

First coincidence search among periodic gravitational wave source candidates using Virgo data

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This paper describes the ongoing work we are doing on the blind search for continuous gravitational waves emitted by isolated asymmetric rotating neutron stars in the data of the interferometric detector Virgo. An optimal blind search for continuous sources cannot be done with the presently available computing power. We have developed a hierarchical procedure which strongly cut the computational needs, with respect to the optimal analysis, at the cost of a small reduction in sensitivity.¹ We have used the data of the two commissioning runs C6 and C7 to build two periodic source candidate data bases. Each candidate is defined by the physical parameters of the source, namely frequency, sky position and value of the spin-down first order parameter. We have performed an all sky analysis, covering the frequency band $50 - 1050 \text{ Hz}$ and spin-down in $0 - 1.52 \cdot 10^{-4} \text{ Hz/day}$. We have done a preliminary search for coincidences between the physical parameters of the two candidate sets. We present the full procedure and the results.

Keywords: Gravitational waves; Continuous sources; Virgo detector.

1. From the short FFT database to the Hough transform

For each data set we start from the 4 kHz h-reconstructed data and apply a data quality procedure, which consists in the identification and removal of impulsive disturbances. From these cleaned data the short FFT database is built. The time duration T_{FFT} of each FFT is chosen in such a way that the Doppler shift is less than a frequency bin, so that the power of a periodic signal would not be spread among more bins. This would lead to a maximum duration $T_{FFT,max} = 1.1 \cdot 10^5 / \sqrt{f} \text{ s}$ where f is the search frequency in Hertz. However in this work, for simplicity and for saving computing power, we have decided to use the same $T_{FFT} = 1048.576 \text{ s}$ in the whole frequency band, with a resulting low sky resolution at low frequency. Each FFT in the database contains also a *very short* periodogram, which is the estimation of the average power, computed with an autoregressive procedure in the frequency domain, in such a way to be not affected by narrow spectral peaks. Then, we compute the ratio between each spectrum and its estimation, and select local maxima above a threshold, so we build the time-frequency peak map, which covers the frequency band $[0, 2 \text{ kHz}]$ and the whole observation time for both C6 and C7, see Astone *et al.*² for more details. The peak map is cleaned removing the most noisy frequency intervals by setting a further threshold on the peaks frequency distribution.

The Hough transform connects the time-frequency plane to the source parameter space: it takes the peak map at input and produce a set of candidates at output, each

defined by 4 parameters: position in the sky, frequency f and frequency derivative \dot{f} . We have carried the analysis over the frequency band $[50Hz, 1050Hz]$, with frequency resolution $\delta f = 9.5367 \cdot 10^{-4} Hz$. The sky resolution varies with frequency from 10° at $50 Hz$ up to 0.5° at $1050 Hz$. We searched for sources with minimum spin-down age from $100 yr$ (at $50 Hz$) to $2100 yr$ (at $1050 Hz$), corresponding to \dot{f} between 0 and $1.52 \cdot 10^{-4} Hz/day$; this range is covered by 40 values of \dot{f} for C6 and 10 for C7, the different values being due to the different observation times. The analysis has been partly carried on the INFN Production Grid^a.

2. Candidate selection and coincidences

On each Hough histogram, corresponding to a given value of f and \dot{f} , we select candidates by the use of a suitable threshold, finding nearly $5 \cdot 10^8$ candidates for C6 (with false alarm probability $1.1 \cdot 10^{-4}$) and more than $1.5 \cdot 10^8$ for C7 (with false alarm probability of $1.7 \cdot 10^{-4}$). The frequency distribution of candidates is shown in Fig.(1). We have an excess of candidates at several frequencies, due to

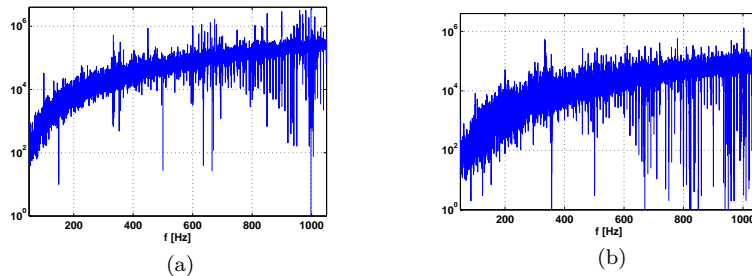


Fig. 1. Candidates frequency distribution for C6 (a) and C7 (b).

disturbances in the data, even if some cleaning has been done as previously said. Moreover, there are many 'spurious' candidates due to the short observation time. We have estimated the sensitivity of our analysis, on the basis of the data and of the search parameters we use, see Fig.(2). With respect to the optimal analysis, we have an *effective* sensitivity loss factor of 2.4 for C6 and 1.8 for C7. In a future work we will discuss the injection of simulated signals in the data. We have found $9.6 \cdot 10^5$ coincidences among candidates found in C6 and C7 data. The corresponding false alarm probability is reduced at the level of $2.2 \cdot 10^{-7}$. The coherent "follow-up", which is not discussed here, would be done only on the coincidences with a computational cost negligible with respect to that of the incoherent step.

We have also performed the analysis, in the frequency band $[50 Hz, 550 Hz]$, over two sets of data obtained by a suitable mixing of the C6 and C7 data sets, in such a way that each of the new sets covers a larger time interval. In this way we have found,

^a<http://grid-it.cnaf.infn.it/>

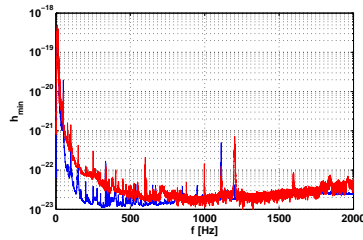


Fig. 2. Search sensitivity for C6 analysis (red) and C7 (blue).

as expected, less 'spurious' candidates and a lower number of coincidences. A more detailed description of the method can be found elsewhere in these Proceedings.³

References

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