Trapped modes of oscillation and buckling of a tectonic plate as a possible reason of an earthquake

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We suggest a mechanical model describing buckling of a tectonic plate due to non-stationary longitudinal wave of compression that propagates along the plate. For low frequencies the interaction of a tectonic plate with its environment can be approximately described by means of the Winkler elastic foundation. Introducing the inhomogeneous Winkler foundation with weakened zone can lead to the existence of trapped modes of transversal oscillation in this mechanical system, and makes possible the localized buckling of the plate. Such an instability can be considered as a possible reason of an earthquake. To describe this mechanism of an earthquake we need a coupled model that can describe both transversal and longitudinal motions of a tectonic plate.

We propose a one-dimensional model of a tectonic plate based on the nonlinear equations of the theory of elastic rods. In the framework of the model we deal with a straight extensible rod, while the shear deformations and the rotational inertia are neglected. The coupled nonlinear equations for longitudinal and transversal motions of the rod are derived. For the case, when the rod is subjected to the slowly varying in time longitudinal load, we proceed with the asymptotic reduction of the nonlinear equations. Finally, we obtain a problem on the evolution of a trapped mode of transversal oscillation in a weakly non-stationary system. If the frequency of the localized oscillation approaches zero, the amplitude of the oscillation can be a growing quantity. This can explain the known experimental fact that ultra-low-frequency seismic pulses are registered before powerful earthquakes. The further increasing of the longitudinal load results in the localized buckling of the tectonic plate that causes an earthquake.