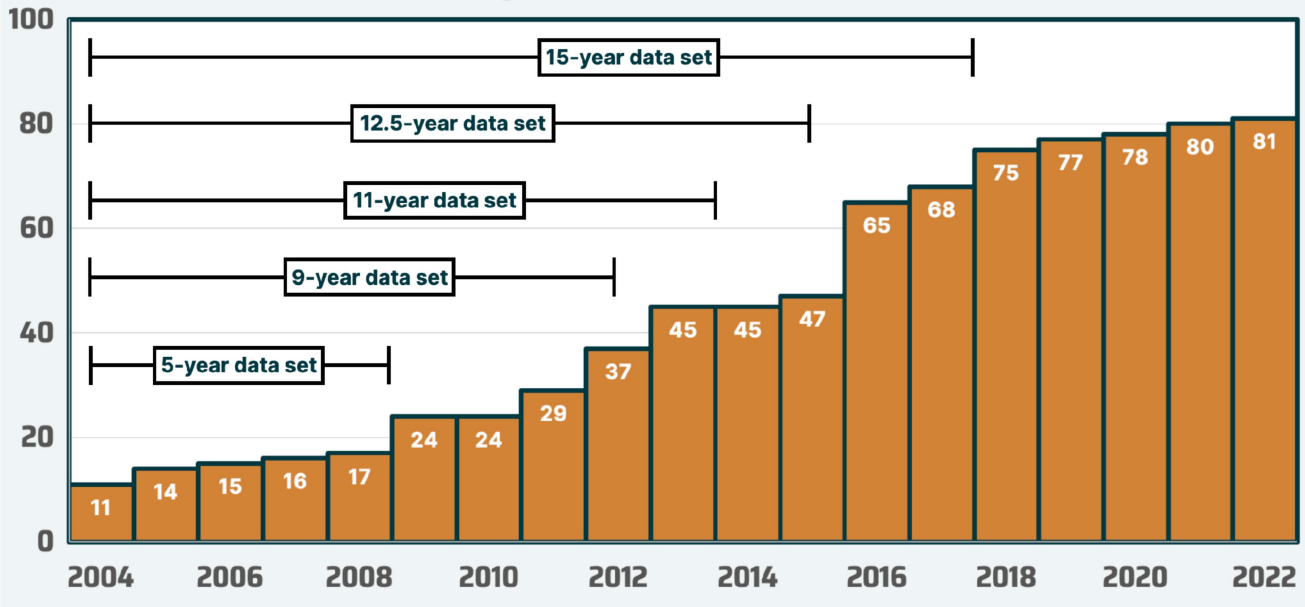
In some cases, information from other wavebands makes finding pulsars easier. Many new sources from NASA's Fermi Gamma-ray Space Telesope have been revealed to be millisecond radio pulsars. These discoveries make up more than a third of the new pulsars added to NANOGrav's pulsar timing array since 2010.

Instrument Upgrades

Improving radio instrumentation makes it possible to observe fainter pulsars with more precision. In 2010 and 2012, the instruments used to record pulsar observations were upgraded at Green Bank and Arecibo, respectively. These changes alone enabled NANOGrav to add a dozen previously-discovered pulsars to the pulsar timing array.

The new instruments also widened the range of radio frequencies that could be collected at one time. This change improved the team's ability to compensate for the effects of interstellar gas on pulse arrival times.

Number of pulsars in NANOGrav's PTA



NANOGrav
Physics Frontiers Center

The NANOGrav Collaboration: Membership Information

The North American Nanohertz Observatory for Gravitational Waves (NANOGrav) is a collaboration of faculty, researchers, and students from institutions around the globe.

