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FULFILMENT OF THE CONDITIONS FOR THE APPLICATION OF THE NEKHOROSHEV THEOREM TO THE ASTEROID BELT

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Abstract. In the thesis the conditions for applying the Nekhoroshev theorem to a real dynamical system, such as the motion of asteroids perturbed by the major planets, are examined. For the examined conditions rigorous definitions are given: of convexity, of quasi-convexity and 3–jet non-degeneracy, also the algorithm of verifying which condition is fulfilled by the quasi- integrable dynamical system under consideration. The algorithm consists of the following steps: 1) by using suitable canonical transformations the Hamiltonian is converted into a form independent of angles, i. e. new variables, the so-called action-angle ones, are introduced; 2) the derivatives of the Hamiltonian in actions up to the third order are calculated; the Hessian matrix is formed and its eigen-values are calculated. If all the eigen-values have the same sign, the Hamiltonian is convex. If at least one of them is different in its sign, then the restriction of the Hessian onto the plane perpendicular to the frequency vector (vector of first derivatives of Hamiltonian in actions) is examined. If now all the eigen-values of Hessian restriction have the same sign, the Hamiltonian is quasi-convex. However, if some of the restriction eigen-values is different in its sign, then one has to examine a more complicated condition given through the third derivatives (Pavlović 2008). The explicit expressions for the derivatives of the integrable part of the Hamiltonian in actions up to the third order are given in Pavlović (2006).

The part of the phase space is analysed where asteroid families Koronis and Veritas are located. Out of 2983 members of Koronis family analysed here, 629 (21.09 %) fulfil the convexity condition, 616 (20.65 %) that of quasi-convexity and 1667 (55.88 %) members fulfil the 3–jet non-degeneracy condition. Thus in this region of the phase space most of the asteroids fulfil the conditions for applying the Nekhoroshev theorem. From the point of view of dynamics, the Veritas family includes members showing the regular motion (1086 Nata), as well as members with strong chaotic motion (490 Veritas). Most of the members of this family fulfil either the convexity condition - 151 (44.41 %) or 3-jet non-degeneracy - 164 (48.24 %), whereas the quasi-convexity is fulfilled for only 12 (3.53 %) members. Because of this the Nekhoroshev theorem can be applied only to the members of this family having regular motion.

The obtained results show that only 71 members of the Koronis family, out of 2983 analysed ones, and 13 members of the Veritas family, out of 340 identified ones, fulfil none of the conditions. In this way the application of the spectral formulation of the Nekhoroshev theorem to selected members of the Koronis family, as well as to the members of the Veritas family showing a regular motion, is justified (Pavlović and Guzzo 2008).

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