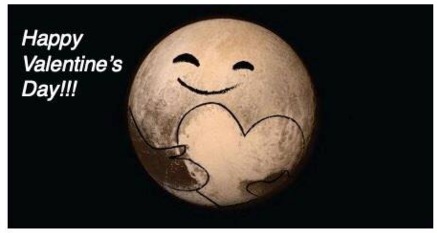
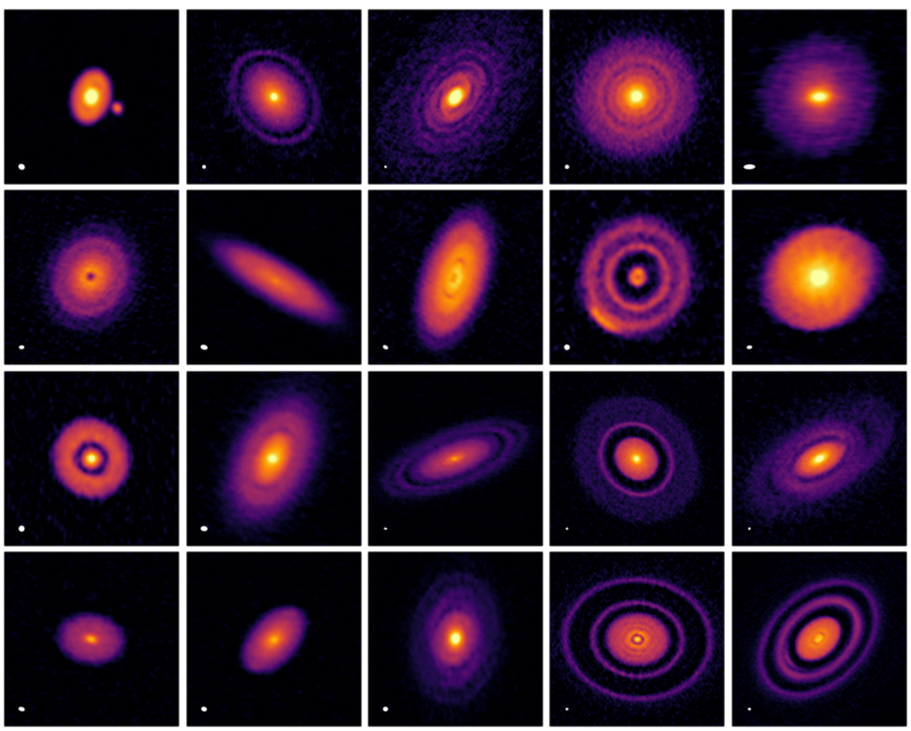


☐ Single

☐ Taken

☑ ***Studying for CUMES!***



Some of the DSHARP disks. Aren't they *lovely*?

Overview

This adorable cume is based on the paper **The DSHARP Rings: Evidence of Ongoing Planetesimal Formation?**, by Stammler et al. (2019). The paper is a short letter and should be a quick read.

The exam contains 8 questions, worth 54 total points. 40 points (75%) guarantees a pass.

Please make sure your writing is legible. I am not fluent in hieroglyphs and I cannot grade what I cannot read! Also, please show all work and do attempt each problem, showing your thought process even if you cannot solve it completely. If during the exam you have any question please email me (wlyra@nmsu.edu). I will also be accessible at the virtual zoom office `https://nmsu.zoom.us/j/7631131283`.

At the end of the exam, put your responses in question order, scan or photograph them, and upload them to the canvas assignment.

Context

1. (6 points) Explain the observation that this letter attempts to explain. Particularly, why is it surprising? Keep your answer brief ($\lesssim$ 5 sentences).

2. (6 points) Explain the proposed solution, and its implications for our understanding of planet formation. Keep your answer brief ($\lesssim$ 5 sentences).

Dust

3. (6 points) The paper often refers to the Stokes number, St, which is a nondimensionalization on the aerodynamical drag time of a dust grain $\tau_{\rm drag}$ in terms of the Keplerian orbital frequency Ω, i.e. $\mathrm{St} = \tau_{\rm drag}\Omega$. Its expression for the regime of interest is given by Eq. (3) of the paper

$$\mathrm{St} = \frac{\pi}{2}\frac{a\,\rho_s}{\Sigma_g}$$

   The same expression appears in Eq. (15), with superscripts i to signify different dust grains. Even though the grain radius a^i, varies from grain to grain, the internal density ρ_s is assumed the same for all grains. Justify this assumption. Again, keep your answer brief ($\lesssim$ 5 sentences).

4. (10 points) Eq. (6) relates the scale height of the dust layer h with the scale height of the gas H.

$$h = \sqrt{\frac{\alpha}{\alpha + \mathrm{St}}}\,H$$

where $\alpha < 1$ is the Shakura-Sunyaev dimensionless turbulent diffusion parameter ($D \propto \alpha$, where D is turbulent diffusion). The limits are $h = 0$ for $\alpha = 0$ or $\mathrm{St} = \infty$, and $h = H$ for $\mathrm{St} = 0$. Explain these limits qualitatively in terms of the physics of the problem, involving aerodynamical drag, turbulent diffusion, and the grain radius.

Diagnostics

5. (6 points) When reading a theoretical paper, it is often necessary to reproduce their analytics. Reproduce Eq. (7)

$$\tau_\nu = \frac{3\pi}{8}\sqrt{\frac{\alpha}{\mathrm{St}^3}}Q_\nu\frac{\rho_d}{\rho_g}$$

given the definitions given in Section 2.

Results

6. Fig. 2 shows emission profiles both convolved and non-convolved with the beam size. The angular resolution of ALMA is $\sim 0.''035$. HD 163296, like most of the nearby disks, is about 100 pc away. a) (3 points) Estimate from the figure the width of the emission profile and b) (3 points) explain why it is needed to convolve the model emission with the instrumental beam (keep your explanation brief, $\lesssim 5$ sentences).

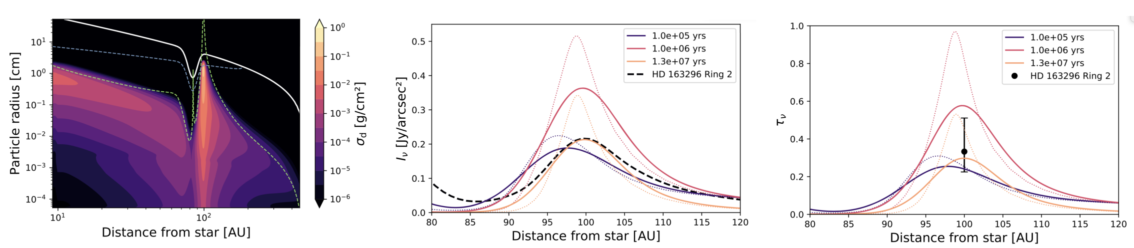


Fig. 2 from Stammler et al. (2019).

7. (6 points) In light of the evolution model described in Sect 3, why is the evolution of the intensity (and optical depth) shown in Fig. 2 non-monotonic in time?

Assumptions and Limitations

8. While the paper presents a very intriguing and exciting idea, a theoretical analysis is only as good as its assumptions. There are indeed many simplifying assumptions done throughout the paper. a) (4 points) Identify two of them, and b) (4 points)

describe how you think the results of the model would change if these particular assumptions were relaxed.