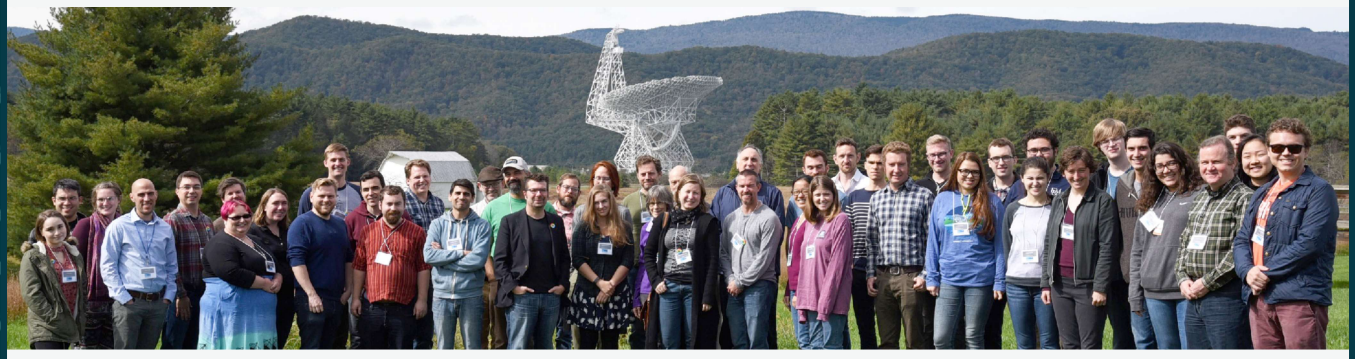


Photo Credit: Tonia Klein for the NANOGrav Collaboration

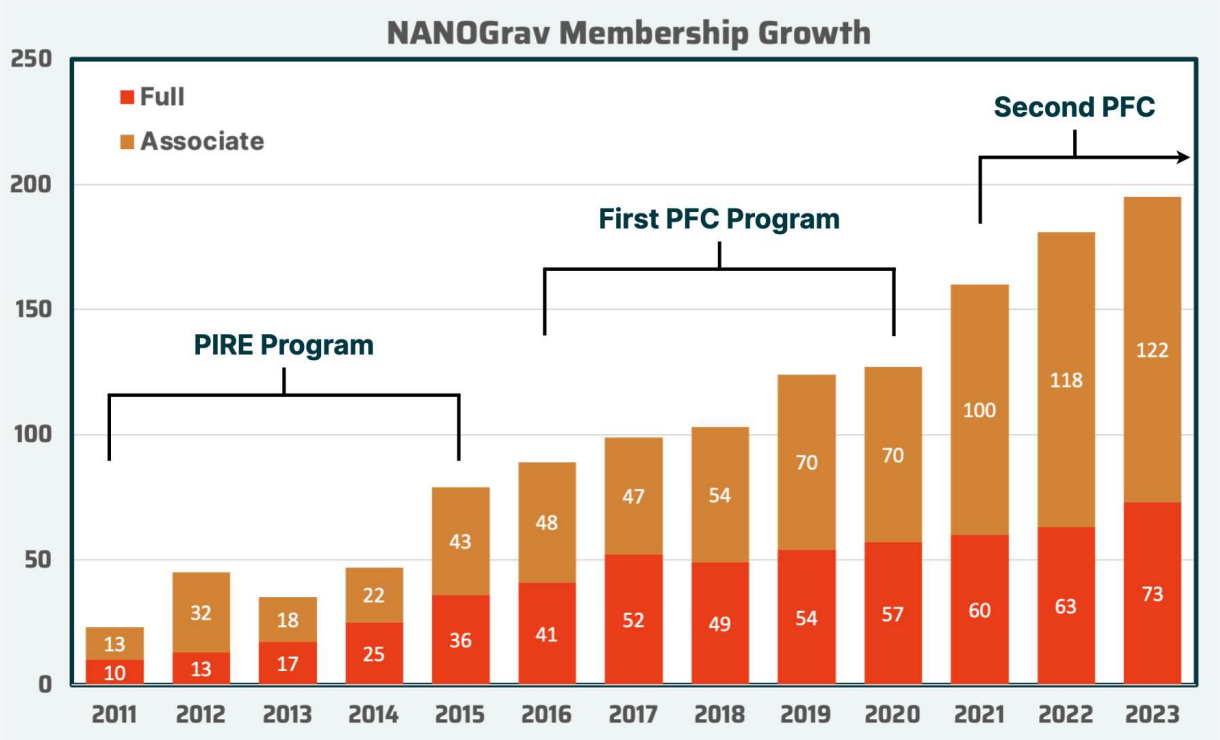
Member roles:

