**ON THE ROLE OF THE LUNAR EJECTA IN THE MINIMOON POPULATION.**

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**Introduction:** Minimoons are small objects (1-10 m size) that are temporarily captured by the Earth [1,2,3]. In-depth numerical calculations of the orbital distribution and lifetime of the objects that can come from the main asteroid belt were performed in [1,2].

In this work, we consider the contribution of ejecta from lunar impact craters to the minimoon population.

**Methodology:** To this end, we propagated the orbits of 120 particles that are ejected from the lunar surface at different speeds (in the range 2.38-5.4 km/s, to include both the classical escape speed and higher values, e.g. [4]), considering 100 initial locations and epochs, for a maximum time span of 54 million years. The total number of particles is thus 12000. During the propagation, if the geocentric Keplerian energy is negative within three Hill radii from the Earth, then we recorded the state of the particle, with a timestep of 0.1 day. If a particle collided with the Moon or a planet or escaped from an extended “Intermediate Source Region” (ISR) [2], then it was removed from the simulation.

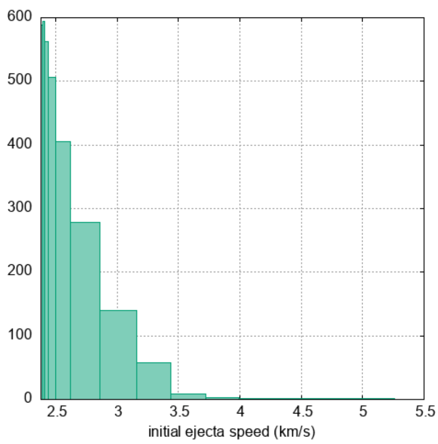


**Figure 1 Initial ejecta speed (km/s) from the lunar surface for the particles that experience a weak capture.**

In this way, we estimated the steady-state population of minimoons of lunar origin and we compared it with the steady-state population coming from the main belt.

**Results**: The outcome shows that the range of speed selected is exhaustive in simulating the particles that can be temporarily captured. As a matter of fact, the highest lunar speed enabling capture is 5.26 km/s (see Fig. 1).

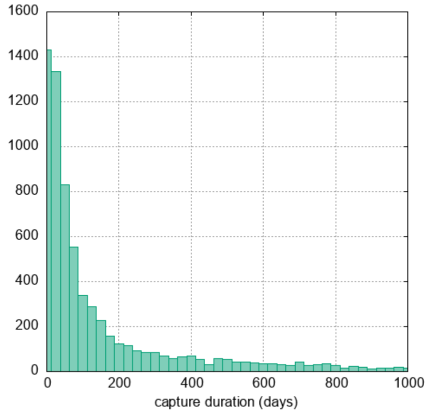


**Figure 2 Capture duration (days) frequency if it is less than 1000 days.**

The capture lifetime is consistent with the results obtained in [1,2] (see Fig. 2), although we have also detected very long capture configurations (see Fig. 3). A possible responsible for this is the Moon, considered as a separate body [1]. The existence of these solutions can indicate natural corridors of temporary capture. An interesting result in this direction, that was not noticed before, because the focus of the previous works was different, is the fact that the temporary capture corresponds to a quasi-satellite configuration inside the Hill’s sphere (see Fig. 3). This is a specific co-orbital regime, described in [5,6]. The same idea of “natural temporary capture corridors” could be supported by the analysis done in [7], that shows that the cost to extend a temporary capture in Earth orbit can be very cheap (up to 10 m/s).

