

What causes the dust's asymmetric emission in the inner parts of protoplanetary disks seen by the VLTI?

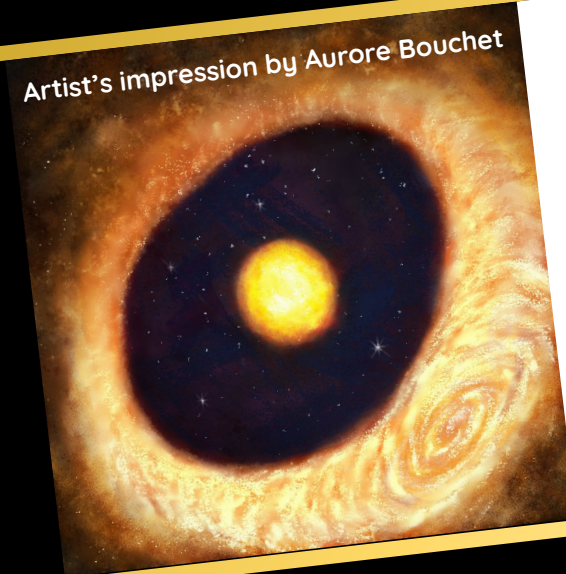
Siméo EVELAIN



Clément BARUTEAU

Héloïse MÉHEUT

Artist's impression by Aurore Bouchet



Exosystems V - 01/04/2026

Observations of arc-shaped structures

Exosystems V

01/04/2026



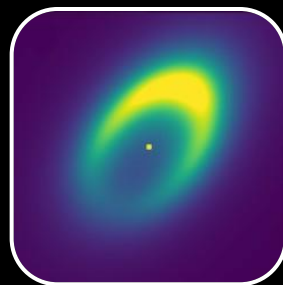
HD 142527
at 1 mm (ALMA)
Boehler+ 2021

660 AU



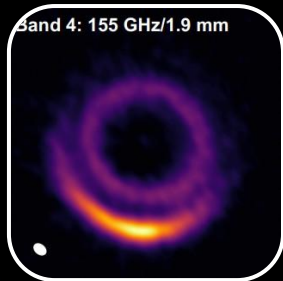
HD 190073
at 1.6 μm
(CHARA/PIONIER)
Ibrahim+ 2023

4.5 AU



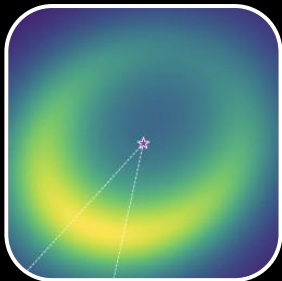
HD 163296
at 3.2 μm
(MATISSE)
Varga+ 2021

1.2 AU



HD 135344B
at 2 mm (ALMA)
Cazzoletti+ 2018

260 AU



HD 98922
at 2.1 μm
(GRAVITY)
Ganci+ 2024

3 AU



HD 163296
at 1.6 μm
(CHARA/PIONIER)
Setterholm+ 2025

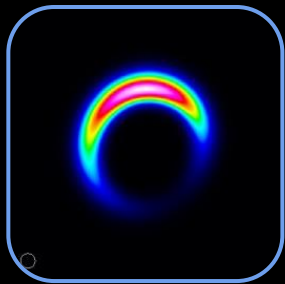
0.8 AU

Observations of arc-shaped structures

Legend : Disk's outer parts (> 100 AU) / sub-millimetric observations

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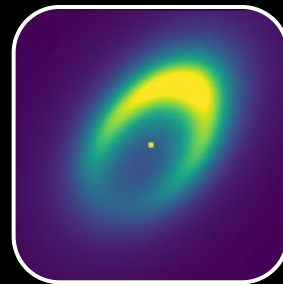
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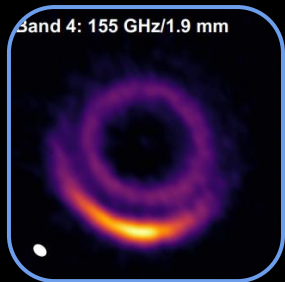
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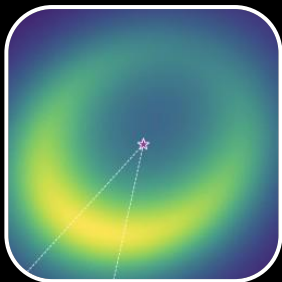
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Observations of arc-shaped structures

