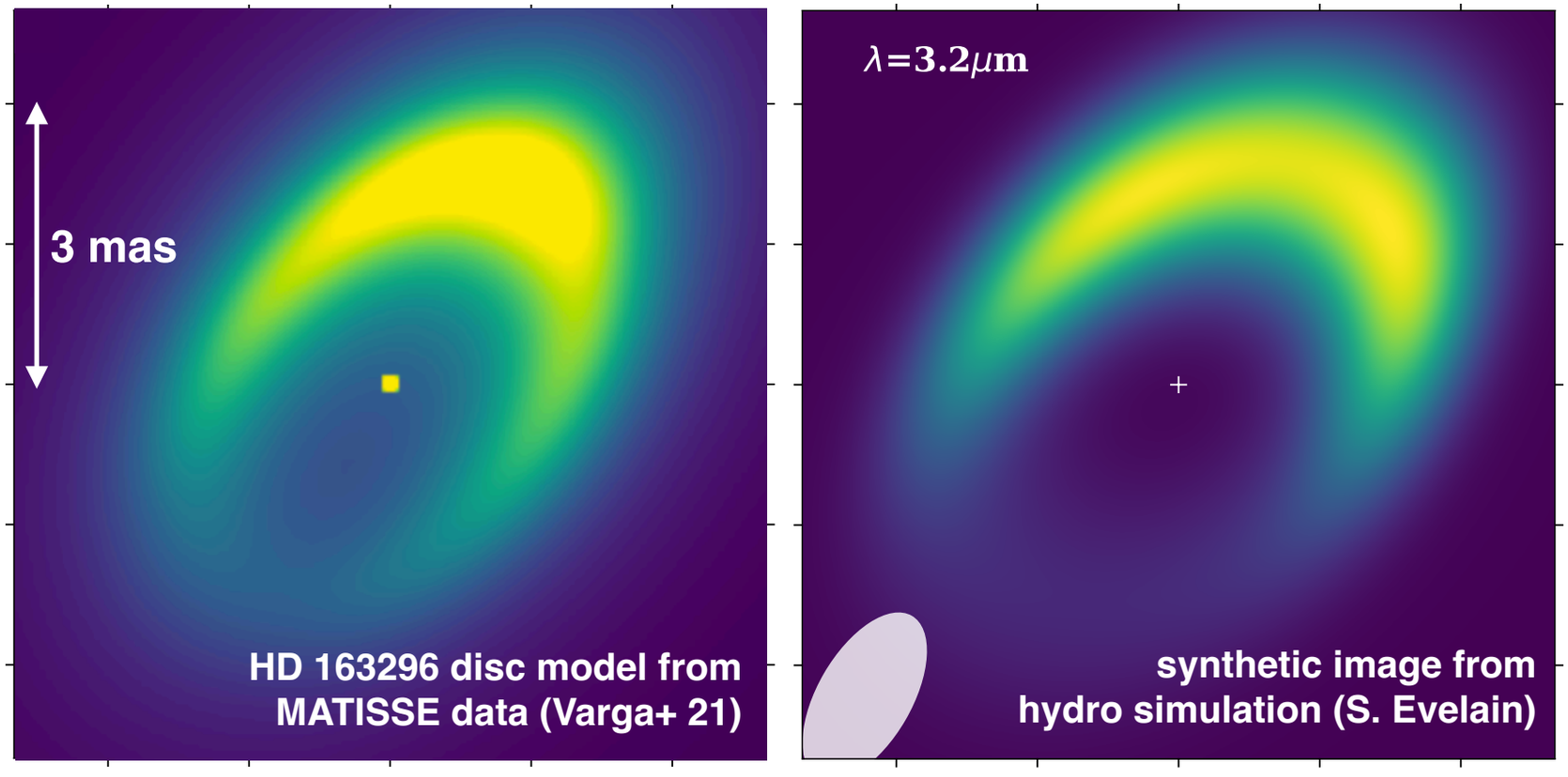
Some aspects of the dynamics of (inner) protoplanetary discs

Clément Baruteau (CNRS/IRAP, Toulouse)

&

Siméo Evelain (IRAP, 1st year PhD), **Héloïse Méheut** (CNRS/Lagrange, Nice)



MATISSE Science meeting, Nice, 7 November 2024

Motivation biased toward planet formation models

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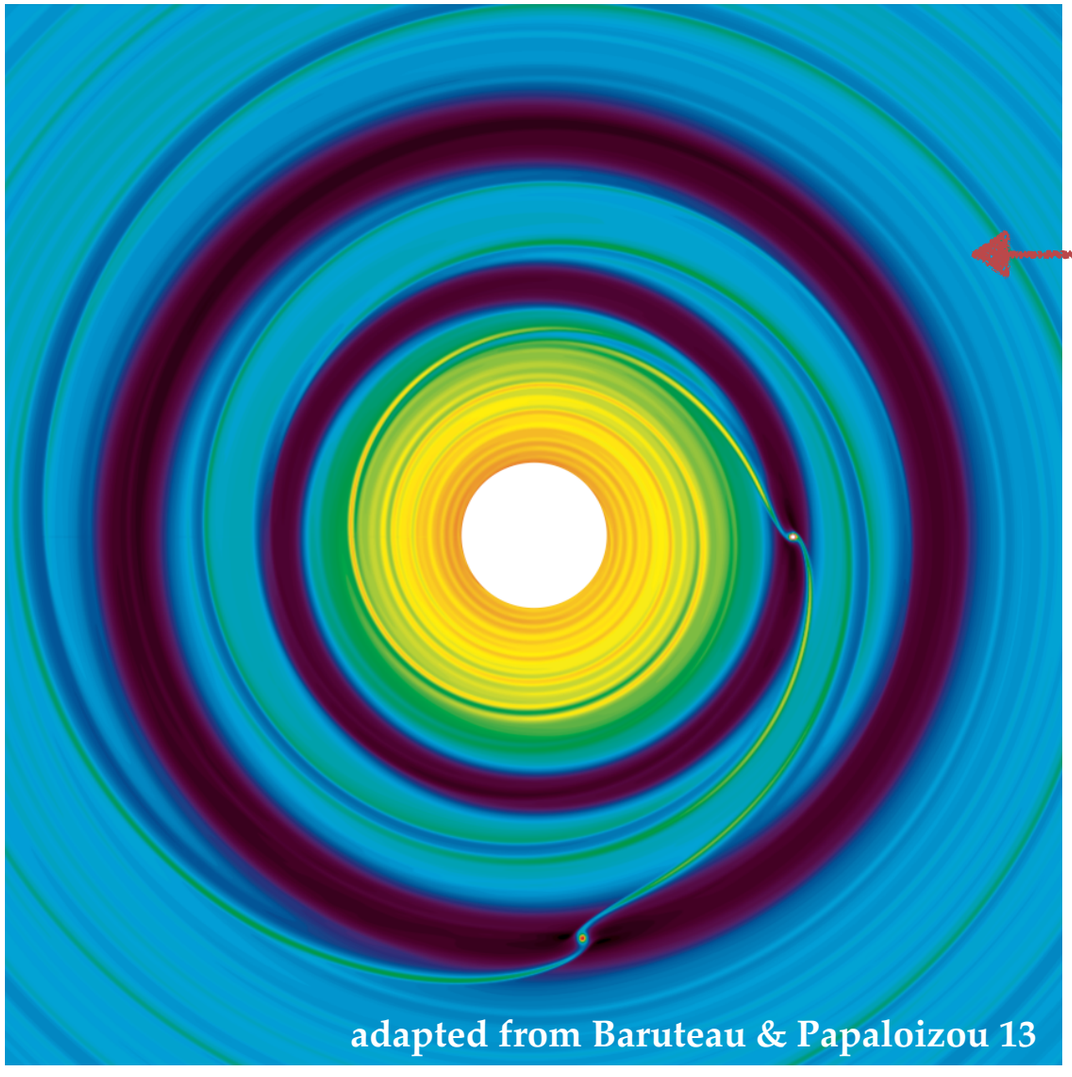

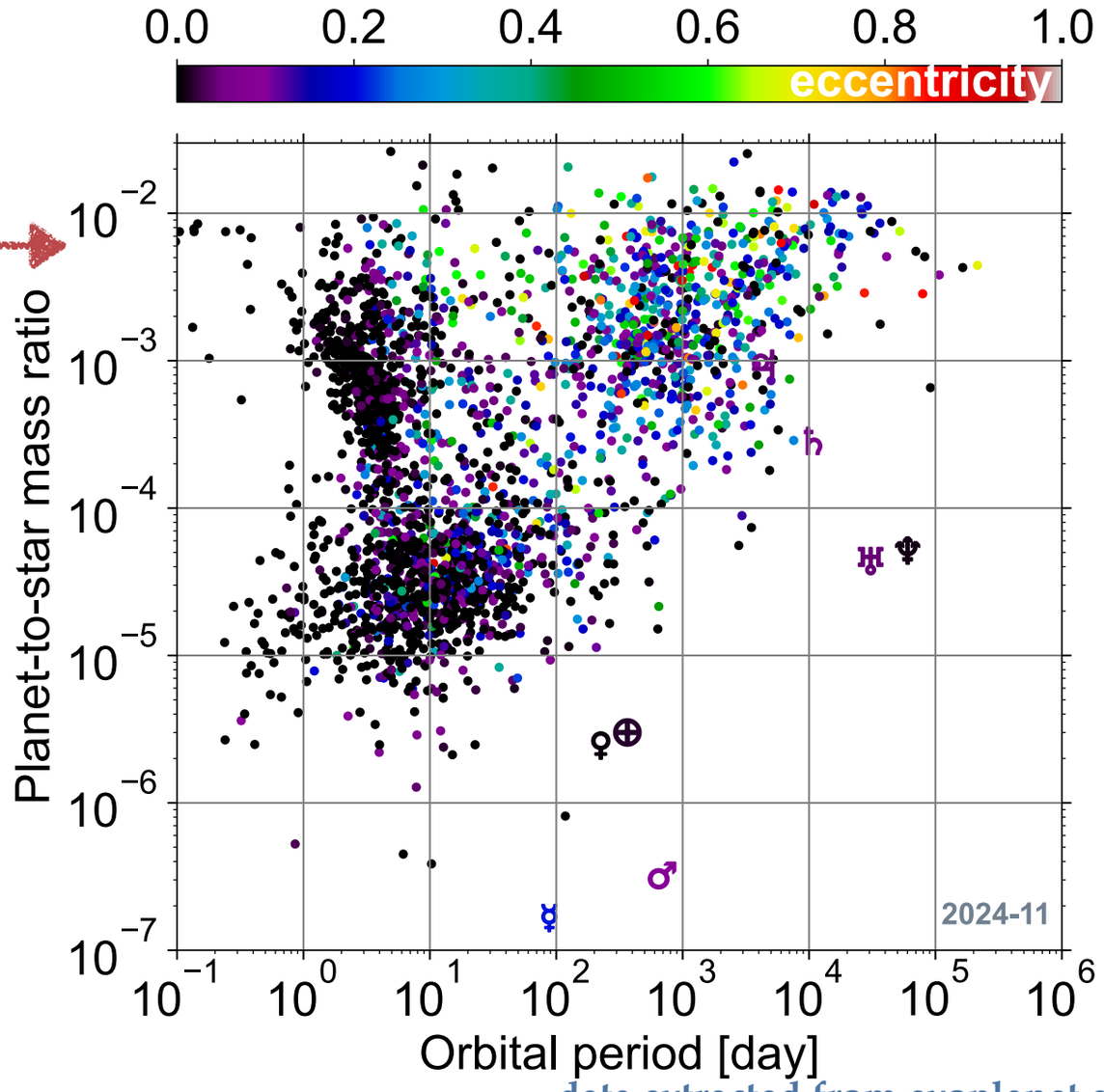

data extracted from exoplanet.eu
(median values shown)

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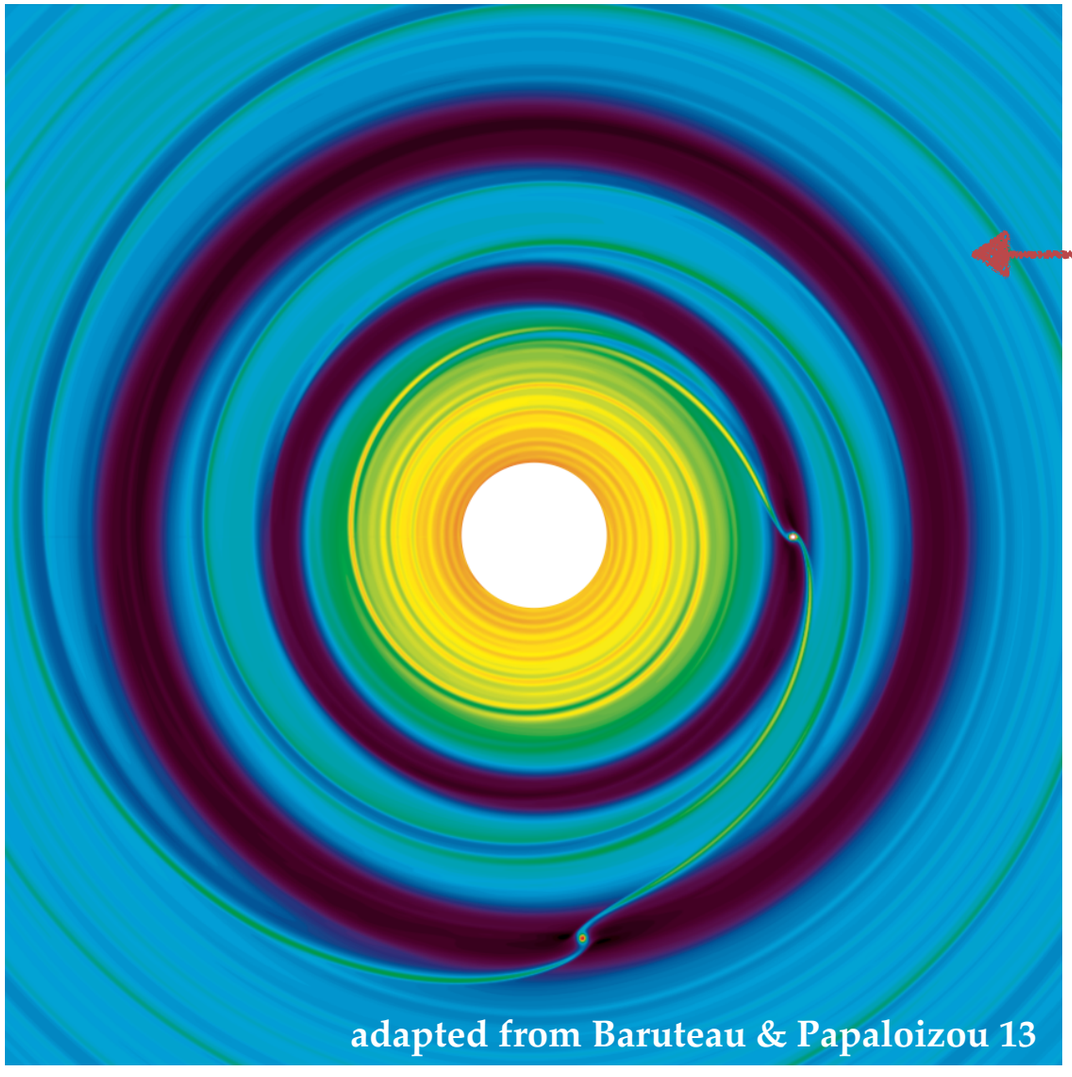

