Planet Migration Via Numerous Stochastic Scattering Events

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Gravitational scattering of a planetesimal disk by recently-formed giant planets may have caused a significant readjustment of planetary orbits. Indeed, an early epoch of planet-migration is often invoked to explain the resonant structure observed in the Kuiper Belt. Had Neptune's orbit smoothly expanded outwards about 7 AU, its 3:2 mean-motion resonance would have swept across much of the early Belt, simultaneously capturing Kuiper Belt Objects (KBOs) and exciting their eccentricities (Malhotra 1993, 1995).

However it should be recognized that planet-migration via gravitational scattering is a stochastic process. To effect this in our planet-migration simulations we add some random jitter to the torque that drives Neptune's outward expansion. This jitter is parameterized by σ, which is the standard-deviation of the planet-migration torque in units of the time-averaged torque. Larger σ increases Neptune's to-and-fro motion as its orbit expands.

We are investigating whether this jitter can account for the e and i excitation observed in the Kuiper Belt. A system of four migrating giant-planets plus numerous massless KBOs has been evolved for various values of σ. We find that the Kuiper Belt's resonance structure can be preserved despite a surprisingly large amount of jitter. For instance, simulations with $0 \lesssim \sigma \lesssim 10$ are largely indistinct due to the very efficient capture of KBOs at resonances. However runs with larger jitter, $25 \lesssim \sigma \lesssim 75$, have reduced capture efficiencies. This allows for the development of a stirred up 'classical disk' as particles have their eccentricities pumped up as they slip through the 2:1 resonance. Substantial inclinations of $i \sim 10^\circ$ are also excited at the 3:2 resonance. Although a higher jitter of $\sigma \simeq 100$ results in a Kuiper Belt that is depleted interior to $a \simeq 45$ AU, inefficient capture still occurs at Neptune's 2:1 resonance. Further comparisons between model and observed endstates will be presented at conference time.

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