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ABOUT PULSARS DYNAMICAL EVOLUTION

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Based on the assumption that pulsars are losing their rotational energy according to:

$$\dot{\nu} = -k\nu^n \,, \tag{1}$$

where ν is the frequency, $\dot{\nu}$ its first derivative, and n is the braking index, four evolutionary models are created. Using them, thousands of artificial pulsar populations were generated. A comparison between these populations, and the no glitches and no milisecond pulsars reported by Hobbs et al. (2004) is performed using a Kolmogorov-Smirnov test (K-S).

The value of n depends on the physical process by which the pulsar loses its rotational kinetic energy and is given as:

$$n = \frac{\nu\ddot{\nu}}{\dot{\nu}^2} \,. \tag{2}$$

In general, $\ddot{\nu}$ is very difficult to measure because of the timing noise, resulting in braking indices too big, too small, or even negative. In 2004, Hobbs et al. achieved a more significant measurement of $\ddot{\nu}$ in 374 pulsars. The populations were created using random distributions (Gaussian, Uniform and Exponential) of 238 pulsars, each distribution was related with some physical variables, e.g. for model 4, the logarithm of magnetic field was taken from a Gaussian distribution with mean -14 and variance 1, t and logarithm of ν from a uniform distribution between $0 - 3.3 \times 10^6$ and 0–0.9, respectively, while an exponential distribution with mean 26 was used for the term A. The models used in this work were:

Model 1: $\dot{\nu} = -k\nu^n$ $\quad \ddot{\nu} = \frac{n\dot{\nu}^2}{\nu}$

Model 2: $\dot{\nu} = -k\nu^n$ $\quad \ddot{\nu} = \frac{n\dot{\nu}^2}{\nu} + A\dot{\nu}$

Model 3: $\dot{\nu} = -ke^{-2t/t_c}\nu^n$ $\quad \ddot{\nu} = \frac{n\dot{\nu}^2}{\nu} - \frac{2}{t_c}\dot{\nu}$

Model 4: $\dot{\nu} = -ke^{-2t/t_c}\nu^n$ $\quad \ddot{\nu} = \frac{n\dot{\nu}^2}{\nu} - \frac{2}{t_c}\dot{\nu} + A\dot{\nu}$

where k is a constant and depends on magnetic field, while the term A is a free parameter.

The respective diagrams are presented in Figure 1. Here it is clear than model 1 does not predict the spread of pulsars observed in the $\dot{\nu}$ vs $\ddot{\nu}$ diagram. Adding the term A to $\ddot{\nu}$ in model 1 (shown in model 2), the points are more spread in that diagram. However, artificial and observed populations are still quite different. If we consider a magnetic field with exponential decay, we have a term that produces a better fit (as in model 3). Although the results are better, they are not yet ideal. In order to achieve the best fit, we add the term A to $\ddot{\nu}$ in model 3, and thus, we reach our best model, model 4. Our results were as follows: exponential magnetic field decay does not cause a spread of points in the diagrams studied. The term A can be related to the timing noise.

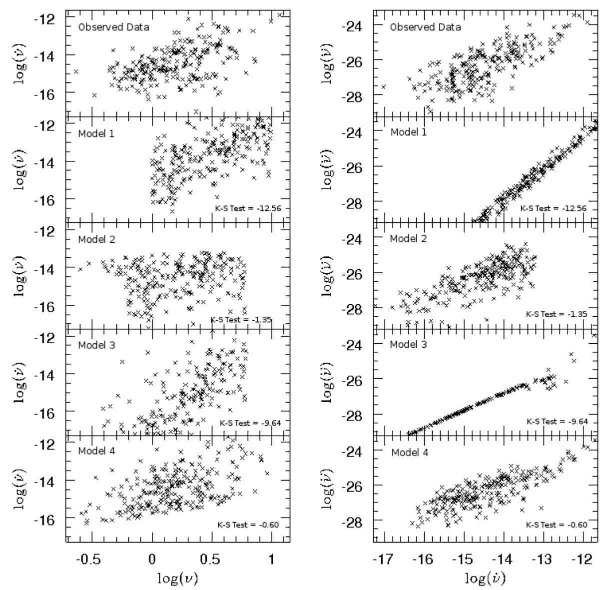

Fig. 1. Logarithmic plots ν vs $\dot{\nu}$ (left) and $\dot{\nu}$ vs $\ddot{\nu}$ (right), show the different populations that were created with the models mentioned before. The two upper diagrams represent the observed population.

REFERENCES

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