Legend: Disk's inner parts (< 5 AU) / near-infrared observations

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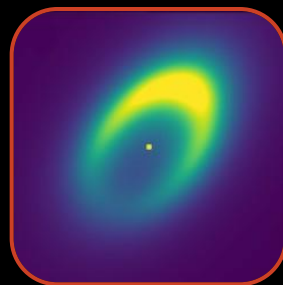
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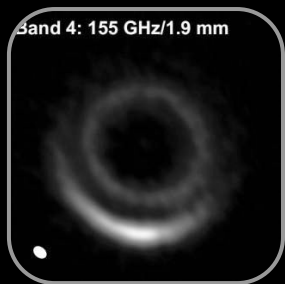
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Observations of arc-shaped structures

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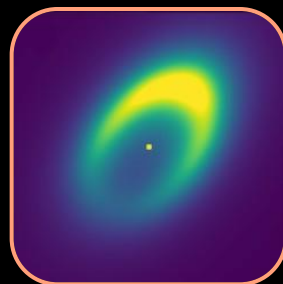
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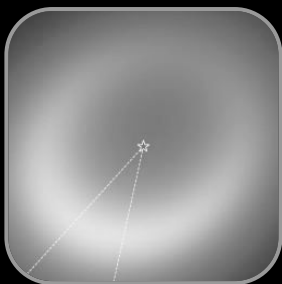
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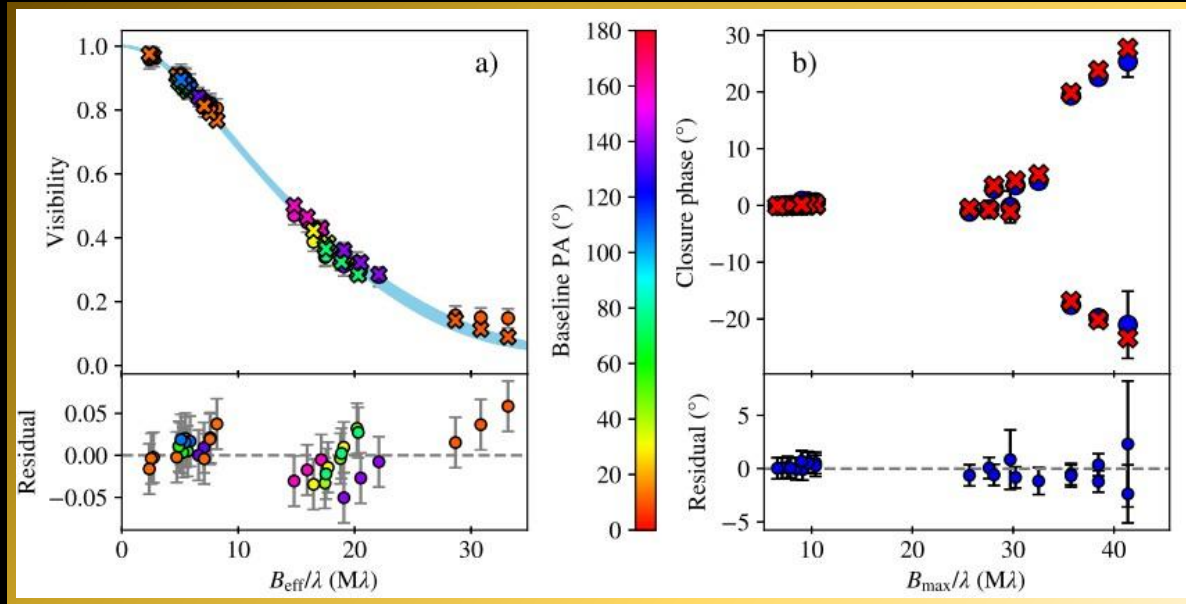