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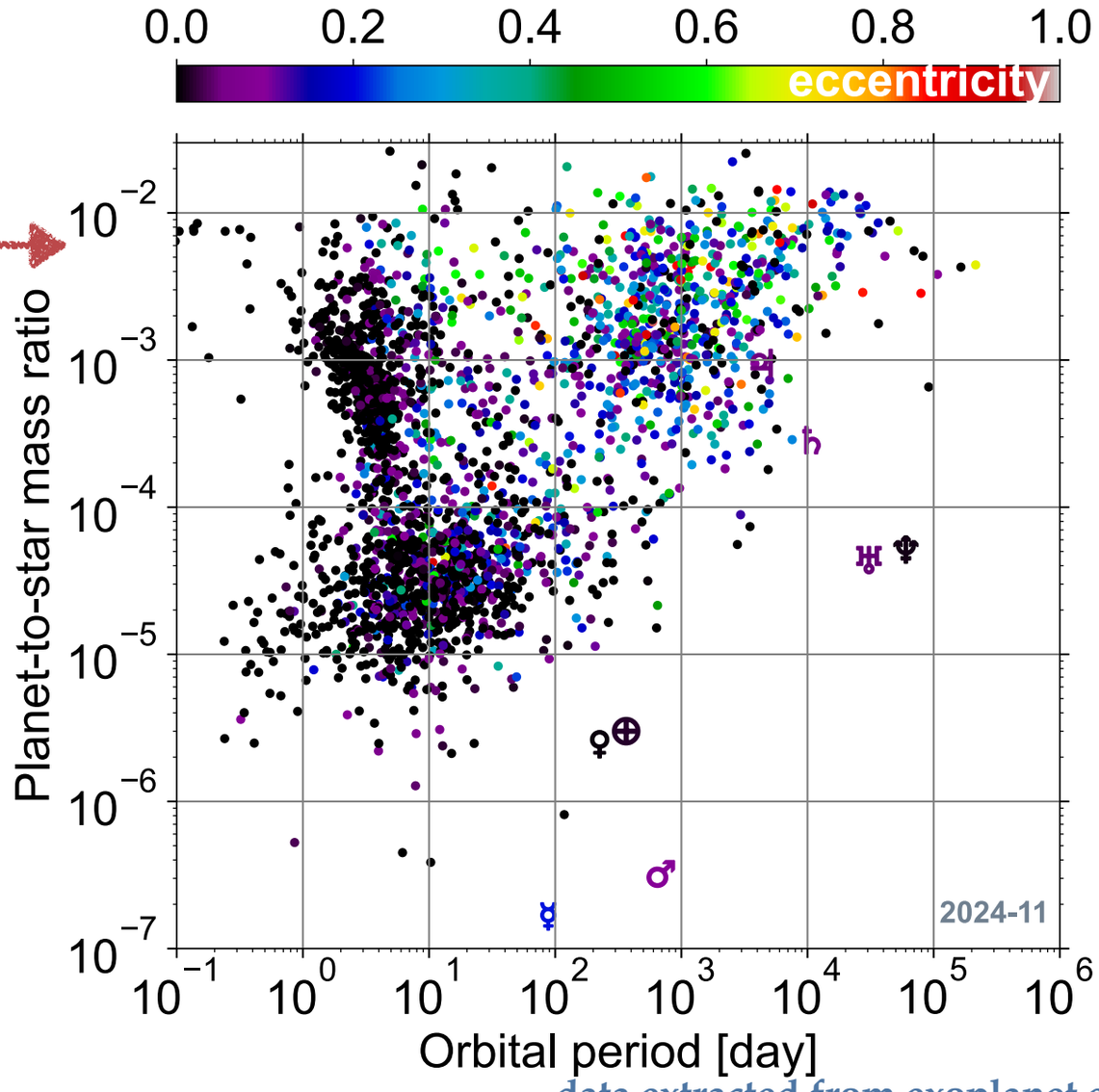

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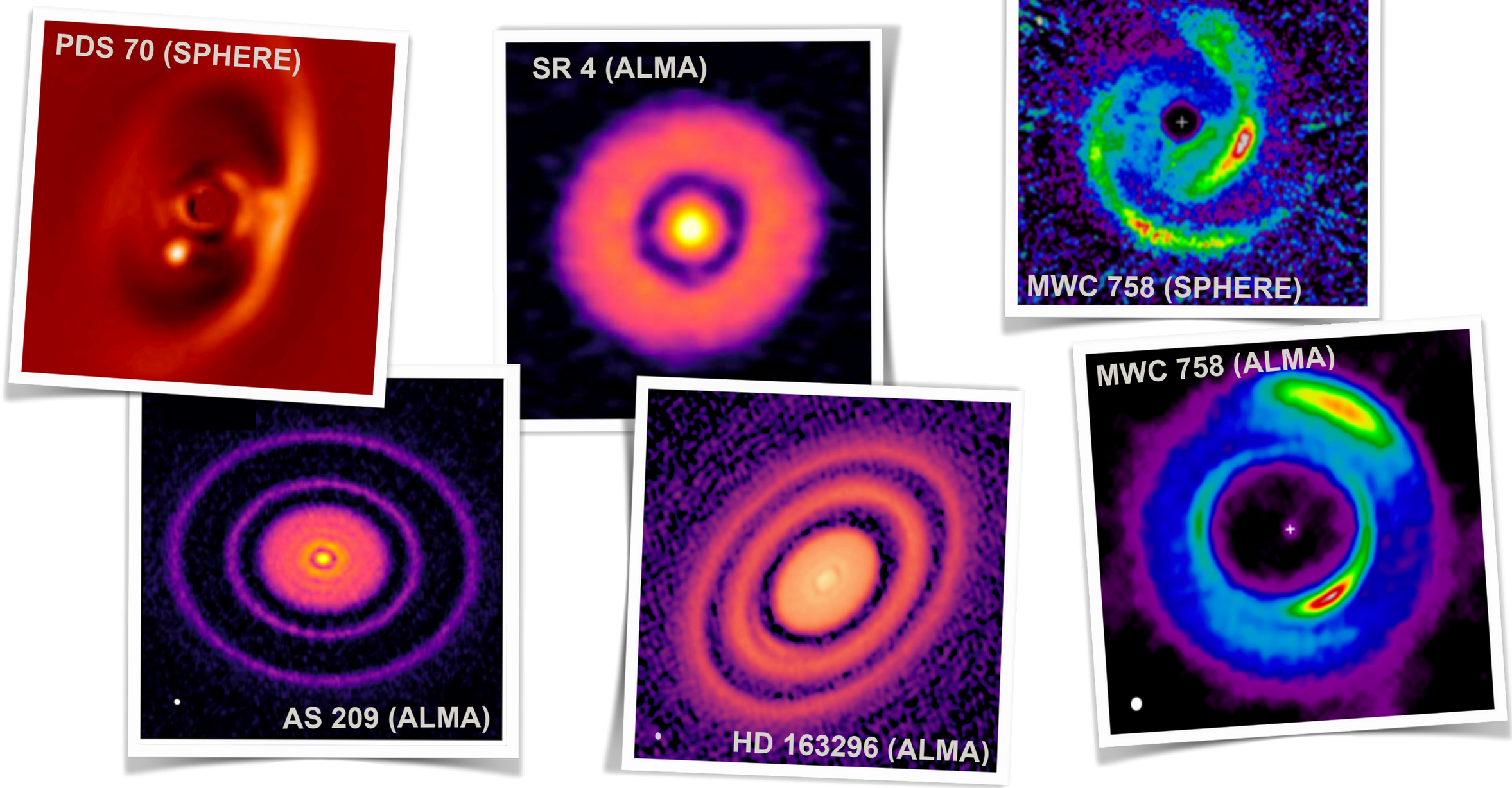

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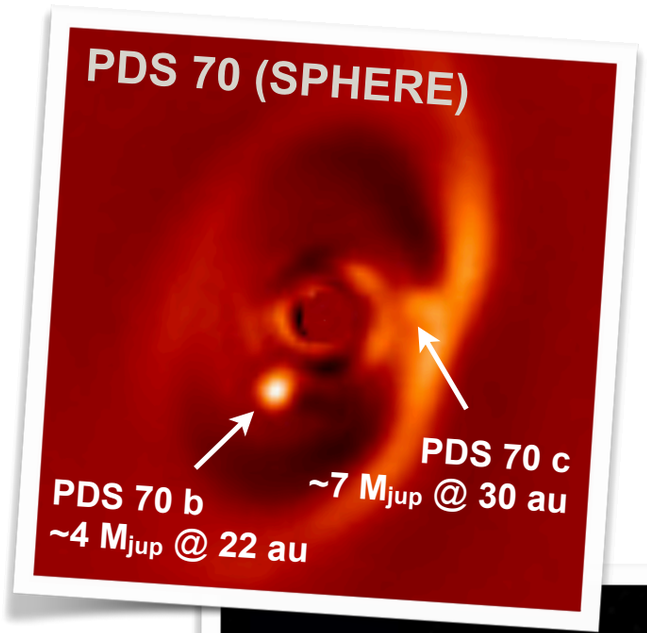

