Secular Resonance Sweeping in a Self-Gravitating Kuiper Belt

J. M. Hahn (LPI), W. R. Ward (SWRI)

One of the more puzzling aspects of the Kuiper Belt is the high inclinations exhibited by Kuiper Belt Objects (KBOs). One possible explanation is that these high inclinations are due to sweeping secular resonances (Nagasawa and Ida 2000). In this scenario the depletion of the solar nebula's gas causes several secular resonances to sweep across the Kuiper Belt and excite substantial eccentricities and inclinations among massless bodies in a Kuiper Belt.

We have reexamined this scenario but for a Kuiper Belt having some modest mass. The secular evolution of our system is computed using a so-called N-ring integrator that treats all the giant planets and small bodies as gravitating rings whose mutual perturbations cause the rings to flex and tilt over time. The secular perturbations from an exponentially decaying nebula gas disk is also included. When this code is applied to a massless Kuiper Belt it reproduces the Nagasawa and Ida result, namely, that large KBO eccentricities and inclinations are excited under certain circumstances and for sufficiently slow dispersal of the solar nebula. But when the primordial Kuiper Belt has sufficient mass, roughly one-tenth the minimum mass, then the giant planets instead launch very long wavelength spiral density and spiral bending waves among the inner KBO rings, and these disturbances propagate further into the outer Kuiper Belt. We find that wave propagation dramatically reduces the level of dynamical excitation that occurs in the inner $a < 45$ AU part of the Kuiper Belt after nebular dispersal, with very low-level excitation instead occurring throughout the Belt.

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