HD 163296
at 1.6 μm
(CHARA/PIONIER)
Setterholm+ 2025

0.8 AU

Interferometric observations

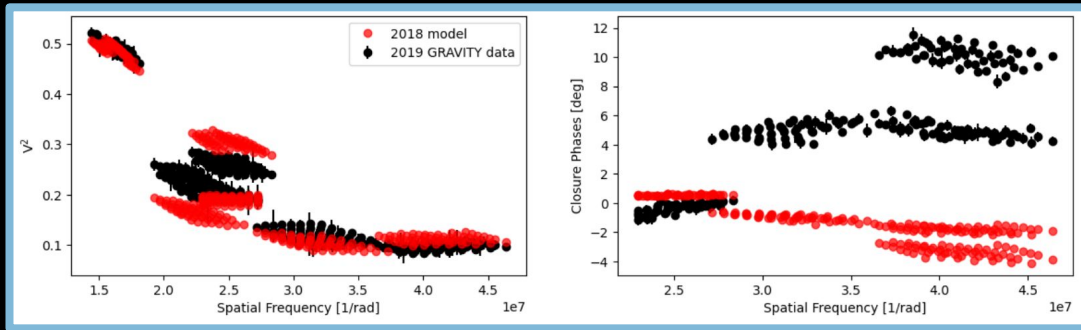
Interferometric data from the observation of HD 163296 (Varga et al. 2021)



