Different History of Comets C/2001 Q4 and C/2002 T7?

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Motivation

C/2001 Q4 NEAT and C/2002 T7 LINEAR, are widely regarded in the literature as dynamically new comets, for the first time visiting the planetary system from the Oort Cloud. It seems, however, that in the standard model of non-gravitational (NG) acceleration [6] one of them is a dynamically new (C/2002 T7) while the other (C/2001 Q4) has visited the inner part of Solar System during the previous perihelion passage [5]. On the other hand, both comets were included [5] into the group of five comets (together with C/1990 K1, C/1993 A1, C/2003 K4) for which – despite of significant improvements of orbit determinations when standard model of NG acceleration is included – some systematic deviations in the O-C (observed minus calculated values) time variations were detected in the NG motion (see Figure 1).

New approach

We examine the past evolution of both comets by exploring a grid of $3/4 \times 3/4$ models using different criteria of astrometric data compilation as well as different models of NG acceleration, $a_i = A_i \cdot h(r) i = 1, 2, 3$, where $A_i$ are NG parameters fitted to data and the dimensionless function $h(r)$ takes one of the forms:

- STD based on water sublimation [6]
  
  \[ g(r) = 0.1113 (r/2.808)^{-2.15} \left[ 1 + (r/2.808)^{5.093} \right]^{0.6142} \]

- GEN generalized $g(r)$ with fitted parameters
  
  \[ g'(r) = \alpha (r/r_0)^{-\beta} + (r/r_0)^{-\gamma} \]

- YAB based on CO sublimation [7]
  
  \[ f(r) = \frac{1.0006}{r^2} × 10^{-0.07295(r−1)} \left( 1 + 0.0006r^2 \right)^{-1} \]

Different forms of NG force do not solve the problem of trends in O-C diagrams taken for complete astrometric data sets. The reason lies in unusual activity of both comets at small perihelion distance that is impossible to be modeled with single set of 3 or 4 NG parameters determined from the entire data set.

Method of calculations

For each comet we construct a dedicated grid of 9/12 independent starting osculating swarms of 5 000 orbits (VC orbits well-fitted to data); each swarm is based on different subsets of positional data and different dependence of NG acceleration on the heliocentric distance.

Next, we follow numerically each VC orbit in the swarms one orbital revolution to the past taking into account planetary and Galactic perturbations and checking for all known stellar perturbers [1][3]. This method allows us to obtain the orbital elements and their uncertainties at the previous perihelion passage (more details one can find in [5] & [4]).

Results in short

- Generalized $g(r)$-like function seems be more adequate to describe the NG effects than the standard $g(r)$-function in the motion of both comets but we were able to estimate only two parameters: scale distance $r_0$, and the exponent $\eta$. Results are summarized in Figure 3 and are in agreement with [2].

- The greatest change in the previous perihelion value related to that obtained in the standard approach results from the type of data subset used for the NG orbit determination. The form of the dependence of NG acceleration on heliocentric distance is of the secondary importance for both investigated comets in this context (see Figure 4).

- Only comet C/2002 T7 passed far beyond the planetary system during its previous perihelion passage while C/2001 Q4 was probably well inside the Saturn orbit at previous perihelion orbit (see Figure 4).

References


http://apollo.astro.amu.edu.pl/WCP

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