- 56 University faculty
- 26 Research scientists
- 38 Postdoctoral researchers
- 75 Graduate students
- 125 Undergraduate students**

** Not all undergraduates working with NANOGrav have joined the collaboration officially.

Current membership:

- 73 Full members
- 122 Associate members
- 25 Junior members
- 1 Legacy member



NANOGrav membership by year. Undergraduate members are not included in these totals.

NANOGrav
Physics Frontiers Center

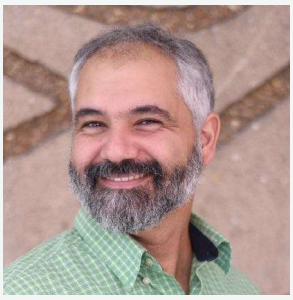
The NANOGrav Collaboration: Key Members

The full collaboration has contributed to the results being reported here.
A number of the members critical to this effort have been highlighted below.

Dr. Joe Swiggum:

Lead for Observations and Timing Paper
Lafayette College

Dr. Joe Swiggum has been an active member of NANOGrav for more than a decade and is currently a PFC Senior Postdoctoral Fellow and 15-year data set development lead. In addition to expertise in pulsar population studies and discovery and timing of new MSPs, he has fostered growth in the PTA community, through outreach to high school students and the general public locally, and by building bridges with international collaborators.



Dr. Jeffrey Hazboun:

Lead for Detector Characterization Paper
Oregon State University

Dr. Jeffrey Hazboun has been studying gravity and gravitational waves for 18 years. He joined NANOGrav as a postdoctoral scholar in 2016 and develops gravitational-wave search algorithms and noise mitigation strategies. He also works on characterizing the PTA as a Galaxy-scale gravitational-wave detector.

Dr. Sarah Vigeland:

Co-Lead for Gravitational-Wave Background Paper
University of Wisconsin Milwaukee

Dr. Sarah Vigeland is an astrophysicist who develops methods to search for gravitational waves and performs these searches on the NANOGrav data set. She has been a member of NANOGrav since 2013, and is currently Chair of the Gravitational Wave Detection Working Group.

Dr. Stephen Taylor:

Co-Lead for Gravitational-Wave Background Paper
Vanderbilt University

Dr. Stephen Taylor joined NANOGrav as a postdoctoral fellow at JPL in 2014. He developed many of the methods and analysis techniques that are the foundation of current PTA gravitational-wave searches. Dr. Taylor leads a research group specializing in PTA science and has authored a textbook on nanohertz-frequency gravitational-wave astronomy.

NANOGrav
Physics Frontiers Center

The NANOGrav Collaboration: Key Members

The full collaboration has contributed to the results being reported here.
A number of the members critical to this effort have been highlighted below.

Dr. Thankful Cromartie:

Timing Working Group Chair
Cornell University

Dr. Thankful Cromartie joined NANOGrav in 2015 and is the current chair of the collaboration's Timing Working Group. She helped develop the NANOGrav pulsar timing pipeline, was a leader in the 15-year data release effort, and uses the data set to precisely measure neutron star masses in order to constrain the dense matter equation of state.

