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# Pulsar watchers race for gravity waves

Radio telescopes vie with laser detectors to hunt for signs of massive cosmic collisions.

Aided by the Universe's best celestial clocks, radio astronomers are embarking on a search for the almost-imperceptible stretching of the fabric of space by gravitational waves — predicted by Einstein's theory of general relativity but not yet detected directly. The approach is competing with more elaborate and expensive approaches to gravitational wave detection.

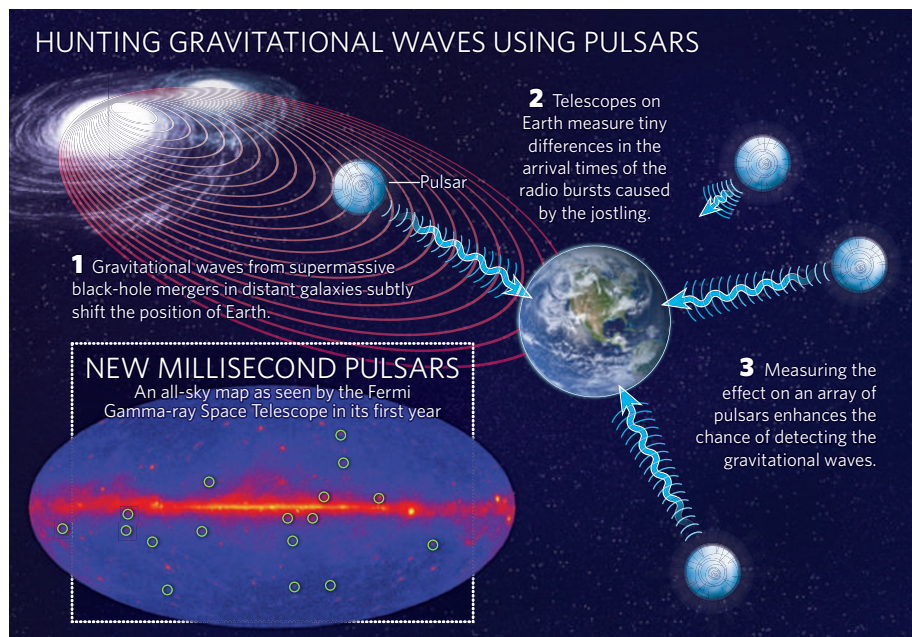
Since the late 1970s, astronomers have known that gravitational waves affect the arrival time of radio-wave bursts that emanate with clockwork regularity from pulsars, the spinning neutron stars left over from exploded supernovae. Now, the idea has moved from theory to application with the recent discoveries of many millisecond pulsars, which emit radio-wave bursts every thousandth of a second or so, more rapidly and more reliably than 'normal' pulsars.

NASA's Fermi Gamma-ray Space Telescope is identifying the locations of dozens of these galactic clocks, allowing radio astronomers to follow up and monitor them. Researchers can deduce whether a passing gravitational wave has jostled Earth by watching for slight variations in the arrival time of pulsar radio-wave bursts — just fractions of a second over the course of years. If these efforts succeed, researchers will have a new tool for exploring the cosmic cataclysms — colliding black holes, for example — that are thought to generate gravitational waves (see graphic).

The shoestring effort, involving groups in Australia, Europe and North America, could beat larger and better-funded groups that use laser interferometry to try to detect gravitational waves by their tiny effects on the movements of test masses. "People are finally taking notice," says Scott Ransom, an astronomer at the National Radio Astronomy Observatory in Charlottesville, Virginia, who last week announced the discovery of 17 millisecond pulsars at a meeting of the American Astronomical Society in Washington DC.

Ransom says that about 100 millisecond pulsars are known in the Milky Way, but only a handful are bright enough and regular enough to be measured to the precision necessary to hunt gravitational waves. Some 20–40 of these pulsars, enough for a full 'pulsar timing array', would have to be monitored for 5–10 years before a gravitational wave signal would stand out. But with new millisecond pulsars now

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NASA/DOE/FERMI LAT COLLABORATION

turning up, researchers are confident that they will soon have enough to compete with the ground-based laser efforts in Italy, Germany and the United States, where physicists have been sifting through petabytes of data for years without bagging so much as a gravitational burp.

These ground-based groups could still get lucky and detect the gravitational wave signature of a rare event, such as the final moments of a nearby neutron star merger. But capturing such an event is not assured until the main US detector — the Laser Interferometer Gravitational-Wave Observatory (LIGO) in Washington state and Louisiana — is upgraded in 2015 to make it sensitive enough to pick up waves from a much larger volume of the Universe. Pulsar astronomers thus have a shot at first detection.

"I think they have a really solid chance of beating the ground-based detectors," says Bruce Allen, director of the Max Planck Institute for Gravitational Physics in Hanover, Germany, who manages shared data analysis among the ground-based detectors. "It's a real race."

The end of the race to detect gravitational waves will mark the beginning of gravitational wave astronomy — yet the different approaches are sensitive to vastly different phenomena. Whereas the interferometers would detect

the rapid pulses of merging neutron stars, the pulsar timing arrays seek the lower-frequency but stronger background signal that comes from violent mergers of supermassive black holes at the centres of distant galaxies. The Laser Interferometer Space Antenna (LISA), a multibillion-dollar space mission being considered by NASA and the European Space Agency, would be sensitive to the gravitational wave frequencies in between, where events such as merging white dwarfs would stand out.

Thomas Prince, an astrophysicist at the California Institute of Technology in Pasadena and LISA mission scientist for NASA, says that the space- and ground-based interferometers will be better at pinpointing gravitational events in the sky. But Ransom says that by comparison, pulsar timing arrays are "dirt cheap" because they use existing radio telescopes instead of requiring a detector such as LIGO, which cost US\$300 million to build and is getting another \$200 million for its upgrade.

Either way, detecting the Universe's most violent events requires extraordinary sensitivity — temporal in the case of the pulsar timing arrays and spatial in the case of the interferometers. Interferometers already monitor the position of their test masses to better than one part in a million million billion ( $10^{-21}$ ) — which Prince likens to measuring the distance to a nearby star to within the width of a human hair.

**Eric Hand**