UPPER LIMITS ON A STOCHASTIC GRAVITATIONAL WAVE BACKGROUND USING LIGO AND VIRGO INTERFEROMETERS AT 600 – 1000 HZ

Using data taken between November 2005 and September 2007, the Laser Interferometer Gravitational-wave Observatory (LIGO) Scientific Collaboration and the Virgo Collaboration have placed upper limits on the amplitude of the stochastic gravitational wave background.

The stochastic gravitational wave background is expected to arise from a combination of sources across the sky that are too faint to observe individually. There are several sources that are expected to contribute to the gravitational wave background, including the combined emission of all the spinning neutron stars and neutron star binary mergers in the universe. Neutron stars are very old stars which have burned all of their nuclear fuel and have collapsed under their own gravity until they are as dense as an atomic nucleus. We also expect a contribution from the Big Bang itself. It is thought that quantum fluctuations in the fabric of spacetime created gravitational waves during the first moments after the Big Bang, these gravitational waves would still be visible today as part of the gravitational wave background.

Scientists used the data from LIGO's fifth science run (known as S5) and Virgo's first science run to search for the combined stochastic gravitational wave background from the whole sky. This is the first time data from both LIGO and Virgo have been used to search for such a signal. The inclusion of Virgo data allows an improvement of the sensitivity across the frequency band. The data from the LIGO and Virgo interferometers were combined to estimate the amplitude of the gravitational wave background. No signal was seen, so the data were used to place upper limits on the amplitude.

The upper limits set by this analysis were seven times more sensitive than the previous most sensitive upper limit in this band, obtained by analysing LIGO data with data from the ALLEGRO bar detector. The analysis also required the development of a new method of combining the data from multiple interferometers, correctly accounting for uncertainty in the calibration of the instruments. This new method will be useful when analysing the data from Advanced LIGO and Advanced Virgo, which are expected to become fully operational in 2014-15.

READ MORE

The publication describing the analysis:
http://arxiv.org/abs/11125004

Repository of data used in the publication:

Article describing the ALLEGRO bar detector:
http://arxiv.org/abs/gr-qc/9609058

Article describing the previous most sensitive upper limit:
http://arxiv.org/abs/gr-qc/0703068

GLOSSARY

bar detector: A gravitational wave detector consisting of a metal bar which will resonate at the frequency of a detected gravitational wave.

Big Bang: Accepted cosmological model according to which the universe began in an extremely hot and dense state.

science run: A period of observation in which data is taken.

stochastic: Non-deterministic, random, can only be analysed using probability and cannot be predicted exactly.

strain: Fractional change in the distance between two measurement points due to the deformation of spacetime by a passing gravitational wave. The typical strain from gravitational waves reaching earth is very small; LIGO measurements limit the strain from the stochastic background in this frequency band to be less than one part in \(10^{-23}\).