Dr. Luke Zoltan Kelley:

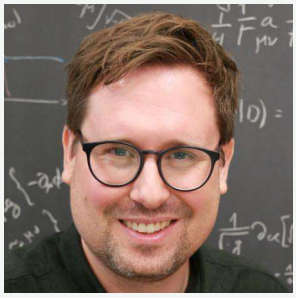
Lead for Astrophysics Interpretation Paper
University of California, Berkeley

Dr. Luke Kelley joined NANOGrav in 2016, and began contributing simulated populations of massive black holes (MBHs) from cosmological simulations. Since then, he has developed an array of methods for predicting and analyzing the gravitational-wave signals and electromagnetic counterparts of MBHs. Dr. Kelley currently serves as chair of the Astrophysics Working Group, where he has led the development of the Holodeck simulation framework and the 15-year astrophysical analysis.

Dr. Andrea Mitridate:

Co-Lead for Signals from New Physics Paper
DESY Hamburg

Dr. Andrea Mitridate is a particle physicist interested in searching for gravitational waves produced in the primordial Universe. He joined the NANOGrav collaboration in late 2020 and has been co-leading the search for signatures of physics beyond the Standard Model in the NANOGrav 15-year data set.



Dr. Kai Schmitz:

Co-Lead for Signals from New Physics Paper
University of Münster

Dr. Kai Schmitz has been an associate NANOGrav member for nearly two years and a full member since April 2023. He is a particle physicist interested in gravitational waves from the Big Bang and has been co-leading the search for signals from new physics in the NANOGrav 15-year data set.

The NANOGrav Collaboration: Key Members

The full collaboration has contributed to the results being reported here.
A number of the members critical to this effort have been highlighted below.

Working Group Leadership

The production of groundbreaking science requires contributions from members in a wide variety of areas. The NANOGrav collaboration contains a diverse array of Working Groups whose leaders help the group's members innovate in each of these areas.

Working Group	Chair(s)
Astrophysics & Sources	Luke Zoltan Kelley *University of California, Berkeley*
Cyber-Infrastructure	Adam Brazier *Cornell University* Nate Garver-Daniels *West Virginia University*
Education & Outreach	Tim Dolch *Hillsdale College / Eureka Scientific* Natalia Lewandowska *SUNY Oswego*
Equity & Climate	Laura Blecha *University of Florida* Dustin Madison *University of the Pacific*
Gravitational Wave Detection	Sarah Vigeland *University of Wisconsin - Milwaukee*
Interstellar Medium Mitigation & Noise Budget	Michael Lam *SETI Institute* Natalia Lewandowska *SUNY Oswego*
Pulsar Searching	Shami Chatterjee *Cornell University*
Pulsar Timing	Thankful Cromartie *Cornell University*

NANOGrav
Physics Frontiers Center

The NANOGrav Collaboration: Management Team

The Management Team oversees all NANOGrav activities and consists of an elected chair, four elected members, and the Principal Investigators of our funding grants.

Dr. Stephen Taylor:

NANOGrav Collaboration Chair
Vanderbilt University

Dr. Stephen Taylor joined NANOGrav as a postdoctoral fellow at JPL in 2014. He developed many of the methods and analysis techniques that are the foundation of current PTA gravitational-wave searches. Dr. Taylor leads a research group specializing in PTA science and has authored a textbook on nanohertz-frequency gravitational-wave astronomy.

Dr. Maura McLaughlin:

Physics Frontiers Center Co-Director
West Virginia University

Dr. Maura McLaughlin is one of the founding members of NANOGrav and serves as Co-Director of the NANOGrav PFC. She was PI of the PIRE award, is PI on the AccelNet award, and is a member of the IPTA Steering Committee. She works primarily on searches for millisecond pulsars, timing, and understanding and mitigating noise in pulsar timing data. She also contributes to education and outreach, in particular through the Pulsar Science Collaboratory.

Dr. Xavier Siemens:

Physics Frontiers Center Co-Director
Oregon State University

Dr. Xavier Siemens is the Principal Investigator of the NANOGrav Physics Frontiers Center and serves as co-Director. A member of NANOGrav for 14 years, he was the first to codify the requirements for detecting a gravitational-wave background with pulsars. He developed statistical techniques essential to the current results, and catalyzed the development of modern PTA gravitational-wave search pipelines.

