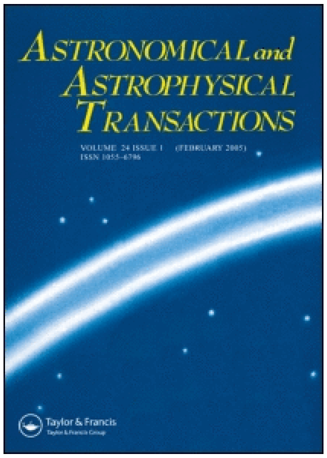

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ON THE DYNAMICAL EVOLUTION OF THE RELICT ENSEMBLE OF COMETARY BODIES IN THE SOLAR SYSTEM

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The possible existence and dynamical evolution of a comet relict reservoir among the giant planets is examined. Permanent gravitational encounters with planets and collisions between cometary nuclei tend to throw them out highly eccentric strongly perturbing orbits. The general coure of this evolution is described as a cosmogonic long dissipation in the Galaxy and to the Sun.

KEY WORDS Cometary bodies, relict ensemble, dynamical evolution

1 INITIAL CONDITIONS

The present state and trend of the dynamical evolution of the cometary body (CB) ensemble in the solar system (SS) are a consequence of its formation and resulting conditions of development. An ensemble of CBs is a relict of the planetesimal disc of the SS from which the planets were formed. The planetesimals of the inner "hot" (because of the Sun's vicinity) zone did not originally contain volatile chemical fractions (present asteroids). On the contrary, in the "cold" zone of the protoplanetary cloud the planetesimals contained a considerable number of "ices": H_2O, CO_2, CO, CH_4, NH_3 among other. Practically there were CB.

2 THE EPOCH OF PLANETARY FORMATION

In the inner planetesimal disc its statistically dynamical evolution resulted in the formation of the group of Earth-like planets. In the "cold" zone the beginning of planetary formation occurred from CBs. Here Jupiter and Saturn were the first to reach the mass sufficient to start gaseous accretion (mainly unfrozen H and He).

They captured the gas component of the protoplanetary disc (forming the second group or type of planets, the "supergiants"). The third group are the giants Uranus and Neptune formed mainly from the planetesimals of this zone (CBs). The density of the planetesimal disc beyond Neptune was found to be evidently insufficient for the accumulation of CBs in the planets. In the early stages of growth of the protoplanets the zones of strong gravitational perturbations in the originally almost planar wide planetesimal rings along the protoplanetary orbits were extended rapidly. This mechanism must remove an enormous number of planetesimals on chaotic (cometary type) orbits. However, the destruction of the interplanetary planetesimal rings did not advance beyond $\sim$ 1 a. u. from the orbit of the accumulating protoplanet, if one judges by the distance from the asteroid belt boundary to the supergiant Jupiter. Ultimately this limited the growth of the giant planets (GPs) (but not the notional total exhaustion of the planetesimals' rings between the GPs due to perturbations).

3 NECESSARY CORRECTIONS TO THE DOMINANT PARADIGM

Ideas about the full escape of planetesimals (CBs) from the zones between the GPs are arbitrary and unproved. Furthermore one can point out that they are directly mistaken. The adoption of these ideas distorts fatally the picture of the initial conditions and consequently the resulting processes of the statistically-dynamical evolution and the present state of the CB ensemble of the SS. The results confirming this idea and suggesting strong (in the cosmogonic time-scale) instability in the motions of the small bodies in the region between Jupiter and Saturn are themselves "insufficiently stable" (differ in the subsequent articles of the ones and the same authors greatly). The conclusions of L. Kresak (1977) confirm the opposite statement: there are regions of stability between the GPs (and beyond). The existence of the asteroid "beside" Jupiter signifies that the presence of stable small bodies in the significantly wider space zones between the GPs is not excepted. The dynamical results of E. I. Kazimirchak-Polonskaya' (1978) on the existence of CB belts between the GPs as the source of short-period comets (SP) (called the "Kazimirchak-Polonskaya belts" by N. A. Belyaev) confirm our ideas. We conclude that there now exists ensemble of relict planetesimals (CBs) in the region of the GPs and this is the source of the SP-comets in the planetary zone (Tsitsin *et al.*, 1985a). As a consequence of the long dynamically-statistical evolution (due to gravitational perturbations, both mutual and from the planets, and also of mutual collisions CBs) the originally very planar CB rings between the GPs has thickened along the Z-coordinate to merge "over and under" the GP orbits and also with the CB zone beyond Neptune (the Whipple belt), which is continuously transforming in the "inner cometary cloud" (the Hills belt, ICC). This cloud determines the boundary of the relict CB reservoir in the SS on the poorly known distances from the Sun (by various estimations, from a thousand to a couple of tens of thousand a.u.).

4 THE DYNAMICS AND EVOLUTION OF THE RELICT CB RESERVOIR IN THE SS (Tsitsin *et al.*, 1985b; 1988; 1993a, b, c)

Gravitational perturbations and mutual CB collisions in the planetary zone lead to the appearance of SP-comets. Gravitational perturbations of the periphery of the ICC on the one hand give birth to the long-period comets (LP), and on the other hand provide quasistationary feeding of the Oort cloud (OC). Further, these objects get away directly or by the OC the CB-dissipant ensemble. Diffusion of the last objects in the stellar field with small hyperbolic abundances of energy occurs in the rather small slowly expanded Galactic neighbourhood of the Sun (Tsitsin *et al.*, 1984). The typical peculiarity of the OC is its instability from the dynamical point of view.

The dynamics of the dissipant ensemble are specific. As a consequence of the small hyperbolic energy abundance a dissipant can easily and even many times change the sign of the total energy by stellar and other perturbations. This returns the dissipant to the ensemble of objects dynamically belonging to the OC even when the distance from the Sun is significantly greater than the average interstellar distance. Such processes explain naturally the origin and dynamics of the near-parabolic, parabolic and known hyperbolic comets. It should be noted that a dissipant ensemble resembles, in its dynamical characteristics, a Laplace ensemble of "interstellar" comets (the principal distinction between these two objects lies in their genesis: a Laplace cometary ensemble is alien to the SS; the ensemble of dissipants from the SS belongs to it genetically). Furthermore, the dissipant ensemble is similar to the "Schiaparelli cometary swarm" accompanying the Sun in its motion among the stars. The CB-dissipant cloud diffusionally slowly expanding from the Sun in the Galactic gravitational field elongates along the Galactic orbit of the Sun. But direct estimates show that since the origin of the SS, the CB-dissipant cloud is able to extend to distances from the Sun insignificant in comparison with the dimension of the solar Galactic orbit. Obviously, along the orbit, the length of the Laplace cometary cloud of the Sun does not exceed a few hundred pc and in the perpendicular direction, one hundred pc. The overlapping of the Laplace (more exactly the Schiaparelli) cometary clouds of different second generation sunlike stars forms the Opik Galactic cometary cloud in the Galactic disc. The properties of this cloud (including the dynamical characteristics) are interesting but obvious enough.

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