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Galactic-scale observatory planned

Sep 22, 2009 3 comments

Physicists have drawn up ambitious plans to detect very low-frequency gravitational waves – ripples in the fabric of space–time that general relativity predicts ought to pervade the universe. But rather than looking for them using existing facilities like the LIGO detectors in the US, which are designed to detect tiny changes in the interference patterns of laser beams sent down pairs of kilometre-long pipes positioned at right angles to one another, the idea is instead to use radio telescopes on Earth. The telescopes would measure tiny variations in the output of pulsars spread thousands of light-years apart.

Listening in

The galactic observatory, proposed by the North American Nanohertz Observatory for Gravitational Waves (NANOGrav), would rely on minute changes in the relative timing of emissions from different pulsars – rapidly rotating neutron stars that emit very regular pulses of radio waves. A gravitational wave passing between a pulsar and a radio telescope affects the time it takes for the emissions to arrive, and so an array of pulsars with different lines of sight to the Earth would reveal the presence of any wave as well as its direction of propagation and polarization.

This idea was first put forward in the late 1970s but requires such high-precision measurements that it has not been technically feasible until now. The NANOGrav team says that it should be possible to correlate the output of 40 pulsars, each with a timing precision better than 100 ns, within the next decade. This would allow astronomers to observe gravitational waves with wavelengths of several light-years coming from sources such as the black-hole binaries that form when galaxies merge, as well as early-universe phenomena such as cosmic strings or inflation.

The NANOGrav consortium says that this could be achieved by expanding the time currently devoted to pulsar observations on existing facilities such as the Arecibo Observatory in Puerto Rico and Green Bank Telescope in West Virginia, US, as well as developing advanced software to process the huge amounts of data involved. It estimates this would cost a few tens of millions of dollars over the next 10 years, in addition to the money spent by their European and Australian collaborators.

This is small fry compared with the hundreds of millions of dollars being spent on gravitational-wave interferometers. Indeed, NANOGrav member Fredrick Jenet of the University of Texas at Brownsville says it is possible that the pulsar network could detect gravitational waves before the interferometers, although he points out that having different approaches not only expands the astrophysics that can be studied, but also improves the chances of detecting gravitational waves in the first place.

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Jim Hough, a gravitational-wave researcher at the University of Glasgow and a member of the GEO-600 gravitational-wave observatory based in Germany, says that pulsar timing "looks a very good way" to search for gravitational waves at extremely low frequencies. He believes that by observing 20 pulsars with a timing precision of better than 100 ns for five years, Jenet and colleagues "have a very good possibility of observing gravitational-wave signals".

About the author

Edwin Cartlidge is *Physics World*'s Italy correspondent

3 comments

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1 **psycherevolt**
Sep 22, 2009 3:43 PM
Hancock, United States

ISM

This article doesn't address how they will handle fluctuations in the density and index of refraction of the Interstellar Medium. Fluctuations of the ISM could lead to large error in their experiment due to slight changes of timing between wavelengths over stellar distances.

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2 **DavidLambert**
Sep 22, 2009 8:57 PM
San Jose, United States

RE: ISM

Hi psycherevolt,

You bring up a good point about the ISM.

The article only mentions steady-state sources of gravitational waves, maybe for the very reason you mention.

My background is in physics, not radio astronomy, but I know that fluctuations in the ISM have been studied and characterized, partly to understand their effect on the pulsar radio wave signal, and partly as a means to understand the ISM itself.

I also know that the radio wave signal from pulsars themselves also fluctuate, due to the details of how pulsars generate radio waves. These fluctuations have also been studied and characterized.

With steady-state sources, we can collect radio waves over a long enough time period that we can statistically separate the input radio waves into their components:
* Fluctuations in the ISM.
* Fluctuations in the pulsar sources.
* Time-averaged pulsar signals.
* Any influence due to gravitational waves.

Quote:

> *Originally posted by **psycherevolt***
> This article doesn't address how they will handle fluctuations in the density and index of refraction of the Interstellar Medium. Fluctuations of the ISM could lead to large error in their experiment due to slight changes of timing between wavelengths over stellar distances.

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3 **ASIWEL**
Sep 26, 2009 3:47 AM
Kalamazoo, United States

Interesting project

I read about this very interesting idea recently in another source, not as detailed as this article. But I still don't quite understand how a network of pulsars hundreds of light years apart can "focus" on a gravitational wave even several light years in wavelength. The timing of the "twinkles" for the same wave would seem to occur years apart (unless the wave was close by). Why not pick out a network of pulsars in some nearby galaxy so that the distance between the individual stars would be a negligible factor when studying intergalactic wavefronts. All would twinkle at about the same time, I would think, as the wave passed between the viewer and the sources.

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