Dr. Michael Lam:

Noise Budget Working Group Co-Chair
SETI Institute

Dr. Michael Lam started in NANOGrav as an undergraduate summer student and has been deeply involved for the last eleven years. He is currently a member of the Management Team, co-chair of the Noise Budget Working Group, and works to characterize the pulsar timing array as a detector and optimize its performance.

NANOGrav
Physics Frontiers Center

The NANOGrav Collaboration: Management Team

The Management Team oversees all NANOGrav activities and consists of an elected chair, four elected members, and the Principal Investigators of our funding grants.

Dr. Dustin Madison:

University of the Pacific

Dr. Dustin Madison joined NANOGrav in 2012 as a graduate student. He led NANOGrav's first searches for signals called "bursts with memory" and has been involved in these searches ever since. He works to improve the way NANOGrav handles the solar wind, an important source of noise that is interesting in its own right. Dr. Madison was elected to the NANOGrav Management Team at the start of 2023.

Dr. Adam Brazier:

Cyber-Infrastructure Working Group Co-Chair
Cornell University

Dr. Adam Brazier has been a member of NANOGrav for 15 years, during which he has been Chair of the NANOGrav Cyber-Infrastructure Working Group, co-chaired the NANOGrav Equity and Inclusion Committee, and has been an elected member of the NANOGrav Management Team since 2019.

Dr. David Nice:

Lafayette College

Dr. David Nice has thirty years of experience using radio telescopes for high precision pulsar timing experiments, with a particular focus on using these observations to measure relativistic phenomena. More than 15 years ago, NANOGrav evolved out of pre-existing long-term observing programs at the Arecibo and Green Bank telescopes led by him and others.

Dr. Scott Ransom:

Ex-Officio Chair
National Radio Astronomy Observatory

Dr. Scott Ransom is one of the founding members of NANOGrav and was the previous Chair of the collaboration (2016-2022). He specializes in searches for new millisecond pulsars, high-precision timing techniques, and improving our pulsar instruments and processing software.

The NANOGrav Collaboration: Member Institutions

The North American Nanohertz Observatory for Gravitational Waves (NANOGrav) is a collaboration of faculty, researchers, and students from institutions around the globe.

Institutions:

- 66 in United States and Canada
- 22 in other nations

Canada:

British Columbia	University of British Columbia
Ontario	University of Toronto

United States:

Alabama	University of Alabama, Huntsville NASA Marshall Space Flight Center
Arkansas	University of Arkansas
California	California Institute of Technology Eureka Scientific Jet Propulsion Laboratory SETI Institute University of California, Berkeley University of the Pacific
Colorado	University of Colorado, Boulder
Connecticut	University of Connecticut Yale University
District of Columbia	Naval Research Laboratory
Florida	Florida Atlantic University Florida Space Institute University of Central Florida University of Florida
Illinois	Adler Planetarium Argonne National Laboratory Fermilab Northwestern University University of Chicago
Indiana	Indiana University Bloomington
Massachusetts	Harvard University Harvard & Smithsonian Center for Astrophysics Tufts University
Maryland	Johns Hopkins University NASA Goddard Space Flight Center Notre Dame of Maryland University University of Maryland University of Maryland, Baltimore County
Michigan	Hillsdale College University of Michigan
Montana	Montana State University
New Hampshire	Dartmouth College
New Mexico	New Mexico Institute of Technology University of New Mexico
New York	Cornell University Flatiron Institute Rochester Institute of Technology Skidmore College State University of New York at Oswego
Ohio	Kenyon College Oberlin College
Oregon	Oregon State University
Pennsylvania	Carnegie Mellon University Franklin & Marshall College Haverford College Lafayette College Penn State University Abington Swarthmore College Widener University
Tennessee	Vanderbilt University
Texas	Texas Tech University University of Texas at Austin
Virginia	George Mason University National Radio Astronomy Observatory University of Virginia
Washington	University of Washington Bothell
Wisconsin	University of Wisconsin Milwaukee
West Virginia	Green Bank Observatory West Virginia University
Puerto Rico	Arecibo Observatory University of Puerto Rico at Mayaguez