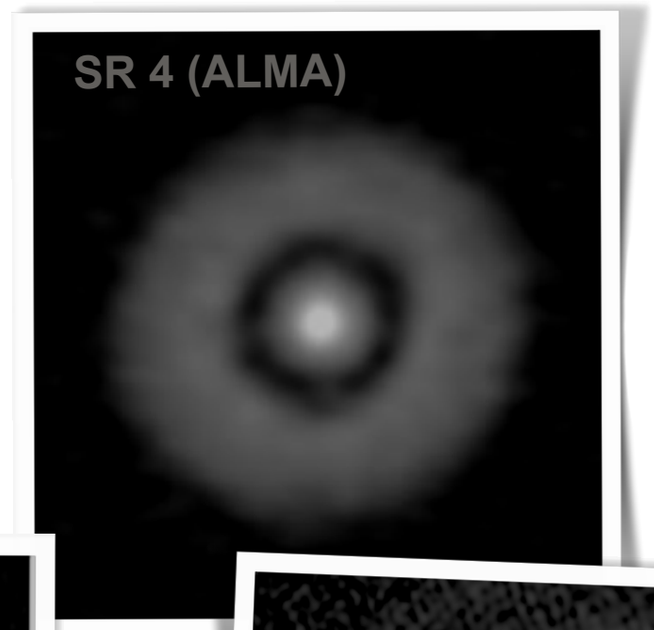

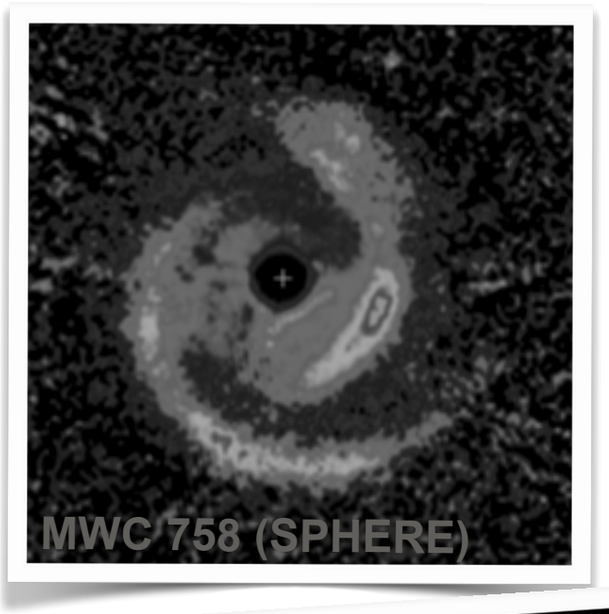

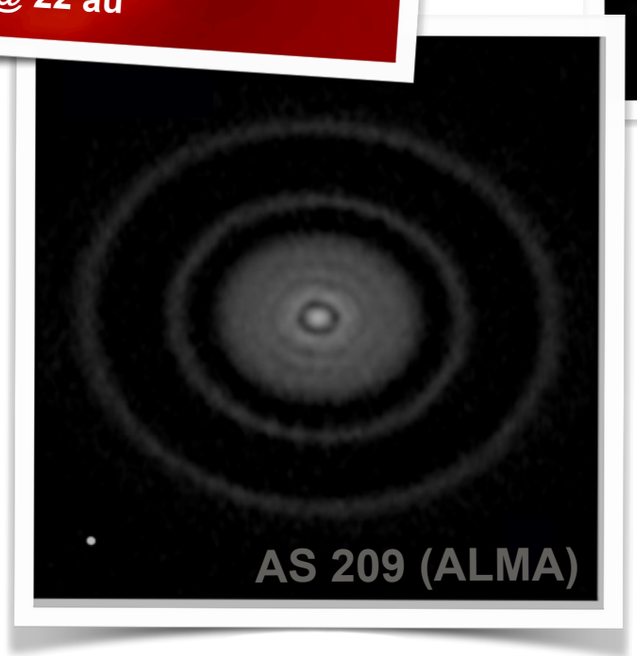

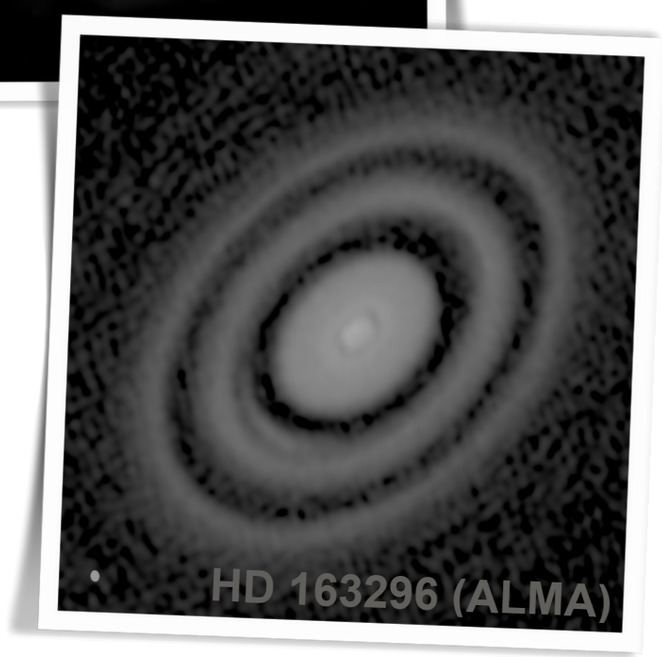

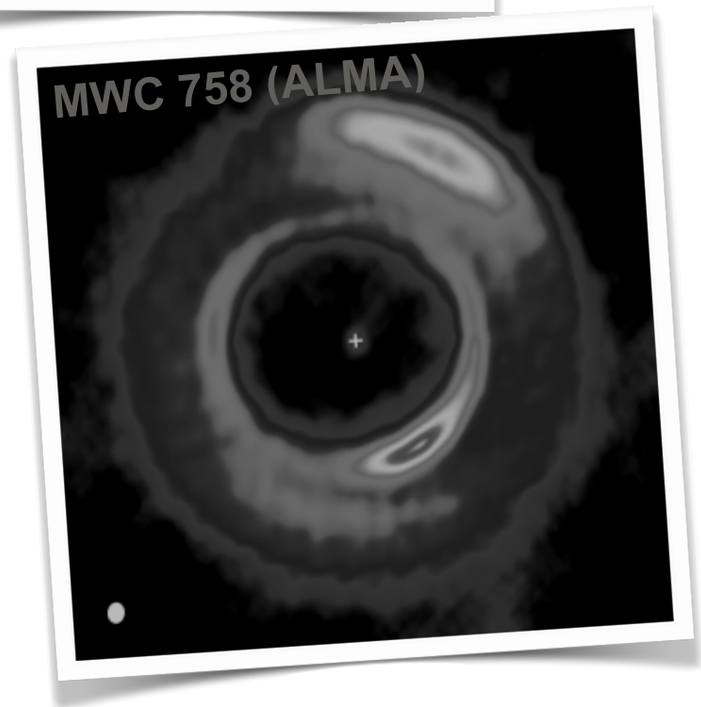

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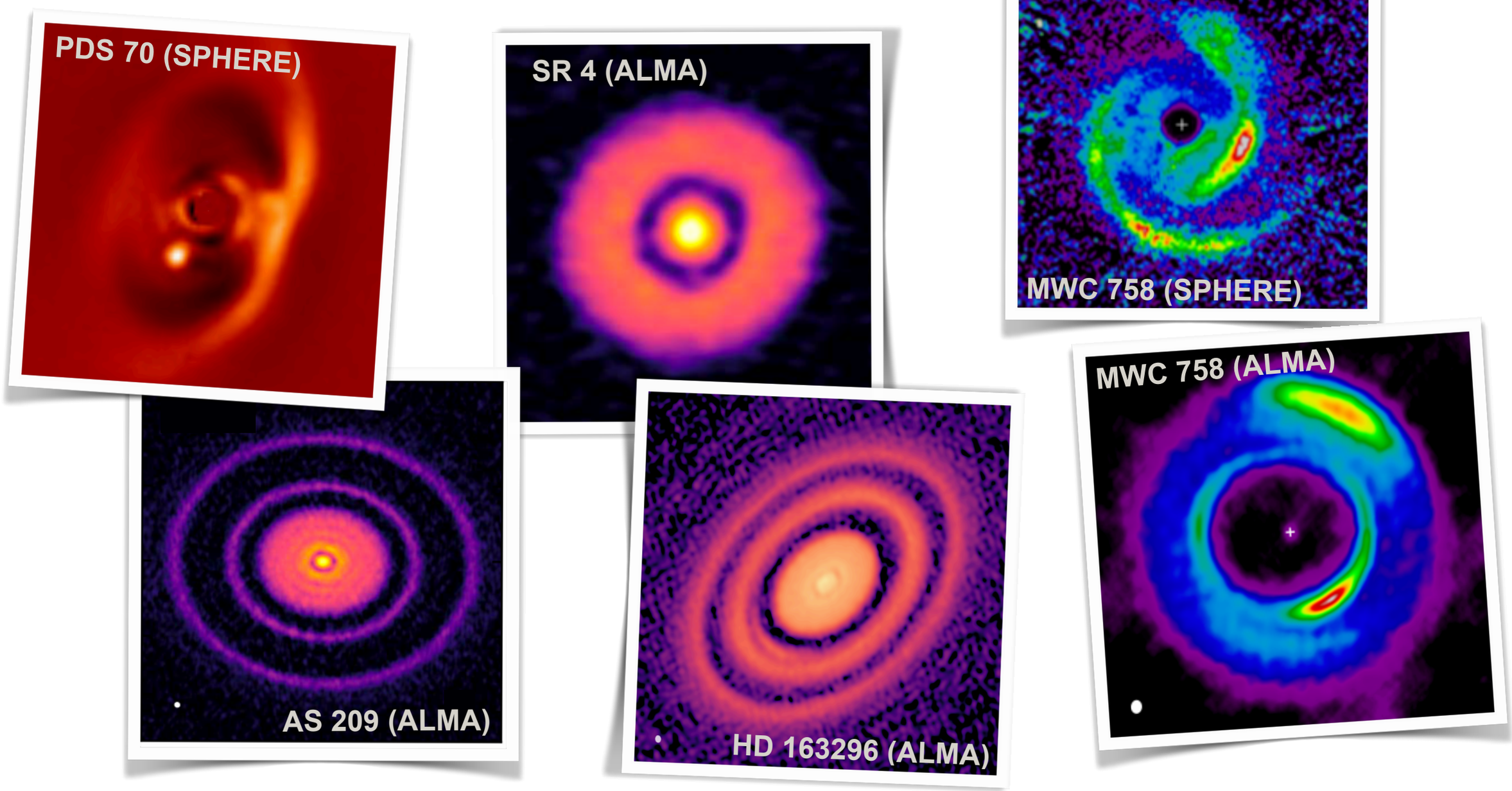

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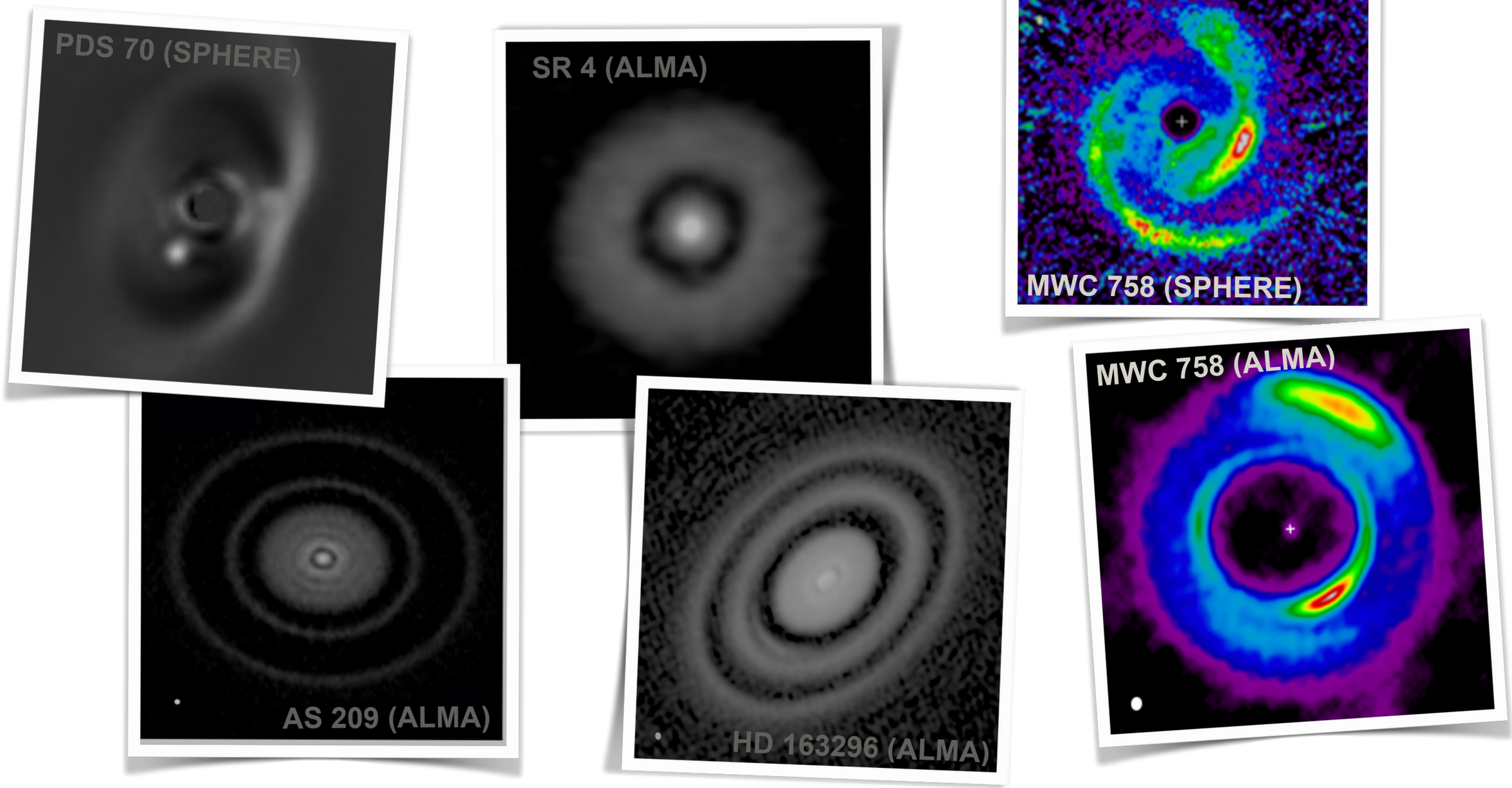

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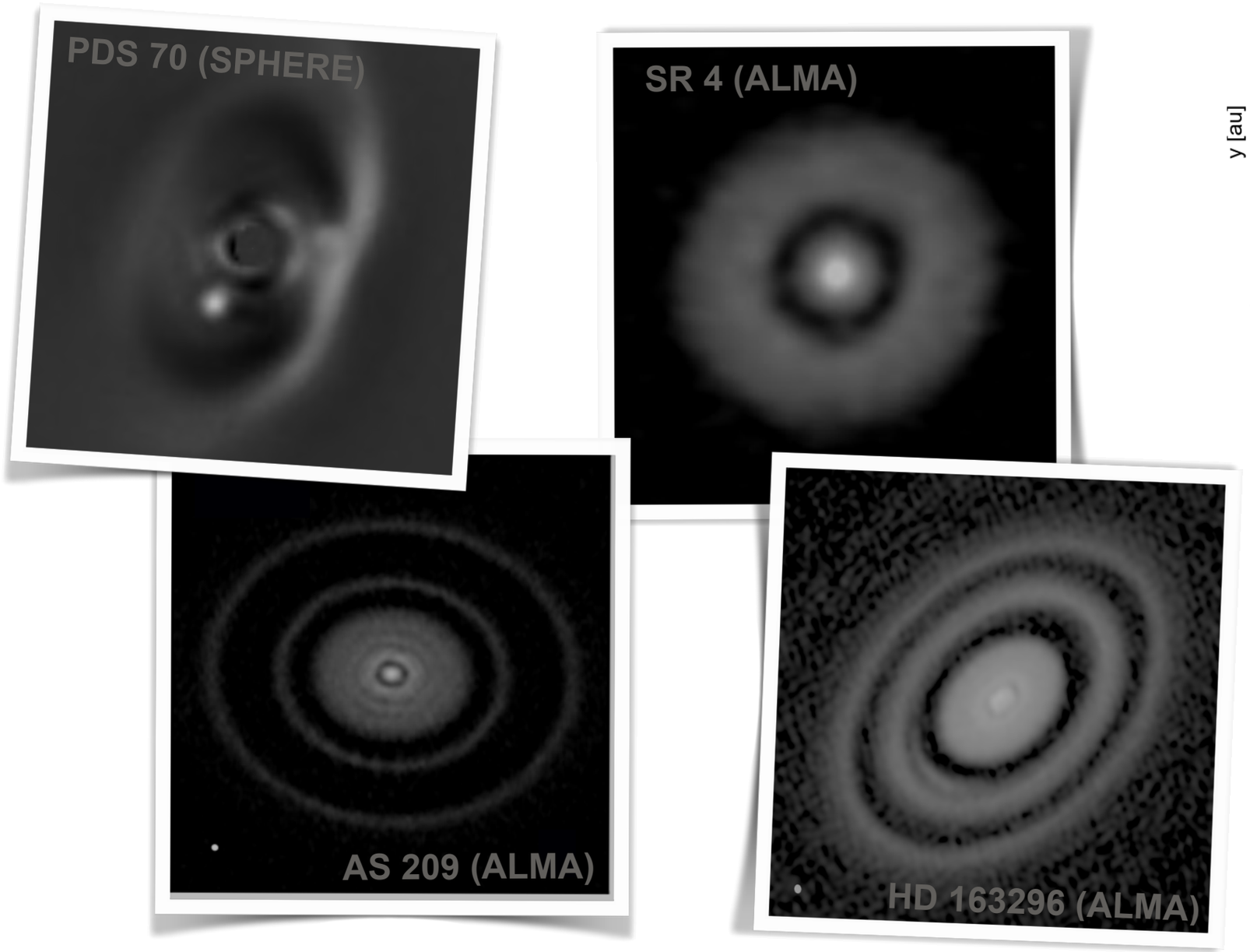

