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Long-term evolution and resonance sticking of scattered disk objects

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The study of trans-Neptunian objects (TNOs) offer important clues about the origin and evolution of the Solar System. In particular, TNOs in typical scattered 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. We investigate the evolution of scattered TNOs over 4 Gyr by conducting simulations using several thousand particles lying initially on Neptune-encountering orbits. We focus our work on resonance sticking, a phenomenon characterized by multiple temporary resonance captures ('resonances' refers to external mean motion resonances with Neptune, which can be described in the form $r : s$, where the arguments r and s are integers). Our main results are:

1) The depletion of scattered TNOs with time is better described by a non-random walk approximation, following $\sim t^{-1.5}$ during the last 1.5 Gyr.

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 4 Gyr, 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 50 AU are located within this distance range (resonances with smaller s).

4) The r:1, r:2 and r:3 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.

In 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.