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# The Earth-Impact Risk of Manx Comets

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## Manx comets

Much of the contemporary work on Near-Earth Object (NEO) detection is focused on discovery of Near-Earth Asteroids. Near-Earth Comets also pose a risk to life on Earth. After a few more decades of NEO searches, a larger fraction of the remaining risk will lie with Near-Earth Comets, which are difficult to detect well in advance.

Pan-STARRS has detected a new class of comets, which have been referred to as “Manx comets,” named after the Manx cat that has no tail. The Pan-STARRS1 telescope is the most prolific discoverer of Manx comets. These objects have comet-like (parabolic or near-parabolic) orbits, but have low or no activity, displaying little or no tail. The first such object, C/2014 S3 (PANSTARRS) [1], has a spectral reflectivity similar to inner solar system S-type asteroids, suggesting that these objects may represent asteroidal material ejected into the Oort cloud, and that these find their way into the inner solar system via the same mechanisms as long-period comets. Due to their very low volatile activity, the Manx comets are much fainter than normal long-period comets of similar size.

The Earth-impact risk from Manx-type comets will be evaluated based on our current knowledge of these objects, and compared to the risk from other comets and Near-Earth Asteroids. Since the Manx comets appear to be made of rocky material like asteroids, they have higher densities than long-period comets. Earth impact velocities from Manx comets are similar to those from long-period comets, and significantly faster than from asteroids. 4000+ synthetic Earth-impacting long-period parabolic orbits were simulated to show the evolution of brightness and motion of Manx comets as they approach (with their anomalous motion, rather than cometary nature, leading to discovery). The Manx population were generated with a size-frequency distribution (SFD) matching that of S-type asteroids – the current SFD for Manx comets is unknown though this work is in progress [3]. The orbital parameters, ephemeris cut-off and typical characteristics of S-type asteroids are given in Table 1. The population distribution against the absolute magnitude, semi-major axis and eccentricity in Figures 1 to 3.

## Results, Further Work and Conclusion

4-detection tracklets were created for each night that the object is visible (V < 23.5) from the Pan-STARRS1 observatory [4,5,6]. The tracklets were individually evaluated through the NEO Digest2 score [2]. The Digest2 score is considered to be a good indicator of the likelihood that an object is of a certain orbit class. NEO candidates above the threshold score > 65 are posted to the NEOCP. This work is still ongoing. Thus far, the Digest2 score for tracklets from 183 orbits have been plotted against the number of days from impact in Figure 4. Figure 4 demonstrates that most tracklets would be ranked beneath the NEO threshold and would never post to the NEOCP and of those that do, we should expect relatively short warning times for this type of Earth-impactor unless the current warning system can be improved or a new one implemented.

## Figures

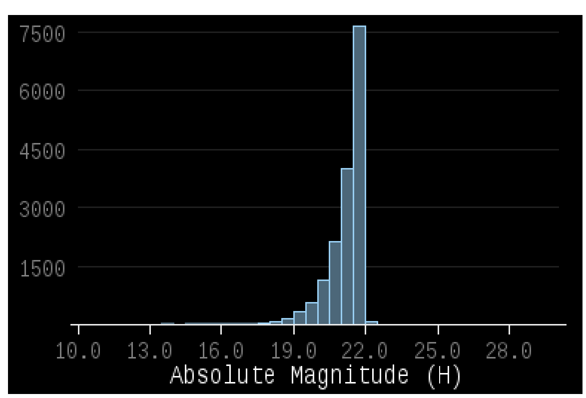


**Figure 1: Synthetic population distribution with respect to the absolute magnitude (H).**

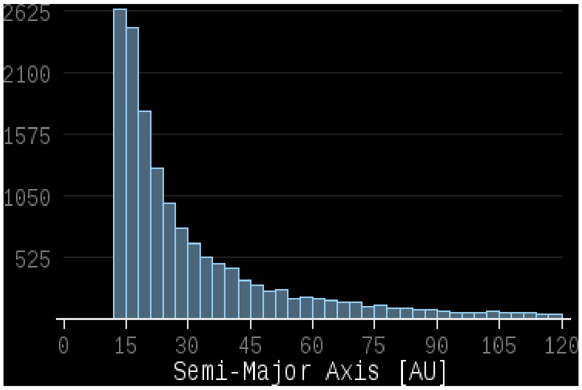


**Figure 2: Synthetic population distribution with respect to the semi-major axis.**

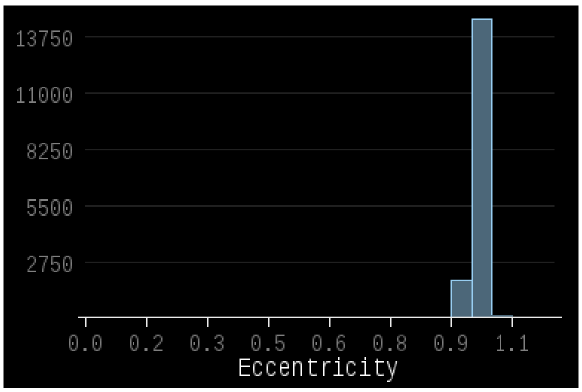


**Figure 3: Synthetic population distribution with respect to the eccentricity.**

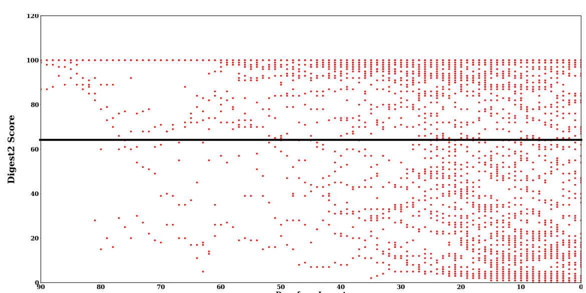


**Figure 4: NEO Digest2 score vs Days from Impact for 183 orbits. Most tracklets would never post to NEOCP. Tracklets with score > 65 (shown by the black line) indicate the relatively short warning time expected.**

# Tables

**Table 1: Parameters for generating synthetic orbits.**

| | |
|---|---|
| **Radial Velocity** | 98 % to 99.% of escape velocity |
| **Impact dates** | Jan 01 2014 to Jan 01 2019 |
| **Period** | > 200 years |
| **Perihelion dist.** | q < 6 AU |
| **Aphelion dist.** | Q > 35 AU |
| **Slope of SFD** | $N(H) \propto 10^{\alpha H}$; $\alpha = 0.5$ |
| **Ephemeris** | |
| $V_{mag}$ | < 23.5 |
| **Altitude** | Object > 20º, Sun < 12º |
| **S-Type Asteroids** | |
| **Mean albedo** | 0.184 ± 0.011 |
| **Mean G** | 0.227 ± 0.020 |
| **Density** | 2.71 g $cm^{-3}$ |

# References

[1] Meech, K..: Inner Solar System Material Discovered in the Oort Cloud, Science Advances Vol. 2, no. 4, e1600038

[2] Keys, S. et al.: The Digest2 NEO Classification Code, PASP 131 064501, 2019.

[3] Boe et al.: The Orbit and Size-Frequency Distribution of Long Period Comets Observed by Pan-STARRS1, submitted.

[4] Skyfield: https://rhodesmill.org/skyfield/

[5] Meeus: Astronomical Algorithms

[6] Heafner: Fundamental Ephemeris Computations