Earth's temporary satellites – population, observations and prospects ⋆

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Abstract. The current knowledge on the Earth's temporary satellites will be presented. Their predicted populations and conducted observations will be discussed together with the prospects for future observations and other studies.

Keywords: asteroids · near-Earth objects · temporary moons

Background

The population of Earth's temporary satellites, colloquially known as minimoons, is a steady-state sub-population of near-Earth asteroids captured on a temporary orbit around the Earth [2]. In order to become a temporary moon, the asteroid is required to make at least one orbit equivalent while being geocentrically bound to the Earth.

The observable size range of temporary satellites (1-10 m) lies in an area undercharted by either surveys or bolide detectors. Therefore, studying their population-level statistics opens the path to bridge the gap in the size-frequency distribution studies of near-Earth asteroids between 50-m-sized asteroids and small grains. Moreover, due to the close approaches to the Earth and spending significant time in its vicinity, temporary satellites provide a natural pool of accessible space mission targets [5, 6] and viable test objects for the first steps of asteroid *in situ* resource utilisation [3, 9].

Population

The population of temporary moons is a sub-population of near-Earth asteroids, "leaking" from the main asteroid belt [8]. It has been estimated that at any given time, the largest object on a temporary geocentric orbit is 75 cm in diameter, and an object with a 3 m diameter appears every 10 years[2, 7]. Theoretical predictions [2, 7] indicate that temporary moons spend on average around 9 months in the Earth's vicinity, making 3 orbits. Only around 1% of all temporary moons impact the Earth during their capture.

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Observations

To date, two temporary satellites have been discovered, both by the Catalina Sky Survey: 2006 RH_{120} [1] and 2020 CD_3 [12, 13]. In terms of detectability, temporary satellites suffer from the same detection challenges as other very small asteroids (i.e. faintness, trailing losses). However, the additional challenge appears because their orbits are similar to distant artificial launches. Thus, their natural origin needs to be confirmed, typically by measurements of the objects' solar radiation pressure signature. The capture duration of 2.5 years of 2020 CD_3 have raised questions whether the close approaches to the Moon play a higher role in capturing temporary moons than anticipated earlier. Recently, asteroid 2022 NX_1 became gravitationally bound to the Earth without completing a single orbit [15], being a first detected example of a predicted transitional population called a temporily-captured flyby, or drifter.

Predictions

The Vera C. Rubin Observatory's Legacy Survey of Space and Time [10] is expected to be the most prominent discovery facilioty of temporary moons in the upcoming decade [4]. It is estimated that the baseline LSST pipeline will be able to detect minimoons on an annual basis, but a dedicated pipeline could improve the detection rate to a level of once every three months [11]. The work on a dedicated pipeline and updating the detectability estimates with refined cadence and tools, including comparisons of linking algorithms is currently ongoing.

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