Dynamical Constraints on the Origin and Activation Mechanism of Main Belt Comets.

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Introduction: Recent observations of icy objects in the asteroid belt have identified a new class of bodies known as Main Belt Comets (MBC). These objects that are dynamically similar to the main belt asteroids (e.g., Tisserand numbers larger than 3), present physical characteristics (e.g., dusty tails) that resemble those of comets. The discovery of main belt comets has raised many questions regarding their origin, regions of existence, activation mechanism, and their possible contributions to the water on Earth. I present the results of an extensive numerical study of the dynamical evolution and collision probability of these objects. I will discuss the results within the context of the Nice model and the in-situ formation, as possible scenarios for the origin of MBCs. I will also present the results of a systematic numerical study of the collision of main belt comets. Observations suggest that collisions between km-sized bodies and m-sized objects may be the possible triggering mechanism for activation of MBCs. I will show the results of the collisions of m-sized bodies with MBCs and discuss their collision probability. I will also discuss the scattering of MBCs to the inner solar system and the possibility of their contribution to the formation of Earth and its water.

Dynamical Evolution and Origin: The stability of the three known main belt comets and several of their clones were studied for different values of their semi-major axes, eccentricities, and inclinations. Results indicate that in the vicinity of the current MBCs (i.e. at ~ 3.2 AU), the clones with eccentricities below 0.2 and inclination smaller than 20 degrees were stable for 1 Gyr. Clones with larger eccentricities and inclinations were ejected from asteroid belt. Figures 1 shows the regions of stability around the two MBCs Elst-Pizarro (top) and Read (bottom), respectively.

The simulations also showed that the majority of unstable MBCs were scattered to large distances. Less than 20% of the unstable MBCs reached the terrestrial region of the solar system and among them only 5% reached the region where they could have been accreted by Earth. This implies that the contribution of MBCs to Earth's water budget is significantly small. The fact that the MBC clones with large eccentricities and inclinations were unstable implies that MBCs may not be the objects that were scattered into the asteroid belt from outer solar system. Simulations show that the majority of such objects enter the asteroid belt at high inclinations and in highly eccentric orbits. The orbits of these objects soon become unstable and they are scattered back to large distances. The out-scattering of these objects suggests against the possibility of their being the origin of main belt comets. This also agrees with the fact that the color of MBCs are much different from those of farther objects such as Kuiper belt comets. The simulations support the idea that MBCs may indeed have formed in-situ at times when the snow line was at closer distances.

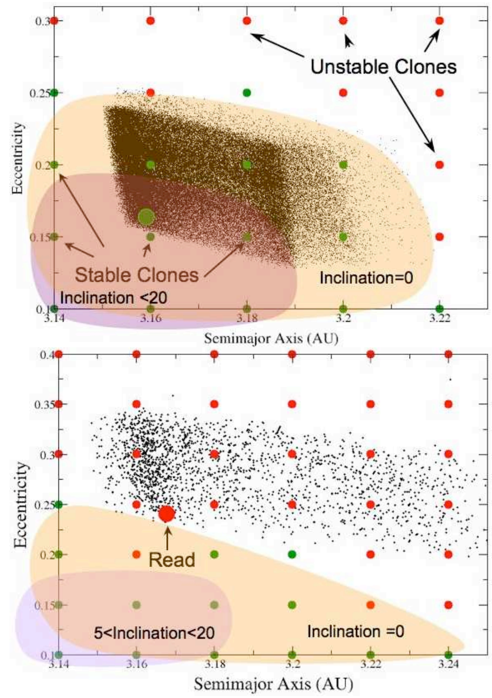

Fig1. Regions of stability of MBC clones in the vicinity of Elst-Pizarro (top) and Read (bottom). The red clones are unstable while the green ones maintained their orbits for 1 Gyr. As shown here, the MBC Read is in the unstable region.

Collision Probability & Activation Mechanism: Observations imply that collisions between m-sized objects and km-sized MBCs may be the triggering mechanism for the activation of these objects. To examine this idea, several thousand m-sized particles, with different eccentricities and inclinations, were randomly distributed throughout the asteroid belt, and their motions were numerically integrated. Results show that the rate of collision of m-sized bodies with MBC clones in 3.2 AU region of asteroid belt is, on average, one in more than 5000 years. I will present more details of the results of these simulations, and discuss their applicability to the existence and triggering activations of MBCs at other parts of asteroid belt.

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