HD142527: A CRIME SCENE INVESTIGATION

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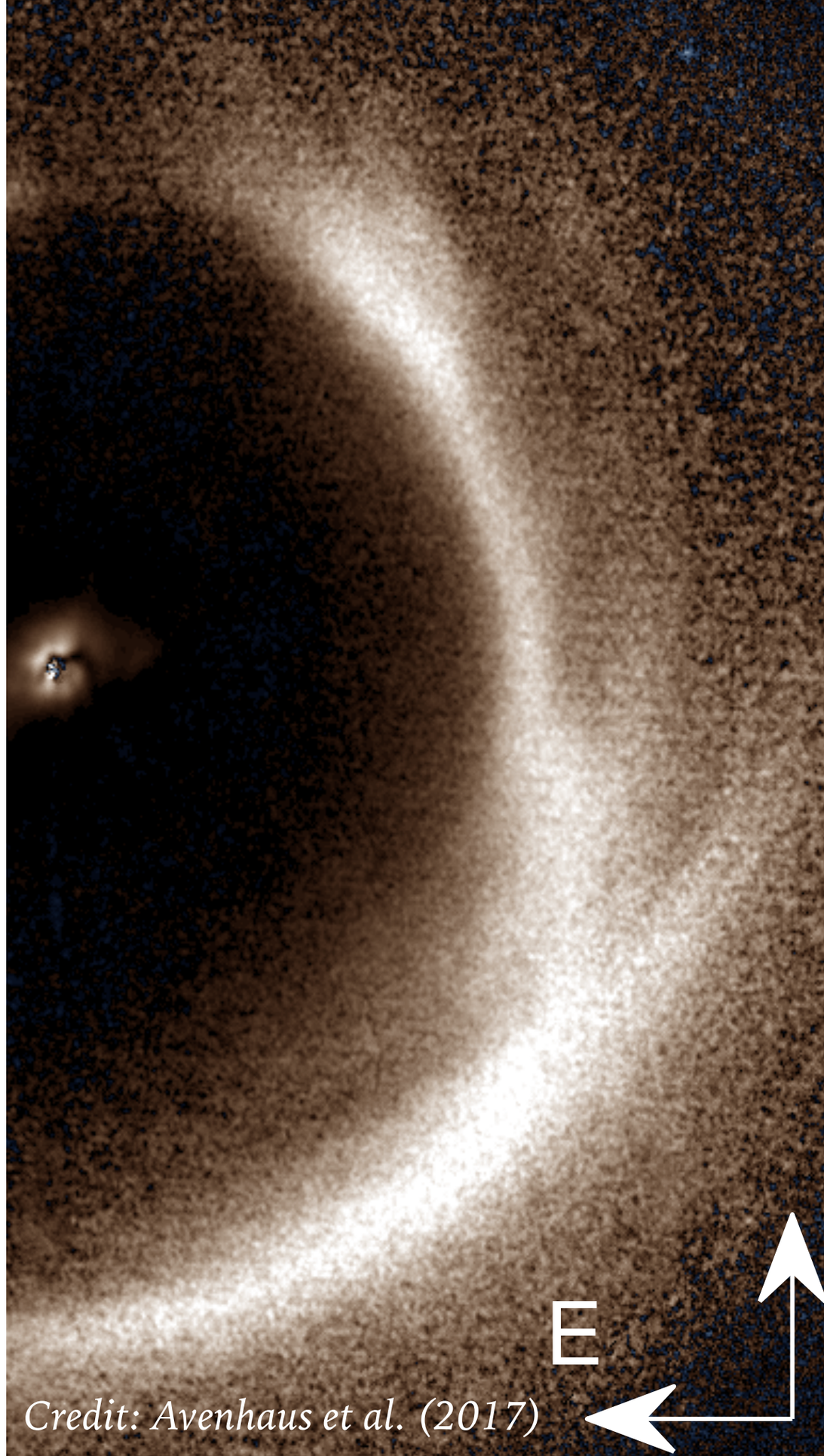
Attila Juhasz (Cambridge)
Enrico Ragusa (Milano)
Giuseppe Lodato (Milano)

Phantom European users workshop
20th June 2018

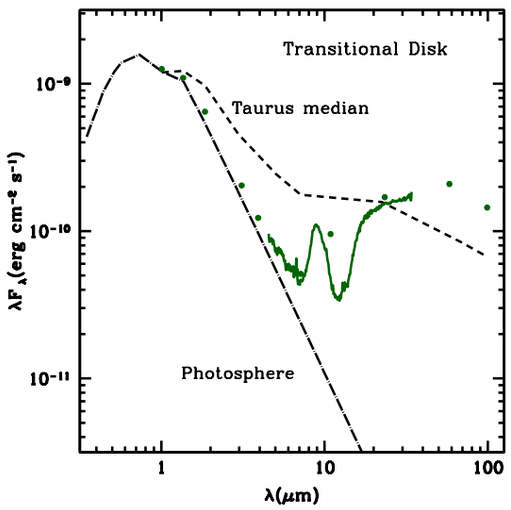


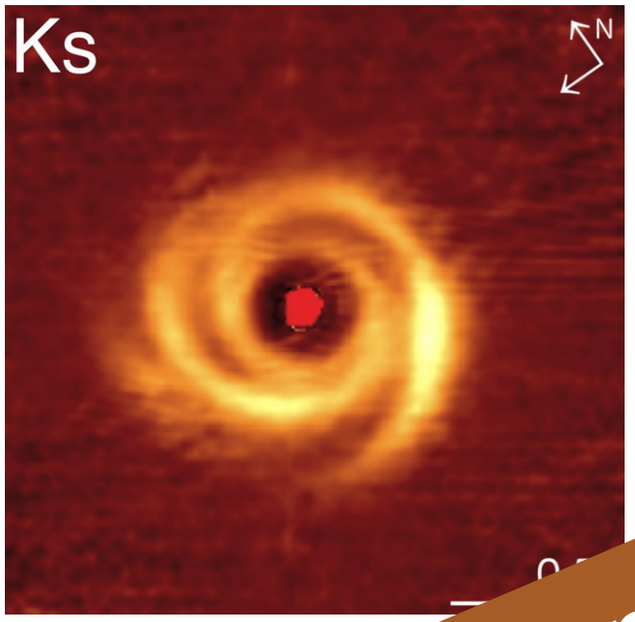
Credit: Avenhaus et al. (2017)

