Can pulsar glitches be explained as "starquakes"?

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Abstract

Pulsars are the best clocks known in universe, with very precisely periodic pulses due to the rotation of a neutron star with a strong dipolar magnetic field. The pulses slow down progressively, due to the release of rotational energy. In addition, there are timing irregularities, the most prominent of which are "glitches", sudden spin-up events, in which about 1 % of the spin-down is "recovered". There are two main mechanisms discussed in the scientific literature to explain this kind of events. The first is the sudden transfer of angular momentum from the superfluid (or part of it) to the solid crust of the star. The second is a "starquake", a sudden breaking of the solid crust due to stress accumulated by the spin-down of the star. Our object of study is the second of these mechanisms, which was previously studied by Baym & Pines (1969). They showed that, for known values of Crab pulsar, starquakes due to spin down cannot explain the relatively short recurrence times (of few years), instead requiring hundreds of years between glitches. For Vela the scenario was much worse, exceeding thousands (even millions) of years the time between glitches. However, the size distribution of glitches is bimodal, so one might still try to explain the smaller glitches through this mechanism. In this investigation, using theory of elasticity to demonstrate how the star is deformed by rotation, we study the plausibility of the model in two scenarios. The first one is a completely solid star, which could store the maximum stress and the second is a more realistic star with fluid core and solid crust. We use observations of pulsars with only small glitches, as the Crab pulsar, and pulsars with bimodal distribution, as the Vela, to test the models.