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Gas in Debris Disks - A New Way to Produce Patterns?

Debris disks should not be completely gas-free, since there is second generation gas from outgassing of planetesimals and dust grains via sublimation, photodesorption, or collisions, generating a system of dust-to-gas ratio close to unity, where hydrodynamics cannot be ignored. I show through linear and nonlinear modeling of the compressible problem that a robust clumping instability exists in this configuration. The model solves the momentum equation for the gas and dust, together with energy and continuity equations. It is found that the system evolves into sharp narrow rings, shepherded by the backreaction of the drag force from the gas onto the dust. The rings are similar to those observed in debris disks and usually attributed to the presence of hypothetical undetected planets. I also show that the eccentricity of these rings, usually presented as convincing evidence for the presence of a planet, can actually be simply explained by a standing wave propagating along the ring. The rings support a spectrum of oscillations, with one particular mode representing epicyclic motion. The apparent eccentricity matches the eccentricity in observed systems. This suggests that the planet possibility, though thrilling, is not necessarily required to explain these systems.