Better hearing with spaced-apart ears

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An ear into space: while researchers convert the other detectors to improve their sensitivity, the German-British GEO600 project in Ruthe near Hanover continues to listen out for gravitational waves. Credit: Albert-Einstein Institute Hannover

(PhysOrg.com) -- Detectors in the US, Germany and Italy are lying in wait to gather evidence that would unveil one of Albert Einstein's last secrets: gravitational waves. Up to now, it has not been possible to detect these ripples in the curvature of space-time directly. However, if the available detectors were to be distributed differently across the globe, the chance of detecting the gravitational waves would increase more than twofold. This is the conclusion reached in a new study by Bernard F. Schutz, Director at the Max Planck Institute for Gravitational Physics (Albert Einstein Institute) in Golm. A further improvement in the detection process could also be achieved through the construction of additional gravitational wave observatories.

Many methods of studying the universe are available to us, most of which are based on the analysis of electromagnetic radiation from space. This involves the examination of photos from different eras, so to speak, which were taken on different wavelengths. Given that the traditional methods of space observation are blind to various phenomena, our perceptive spectrum would be extended considerably if we could also find a way of using our ears in this process.

Gravitational waves provide information about star explosions, collisions between black holes and neutron stars, and even about the Big Bang. Their frequencies do not lie in the electromagnetic range but in the acoustic range. These dents in space-time move at the speed of light and make the universe resonate.

Researchers have already constructed "telescope ears" for the detection of gravitational waves in Germany (GEO600), at two locations in the United States (LIGO) and in Italy (Virgo). These gravitational wave detectors measure and evaluate data together in a network. The observatories in the US and Italy are now being upgraded to enable the direct detection of gravitational waves for the first time and will recommence operation from 2016, taking measurements of ten times greater sensitivity than it is possible to do at present.

Up to now, the scientists have assumed that they would be able to observe an average of 40 melting neutron stars or black holes annually. Bernard F. Schutz's study now reveals that a total of 160 such events could in fact be observed per year. However, this cannot be achieved with the current spatial distribution of the detectors. What is needed is a measuring instrument on the other side of the world – an "ear" at the "back of the head", as it were.

The measuring sensitivity of a detector network depends on the sensitivity of the individual detectors and their position on earth. In his study, Bernard F. Schutz demonstrates how this relationship can be characterised by three figures for any network: the distance from which the gravitational wave in the sky can be perceived by the individual detector; the minimum signal-to-noise ratio at which gravitational wave detection is possible; the geometric arrangement of the detectors in the network.

“The transfer of one of the existing LIGO instruments from the US to Australia alone would increase the detection rate by a factor of two to four and provide far more accurate information about the events observed,” says Schutz. If – as planned – gravitational wave detectors commence operation in Japan, Australia and India, the scientists will be able to observe around 370 astronomical events annually - a figure that should increase to 500 per year once operation has become routine. The benefits gained from the improvement in measurement accuracy will fully offset the necessary investment.

“A new gravitational wave detector in Japan, whose construction was decided on last year, would further increase the sensitivity and reliability of the detector network and, moreover, enable the observation of a larger proportion of the sky,” says Schutz. “Not only would we be more certain than ever before of being able to measure Einstein’s waves directly, we would also obtain completely new information about neutron stars and gamma-ray bursts. This would mark the advent of a whole new type of astronomy.”

More information: Bernard F. Schutz, Networks of gravitational wave detectors and three figures of merit, *Classical and Quantum Gravity*, 2011. iopscience.iop.org/0264-9381/28/12/125023

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