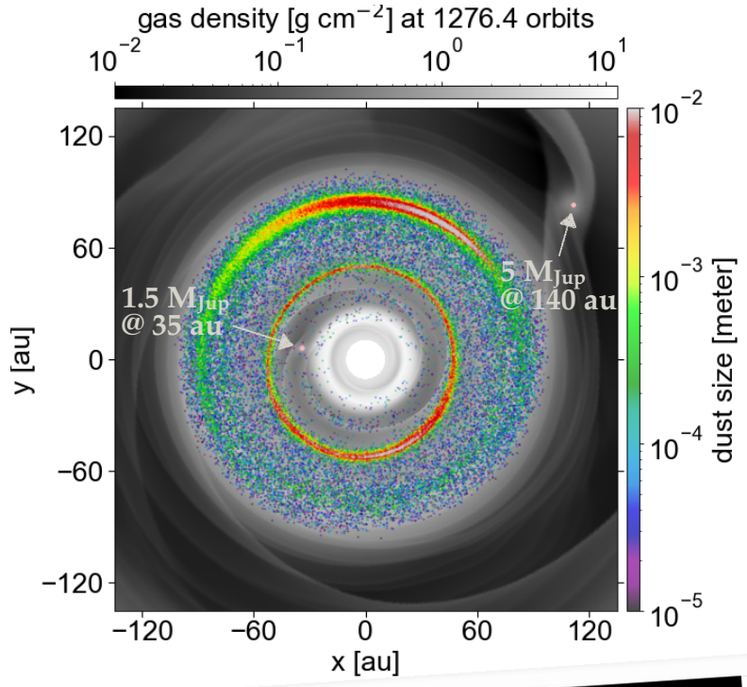

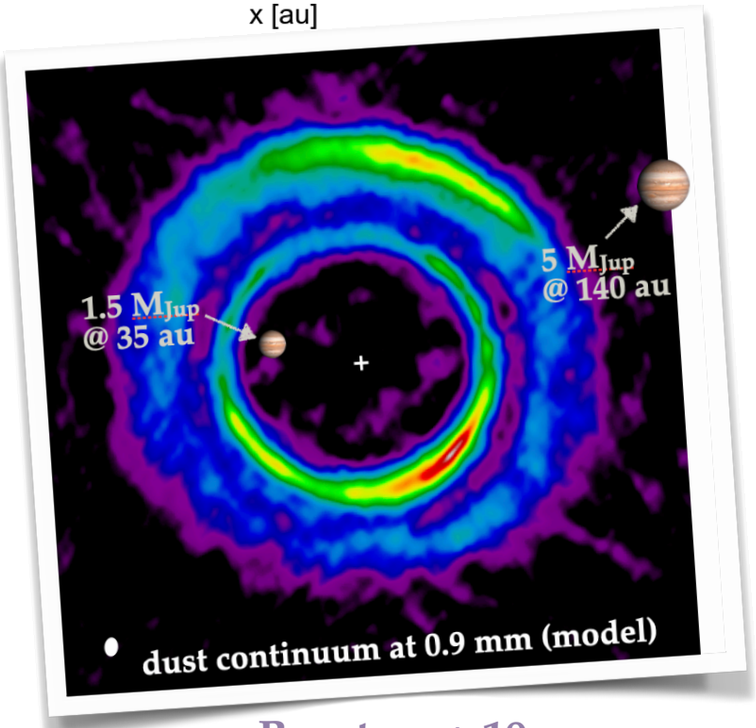

Baruteau+ 19

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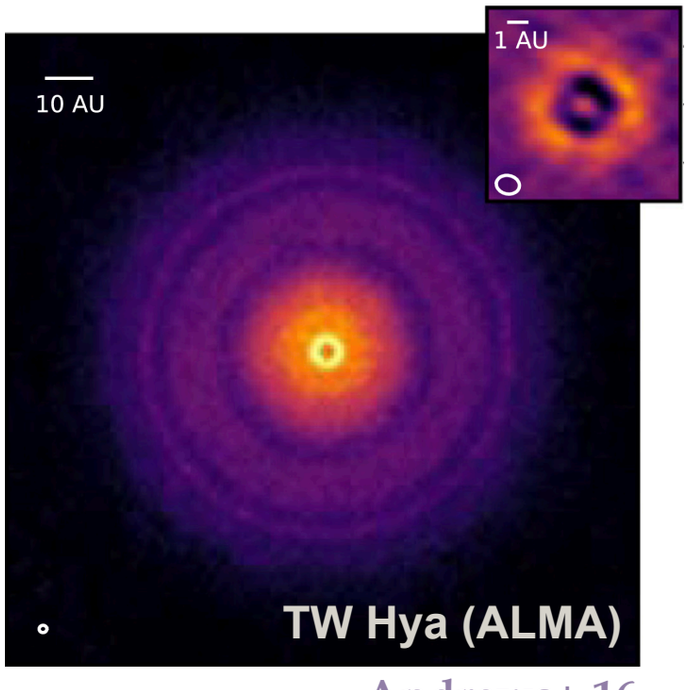
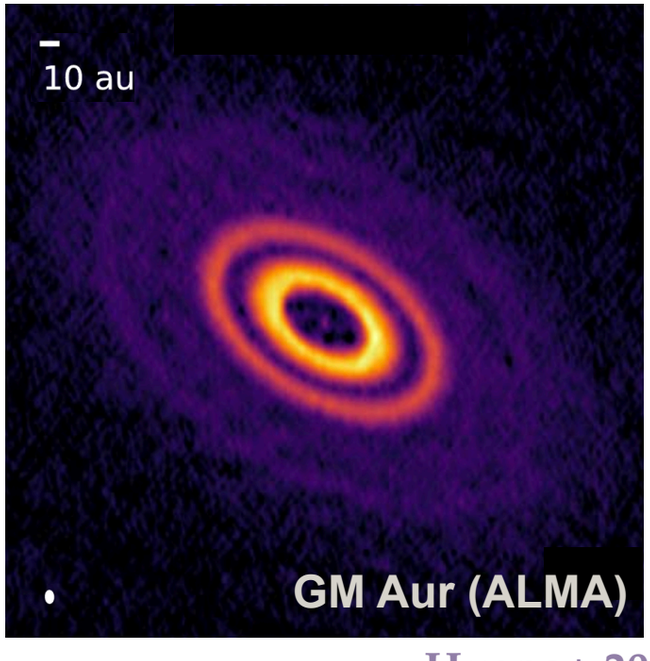
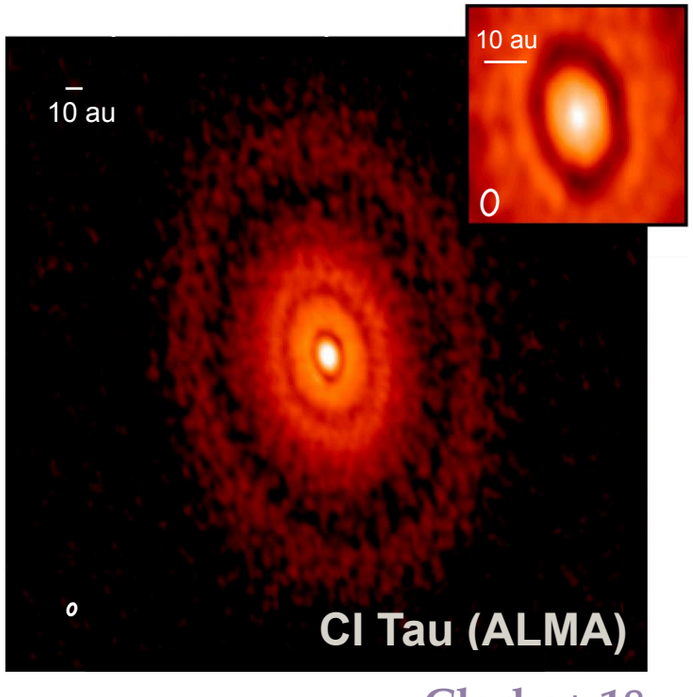


Andrews+ 16



Huang+ 20



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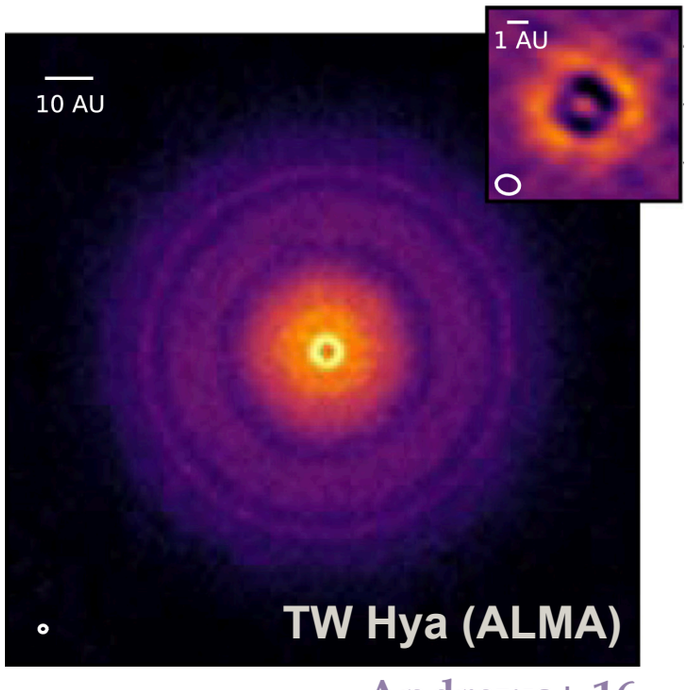

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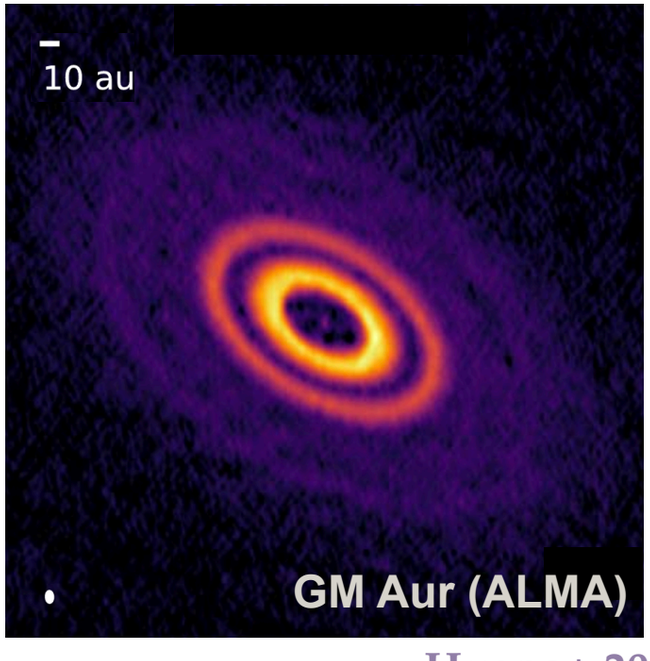

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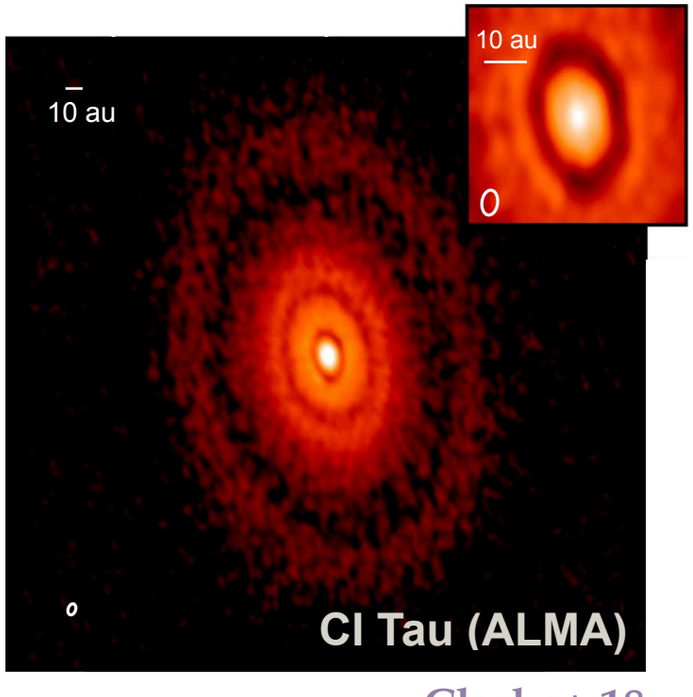

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  - access **emission** of **inner** disc regions, whose **dynamics** can be constrained

NB: ~**half** of exoplanets orbit main-sequence stars in <~ **10 days**!

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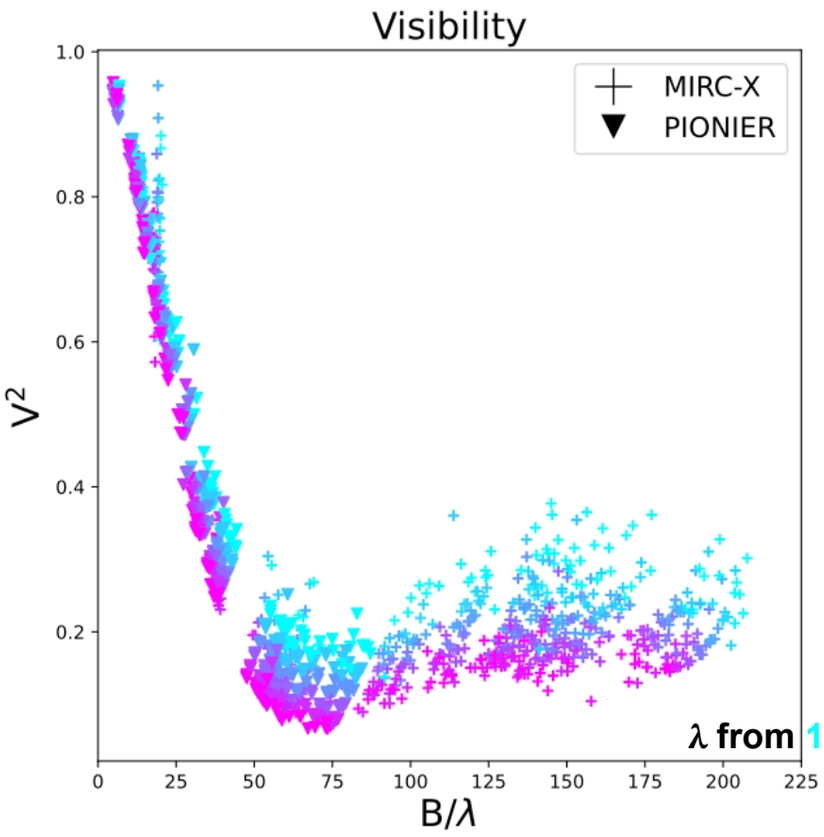

