Gravitational Wave Background in Coincidence Experiments with Doppler Tracking of Interplanetary Spacecraft

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It is possible that a gravitational wave background, analogous to the electromagnetic one, fills the whole Universe. Very little can be said about the total energy content and the spectral distribution of this radiation field, due to our limited knowledge of the primordial Universe. However other mechanisms have been proposed for the generation of a stochastic background, which can be related to well known astrophysical scenarios (black-hole formation, binary systems, cosmic strings, etc.).

In the low frequency range ($10^{-4} - 10^{-1}$ Hz) Doppler tracking of spacecraft provides a unique experimental method of search. A distant interplanetary spacecraft receives and coherently transponds a radio signal to Earth. By measuring with high accuracy the frequency of the transmitted and received signals one can construct the Doppler shift. The gravitational wave contribution to this observable has been derived by Estabrook and Wahlquist (1975). Previously, several attempts have been made for detecting such a stochastic background with this technique, using only one spacecraft (Anderson and Mashhoon (1985), and references therein).

In March 1993 a three-weeks coincidence experiment with the three spacecraft Galileo, Ulysses and Mars Observer was performed. Similar experiments are planned in the next decade involving also the spacecraft Cassini. We analyze a method for combining the Doppler data from various spacecraft which are tracked simultaneously. Moreover we consider what assumptions should be made on the stochastic behaviour of the background in order to apply the same technique to Doppler data recorded at different epochs.

References

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