Astronomers seek gravitational waves with renewed NSF grant

By Kate Blackwood

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The National Science Foundation (NSF) has renewed a Physics Frontiers Center grant to the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) consortium, giving Cornell astronomy researchers in the College of Arts and Sciences (A&S), together with more than 200 collaborators around the world, five more years to seek gravitational waves.

"We are highly optimistic that we will detect long-wavelength gravitational waves and their properties, and we will seek detection of individual binary supermassive black holes," said James Cordes, the George Feldstein Professor of Astronomy, a co-principal investigator on the project.

In addition, NANOGrav collaborators hope to make substantial discoveries having to do with the nature of matter in extreme states – such as high density, high magnetic fields – and about the origin of neutron stars, Cordes said.

Sharing in Cornell's $2 million portion of the $17 million, five-year grant are Adam Brazier, computational scientist at the Cornell University Center for Advanced Computing, and Shami Chatterjee, principal research scientist with the Cornell Center for Astrophysics and Planetary Science in A&S.

Low-frequency gravitational waves, which are ripples in spacetime predicted by Albert Einstein's Theory of Relativity, arise from cosmic events involving extremely large masses. These events produce distortions that can be measured with radio telescopes.

The detectors of low-frequency gravitational waves are millisecond pulsars – rapidly spinning, superdense remains of massive stars that have exploded as supernovas. These ultra-stable stars are precise celestial clocks, appearing to "tick" every time their beamed emissions sweep past Earth. Gravitational waves may be detected in the small but perceptible fluctuations – a few 10s of nanoseconds over 10 or more years – they cause in the measured arrival times at Earth of radio pulses from these millisecond pulsars.

In the first five years (plus one additional year) of the initial Physics Frontiers Center grant, NANOGrav increased the number of pulsars used to detect gravitational waves, Cordes said.

"Our sensitivity increases with this number of objects, but also our telescope time requirements go up," Cordes said. "We monitor these objects at least once per month at radio observatories."

The project used the Arecibo telescope in Puerto Rico and the Green Bank Telescope (GBT) in West Virginia. The researchers also used the National Radio Astronomy Observatory's Very Large Array in New Mexico for a small percentage of data collection.

With the loss of Arecibo in late 2020, NANOGrav has increased use of the GBT and seeks additional resources, possibly including a new telescope array being developed by the California Institute of Technology.

Since launching in 2015, NANOGrav has developed new algorithms and statistical methods for increasing sensitivity, Cordes said. "With our latest data release – 12.5 years of data," he said, "we now see hints of the stochastic background of gravitational waves produced by the ensemble of orbiting pairs of supermassive black holes in the universe."

The stochastic background, Cordes, said, is the combined signal from the many black hole binaries in the universe that are emitting gravitational waves: "Think of it as the ensemble sound from a large number of cicadas as opposed to hearing just a single cicada," he said.

The next release of data, 15 years' worth, will enable stronger statements about gravitational waves, Cordes said.

Thankful Cromartie, NASA Einstein Fellow at Cornell, is a key member of the Physics Frontiers Center, chairing the Timing working group. Doctoral students Ross Jennings and Stella Koch Ocker are also part of the team, as are several undergraduates.

Kate Blackwood is a writer for the College of Arts and Sciences.

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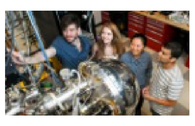

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