Dusty White Dwarfs and the Late Stages of Planetary Systems

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Abstract

Observations of white dwarfs (WD) that show metal enrichment and dusty disks are thought to be caused by planetesimals that survive main sequence evolution and are subsequently disrupted by the central star. Studies of the chemical abundances and dynamics of these observed enrichments suggest that the material is consistent with terrestrial bodies, which links the dusty disk to the dynamical evolution of the planetary system, though the precise physical mechanism is not well understood. The recent study by Debes et al. 2012 used numerical N-body simulations to demonstrate that the dusty disk around white dwarfs can be produced by interior mean motion resonances (IMMRs) between a giant planet and surviving planetesimals. The IMMR perturbs the planetesimals from the asteroid belt into highly eccentric orbits that eventually cross close enough to the central star to be tidally disrupted. This method appears to be most efficient at the 2:1 IMMR, and can be shown to provide material to the disk over timescales comparable to what is needed to fit observations.

This study is important because it can help to tie down the eventual fate of solar systems similar to our own, as well as supplying information about the type of planetary systems that existed during the main sequence evolution of observed WDs. In particular, this method can be used to estimate the frequency and mass of asteroid belts as well as the characteristics of large surviving planets in WD systems.

The Debes et al. article explored the ability of IMMR to produce the observed WD characteristics starting with initial conditions found in our solar system. To fully understand the broad-scale applicability of this phenomenon as a whole requires understanding how it would behave in other solar systems beyond our own. Following the methods used by Debes et al., I wil use the MERCURY n-body simulation code to repeat the mass accretion simulation over a wider parameter space. By varying characteristics such as the mass of the central star, mass and semi-major axis of the large planet, and initial distribution of planitesimals, we will understand more about where IMMR is efficient at supplying mass to the central WD and to what type of systems we would expect this to be a significant factor.

References

Debes, J. H. and Walsh, K. J., Stark, C., 2012, ApJ, 747, 148