Disentangling the structure in debris disks: Planets or just gas?

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Outline

Brief intro. on debris disks

What is their importance?

How do we explain their structures?

Results pertaining to dust and gas

Future Research

What is a debris disk?

Leftover dust and gas around a star, remnants of planet formation

They have a radius of 10-100 AU in diameter.

They are optically thin and emit radiation in the infrared



Debris disks point towards planets



Planets \rightarrow arcs, clumps



TW Hydrae

Other than planets, is this structure possible?

Takashi Tsukagoshi et al.(2016)

It is...



HD 141569A



Perrot et al. (2016)

Lyra & Kuchner (2013)

Through photoelectric instability



Adapted from Whipple (1972)

Our research: Differentiate planets from gas



Kalas et. al (2012)

The Model

$$\begin{aligned} \frac{\partial \Sigma_g}{\partial t} &= -\left(\boldsymbol{u} \cdot \boldsymbol{\nabla}\right) \Sigma_g - \Sigma_g \boldsymbol{\nabla} \cdot \boldsymbol{u} \\ \frac{\partial \boldsymbol{u}}{\partial t} &= -\left(\boldsymbol{u} \cdot \boldsymbol{\nabla}\right) \boldsymbol{u} - \frac{1}{\Sigma_g} \boldsymbol{\nabla} P - \boldsymbol{\nabla} \boldsymbol{\Phi} - \frac{\Sigma_d}{\Sigma_g} \boldsymbol{f}_d \\ \frac{\partial S}{\partial t} &= -\left(\boldsymbol{u} \cdot \boldsymbol{\nabla}\right) S - \frac{c_v}{T} \frac{\left(T - T_p\right)}{\tau_T}. \\ \frac{d\boldsymbol{x}}{dt} &= \boldsymbol{v} \\ \frac{d\boldsymbol{v}}{dt} &= -\boldsymbol{\nabla} \boldsymbol{\Phi} + \boldsymbol{f}_d \\ \boldsymbol{f}_d &= -\frac{\left(\boldsymbol{v} - \boldsymbol{u}\right)}{\tau_f} \\ T_p &= T_0 \frac{\Sigma_d}{\Sigma_0}. \end{aligned}$$

Results of global disk model



Results from average dust density



Results from average gas density



More dust \rightarrow less gas



Conclusions:

We can only disentagle the effects of a jupiter-mass planet in these debris disks

Finding gaps in the gas density at the orbit of the planet

Finding higher densities of dust in the outer edges of the planet orbit

We also find a correlation between a high dust density paired with a low gas density