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On the dynamical foundations of the Lidov–Kozai Theory

The Lidov–Kozai theory developed by each of the authors independently in 1961–1962 is based on qualitative methods of studying the evolution of orbits for the satellite version of the restricted three-body problem (Hill's problem). At present, this theory is in demand in various fields of science: in the field of planetary research within the Solar system, the field of exoplanetary systems, and the field of high-energy physics in interstellar and intergalactic space. This has prompted me to popularize the ideas that underlie the Lidov–Kozai theory based on the experience of using this theory as an efficient tool for solving various problems related to the study of the secular evolution of the orbits of artificial planetary satellites under the influence of external gravitational perturbations with allowance made for the perturbations due to the polar planetary oblateness. The specular component of the perturbing function was obtained by Lidov and Kozai based on the first three terms of the expansion of the perturbing function of Hill's problem twice averaged over the periods of the motion of the second and third bodies relative to the first body (assuming the periods to be incommensurable). Three first integrals and a completely integrable system of Lagrange differential equations corresponding to the secular component of the perturbing function. Lidov (1963) demonstrated an impressive example of the evolution of a hypothetical "Vertical Moon" in an orbit perpendicular to the ecliptic plane. The orbital evolution of the Vertical Moon resulted in its collision with the Earth within less than 4.5 years. The result obtained made a great impression on the scientific community and raised the question of why this effect is not extended to the evolution of the orbits of Uranus's satellites, which are almost perpendicular to the ecliptic plane. To explain this fact, Lidov had to investigate a mixed problem that took into account the perturbations from the planet's oblateness. The results of these studies published by Lidov (1963) showed that the secular evolution of the orbits of Uranus's satellites occurs under the predominant influence of the planet's polar oblateness. The paper by Lidov and Yarskaya (1974) is devoted to investigating the integrable cases of secular evolution in the mixed problem with allowance made for the influence of oblateness and external gravitational perturbations. To justify the application of these approximate methods to solving practical problems, I analyzed the scope of the theory under consideration from a study of the secular evolution of high-apogee orbits, where external gravitational perturbations play a major role. In the course of these studies (Prokhorenko 2007) I managed to prove the theorems on the manifolds of initial conditions whereby the secular evolution of the eccentricity leads or (does not lead) to a collision of the satellite with the surface of the central body. Then, the problem of estimating the regions of predominant influence of the gravitational perturbations from external bodies and predominant influence of the gravitational field due to the polar oblateness of the central body naturally arose (Prokhorenko 2010, 2011). I have shown that the Lidov–Kozai theory can be used in solving a broad range of problems. Qualitative studies of the orbital evolution of natural satellites of Solar system planets and the choice of spacecraft orbits to study the near-Earth space by taking into account the evolution of their orbits can be attributed to such problems. Such studies can be used in choosing the orbits for satellites of Solar system planets by taking into account the dynamical parameters of the planets. Similar qualitative methods can be used in studying the dynamics of exoplanetary systems as well as double and multiple stars in the Galaxy based on the dynamical parameters of the corresponding systems.

Biography

Victoria I Prokhorenko is currently working in the Space Research Institute, Russia; he has extended his valuable service in field of Space science for several years and has been a recipient of many award and grants. His international experience includes various programs, contributions and participation in different countries for diverse fields of study. His research interests reflect in his wide range of publications in various national and international journals.

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