Towards a better understanding of the apparent source of long period comets

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We report the current status of the on-going project aimed at advancing our understanding of the source or sources of the actual long-period comets (LPCs). For the last several years, we have been developing several new methods and numerical packages to study, in detail, the motion of well-observed LPCs. Our main goal is to increase the thoroughness and precision of each step, starting from a sophisticated astrometric observation treatment through osculating orbit determination with different dynamical models, including different formulations of non-gravitational forces (NGF) and, if necessary, adjusting the observational interval to obtain the most accurate past (original) and future orbits. Then we trace the LPC motion for one orbital period backward and forward. In this last step, we fully take into account Galactic perturbations as well as the gravitational influence of all known potential stellar perturbers acting during the relevant time interval around present time. At each step, we carefully propagate observational uncertainties by means of replacing each comet with a swarm of thousands of randomly generated virtual comets, all fully satisfying observational constraints.

At the current stage of the project, we have determined osculating orbits for over 100 LPCs, some of them in several different variants. We carefully chose the appropriate variant for past and future studies of motion and follow numerically the LPC motion up to 250 au distance from the Sun, obtaining original and future orbits.

To study their motion further, we have selected over 90 stars as potential perturbers and include their influence in the numerical integration of cometary motion. Our computer tools are fully prepared to use more stellar data, e.g., from the Gaia mission.

We already noticed several important facts:

1. Including NGF in the osculating orbit determination process improves significantly our knowledge on the past and future motion of the comet.

2. In case of well observed comets with long periods covered with astrometric data, it can be fruitful to obtain original or future orbits not from the whole set of observations but from shorter arcs, e.g., to exclude observations close to perihelion, where violent non-gravitational effects can disturb the comet motion.

3. Taking into account the observational uncertainties for $1/a$-distribution of original/future orbits, we produce a detailed shape of the famous 'Oort spike' that fully reflects observational constraints.

4. We found that a significant percentage of LPCs have their previous perihelia deep in the planetary region — as a result, one cannot treat them as 'new comets' since they experienced both planetary perturbations and solar radiation heating at least during their previous perihelion passage.

5. The widely used concept of the Jupiter-Saturn barrier should be revised since a significant number of LPCs can migrate through it without any significant orbital changes.

6. None of the known stars have significantly changed any of the studied LPCs orbits.

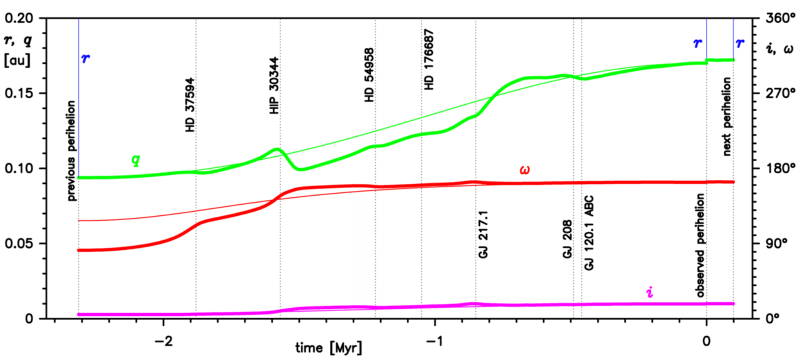

Figure: Example of the orbital evolution of a comet — the famous comet C/2006 P1 McNaught. Thin lines – stellar perturbations excluded, thick lines – full model. Angular elements are in the Galactic frame. Several individual stellar perturbations are marked.