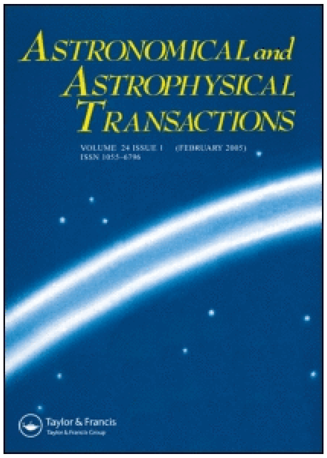

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

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Online Publication Date: 01 January 1999
To cite this Article: Tsitsin, F. A., Chepurova, V. M. and Genkin, I. L. (1999) 'The relict reservoir of cometary bodies as a unitary store of comets of the solar system', Astronomical & Astrophysical Transactions, 17:5, 351 - 354
To link to this article: DOI: 10.1080/10556799908244084
URL: http://dx.doi.org/10.1080/10556799908244084

Astronomical and Astrophysical Transactions, 1999, Vol. 17, pp. 351–354
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THE RELICT RESERVOIR OF COMETARY BODIES AS A UNITARY STORE OF COMETS OF THE SOLAR SYSTEM

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(Received December 15, 1996)

Solar system (SS) comets come from a relict reservoir (RR) of cometary bodies (CB). The reservoir consists of two components of common origin, but highly different spatial, dynamical and kinematical characteristics: (1) a dynamically stable component on cosmogonic time-scale formed by Kazimirchak–Polonskaya (KP) belts lying between the giant planets (GP) and beyond Neptune. This component (thanks to CB collisions pushing the CB away from the zone of stability) provides us with periodic comets. (2) a swarm of dissipants moving on Brownian-type trajectories; at present the swarm may be of a size of no more than 100 ps, but expands diffusing "into the Galaxy", and provides, thanks to statistically inevitable returns of part of the CB to the Sun, "quasiparabolic" comets, including: (a) elliptic quasiparabolic; (b) non-distinguishable from parabolic;(c) slightly hyperbolic comets. The belt between the orbits of Jupiter and Saturn populating CB must be as bright as 23^m–24^m and consequently may be observable.

KEY WORDS Cometary relict reservoir, cosmogony, origin of comets

1 COSMOGONIC PREMISES

It was Schmidt's cosmogonic theory that had first considered the formation of cometary bodies (CB) as part of the general process of planetogenesis - the CB had originated in the ample cool outer regions of the primordial planetesimal disc. Still, in the frame work of the same theory the following concept was developed: the zones of instability between the orbits of the giant planets (GP) not only amplified but merged as the planets grew; consequently, practically all the CB were driven away from the GP zone "out into the Galaxy"; only about 1% of the original number of CB remained, because of stellar perturbations, and formed the Oort cometary cloud (OC) – the present supplier of comets.

The statement of "general ejection", however, has not been proved as yet. Even its author (Levin, 1949, 1978) did allow for the existence of a certain number of "non-observable" asteroid-like bodies (e.g. cometary bodies) in the GP zone. Similar assumptions were made by several other authorities in asteroid-cometary problems (D. Ya. Martynov, A. Delsemm, A. N. Simonenko, K. I. Churyumov, etc.). L. Kresak (1977) showed from a theoretical standpoint that ring-shaped zones of dynamically stable minor bodies exist in front of, between and beyond the GP zones. E. I. Kazimirchak-Polonskaya (1978) proved that short-period comets drift into their observed orbits precisely from the belts lying between the GP (N. A. Beljaev has named these stores of comets "KP belts"). Kazimirchak-Polonskaya herself had assumed that comets find their way into the belts through "gradual diffusion" from the Oort cloud.

However, this method of replenishing the KP belts with comets meets grave theoretical difficulties (Tsitsin, 1993). The same is true in respect of practically all the other hypotheses for the origins of the CB that evolve to short-period orbits from the KP belts. (These are, as a rule, alternative with respect to each other: cometary capture from the OC and giant molecular clouds, ejection by volcanos on GP satellites or by explosions of the hydrospheres of frozen satellites, etc.). Sagdeev (1989) has thus summarized the situation: "The problem of cometary origins remains unsolved. ...To solve it, we must, in the first place, bring the cometary material down to Earth". Here is a clear recognition of the fact that the theory for cometary origins has come to a dead end.

We arrive at the conclusion that the difficulties of cometary cosmogony developed in the frame work of Schmidt's general cosmogony that has so successfully worked out a huge number of CB at the planetesimal disc, originate out of the statement, erroneous in principle, of the "total ejection" of CB out of the GP zone by gravitational perturbations from the GP. What does cometary cosmogony gain by dropping that arbitrary statement? (Tsitsin *et al.*, 1984, 1985a, b; Tsitsin *et al.*, 1990).

2 PERIODIC COMETS

The KP belts retain their cosmogonic base. All the other explanations of the existence of the belts (as well as the origins of the short-period comets) become superfluous.

The CB, remaining on stable orbits since the Solar System was formed, were affected by Solar radiation. Solar and stellar wind, cosmic radiation, etc., lost volatile elements from their thick (but later thinned) outer layers and formed a very dark silicon-metal crust with a certain organic admixture. Parts of the crust are stripped away through statistically inevitable collisions between CB. CB "shocking" (up to complete destruction) and shock perturbations of CB orbits also take place. A CB may jump, all of a sudden, into a "cometary" orbit of short perihelion distance or be thrown into a non-cometary-type orbit traversing one of the zones of strong perturbations near a GP orbit. Further dynamical evolution of such CB orbits is evident.

