Dynamically New Comets in the Solar System

Piotr A. Dybczyński and Halina Prętka–Ziomek
Astronomical Observatory of A. Mickiewicz University
ul. Słoneczna 36, 60-286 Poznań, Poland
E-mail: dybol@amu.edu.pl, pretka@amu.edu.pl

Traditional definition of a dynamically 'new' comet, which is the comet for the first time visiting our planetary system, is that it should have its $1/a < 1\times 10^{-4}$ AU^{-1} (eg. Oort and Schmidt, 1951). This definition is based on the value of semimajor axis of the comet at the moment it is observed, but it does not take into regard its dynamical history. Such a long–period comet has semimajor axis larger than 10 000 AU so, while travelling through the space, is influenced by gravitational attraction from all the visible and invisible matter in the Galaxy. Constant galactic perturbations as well as the stochastic influence of individual stars passing close to the Sun can change the cometary orbit, in particular its perihelion distance, which is the critical parameter, determining whether the comet will or will not enter into the planetary region.

We have investigated the dynamical history of the observed long–period comets going backwards to its previous return to the Sun. We studied past evolution of 307 long–period comets from the Catalogue of Cometary Orbits (Marsden and Williams, 1997) and 20 comets that have been newly discovered after publishing the Catalogue. For each comet we calculated at first its barycentric, original orbit, that is the orbit the comet had before it entered the planetary system. We traced backwards the motion of comets, taking into account gravitational influence of all planets and the Moon as well as relativistic effects according to the dynamical model used by (Yau et al., 1994). We stopped the integration when the comet reached the distance of 250 AU from the Sun. From further investigation we rejected 44 comets that did not reach the limit of 250 AU and 28 comets having original hyperbolic orbits. As a result we obtained 255 comets with original elliptical orbits, among them 85 comets had $a > 10\ 000$ AU.

Then, starting from their original orbits, we traced the past evolution of all comets with elliptical orbits, including the gravitational attraction of the Galaxy. As the dynamical model we used the model proposed by (Heisler and Tremaine, 1986), restricted only to the galactic disk which is considered to be the most dominant part of the tidal galactic potential in the vicinity of the Sun. We integrated the motion of comets backwards to their previous return to the planetary region, namely to their previous perihelion passage.

For 170 comets that had $a < 10\ 000$ AU galactic perturbations were very weak and did not change the cometary orbital elements significantly. These comets are 'old' since during the previous return to the Sun they had their perihelion distances small enough to be perturbed by planets. For the rest of the comets, called 'new' in the Oort sense, the situation is more complicated. In Table I we present results of our calculation for 85 elliptical comets having their original $a > 10\ 000$ AU. Additional, we show here the subset of comets with the observed perihelion distance greater than 1.5 AU and orbits of class 1. These comets have their orbits very well determined and, thanks to having their perihelion distances large enough, they do not pass close to the Sun, so they do not suffer from nongravitational effects.

Table I. The distribution of the previous perihelion distance for long–period comets, called 'new' in the Oort sense.

Previous q [AU]	$q_{obs} > 1.5$ AU class 1	all comets
0 – 2	3	10
2 – 5	24	31
15 – 40	6	12
> 40	20	32
Total number	53	85

One can see that from 85 comets called 'new' in the Oort sense as many as 41 comets passed closer to the Sun than 15 AU during their previous return. These comets should be considered as dynamically 'old' ones since they had passed the planetary region deep enough to have their previous orbits perturbed by the planets. Only 44 comets from the whole population can be called 'new' in the dynamical sense. A detailed description of this investigation including also a discussion of the stellar perturbations and physical properties of long–period comets can be found in (Dybczyński, 2001).

References

Dybczyński, P.A.: 2001, submitted to *Astron. and Astrophys.*
Heisler, J. and Tremaine, S.D.: 1986, *Icarus*, **65**, 13.
Oort, J.H. and Schmidt, M.: 1951, *Bull. Astron. Inst. Nether.*, **11**, 259.
Yau, K., Yeomans, D. and Weissman, P.: 1994, *MNRAS*, **266**, 305.