Properties and evolution of near-Earth-object families created by tidal disruption at the Earth

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We have calculated the coherence and detectable lifetimes of synthetic near-Earth object (NEO) families created by catastrophic disruption of a progenitor as it suffers a very close Earth approach. The closest or slowest approaches yield the most violent 'S-class' disruption events and create a 'string of pearls' configuration of the resulting fragments after their reaccummulation into gravitationally bound components [3]. We found that the average absolute magnitude (H) difference between the parent body and the largest fragment is $\Delta H \sim 1.0$. The average slope of the absolute magnitude (H) distribution, $N(H) \propto 10^{(0.55\pm0.04)\,H}$, for the fragments in the S-class families is steeper than the slope of the NEO population [2] in the same size range.

The families remain *coherent* as statistically significant clusters of orbits within the NEO population for an average of $\bar{\tau}_c = (14.7 \pm 0.6) \times 10^3$ years after disruption. The *detectable* lifetimes of tidally disrupted families are extremely short compared to the multi-Myr and -Gyr lifetimes of main belt families due to the chaotic dynamical environment in NEO space — they are *detectable* with the techniques developed by [1] and [4] for an average duration ($\bar{\tau}_{det}$) ranging from about 2,000 to about 12,000 years for progenitors in the absolute magnitude (H_p) range from 20 to 13 corresponding to diameters in the range from about 0.5 to 10 km respectively. The maximum absolute magnitude of a progenitor capable of producing an observable NEO family (i.e. detectable by our family finding technique) is $H_{p,max} = 20$ (about 350 m diameter). The short detectability lifetime explains why zero NEO families have been discovered to-date. Nonetheless, every tidal disruption event of a progenitor with diameter greater than 0.5 km is capable of producing several million fragments in the 1 m to 10 m diameter range that can contribute to temporary local density enhancements of small NEOs in Earth's vicinity.

These objects may be suitable targets for asteroid retrieval missions due to their Earth-like orbits with corresponding low v_∞ which permits low-cost missions. The fragments from the tidal disruptions evolve into orbits that bring them into collision with terrestrial planets or the Sun or they may be ejected from the solar system on hyperbolic orbits due to deep planetary encounters. The end-state for the fragments from a tidal disruption at Earth have $\sim 5\times$ the collision probability with Earth compared to the background NEO population.

References: [1] Fu, H., Jedicke, R., Durda, D.D., Fevig, R., Binzel, R. P., Icarus 178, 2, 434–449 (2005). [2] Mainzer, A., and 36 co-authors, Volume 743, Issue 2, article id. 156, 17 pp. (2011). [3] Richardson, D. C., Bottke, W. F., Love, S. G., Icarus 134, 1, 47–76 (1998). [4] Schunova, E., Granvik, M., Jedicke, R., Gronchi, G., Wainscoat, R.J., Abe, S., Icarus 220, 1050–1063 (2012).