Visibility → the radial distribution of the emission flux

Closure phase → the (non-) axisymmetry of the emission flux

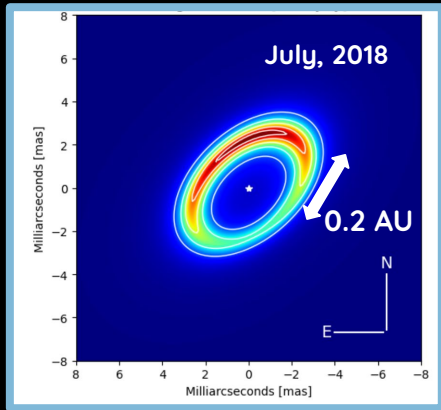
Time variability



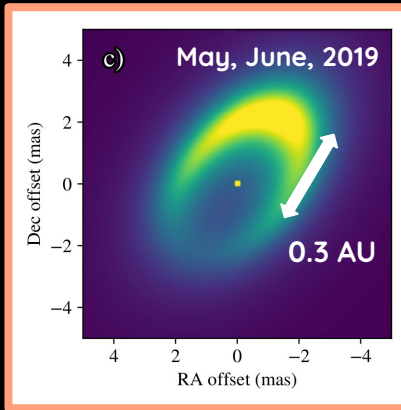
GRAVITY Collaboration, 2021

Exosystems V

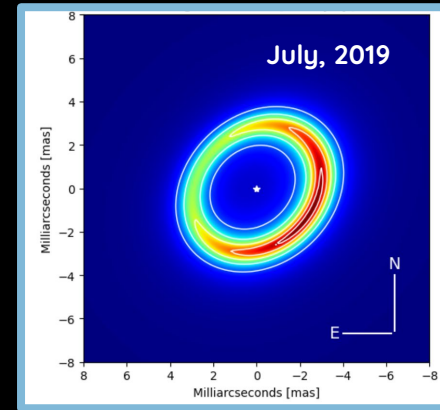
01/04/2026



GRAVITY Collaboration, 2021

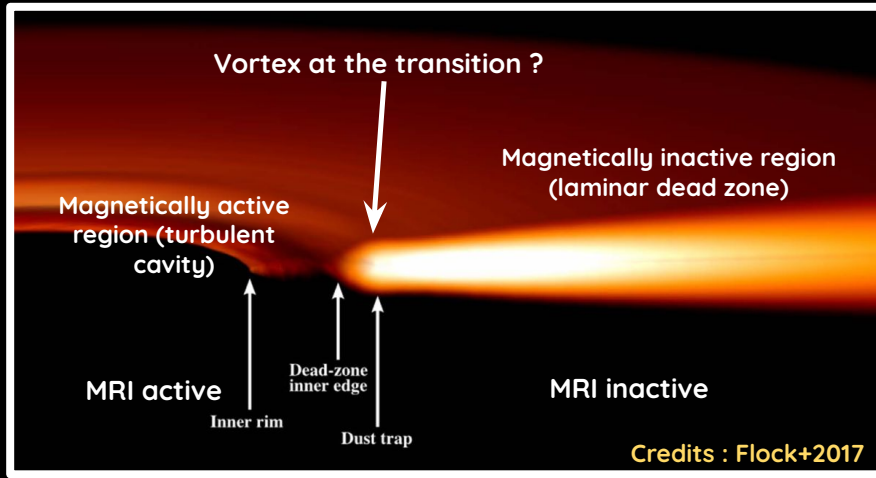


Varga et al., 2021

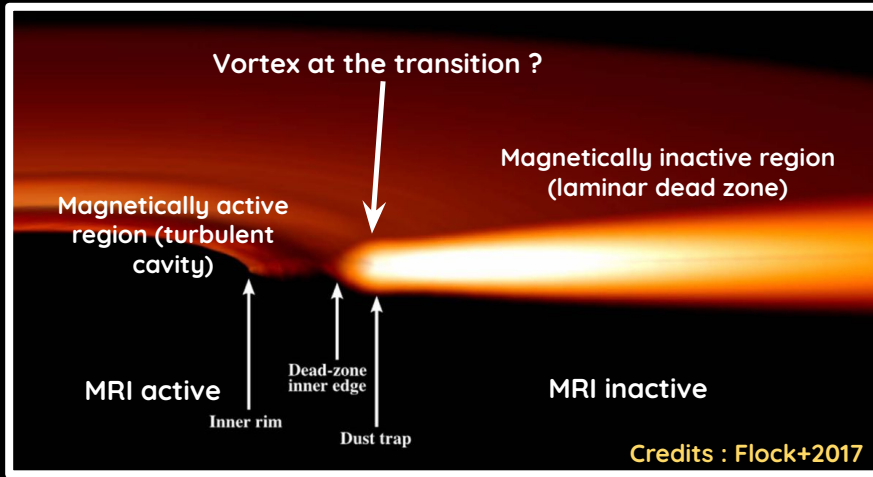


GRAVITY Collaboration, 2021

Objectives of the research work



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Hypothesis : a **dust-trapping vortex** at 0.3 AU ?

Sufficient condition to trigger the RWI :