THE BACKGROUND

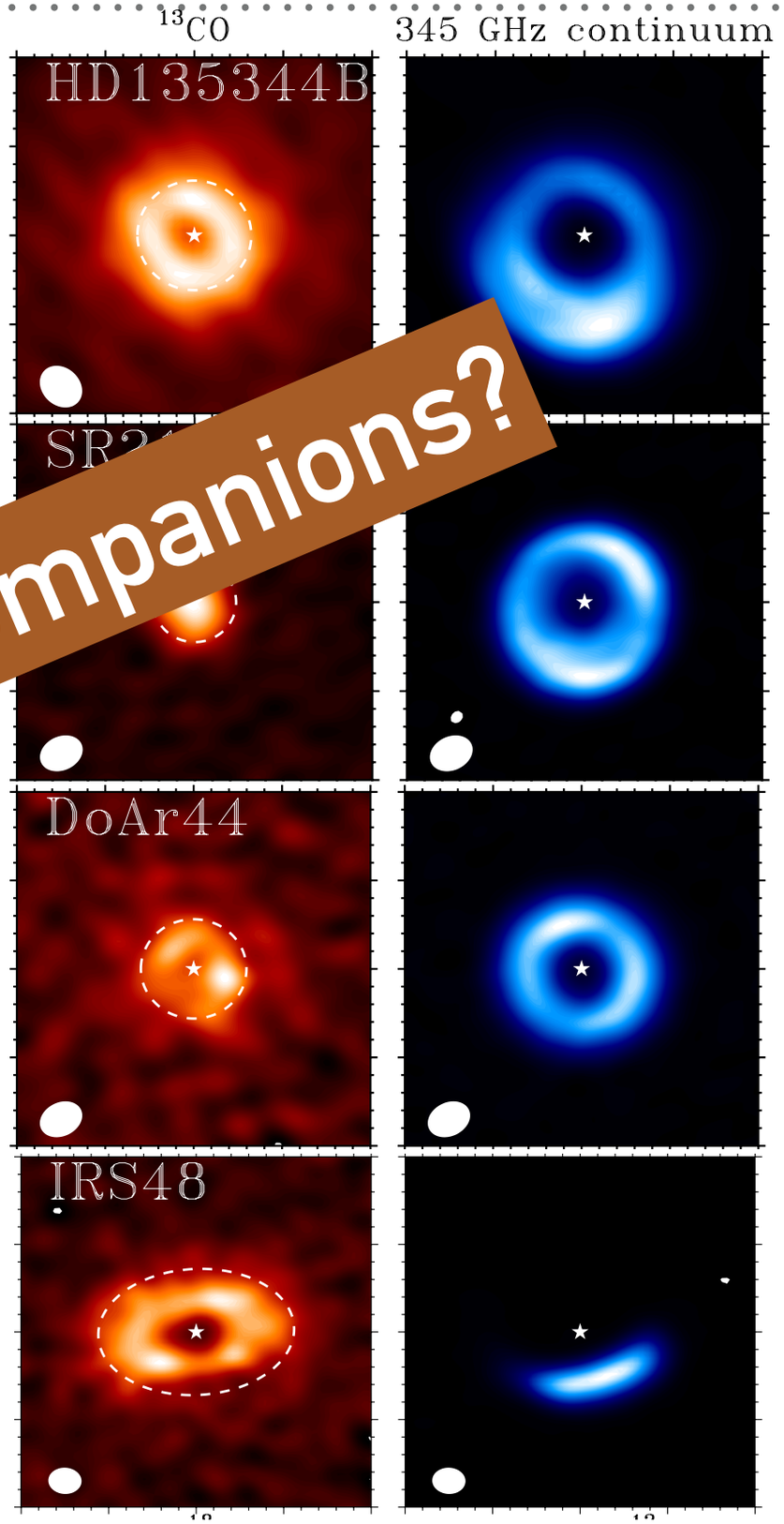
TRANSITION DISCS

Strom et al. (1989), Calvet et al. (2005), Espaillat et al. (2014), Casassus (2016), Owen (2016)

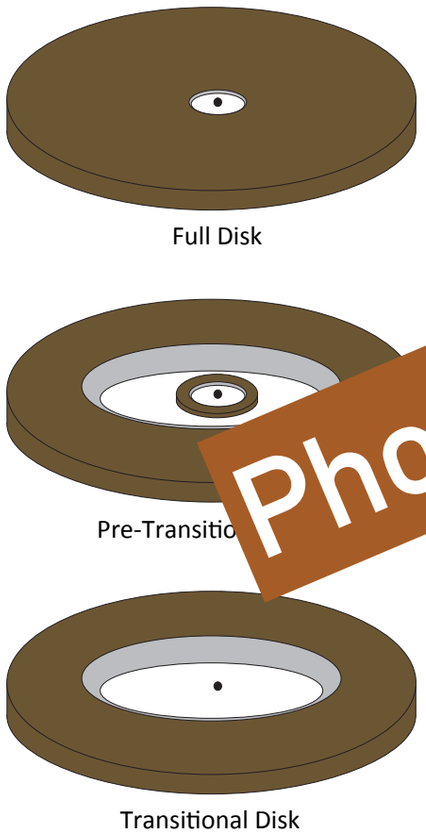




Garufi et al.