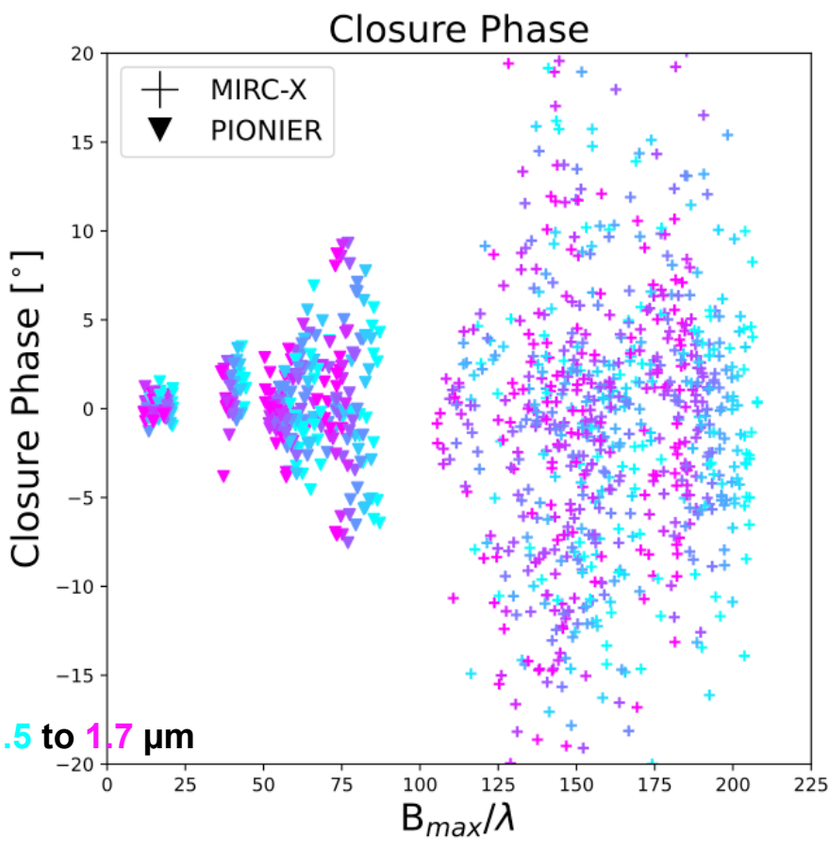

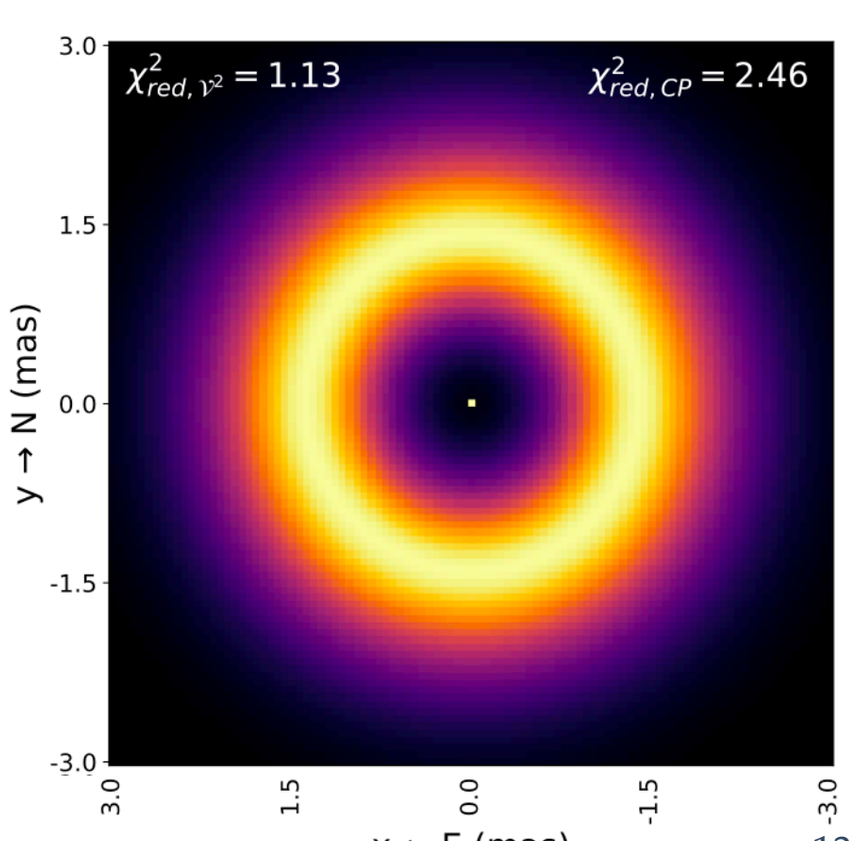

Ibrahim+ 23 (HD 190073 seen by CHARA & VLTI)

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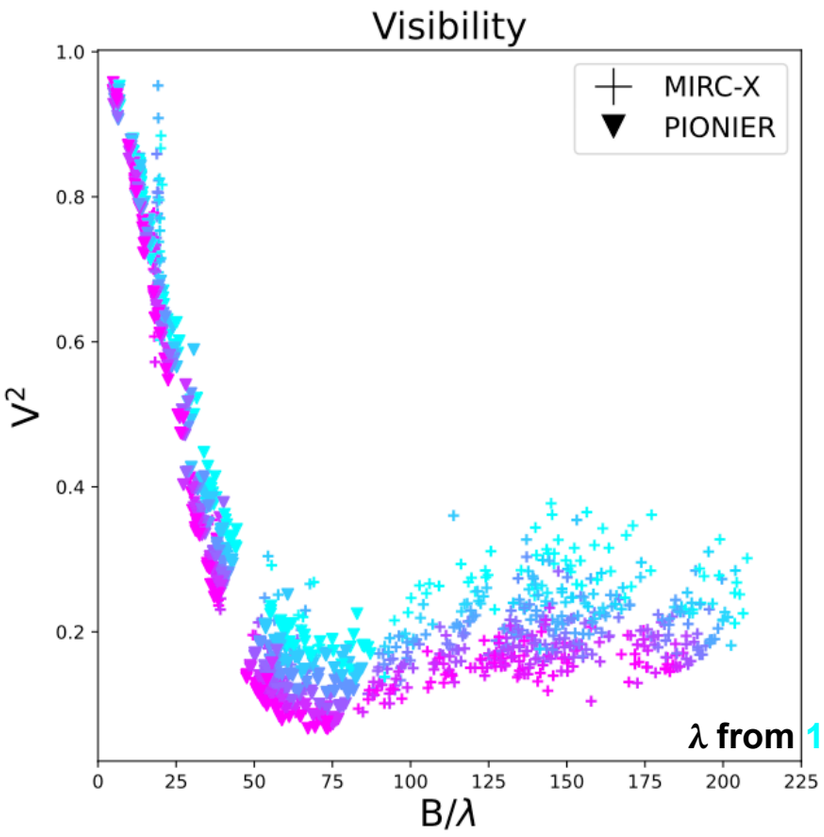

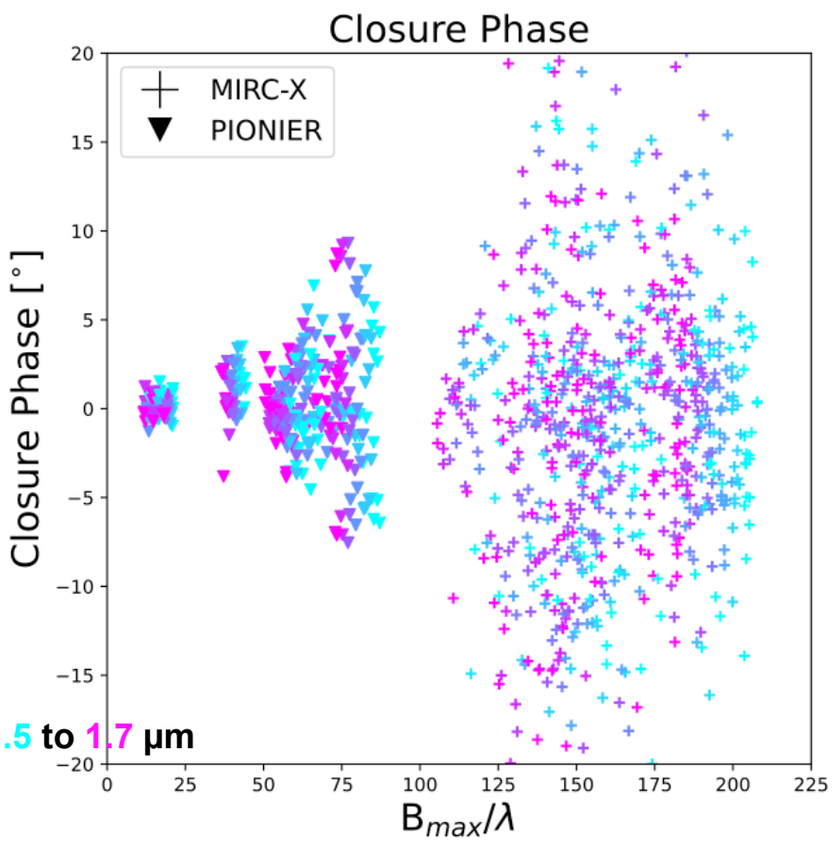

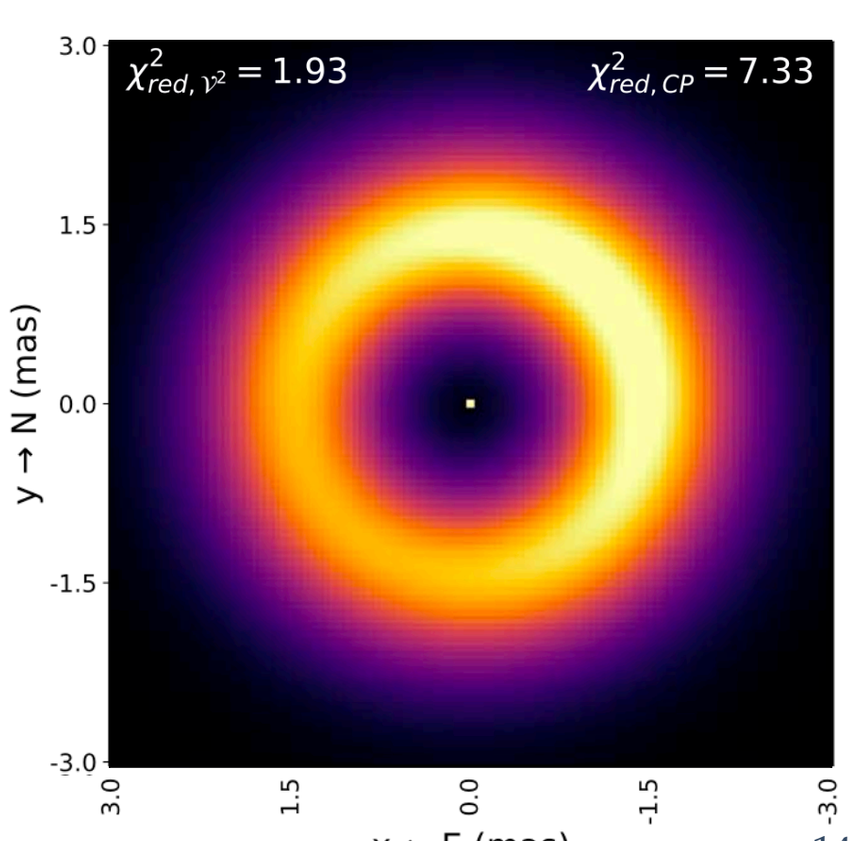

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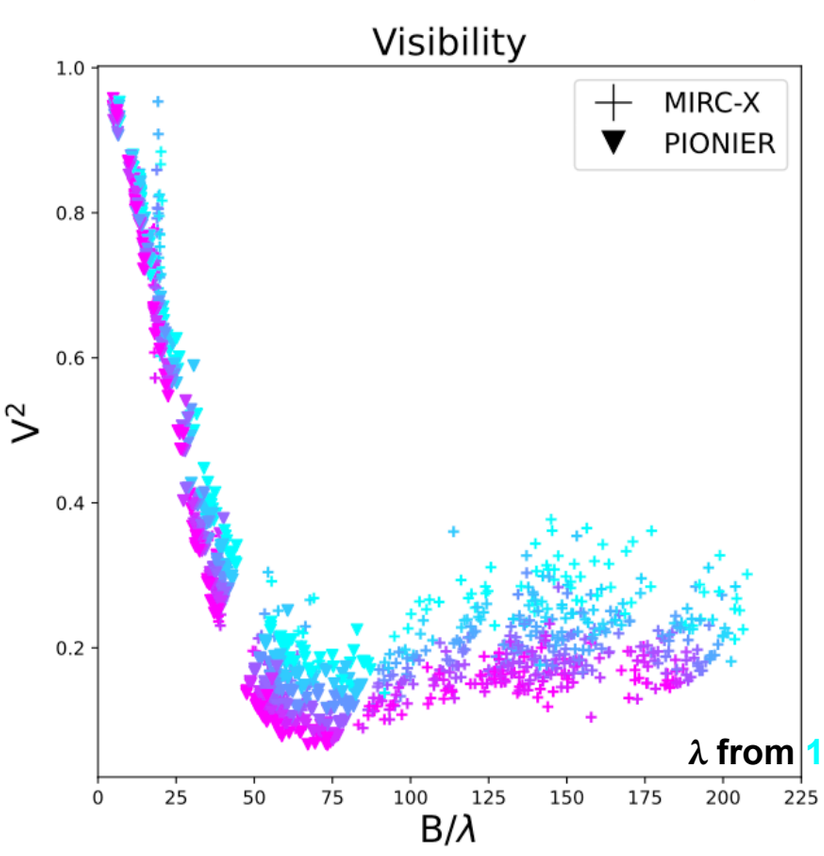