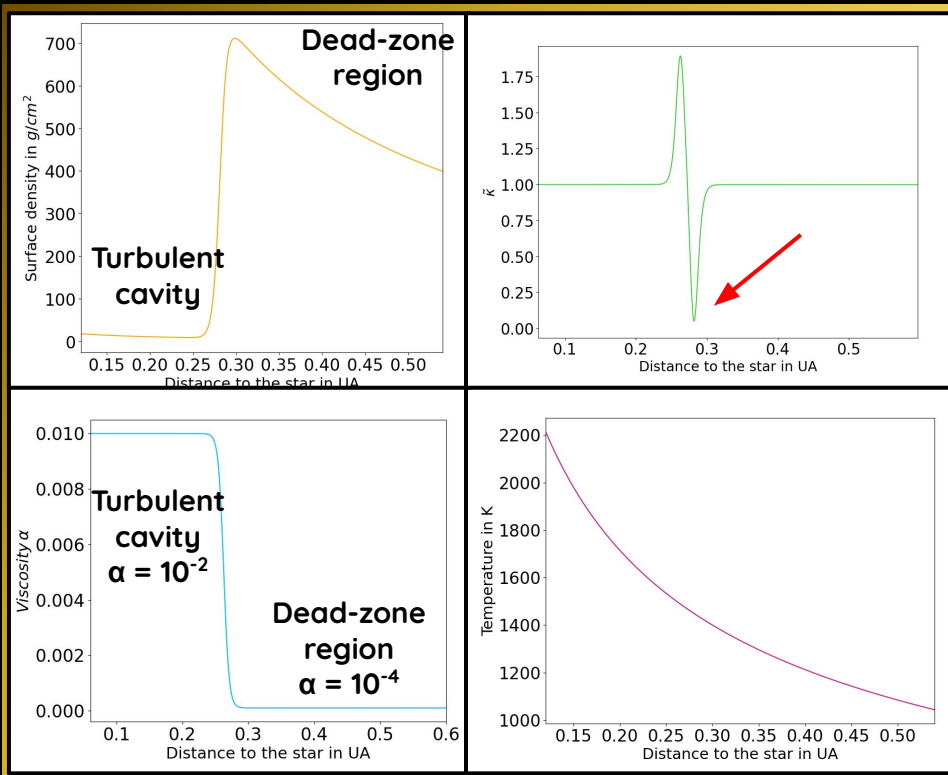
$$\min(\tilde{\kappa}) < 0.5$$

Chang&Youdin+2024

$$\tilde{\kappa} = \frac{\kappa^2}{\Omega^2}$$

The chosen model

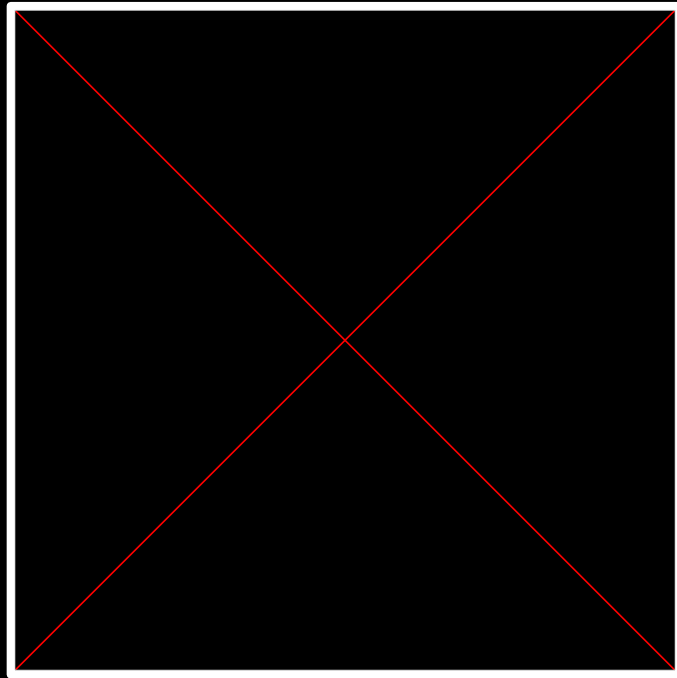
Cavity profile =
maximum density at the
edge of the cavity



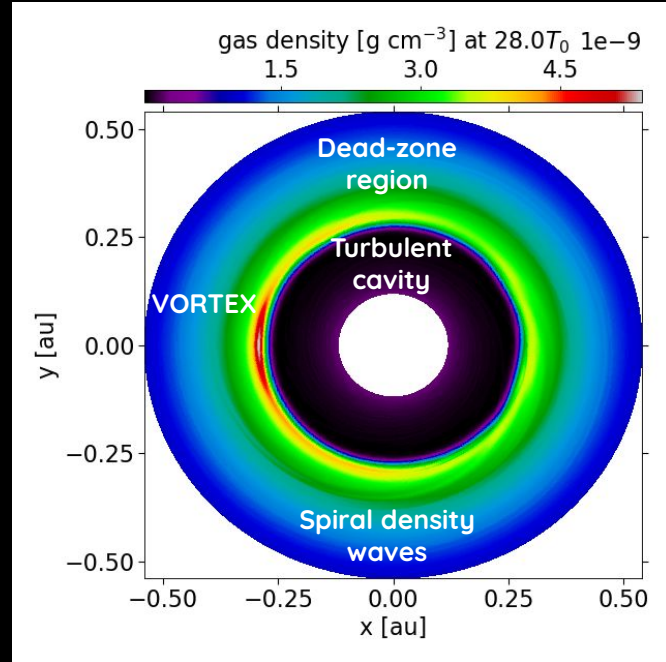
Minimum of $\tilde{\kappa}$ close to
5% : RWI triggering at
~0.3 AU

Power-law initial
temperature profile +
energy equation

Results : lifetime of the vortex

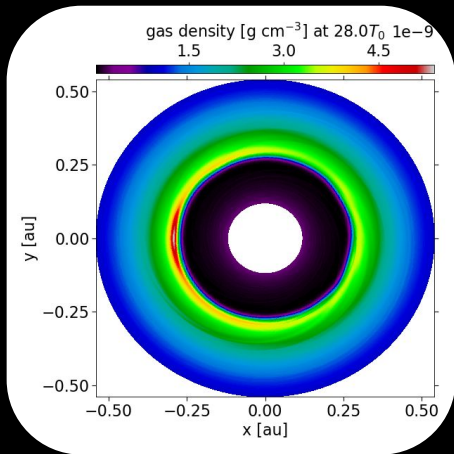


Gas midplane density

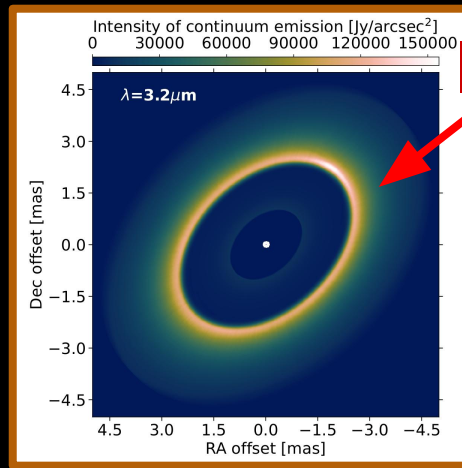


Results : dust radiative transfer calculations

Transfer code RADMC-3D : thermal Monte-Carlo + ray-tracing



Gas midplane density



VORTEX !