Van-der-Marel et al. (2016)

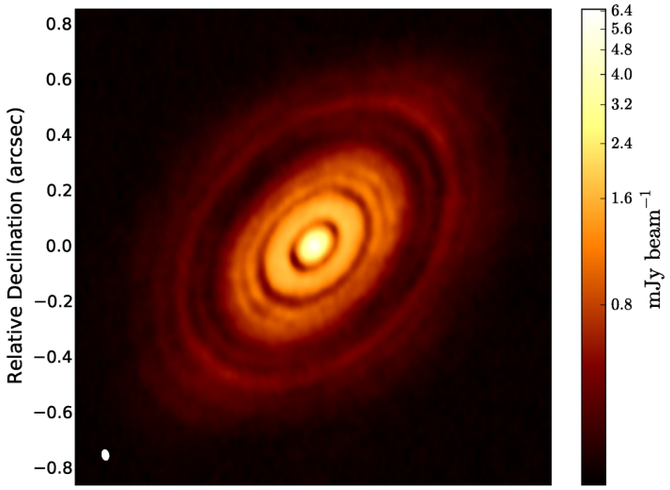


Espaillat et al. (2014)

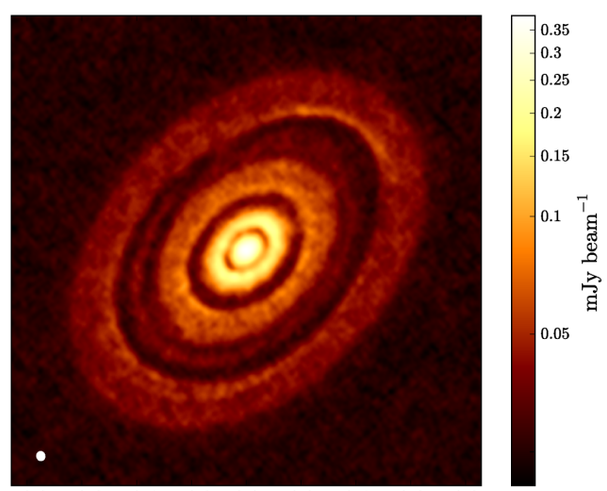
Benisty et al. (2016)

Photoevaporation or companions?

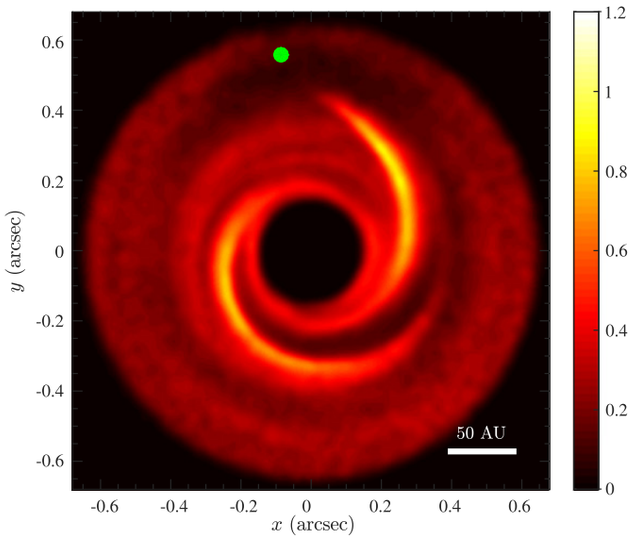
DISCS IN THE ERA OF ALMA + EXTREME ADAPTIVE OPTICS



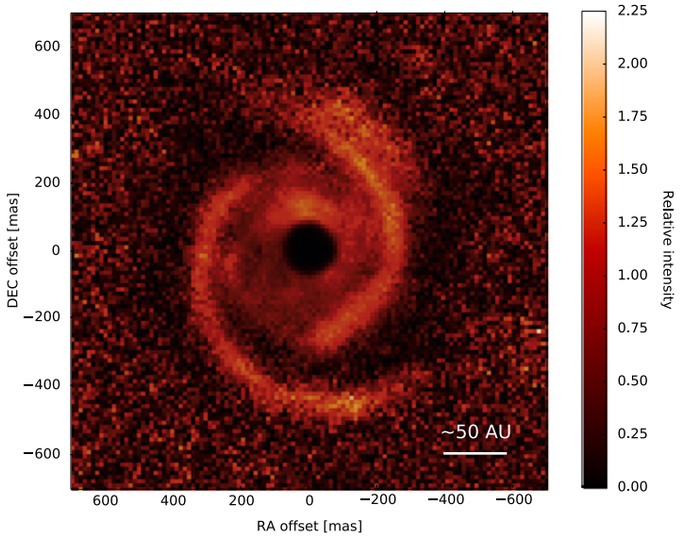
ALMA et al. (2015)



Dipierro et al. (2015)



Dong, Zhu, Rafikov & Stone (2015)



Benisty et al. (2015)

Companions or other physics?

e.g.

Lyra & Kuchner (2012)

Pinilla (2012)

Takahashi & Inutsuka (2012)

Zhu & Stone (2014)

Dipierro et al. (2014)

Zhang, Blake & Bergin (2015)

Loren-Aguilar & Bate (2015)

Flock et al. (2015)

Dong (2015)

Meru et al. (2017)