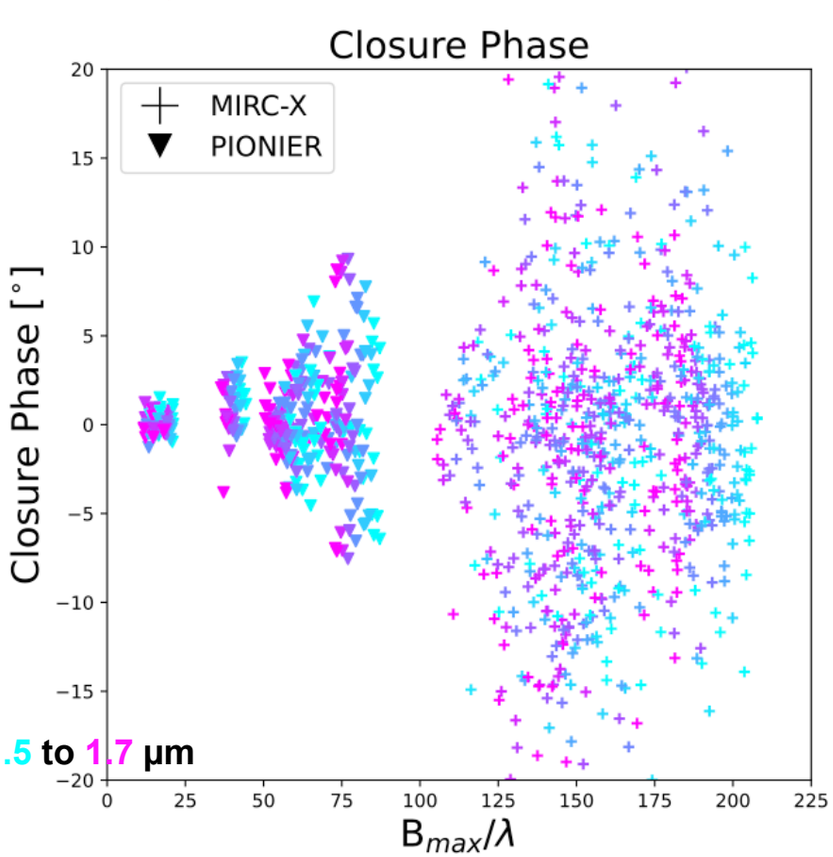

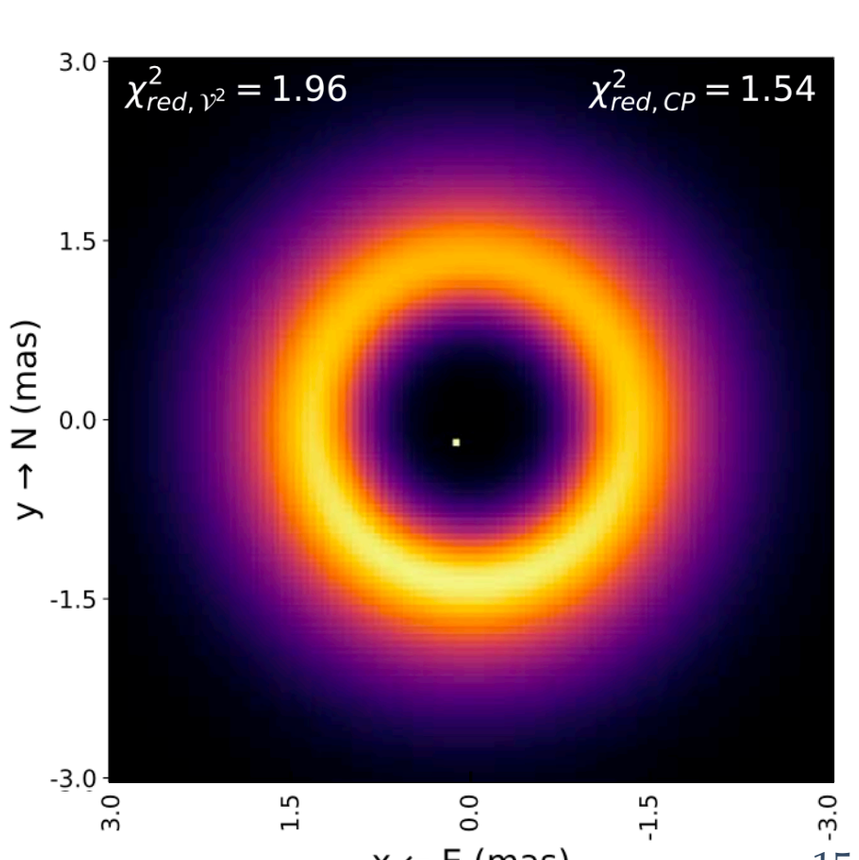

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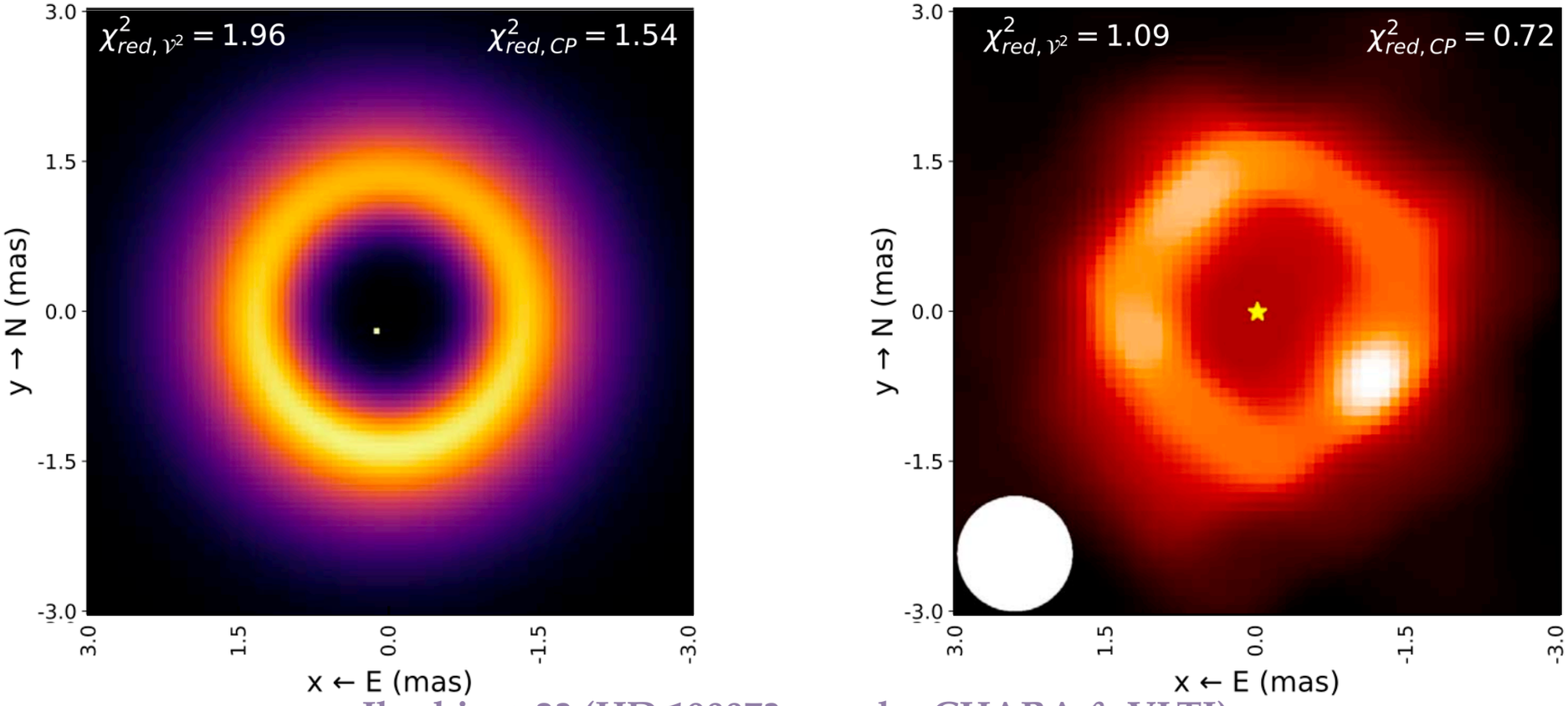

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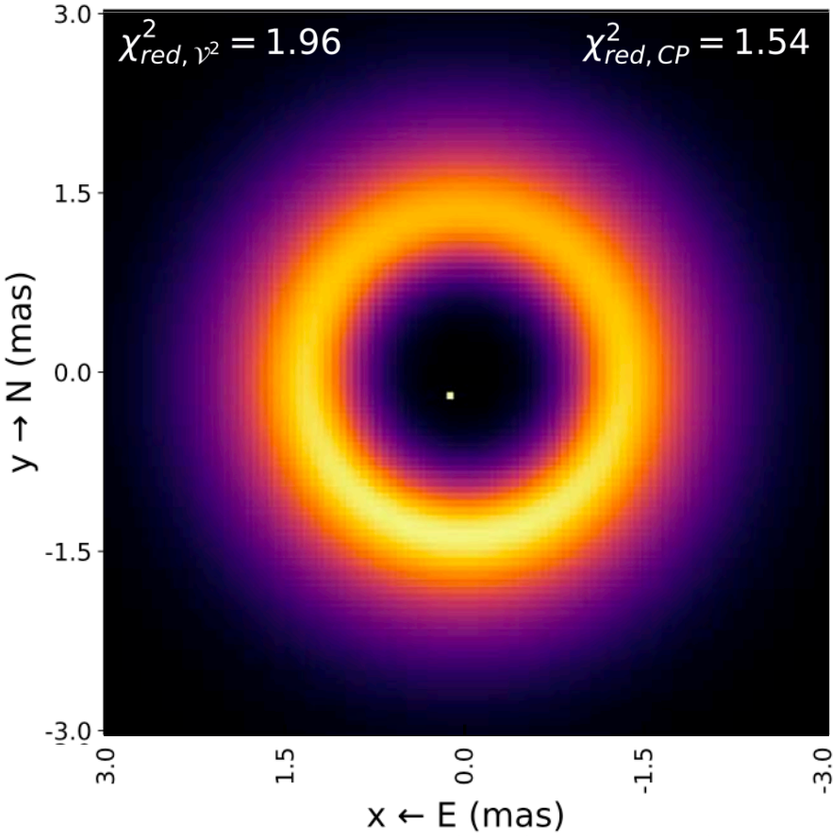

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→ binary companion?

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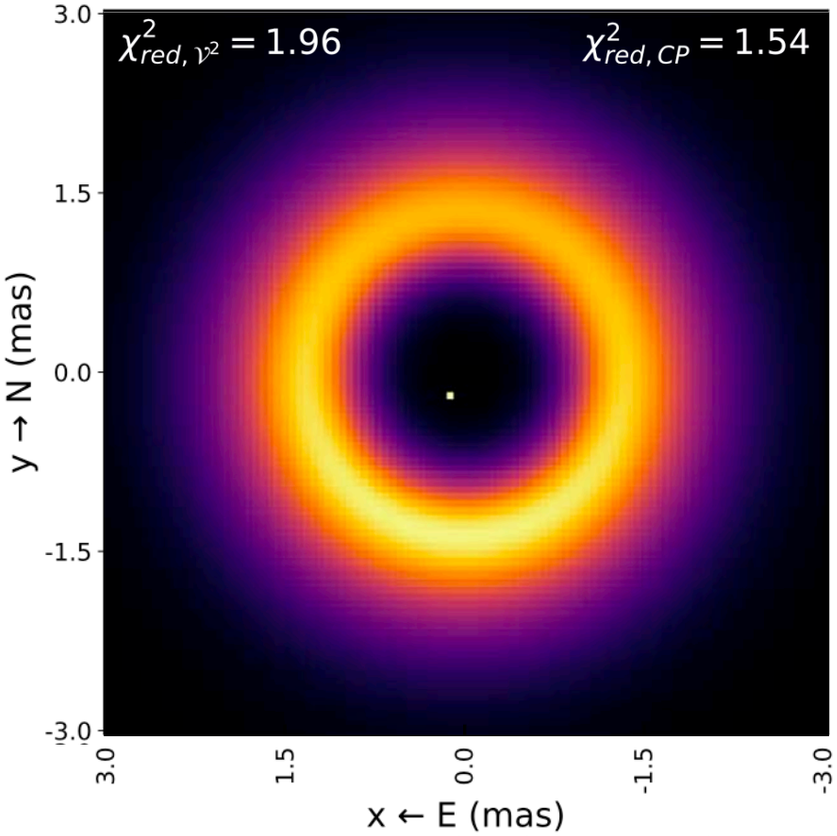

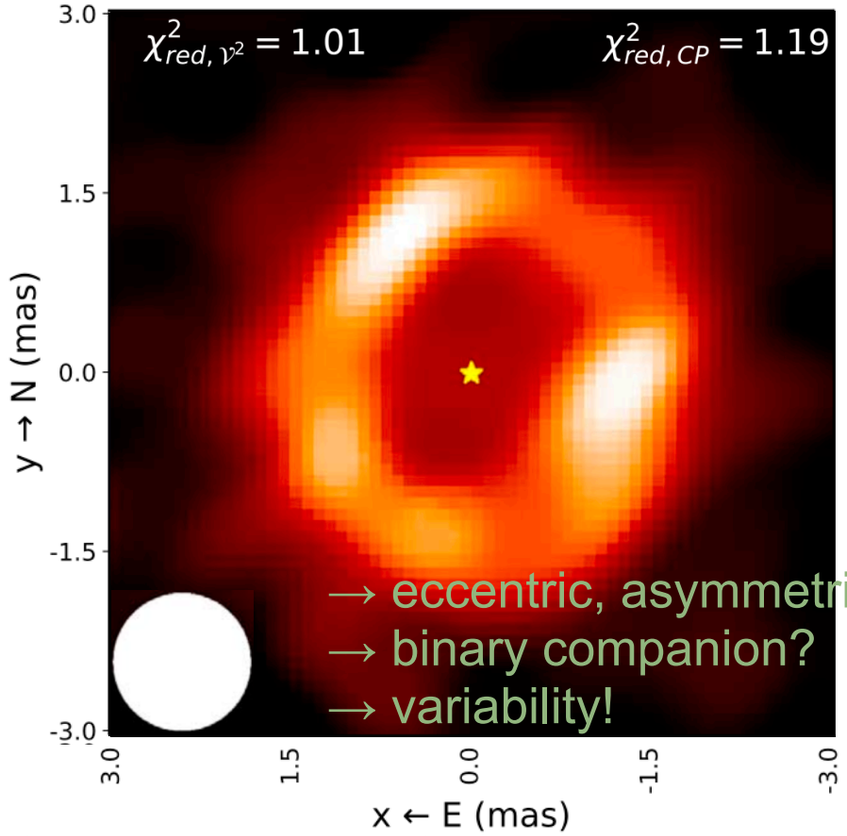

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→ binary companion?
→ variability!

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Our ongoing work on HD 163296

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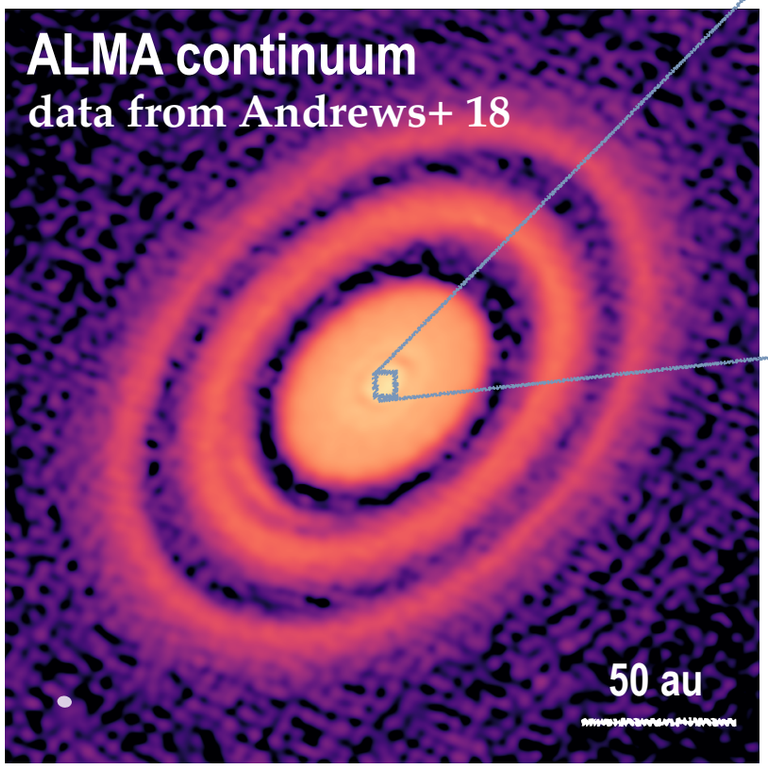