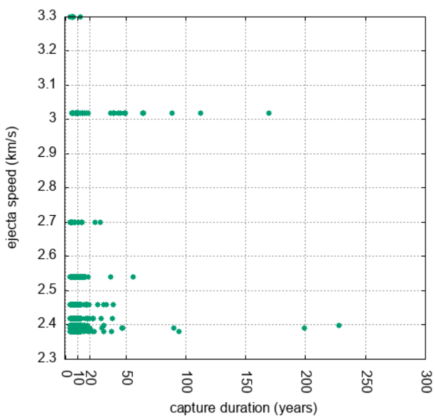


**Figure 3 Cases of capture longer than 3 years.**

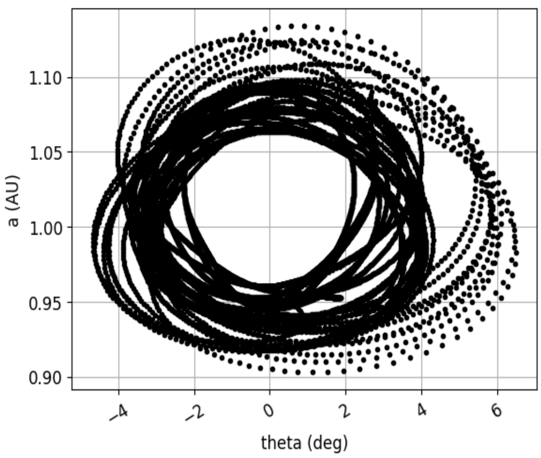


**Figure 3 Example of quasi-satellite behavior corresponding to a temporary capture.**

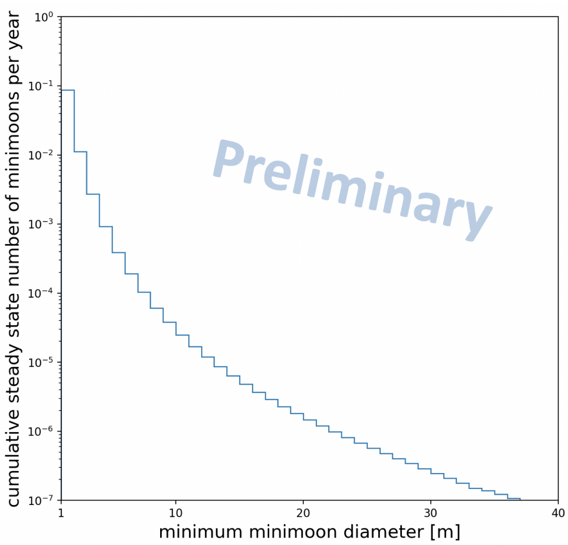


**Figure 4 Minimoon size-frequency distribution from lunar ejecta.**

The results of the integration were then used to determine the fraction of ejecta that become temporarily captured and their average lifetime as minimoons, both as a function of their ejection speed. We also tracked whether the captures were 'prompt', within the first 10 days after ejection, or 'delayed'. Combining these results with an impactor size-frequency distribution and rate [8], an impactor speed distribution [9], a crater scaling relation [10], and the relationship between ejecta speed and diameter [11], allowed us to calculate the steady-state number and orbit distribution of Earth's minimoons (see Figs. 4 and 5).

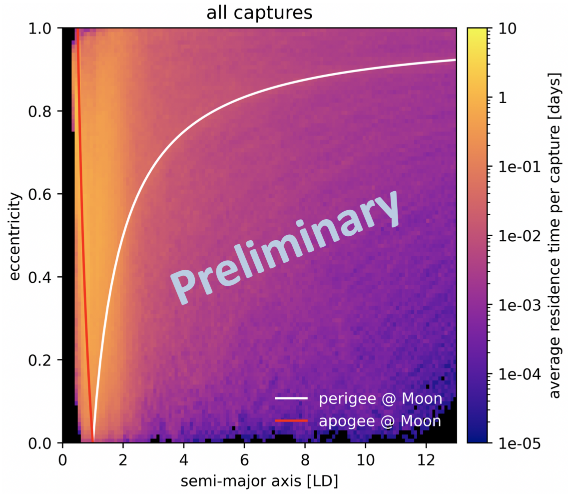


**Figure 5 The average residence time of minimoons of lunar origin in geocentric semi-major axis bins of 0.1 lunar distances (LD) and 0.01 in eccentricity.**

**Conclusions:** We find that the steady-state annual number of minimoons of 1 meter diameter or larger of lunar origin is about 0.1, about 10x smaller than the estimated population of minimoons of main belt provenance.

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