THE CRIME SCENE

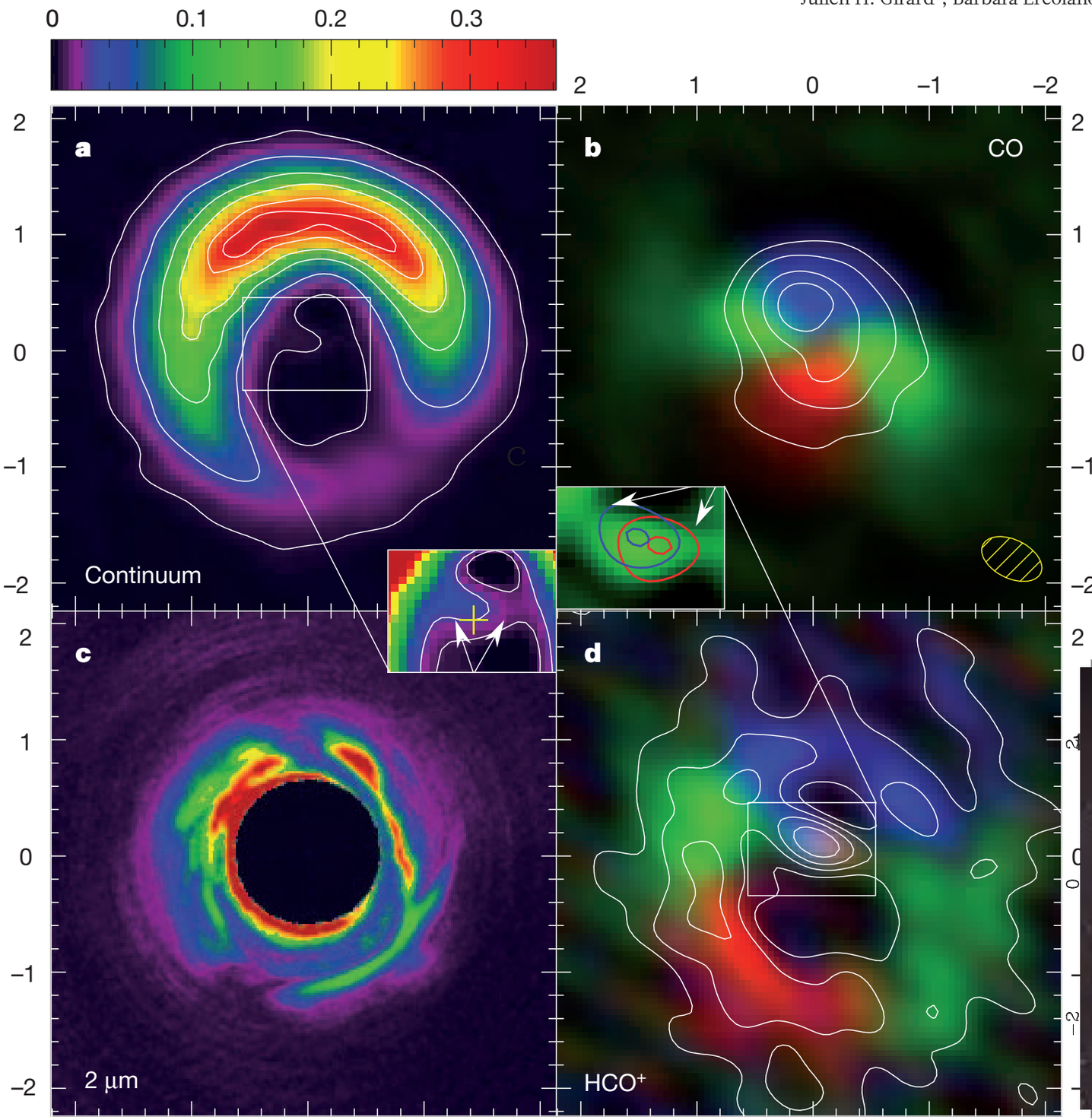
HD142527: CRIME SCENE

LETTER

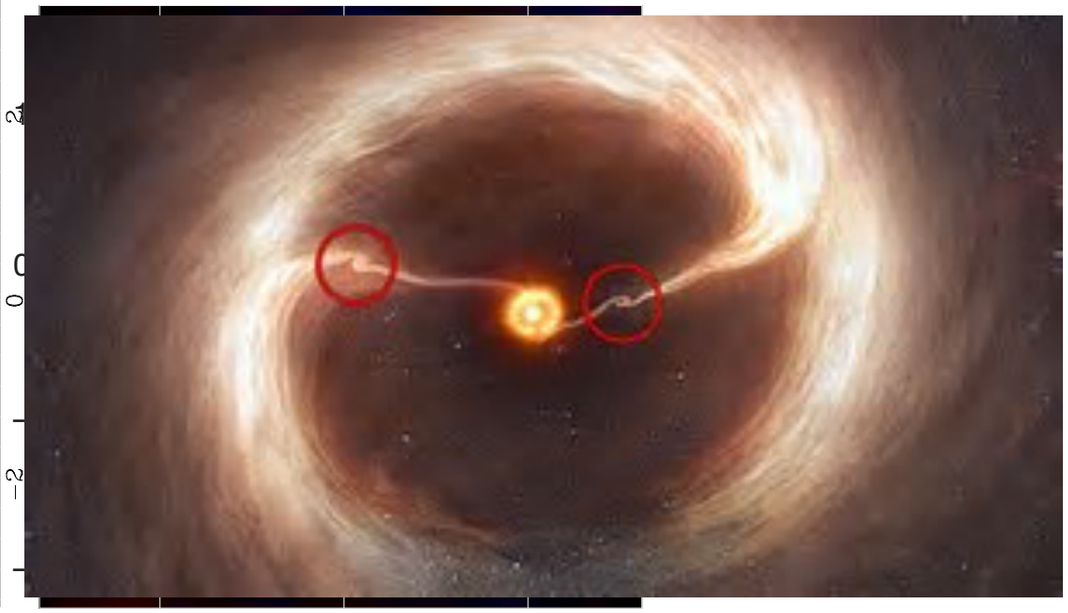
doi:10.1038/nature11769

Flows of gas through a protoplanetary gap

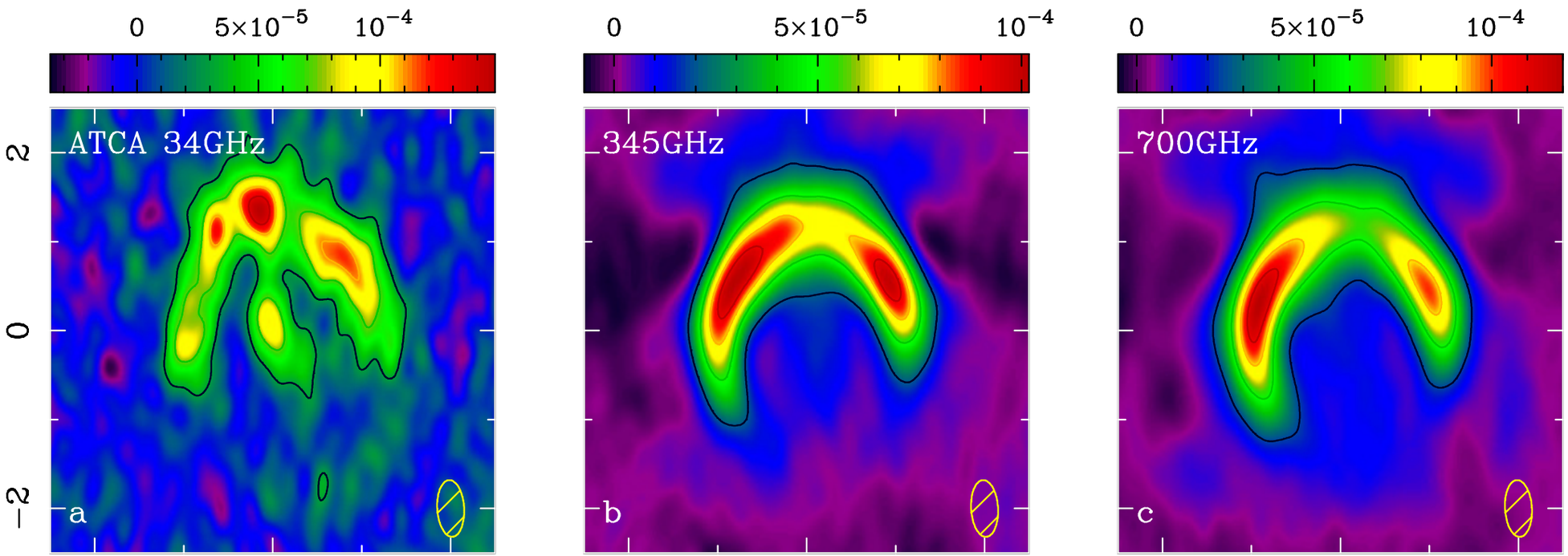
Simon Casassus[1], Gerrit van der Plas[1], Sebastian Perez M[1], William R. F. Dent[2,3], Ed Fomalont[4], Janis Hagelberg[5], Antonio