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The Distribution of Q-types among NEOs

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Abstract

We present the orbital distributions of ∼40 spectral Q-type near-Earth asteroids. Their spectra are consistent with a young, fresh surface indicating they have recently (< 1My, [1]) been altered. Through these orbital distributions we seek to further constrain both how and when their surfaces are freshened. The relative scarcity of Q-types with semi-major axes just greater than 1 AU compared with Atens (a < 1 AU) leads us to investigate the orbital effects of a close planetary encounter. The existence of Q-types with large perihelia (q > 1.2 AU) leads us to consider additional freshening mechanisms to Earth encounters.

1. Introduction

Asteroids found most commonly among NEOs that match ordinary chondrites, spectroscopic Q-types, are expected to have had their surface regolith disturbed, overturning the space weathered grains and revealing a fresh, young surface. Multiple mechanisms have been postulated to cause this freshening such as tidal effects from close planetary encounters, YORP spinup, asteroid collisions, and electrostatic levitation of grains from passing through Earth's magnetosphere [2-7]. Based on a dataset of 95 objects, Binzel et al. [4] find that all 20 spectral Q-types have an extremely low Minimum Orbit Intersection Distance (MOID) to the Earth. They propose that Earth tidal forces due to close Earth encounters, as suggested by Nesvorny et al. [2], are the dominant mechanism for surface refreshening. Nesvorny et al. [5] note that the orbital distribution of these Q-types is potentially bimodal. Due to the difficulty simultaneously simulating both the low and high semi-major axis groups and they suggest perhaps this bimodality is due to two different freshening mechanisms.

2. New Investigation

As part of the MIT-UH-IRTF Joint Campaign for NEO Spectral Reconnaissance [8], we have increased the sample size to about 40 Q-type NEOs. Ten of these have visible and near-infrared data, the others that have near-infrared data have gone through a series of tests to determine they are much more likely Q (fresh) than Sq (moderately weathered).

By examining the orbital distribution of Q-types we seek to understand how and when their surfaces are refreshed. We examine what seems to be a difference in the abundance of Q-types with semi-major axes just inside of and outside of Earth's orbit. Dynamically there should be no difference between these regions of space. Because objects residing in this region are expected to frequently encounter Earth, we seek to understand how a planetary encounter affects the orbit. By computing many artificial NEO trajectories originally for the purpose of planning the NEOSSat pointing strategy [9], we investigate whether the post-encounter orbital distribution of NEOs suffering extremely-close Earth and Venus encounters is the same as for the general NEO orbital distribution.

We will also investigate a few Q-type objects with perihelia distances greater than 1.2 AU. MOID calculations, performed in the same manner as in [4], will reveal whether these asteroids have an orbital history that allows an encounter with Earth. Alternative freshening mechanisms such as Mars encounters or YORP spinup will be explored for these asteroids.

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