Synthetic dust emission map

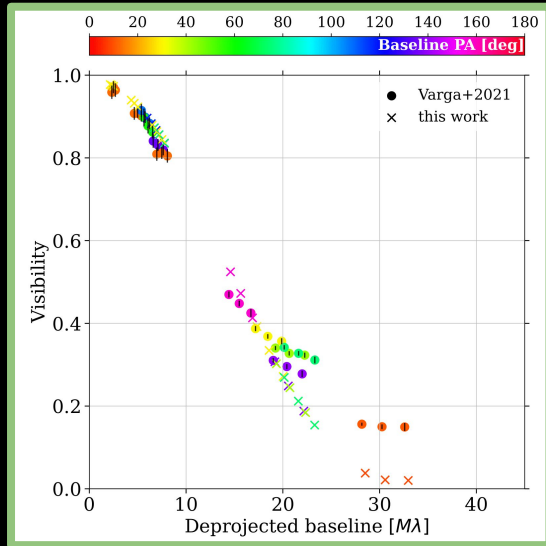
Dust-to-gas mass ratio = 10^{-7}

Star-to-disk flux ratio in the

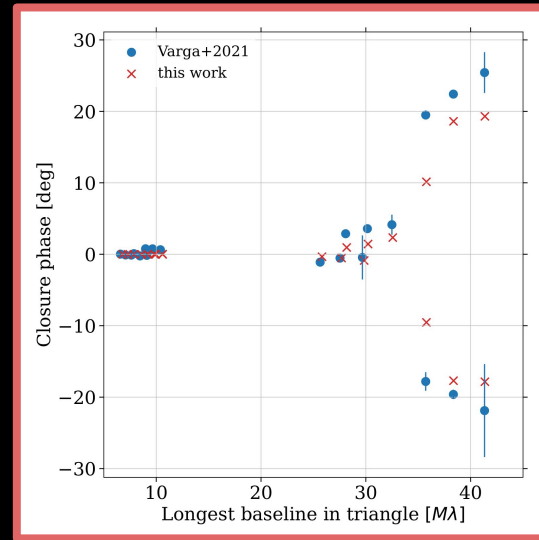
L-band : 9.8%

Results : a good fitting of visibilities and closure phases ?

ASPRO2 : compute synthetic interferometric observables with the same VLTI configuration used by **Varga et al. 2021**



Visibilities



Closure phases

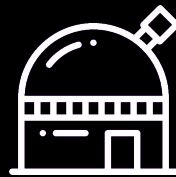
Conclusion



To explain the crescent-shaped structures in dust emission :
Dust-trapping vortex at the edge of the turbulent cavity.

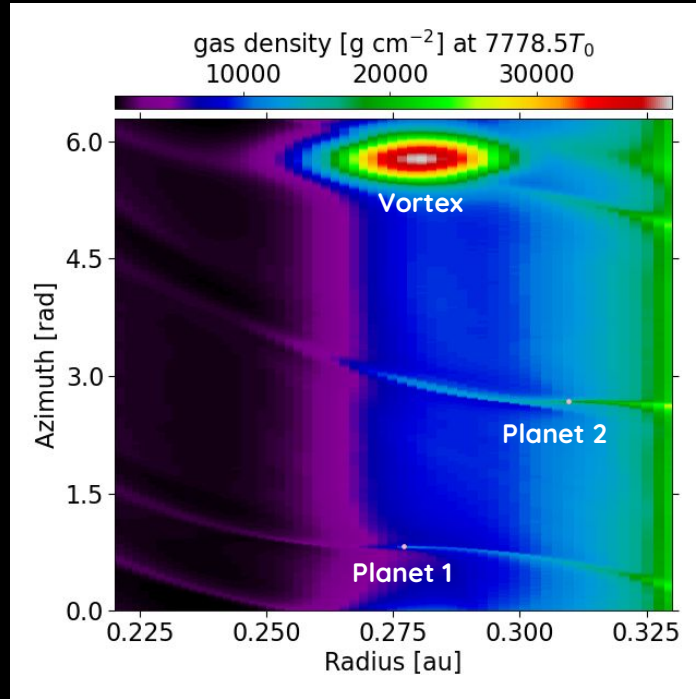
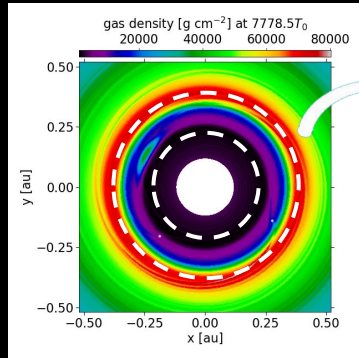