Hales[2,4], Andrés Jordán[6], Dimitri Mawet[3], Francois Ménard[7,8], Al Wootten[4], David Wilner[9], A. Meredith Hughes[10], Matthias R. Schreiber[11], Julien H. Girard[3], Barbara Ercolano[12], Hector Canovas[11], Pablo E. Román[13] & Vachail Salinas[1]

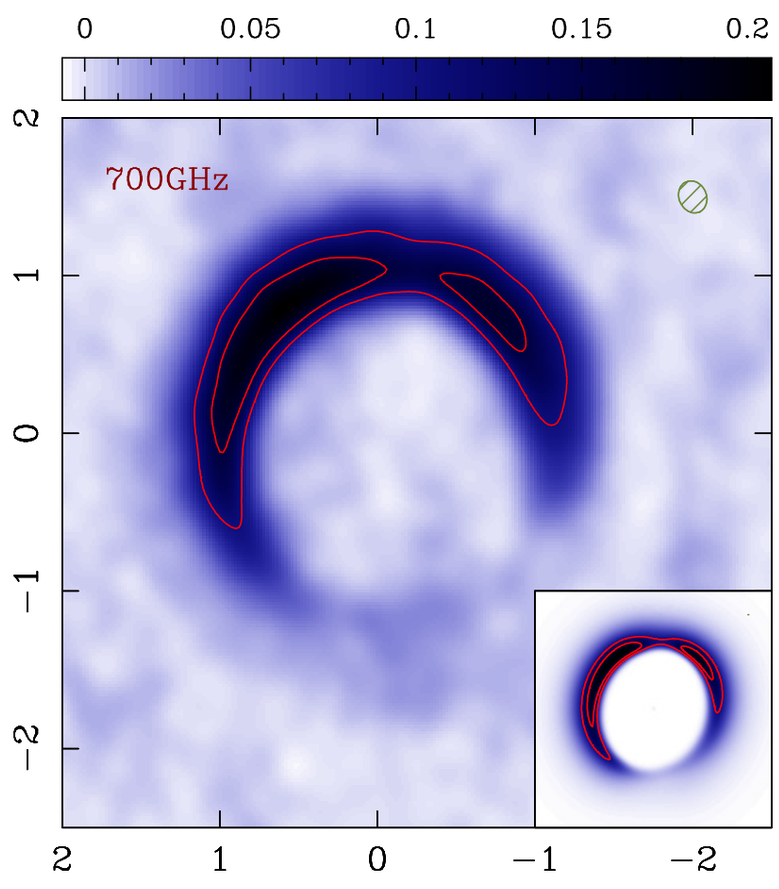


- Large ~100 au cavity
- Horseshoe in mm emission
- Gap-crossing filaments?