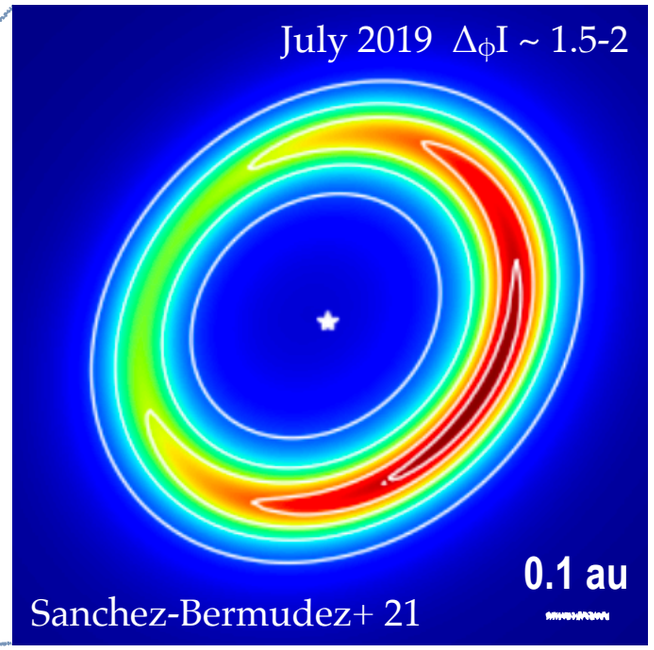

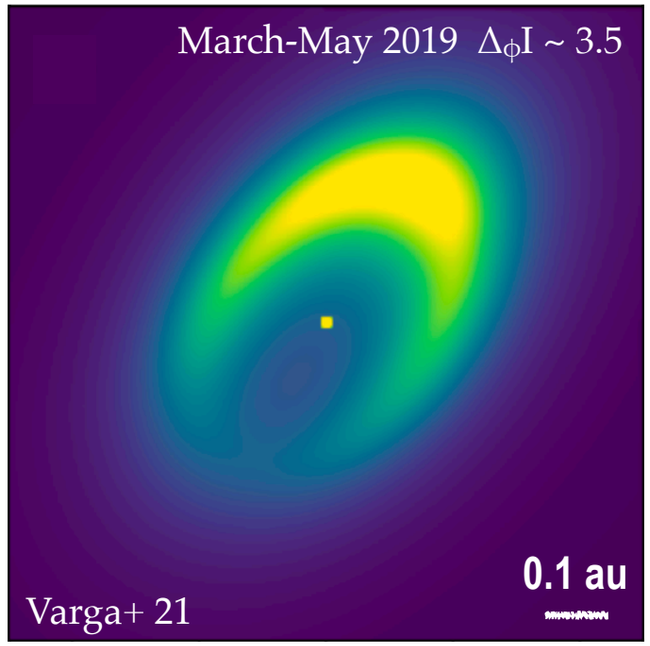

model images of GRAVITY (left) and MATISSE data (right)
NB: orbital period at 0.3 au ~ 40 days

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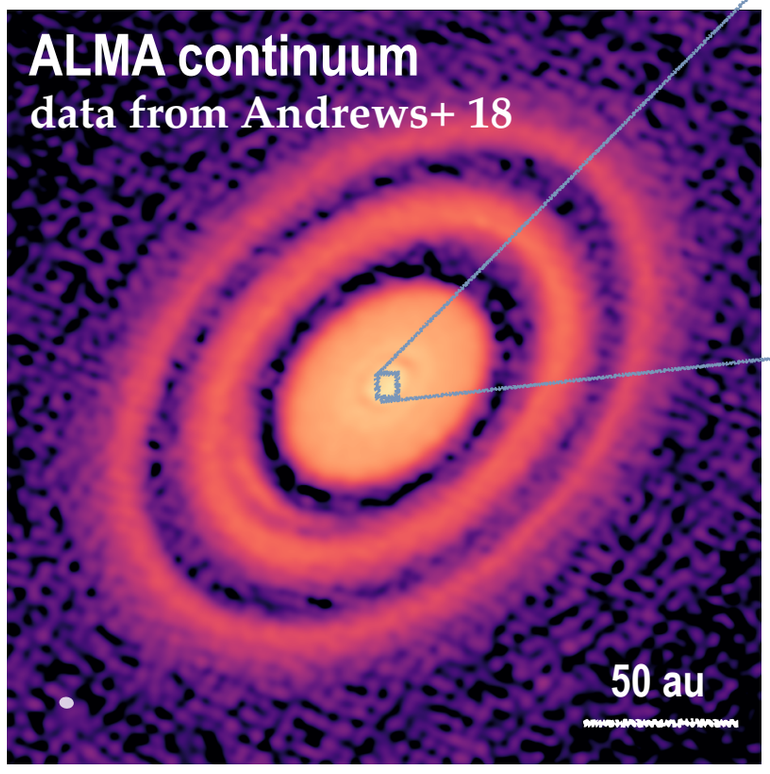

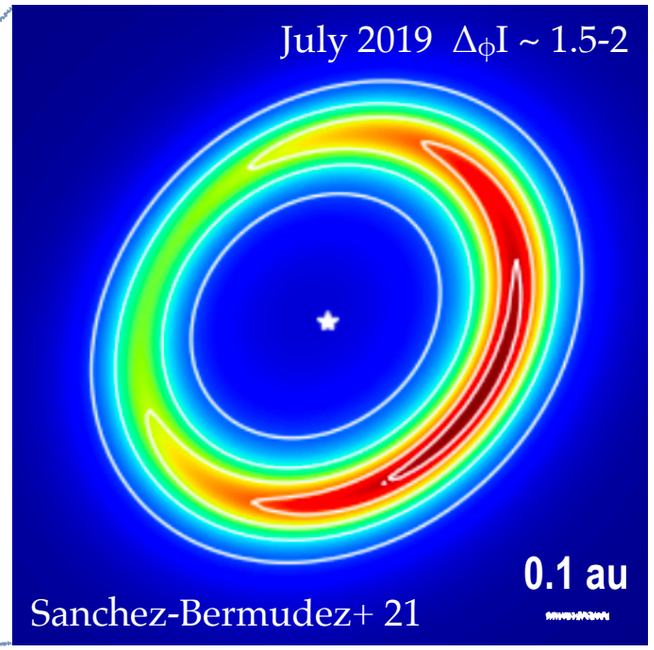

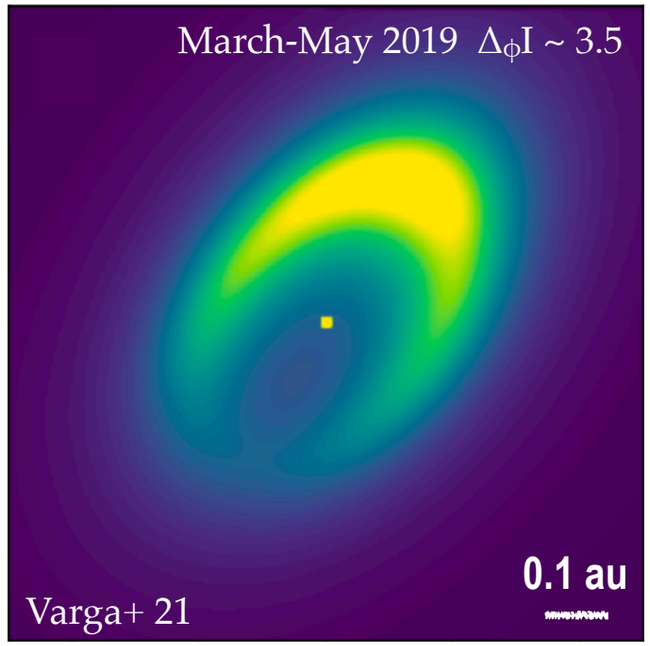

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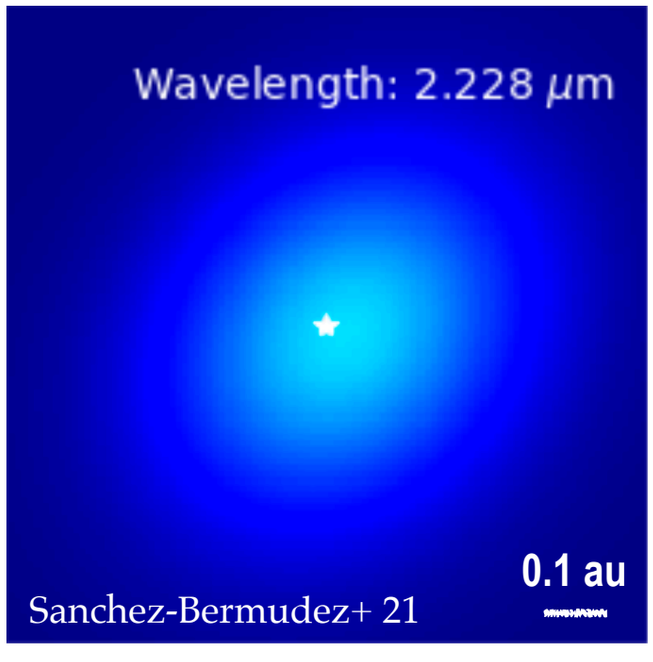
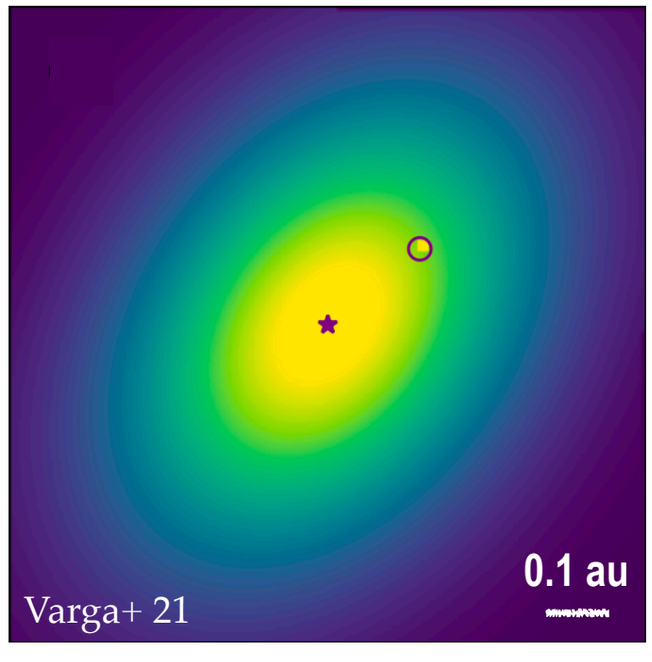
OR

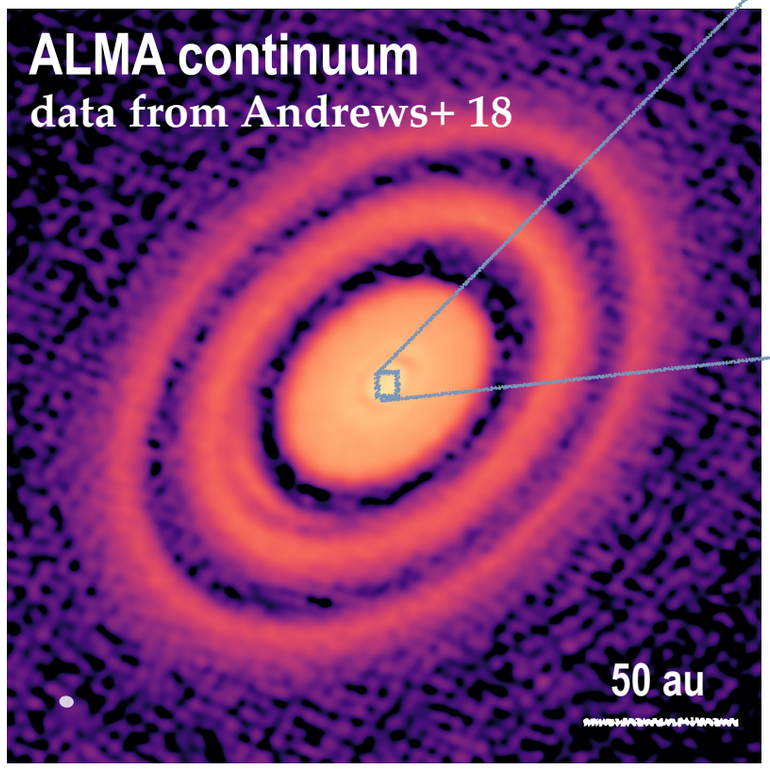


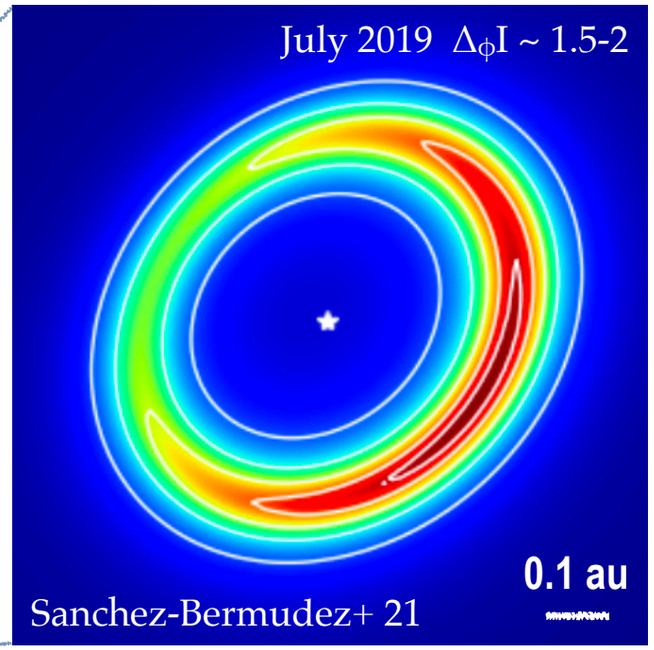


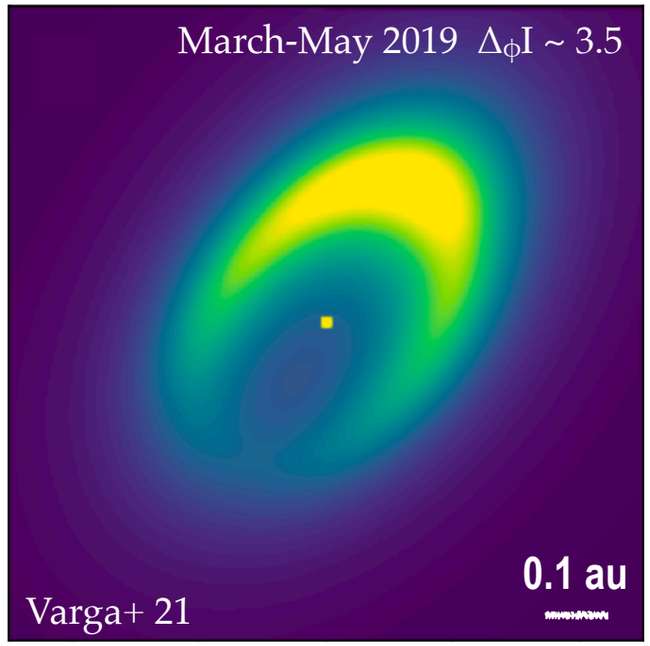
alternative model images of GRAVITY (left) and MATISSE data (right)

Our ongoing work on HD 163296

- An asymmetric dust inner ring?