Similar phenomena take place, in particular, at the area extending from beyond Neptune through out the zone of the dynamically stable relict CB reservoir up to the borders, unknown to us, of the zone of planetesimal formation.

So then, by dropping the "total ejection" statement, we gain an explanation, free from the usual difficulties and paradoxes, of periodic cometary origins (with the exception, at present, of the quasiparabolic ones). Yet, our approach is valid for the quasiparabolic comets as well.

3 QUASIPARABOLIC COMETS

The statement of general (not total!) ejection of CB from the GP zone (up to 10^{30} g, 10^{14}–10^{15} CB) at the time of GP formation is one of the fundamental deductions of Schmidt's cosmogonic theory. The mechanism of the ejection permits us to assume an extremely small value of the energy excess of an average ejected CB (the velocity at infinity $v \sim 0.5$ km/s). The full energy h of such a CB may undergo brusque changes through stellar perturbations, up to changing the sign. The CB that would get an $h < 0$, return to elliptical heliocentric orbits (no matter what the heliocentric distance of the CB), and, if perturbed no more, reach the vicinity of the Sun.

The motion of the CB through perturbing media must have, under the above condition, a Brownian-like character. The swarm of CB as a whole would expend, diffuse, and decelerate with time in direct proportion with the square root of t (t being the time of ejection, e.g. the age of the Solar System). (But see Radzievskij, 1954.)

In accordance with the Polya theorem (Feller, 1967) separate members of such a swarm are to return to "the source" (e.g. the Sun) with an asymptotic probability of ~ 0.35. Such a CB moving along the cometary orbit would be interpreted as a slightly hyperbolic ($h > 0$) or near-parabolic ($h < 0$) elliptic comet. (All the CB of sufficiently small modulus h would be described as non-distinguished from parabolic comets.)

So, both types of quasiparabolic comets (including those non-distinguished from parabolic) may be explained on the basis of the practically established "theoretical fact" of general ejection of CB from the GP zone at the epoch of Solar System formation.

Summing up: all the ensemble of the observed Solar System comets may easily be explained qualitatively if we assume the existence of a relict CB reservoir consisting of two spatial-dynamic components of the same age and origin, but of different character: (1) a dynamically stable component extending from the zone of GP to the limits of the region of planetesimal formation; (2) a cloud of ejected CB that diffuses "into the Galaxy" (kinematically analogous to the Schiaparelli Swarm). (Tsitsin *et al.*, 1998.)

4 OBSERVATIONAL ASPECTS OF THE PROBLEM

The Galactic cometary cloud is composed of repeatedly overlapped diffuse cometary clouds of separate stars. The average fraction of "native comets" in a local Opic cometary cloud, in the neighbourhood of any given star, the Sun, for example, is very small. Still, we know of no "alien" comet as yet, may be because the "native comets", having extremely small energy (velocities) with respect to the Sun, are strongly focused by its gravitational field (Radzievskij *et al.*, 1969).

The observational proofs of the existence of the OC are just a misinterpretation: the OC is thought to be the home of all the observed objects belonging in fact to the Schiaparelli Swarm. In fact, there is no further need for the existence of the OC.

The short-period comets we observe come from Solar System relict cometary reservoirs (in all probability, mostly from the Jupiter–Saturn belt). Consequently, we can ascribe certain characteristic parameters to the CB: a size d of 1–3 km (Churyumov, 1996), and an albedo A, probably ~ 0.04. It follows that the CB of the middle of the belt (the expected highest abundance zone of CB) should be as bright as 23^m–24^m, that is, in principle, accessible to observations. The relict reservoirs of the Solar System CB may yet be discovered (Tsitsin *et al.*, 1989).

Reference

Churyumov, K. I. (1996) *Zvezdochiot* **8**, 13 (in Russian).
Feller, W. (1967) *An Introduction to Probability Theory and its Applications*, Mir, Moscow **1**, 353 (in Russian).
Kresak, L. (1977) *Bull. Astron. Inst. Czech.* **28**, 65.
Kazimirchakh-Polonskaya, E. I. (1978) *Problems of Investigations of the Universe, Astrometry and Celest. Mechan.*, M.-L. **7**, 340, 384 (in Russian).
Levin, B. Yu. (1949) *Priroda* **10**, 3 (in Russian).
Levin, B. Yu. (1978) *Pis'ma v Astron. Z.* **4**, 102 (in Russian).
Radzievskij, V. V. (1954) *Astron. Z.* **31**, 436 (in Russian).
Radzievskij, V. V. and Dagaev, M. M. (1969) *Astron. Z.* **46**, 56 (in Russian).
Sagdeev, R. (1989) *Priroda* **1**, 33 (in Russian).
Tsitsin, F. A., Chepurova, V. M., and Rastorguev, A. S. (1984) *Astron. Tsirk.* **1310**, 5; (1985a) Ibid. **1378**, 1; (1985b) Ibid. **1408**, 5 (in Russian).
Tsitsin, F. A., Chepurova, V. M., and Genkin, I. L. (1989) *Comet. Tsirk.* **405**, 5 (in Russian).
Tsitsin, F. A, Chepurova, V. M., Rastorguev, A. S., and Genkin, I. L. (1990) *The Questions of the Celest. Mech. and the Stellar Dynam.*, Alma-Ata, p. 197 (in Russian).
Tsitsin, F. A. (1993c) *Latv. Univers. Zin. Raksti*, No. 586; *Astron. Ser.* **19**, 97 (in Russian).
Tsitsin, F. A., Chepurova, V. M., and Genkin, I. L. (1998) *The Informations of Russian Academy of Sciences* **62**, No. 9, 1888 (in Russian).