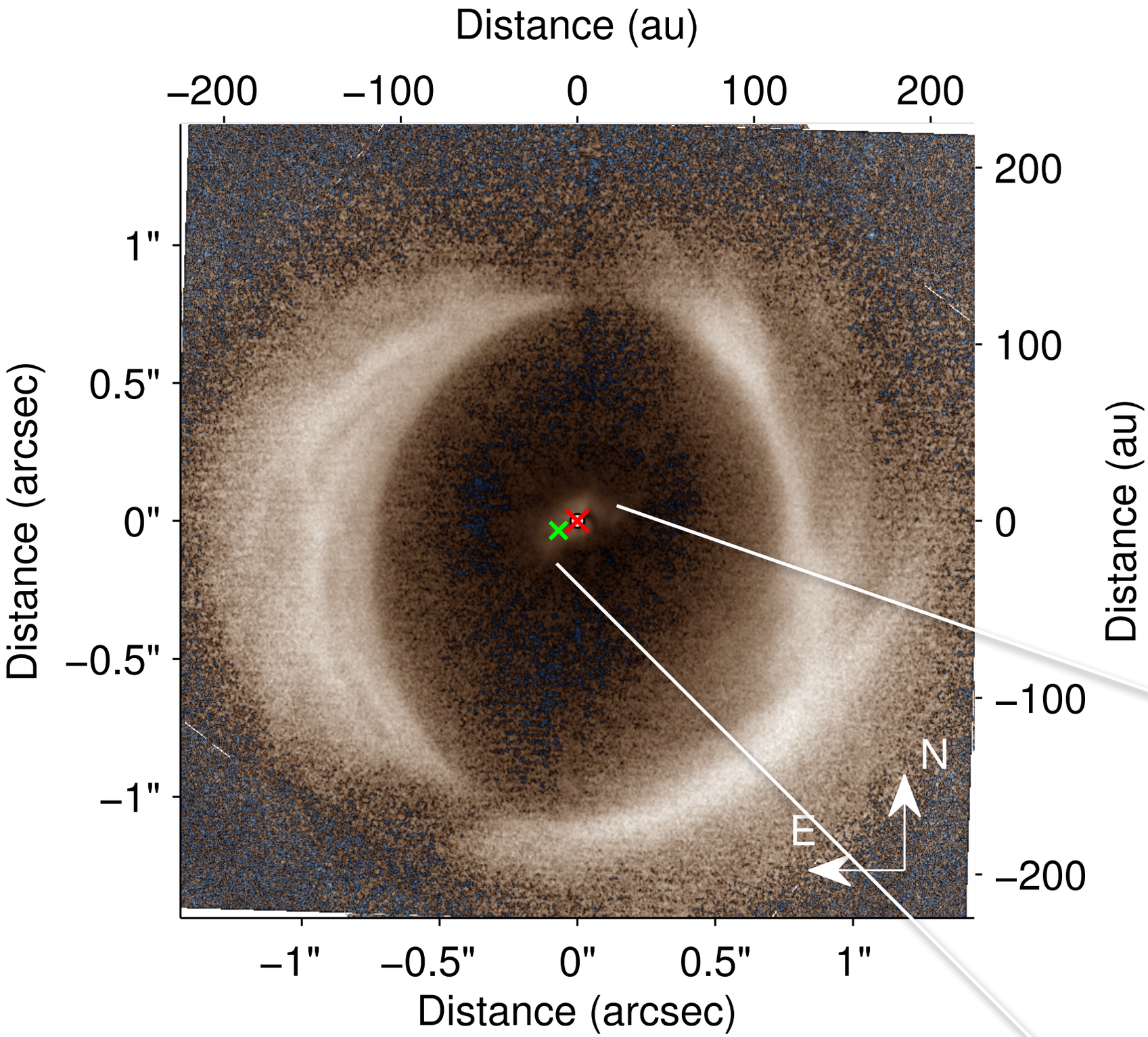
THE DUST HORSESHOE





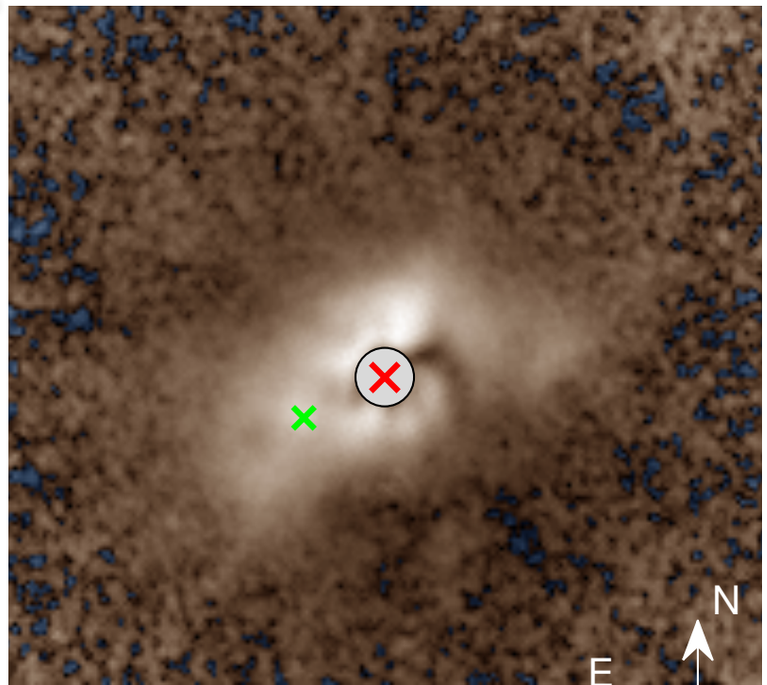
Casassus et al. 2015b

SPIRAL ARMS



VLT-SPHERE Image of HD142527

(Avenhaus+ 2017)