Formation of vortex is **possible** but it has **short lifetime**. The addition of an energy equation or a temperature transition does not improve this lifetime.

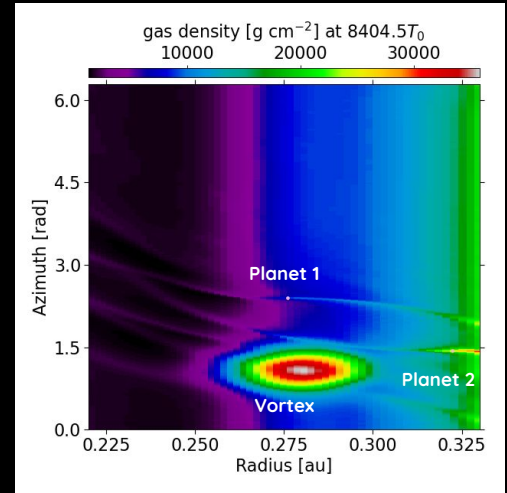
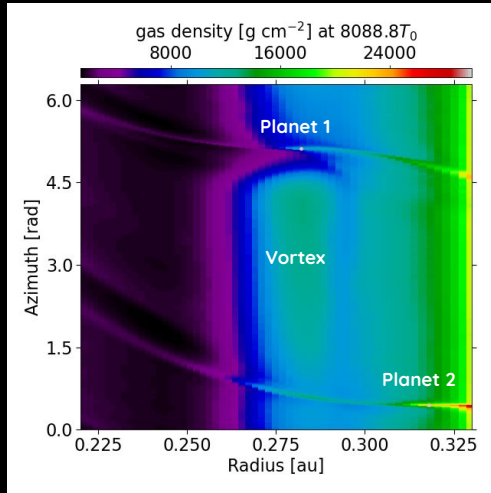
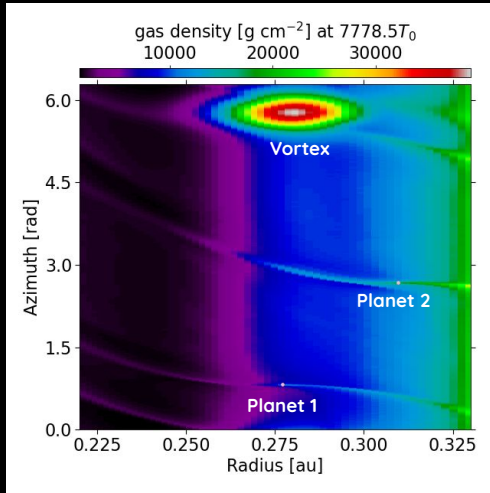


Difficult to reproduce all the visibilities but closure phases are **nearly reproduced** when the vortex is still present.

