論文内容の要旨

論文題目　Search for continuous gravitational waves from PSR J0835-4510

(PSR J0835-4510 起源の連続重力波探査)

氏名　　阿久津　朋美

In this thesis, continuous gravitational waves from PSR J0835-4510 (Vela) was searched by analyzing observation data from the Cryogenic Laser Interferometer Observatory (CLIO).

A gravitational wave is predicted from the general theory of relativity. Gravitational waves are supposed to be emitted from astrophysical phenomena concerning with compact stars, such as inspiraling compact stars binaries and supernovae.

Pulsars which are rotating neutron stars are also considered to be sources of gravitational waves. In various pulsars which were discovered by other instruments, we chose PSR J0835-4510 as a target source of gravitational waves. PSR J0835-4510 is supposed to be the nearest source of the pulsar, located at 250～500 pc, which produce the largest theoretical amplitude upper limit. Then, search for gravitational waves form PSR J0835-4510 interests us from a point of view to revel a mechanism of neutron stars.

The gravitational wave frequency of PSR J0835-4510 is about 22 Hz. The search for pulsars with gravitational wave frequency below 50~Hz had never been performed in spite that there are many sources, because gravitational wave detectors around the world didn't have good sensitivity in frequency range below 50 Hz.

In this thesis, first observation data of the CLIO was used, which had good sensitivity in low frequency range. CLIO is one of interferometric gravitational wave detectors with 100-m base line arms. In spite of short arm length, the CLIO performed comparable sensitivity at 20 Hz with km-scale interferometric detectors at February 2007.

The CLIO has two specific points in contrast with other detectors. One is a location. The CLIO is located in the Kamioka mine (underground). The other is an usage of cryogenic techniques. These points would benefit the sensitivity in low frequency bands,

which suffers from seismic noise and thermal noise. During February 12 -18 2007, the CLIO interferometer was operated for the observation at room temperature.

In this search, Matched Filtering is used, which is an optimal method when a waveform is well predicted. Gravitational waves from pulsars are so faint that we need to integrate long term data in order to increase a signal to noise ratio. However, there are two problems for the long integration. One is the problem about quantity of data. The sampling frequency of the interferometeric detector is a few 10~ kHz. Then, calculation time increases for the long integration. In order to solve this problem, data was compressed with heterodyne method. The other is the problem about quality of data. Real observational data from the interferometer is not simple Gaussian and not stationary. It includes inferior data which can not be used for the search and transient noise due to an instability of the interferometer. The noise level of the data also varies by circumstances, such as fluctuation of temperature, atmosphere pressure, seismic noise level and so on. They deteriorate the signal to noise ratio. Then, we implemented weighting to the data in order to decrease a contribution of the inferior data, i.e. a normalization of noise was implemented.

Although the Matched Filtering needs an exact waveform, there are unknown parameters about pulsars, such as a polarization angle and an angle between a total momentum vector of the source and a direction from the pulsar to the Earth. These unknown parameters also cause degenerations of the signal to noise ratio. Then, we used signal templates about two parameters in order to suppress the signal to noise ratio loss with 2 %. We used 102 signal templates in total. Then we implemented the Matched Filtering for the CLIO data.

Searches were done for all spectrum in frequency range from -0.003 to 0.003~Hz for gravitational wave frequency. We discussed the largest power event as a candidate of the gravitational waves. As a result, the candidate was discarded and we set an amplitude upper limit of 5.3×10^{-20}. An amplitude upper limit can be interpreted as an upper limit on the neutron star's equatorial ellipticity. Converting this upper limit on the ellipticity upper limit, 29 was obtained.