The Astrophysical Journal Letters, 798:L44 (4pp), 2015 January 10

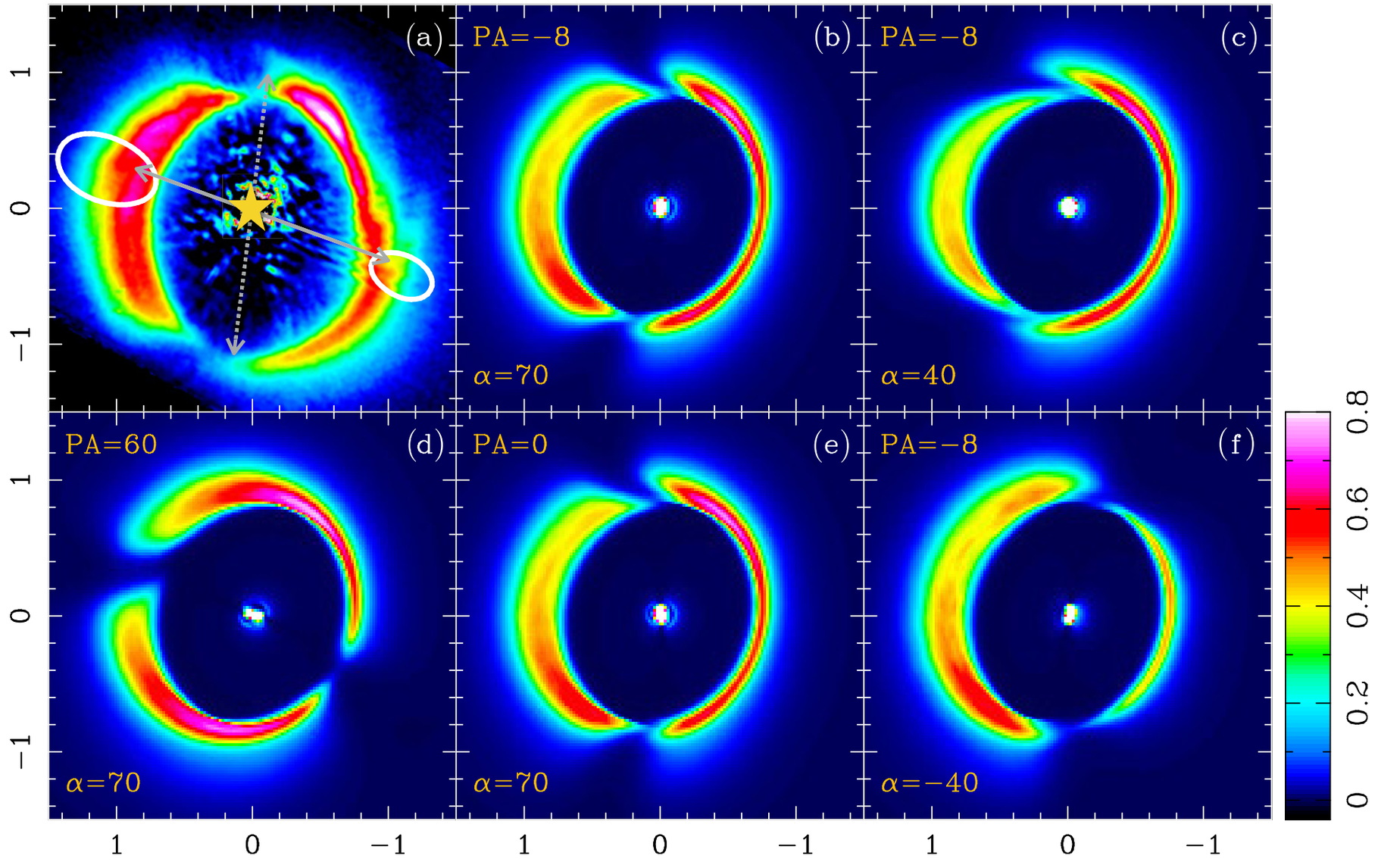
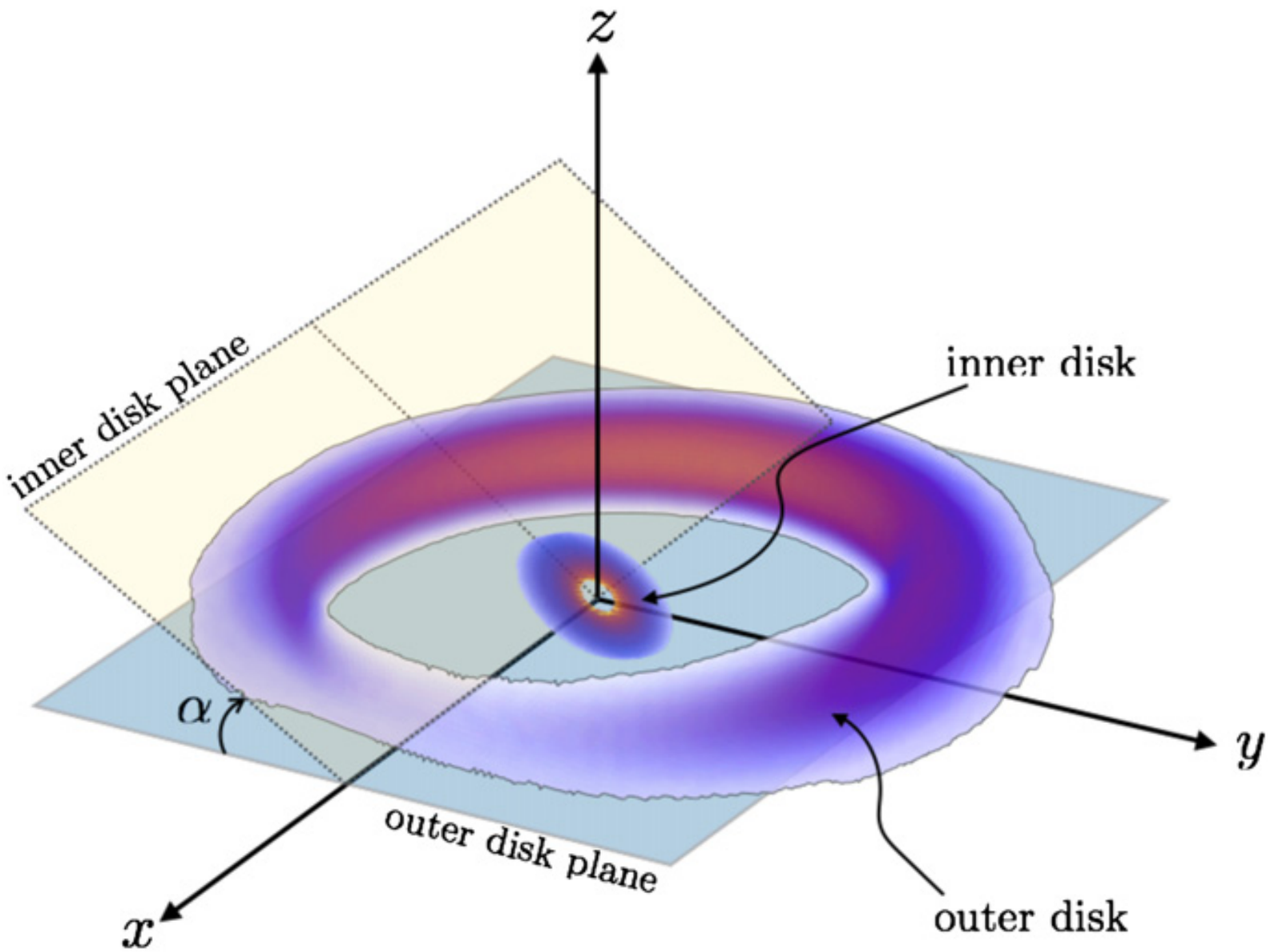


Figure 2. Impact of the inner disk orientation on the *H*-band light scattered off the outer disk. (a) NACO-PDI *H*-band image from Avenhaus et al. (2014) compared with the $C^{18}O(2–1)$ emission at systemic velocity from Perez et al. (2014). The $C^{18}O(2–1)$ emission, represented here as one white contour at 0.75 maximum, shows that the position angle (P.A.) of the outer disk is at $-20°$ east of north, and perpendicular to the solid gray double arrow, while the position angle of the intensity nulls is indicated by the dashed double arrow ($-8°$). (b)–(f) Radiative transfer prediction for polarized intensity in the *H* band for different inner disk P.A.s (indicated in degrees on the plots) and for different relative inclinations α between the inner and the outer disks. The $x-$ and $y-$axes indicate offset along R.A. and decl., in arcsec.