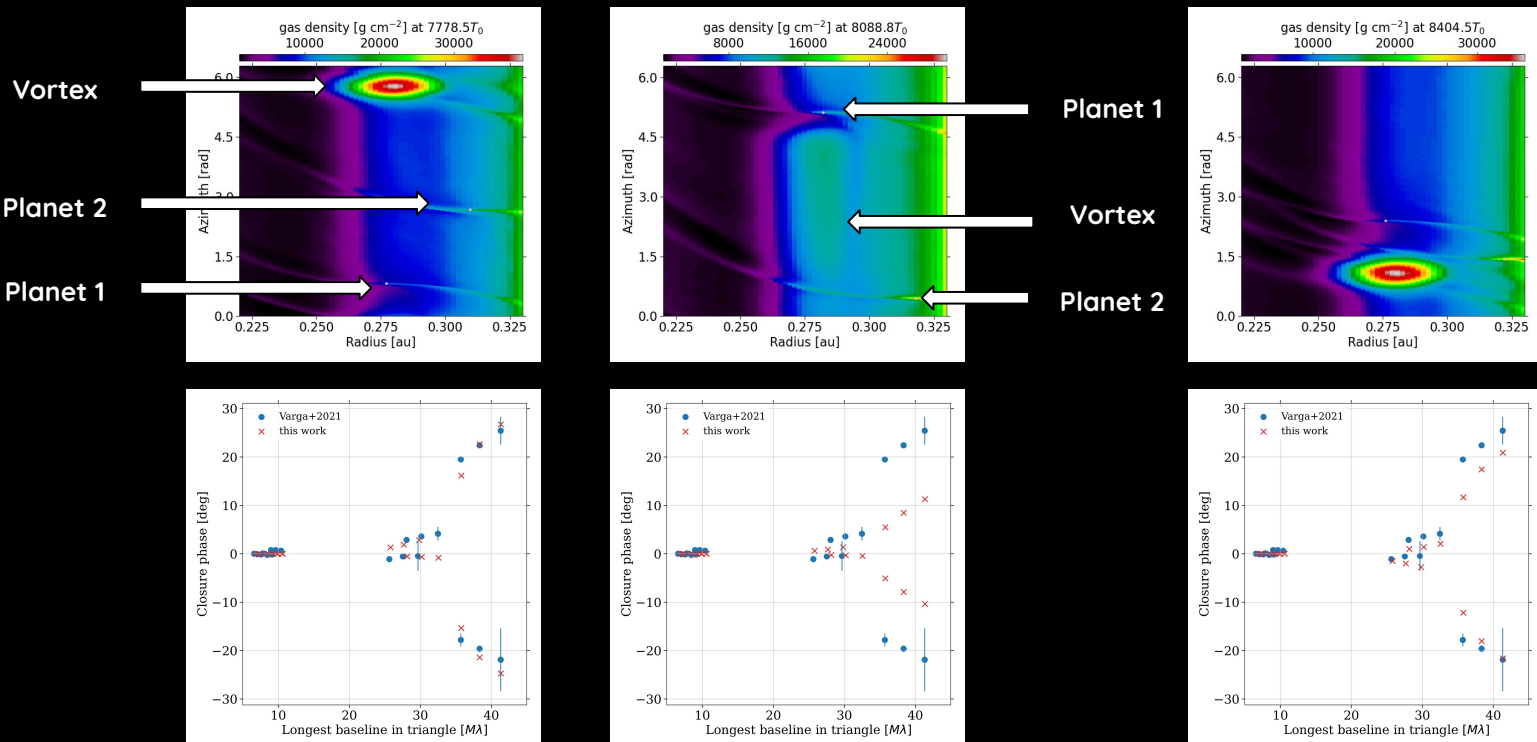
Perspectives



Perspectives



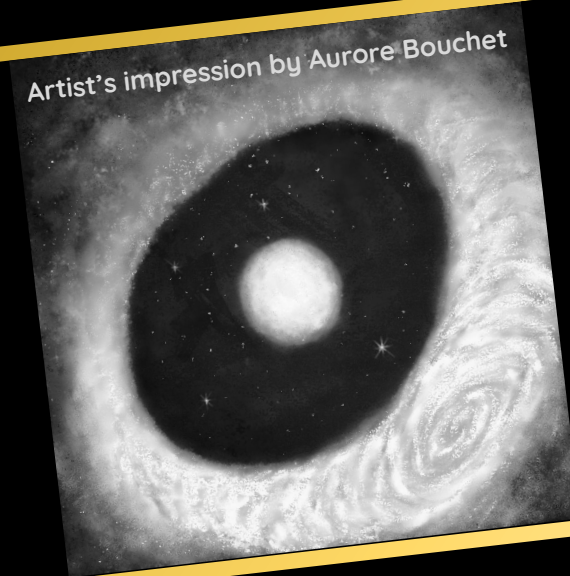
Perspectives



What causes the dust's asymmetric emission in the inner parts of protoplanetary disks seen by the VLTI?

**THANK YOU
FOR YOUR
ATTENTION !**

Artist's impression by Aurore Bouchet



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⇓
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Bonus slide

