LONG-TERM DYNAMICAL EVOLUTION OF TRANS-NEPTUNIAN OBJECTS IN THE SCATTERED DISK. P. S. Lykawka[1], and T. Mukai[1], [1]Kobe University, Dept. of Earth and Planetary Sciences, Kobe, Japan – patryk@dragon.kobe-u.ac.jp.

Introduction: The study of trans-Neptunian objects (TNOs) offer important clues about the origin and evolution of the solar system [1]. These icy/rocky objects orbit in two reservoirs: the Kuiper belt and the scattered disk, at typically semimajor axes $a>48$AU [2]. Observations have been revealing a complex structure with the existence of distinct dynamical populations in the scattered disk: scattered, resonant, and detached TNOs (perihelion $q>40$AU) [2,3]. TNOs in typical Neptune-encountering orbits (scattered TNOs) contribute to several distinct populations of minor bodies in the solar system, including the Centaurs (objects crossing the orbits of giant planets), and Jupiter-family, Halley-type and Oort cloud comets [4-7].

Motivation: Apart from gravitational scattering of planetesimals by Neptune [3], another important mechanism dictating the orbital evolution of scattered TNOs is resonance sticking, a phenomenon characterized by multiple temporary resonance captures during the object's dynamical lifetime ('resonances' refers to external mean motion resonances with Neptune, which can be described in the form *r:s*). We focus our work on resonance sticking over billions of years, thus providing a more complete description of the long-term behavior of these bodies in the scattered disk.

Methods: We numerically evolved a population of 22,380 particles lying initially on Neptune-encountering orbits over 4Gyr. The four giant planets were included at their current orbital positions in the calculations. The simulation was conducted using the symplectic integrator EVORB [8]. Finally, we used the RESTICK code [9] for resonance identification and calculation of resonant properties.

Main results: We found that all particles experienced multiple resonance trapping events during their lifetimes (4Gyr). Each body was typically captured tens or hundreds of times in various resonances across the scattered disk (on the averaged in 88 distinct resonances). In addition, we identified all detectable resonance captures and obtained their durations over the 4Gyr available for each particle. Scattered particles spent on average ~38% of their lifetimes trapped in resonances. Resonance sticking occurred mostly at $a<250$AU, corresponding to 99% of the time of all resonance captures in the sample that survived 4Gyr (255 objects). Finally, we also determined the resonance strength and stickiness for 464 identified resonances. Resonance strength was obtained by solving the strength function $SR(a,e,i,\omega)=\langle R\rangle-R_{min}$, where ω is the argument of perihelion, $\langle R\rangle$ is the averaged value of the resonant disturbing function R, and R_{min} is the minimum value of R [10]. Resonance stickiness was calculated as the ratio of cumulative total residence time in each resonance to the cumulative total time in all resonances (weighted by the number of trapped particles). Resonance stickiness illustrates the likelihood of capture into a resonance, and the ability of that resonance to retain a captured object (i.e., timescale). Worth noting, we found that longer temporary captures and higher capture probabilities during resonance sticking were associated with resonance strength.

Conclusions: 1) The depletion of scattered TNOs with time is better described by a non-random walk approximation; 2) All scattered TNOs evolve through intermittent temporary resonance captures and gravitational scattering by Neptune. Each scattered TNO experiences tens to hundreds of resonance captures over a period of 4Gyr, which represents about 38% of the object's lifetime (mean value); 3) Resonance sticking plays an important role at semimajor axes $a<250$AU, where the great majority of resonance captures occurred. In fact, the stickiest/strongest (i.e., dominant) resonances beyond 50AU are located within this distance range (resonances with smaller *s*); 4) The *r*:1 and *r*:2 resonances played the greatest role during resonance sticking evolution, often leading to captures in several of their neighboring resonances; 5) The timescales and likelihood of temporary resonance captures are roughly proportional to resonance strength.

Summary: Resonance sticking has an important impact on the evolution of scattered TNOs, contributing significantly to the longevity of these objects. This in turn would yield important consequences for the influx of Centaurs and comets in the inner solar system.

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