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# Dynamics of main-belt comets: a role of non-gravitational effects

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## Abstract

In this work we have investigated a role of the Yarkovsky thermal effect on the long-term dynamical stability of the main-belt comets (MBCs). Here we present our preliminary results.

## 1. Introduction

MBCs are objects that are dynamically indistinguishable from main belt asteroids, but which exhibit comet-like activity due to the sublimation of volatile ice [5]. To date, seven such objects have been discovered.

Dynamical simulations show that it is unlikely that present-day objects with main-belt orbits originated in the Kuiper Belt, assuming the current configuration of the major planets [2]. This indicates that MBCs are likely native to the main asteroid belt. Still, Levison et al. show that during the early violent dynamical evolution of giant planet orbits, as required by the so-called Nice model [12, 11, 3], some icy trans-Neptunian bodies may have been transported in the asteroid belt [10]. It is expected that most of these objects are located in the outer belt, but they might be found anywhere with semi-major axes larger than about 2.6 AU.

Also, numerical simulations performed to assess the dynamical stability of MBCs suggest that the orbits of the currently known objects are stable, supporting an idea that they are likely native to their current locations [4, 7, 6]. The only exception is P/2008 R1 (Garradd), which appears to be dynamically unstable [8]. These simulations, however, did not take into account non-gravitational effects, that may play an important role in the long-term stability of the MBCs.

Similarly as in the case of "regular" comets, the activities of MBCs are only episodic and usually detectable only at (or close to) their perihelion passages. Consequently, a rate of mass-loss of the MBCs is relatively small, and, thus, its effect on the long-term dynamics of these objects is a limited. In contrast, a role of the Yarkovsky effect [1] should not be neglected as most of the MBCs are small objects. This is the problem we address here.

## 2. An example: P/2010 R2 (La Sagra)

In order to estimate the role of the orbital uncertainty and of the Yarkovsky force on the stability of LaSagra, we investigate dynamical stability for a set of statistically equivalent orbits. We took into account the current orbital uncertainty of the nominal orbit and different possible evolutions of the semi-major axes due to the Yarkovsky effect. First, a set of 100 clones was drawn from $3\sigma$ interval of the formal uncertainties of orbital elements (assuming Gaussian distribution). Then, for each of the orbit clone an additional set of 20 different 'yarko' clones was generated as well. These clones are uniformly distributed over the interval stretching from zero to the maximum expected drift due to the Yarkovsky force, which is in the case of LaSagra estimated to be $2.9 \times 10^{-4}$ AU/Myr. In this way a total of 2000 statistically equivalent clones were produced.

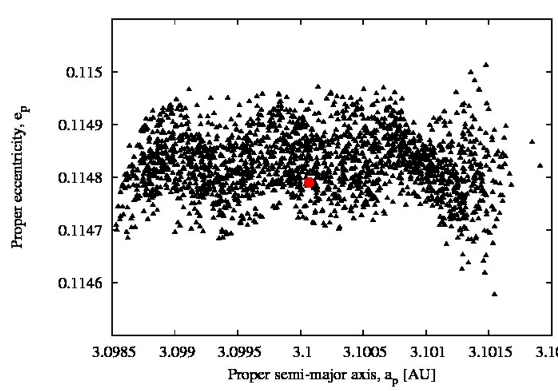


Figure 1: The distribution of 2000 clones of LaSagra main-belt comet in the proper elements space. The position of the nominal objects is shown as a large red circle.

The orbits of the clones were numerically propagated for 10 Myr using the *Orbit9* software, and, subsequently, their synthetic proper elements [9] were calculated. A preliminary obtained results are shown in Fig. 1. According to these results Yarkovsky induced drift of the orbital semi-major axis may significantly change dynamical stability of this main-belt comet.

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