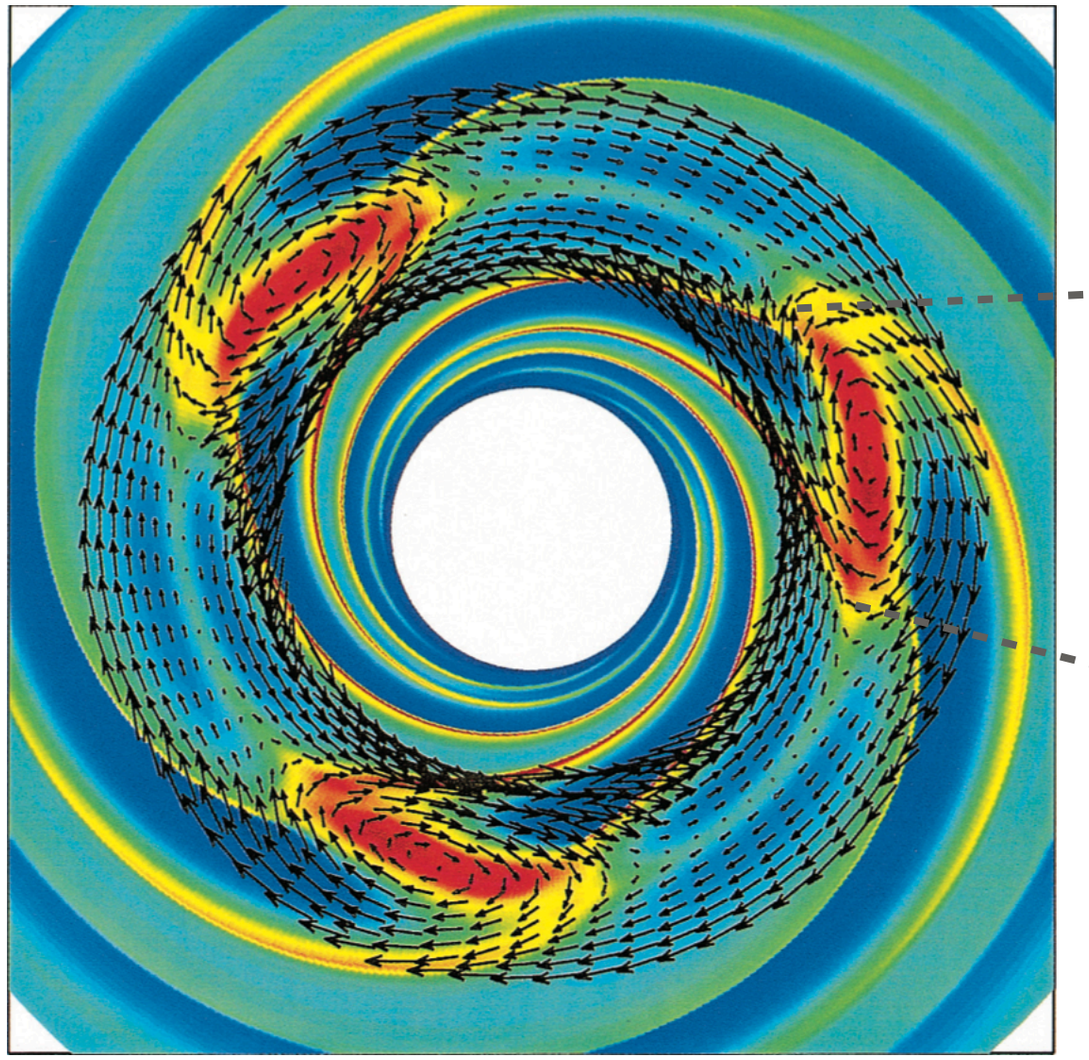
model images of GRAVITY (left) and MATISSE data (right)
NB: orbital period at 0.3 au ~ 40 days

→ if dust emission is **optically thick** and not dominated by scattering, Δ_φI~3.5 at λ~3.2 μm implies Δ_φT~1.4 (e.g., T goes from 1000 K to 1400 K along the ring at R~0.3 au): plausible?

→ could emission be **optically thin?**

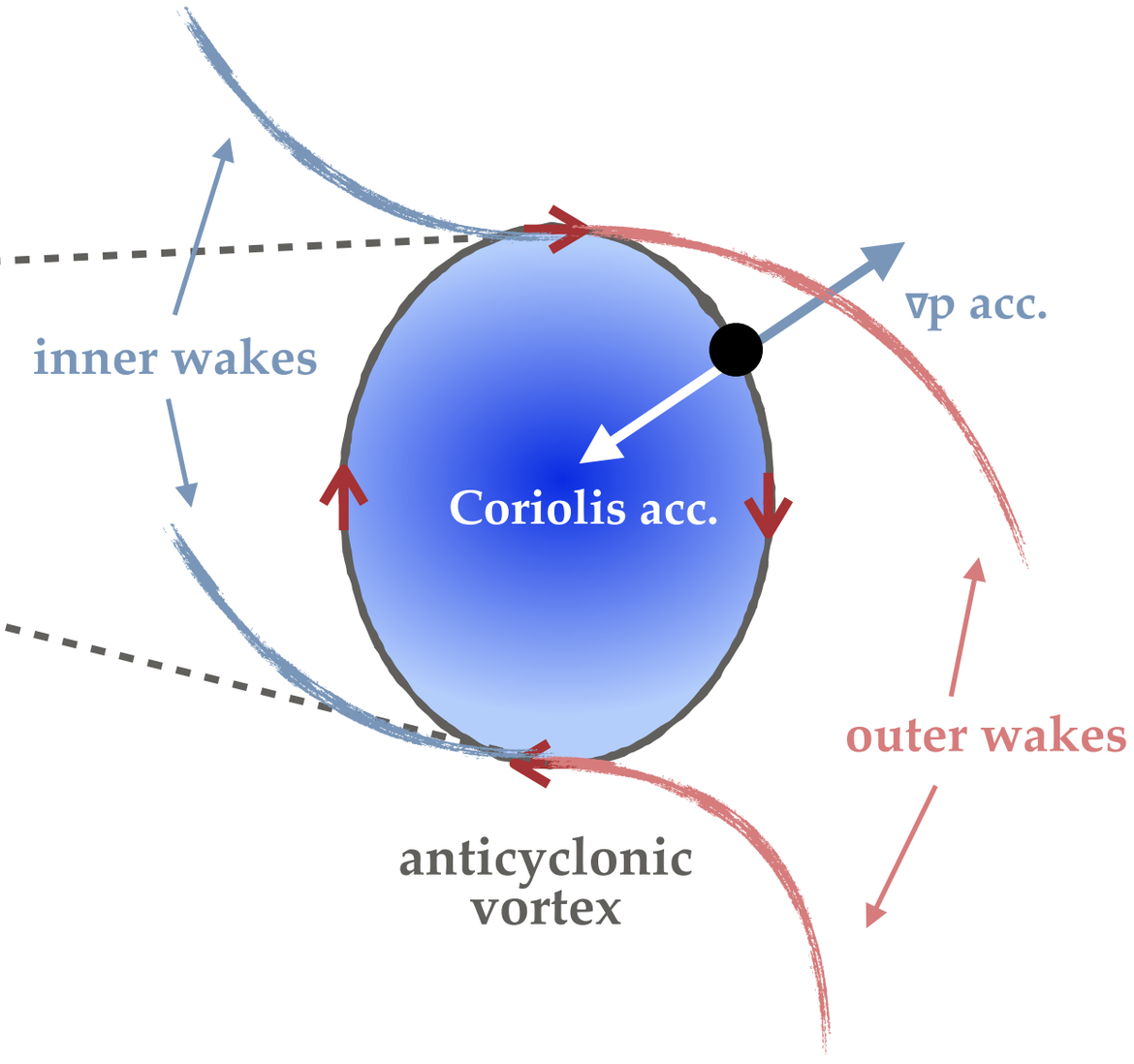
Our ongoing work on HD 163296

- An asymmetric dust inner ring?
- How? By the Rossby-Wave Instability (RWI)?
  - a **linear, non-axisymmetric** shear instability
  - saturates into few **anticyclonic vortices** that tend to **merge** over time and **trap dust**



disk's perturbed pressure

Li+ 01

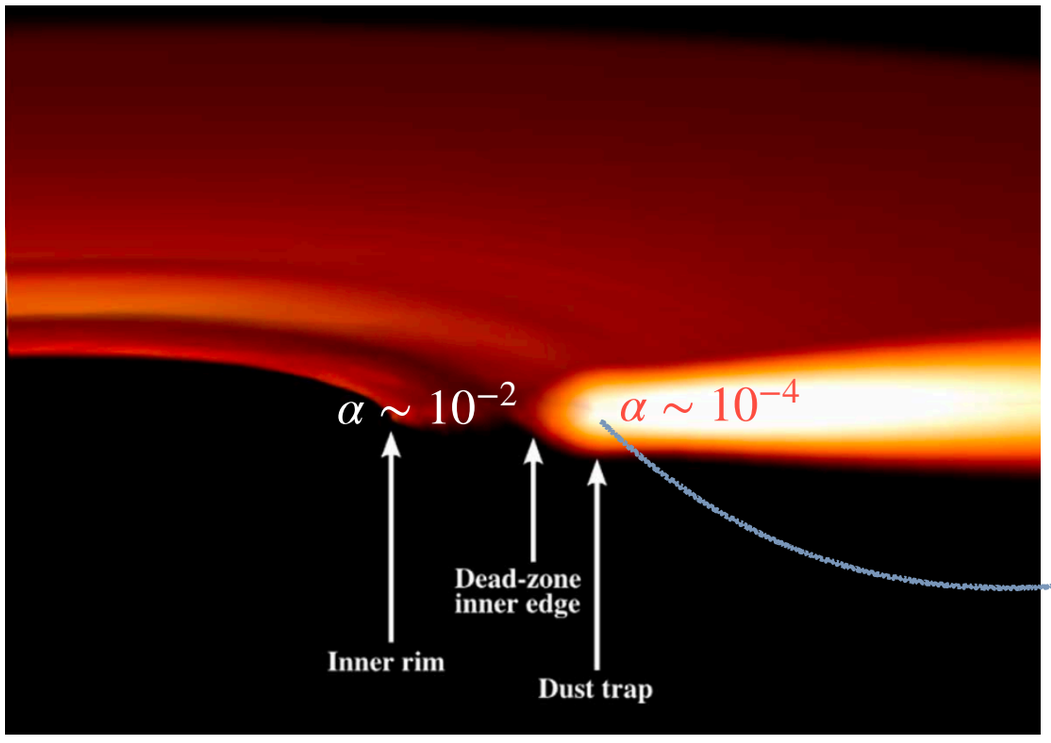


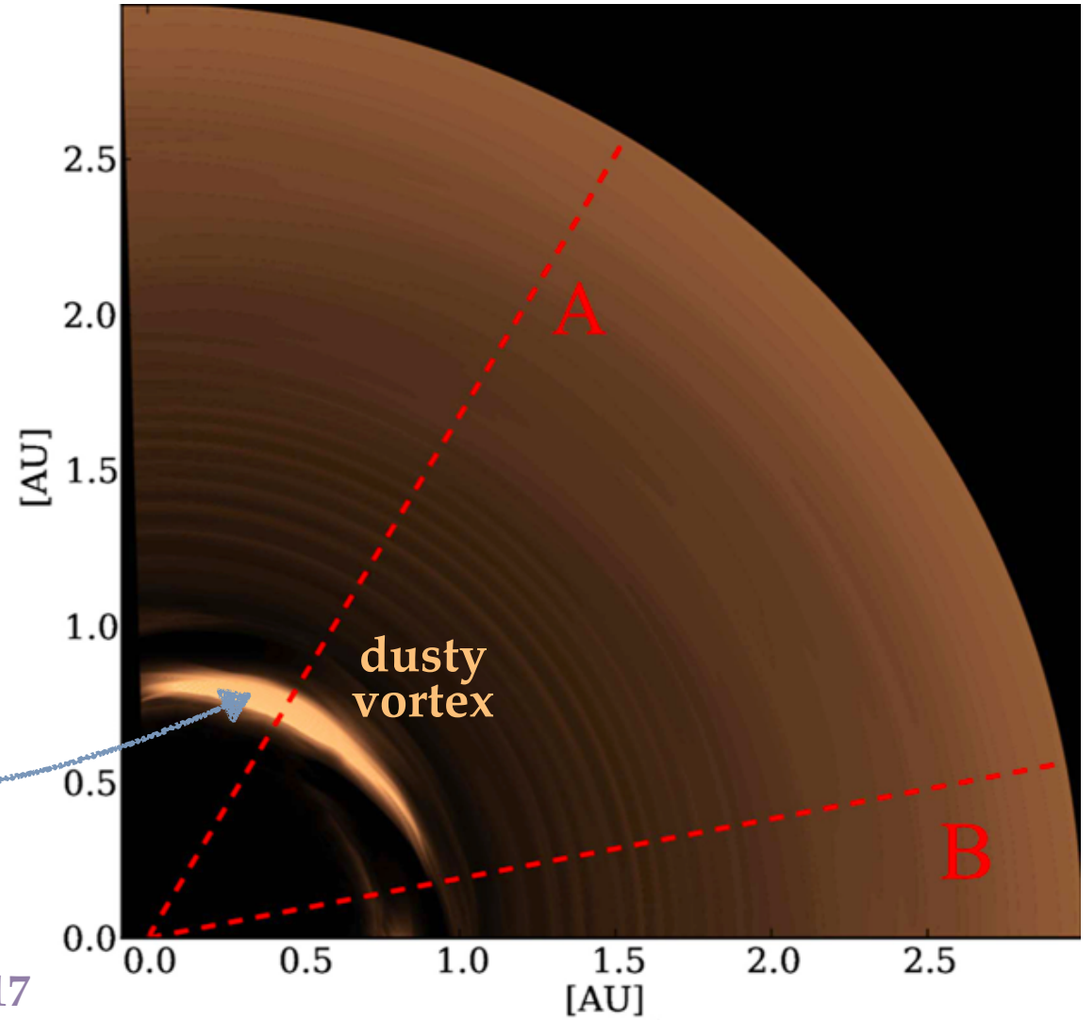
Our ongoing work on HD 163296

- An asymmetric dust inner ring?
- How? By the Rossby-Wave Instability (RWI)?
  - a **linear, non-axisymmetric** shear instability
  - saturates into few **anticyclonic vortices** that tend to **merge** over time and **trap dust**
  - **necessary** condition for onset of instability: a radial **extremum** in $\mathscr{L} = \frac{\Sigma\Omega}{\kappa^2} S^{2/\gamma}$ with $\kappa^2 = \frac{2\Omega}{R}\frac{d(R^2\Omega)}{dR}$ the radial epicyclic frequency squared and $S \equiv p/\Sigma^\gamma$ the specific entropy

Li+ 00

e.g., at the edges of a **planet gap**, between **magnetically** *active* and *dead* regions





Flock+ 17

Our ongoing work on HD 163296

- An asymmetric dust inner ring?
- How? By the Rossby-Wave Instability (RWI)?
  - a **linear, non-axisymmetric** shear instability
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  - **sufficient** condition recently worked out for isentropic discs: $0 < \min(\kappa^2/\Omega^2) \lesssim 1/2$ — **Chang & Youdin 24**

- The original presentation then showed results that aren't published yet, so we decided to remove them from the online presentation!

... thanks!