Other Nations:

Australia	Curtin University
Brazil	Observatório Nacional
China	Chinese Academy of Sciences National Astronomical Observatories Peking University
Denmark	University of Copenhagen University of Southern Denmark
Germany	DESY, Hamburg Mainz University Max Planck Institute for Gravitational Physics University of Münster
Hungary	Eötvös Loránd University
Israel	Ben-Gurion University Weizmann Institute
Italy	Scuola Normale Superiore, Pisa
Japan	Kumamoto University Osaka Metropolitan University
Singapore	National University of Singapore
Spain	Basque Foundation for Science
United Kingdom	Newcastle University University of Birmingham University of Hertfordshire University of Hull

NANOGrav
Physics Frontiers Center

The NANOGrav Collaboration: Funding Sources

Various federal agencies, universities, and private entities have contributed to NANOGrav – providing funding for instrumentation, data acquisition, analysis, and scientific investigations. Below is a non-exhaustive list of our backers.

National Science Foundation

The National Science Foundation (NSF) is an independent agency of the United States government that supports fundamental research and education in all the non-medical fields of science and engineering.

Physics Frontiers Center

The NSF's Physics Frontiers Centers (PFC) program supports university-based centers and institutes where the collective efforts of a larger group of individuals can enable transformational advances in the most promising research areas.

PFC Website

AccelNet

The NSF's Accelerating Research through International Network-to-Network Collaborations (AccelNet) program is a mechanism that accelerates the process of scientific discovery and prepares the next generation of U.S. researchers for multi-team international collaborations. The AccelNet program supports strategic linkages among U.S. research networks and complementary networks abroad that will leverage research and educational resources to tackle grand research challenges that require significant coordinated international efforts. The program seeks to foster high-impact science and engineering by providing opportunities to cooperatively identify and coordinate efforts to address knowledge gaps and research needs.

AccelNet Website

Partnerships for International Research and Education

The NSF's PIRE (Partnerships for International Research and Education) is a funding mechanism that supports multi-stakeholder and international partnerships that are essential to address challenges of critical societal importance at a regional or global scale.

PIRE Website

Radio Telescope Facilities

The NSF has been the primary source of funding for three of the radio telescopes used by NANOGrav.

Other NSF Support

Astronomy & Astrophysics Program Grants
Physics Program Grants
Graduate Research Fellowship Program
Astronomy & Astrophysics Fellowship Program
Major Research Implementation Award
CAREER Awards
Grote Reber Fellowship Program
Research Experience for Undergraduates
Established Program to Stimulate Competitive Research: Track 1

NANOGrav
Physics Frontiers Center

The NANOGrav Collaboration: Funding Sources

Natural Sciences and Engineering Research Council of Canada

The Natural Sciences and Engineering Research Council of Canada (NSERC) is the major federal agency responsible for funding natural sciences and engineering research in Canada. NSERC directly funds university professors and students as well as Canadian companies to perform research and training.

NSERC Website

Canadian Institute for Advanced Research

The Canadian Institute for Advanced Research (CIFAR) is a Canada-based global research organization that brings together teams of top researchers from around the world to address important and complex questions. It was founded in 1982 and is supported by individuals, foundations and corporations, as well as by the Government of Canada and the provinces of Alberta, British Columbia, Ontario and Quebec.

CIFAR Website

Gordon and Betty Moore Foundation

The Moore Foundation is an American foundation established by Intel co-founder Gordon E. Moore and his wife Betty I. Moore in September 2000 to support scientific discovery, environmental conservation, patient care improvements and preservation of the character of the Bay Area. The foundation's aim is to tackle large, important issues at a scale where it can achieve significant and measurable impacts.

