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Tkachenko waves, glitches and precession in neutron stars

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Abstract

Here I discuss possible relations between free precession of neutron stars, Tkachenko waves inside them and glitches. I note that the proposed precession period of the isolated neutron star RX J0720.4-3125 [1] is consistent with the period of Tkachenko waves for the spin period 8.4 s. Based on a possible observation of a glitch in RX J0720.4-3125 [2], I propose a simple model, in which long period precession is powered by Tkachenko waves generated by a glitch. The period of free precession, determined by a NS oblateness, should be equal to the standing Tkachenko wave period for effective energy transfer from the standing wave to the precession motion. A similar scenario can be applicable also in the case of the PSR B1828-11.

Precession of neutron stars and RX J0720.4-3125

Isolated neutron stars (NSs) being non-spherical bodies are expected to demonstrate free precession (for a brief review see, for example, [3]). However, examples of this phenomena are less than few, and even in rare cases when a precession-like behavior is observed different interpretations can be discussed.

Recently, appeared another possible example of long period free precession in NSs. The existence of ~ 7 years precession period in RX J0720.4-3125 – was suspected [1] So, this object was added to the list, and the paradoxical situation of long precession in presence of superfluid vortices was reconsidered in [6].

Clearly, the problem of free precession in NSs is far from being solved completely. In this brief note, based on coincidence between Tkachenko wave period and precession period in cases of PSR B1828-11 and RX J0720.4-3125, I discuss a mechanism to support precession in isolated NSs.

Tkachenko waves

A simple model for long period precession of isolated NSs proposed here is related to the so-called Tkachenko waves [7]. These are displacement waves in the vortex line array that exist in rotating superfluid, or in other words a kind of sound waves propagating in the lattice of neutron votices perpendicular to them. A good introduction to the Tkachenko waves physics can be found in the paper by [8]. The period of Tkachenko waves in neutron stars was estimated in [9].

Proposed scenario

For RX J0720.4-3125 the following scenario is proposed: a glitch (most probably due to a starquake) generates Tkachenko waves; the period of a standing Tkachenko wave is equal to the free precession period for this NS; due to the standing wave precession starts after a glitch, or just there is an energy input into the pre-existing precession motion.

Tkachenko waves periodically change the spin frequency and moment of inertia of a NS. Waves move perpendicular to the vortex lines, which are parallel to the spin axis. The moment of inertia of a star can be non-symmetric respect to this axis, for example if oblateness is due to strong magnetic field. I speculate that periodic modulation of spin frequency and all components of moment of inertia in resonance with the precession period (determined by oblateness) would lead to energy transfer from Tkachenko waves to the precession motion.

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