Moore Foundation

Other Grants and Support

- Associated Universities, Inc.
- Association of Universities for Research in Astronomy, Inc.
- Ben-Gurion University Kreitman Fellowship Program
- Brinson Foundation
- California Institute of Technology
- Caltech & JPL's President's and Director's Research and Development Fund
- Center for Interdisciplinary Exploration & Research in Astrophysics and Adler Planetarium Post-doctoral Fellowships
- Council for Higher Education and Israel Academy of Sciences & Humanities Excellence Fellowship Program
- The Dunlap Institute
- Eötvös Loránd Research Network
- Flatiron Institute
- George and Hannah Bolinger Memorial Fund at OSU
- The German Research Foundation
- Jet Propulsion Laboratory
- Larry W. Martin & Joyce B. O'Neill Endowed Fellowship at OSU
- National Aeronautics and Space Administration
- NASA Hubble Fellowship Program
- National Radio Astronomy Observatory
- Naval Research Laboratory
- Research Corporation for Science Advancement
- Science and Technology Facilities Council
- Simons Foundation
- Sloan Foundation Fellowship Program
- Space Telescope Science Institute
- University of British Columbia Fellowships
- Vanderbilt Initiative in Data Intensive Astrophysics Fellowship Program
- WVU Center for Gravitational Waves & Cosmology
- WVU Research Corporation

The NANOGrav Collaboration: Files, Images, Graphics, and Attributions

Caption: Aerial view of the Arecibo Telescope before its collapse in December 2020.

Filename: Arecibo_Telescope.jpg

Credit: Arecibo Observatory, a facility of the NSF

Caption: Flowers accompanying the Very Large Array on the Plains of San Agustin, NM.

Filename: VeryLargeArray.jpg

Credit: NRAO/AUI/NSF

Caption: The radio frequency receiver platform for the Green Bank Telescope rises above the dish.

Filename: GreenBank_Telescope.jpg

Credit: Jay Young for Green Bank Observatory

Caption: Photo of NANOGrav Collaboration members at a scientific conference held at the Green Bank Observatory in West Virginia in 2018.

Filename: NANOGrav_GBMeeting_2018.jpg

Credit: Tonia Klein for the NANOGrav Collaboration

NANOGrav
Physics Frontiers Center

Suggested Non-NANOGrav Expert Contacts

Experts in Pulsar Observations

Dr. Jocelyn Bell-Burnell
University of Oxford
jocelyn.bellburnell@physics.ox.ac.uk

Dr. Deepto Chakrabarty
Massachusetts Institute of Technology
deepto@mit.edu

Dr. Paulo Freire
Max Planck Institute for Radio Astronomy
pfreire@mpifr-bonn.mpg.de

Dr. Joseph Taylor
Princeton University
joe@princeton.edu

Experts in Pulsar Noise Analysis

Dr. Roger Romani
Stanford University
rwr@astro.stanford.edu

Dr. Dale Frail
National Radio Astronomy Observatory
dfrail@aoc.nrao.edu

Dr. Joel Weisberg
Carleton College
jweisber@carleton.edu

Dr. Marten van Kerkwijk
University of Toronto
mhvk@astro.utoronto.ca

Experts in Gravitational-Wave Analysis

Dr. Gabriela Gonzalez
Louisiana State University
gonzalez@lsu.edu

Dr. Jocelyn Read
California State University, Fullerton
jread@fullerton.edu

Dr. Sanjit Mitra
Inter-University Center for Astronomy & Astrophysics
sanjit@iucaa.in

Dr. Will Farr
Stony Brook University & Flatiron Institute
will.farr@stonybrook.edu

Experts in Gravitational-Wave Astrophysical Interpretation

Dr. Zoltan Haiman
Columbia University
zoltan@astro.columbia.edu

Dr. Kelly Holley-Bockelmann
Vanderbilt University
k.holley@vanderbilt.edu

Dr. Robert Caldwell
Dartmouth College
Robert.R.Caldwell@dartmouth.edu

Dr. Chiara Caprini
University of Geneva
Chiara.Caprini@unige.ch

Note: Image not for reproduction