SHADOWS = INCLINED INNER DISC?

The Astrophysical Journal Letters, 798:L44 (4pp), 2015 January 10



Marino, Perez & Casassus (2015)

"FAST RADIAL FLOWS" = DISC TEARING?

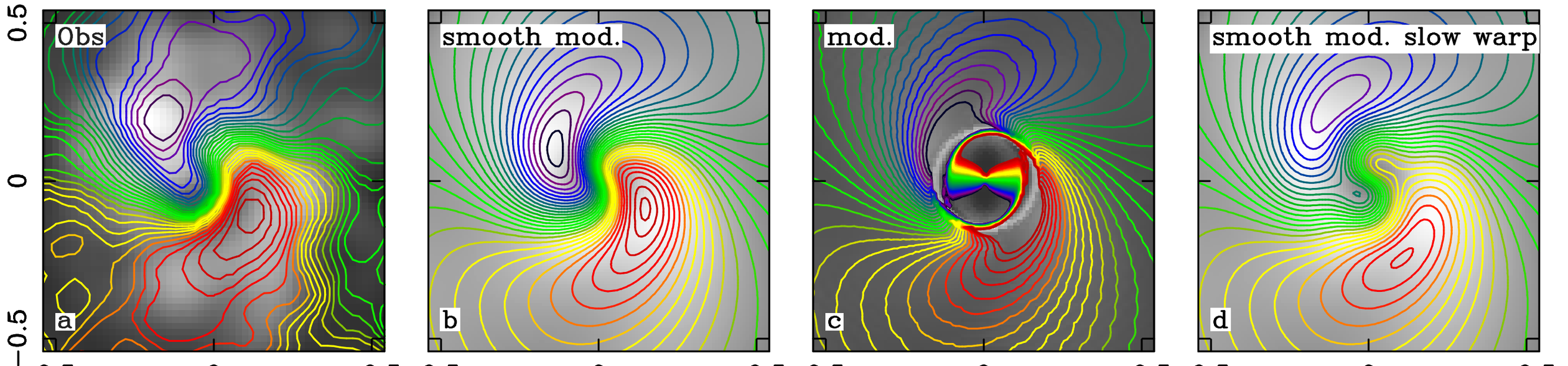
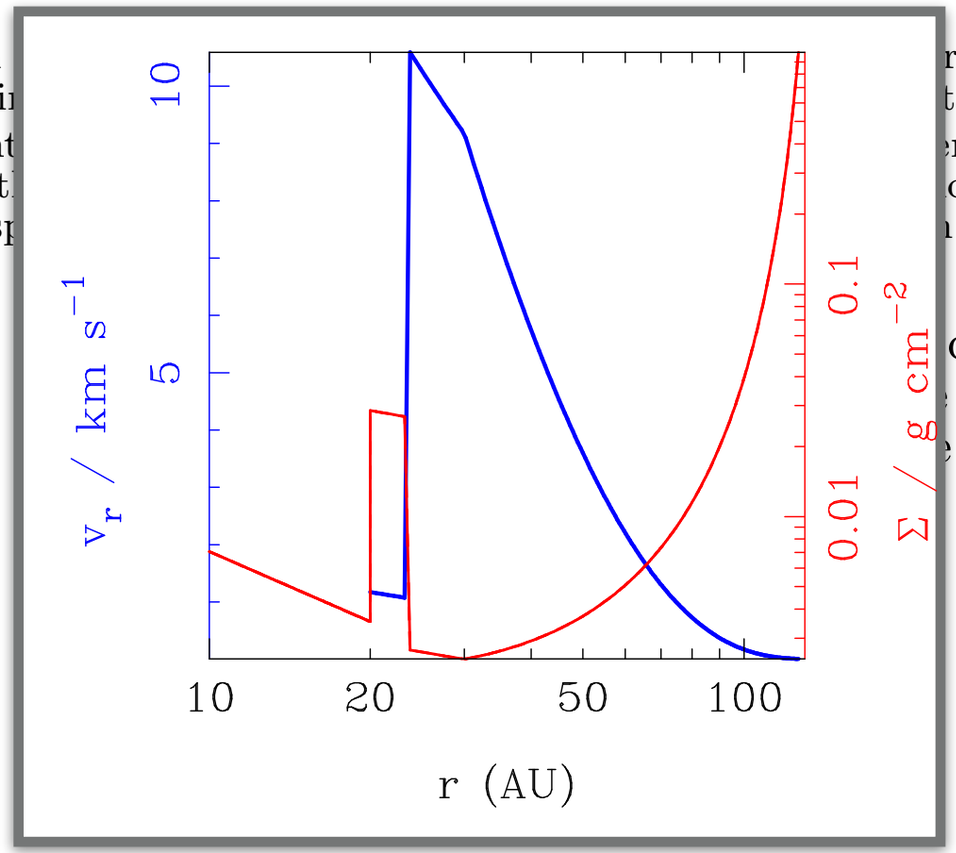


Figure 7. Comparison of observed and model CO(6-5) kinematics in … rdinates is set to the stellar position. Velocity-integrated intensity in CO(6-5) is shown i… tant interval and are spread over $[0.21, 7.87]$ km s^{-1} (as in Fig. 1). **a)**: Observed moment… nts extracted on the radiative transfer prediction, after smoothing to the resolution of t… odel resolutions, without smoothing. Regions without contours near the origin corresp… a slow velocity component perpendicular to the disk plane ($v_{\rm warp}$ in the text).

dubbed disk tearing (Nixon et al. 2013; Nealon et al. 2015; Doğan et al. 2015), where nodal precession torques induced by the binary produce a warp at the inner edge … companion on … 100 AU scale … cavity. It is

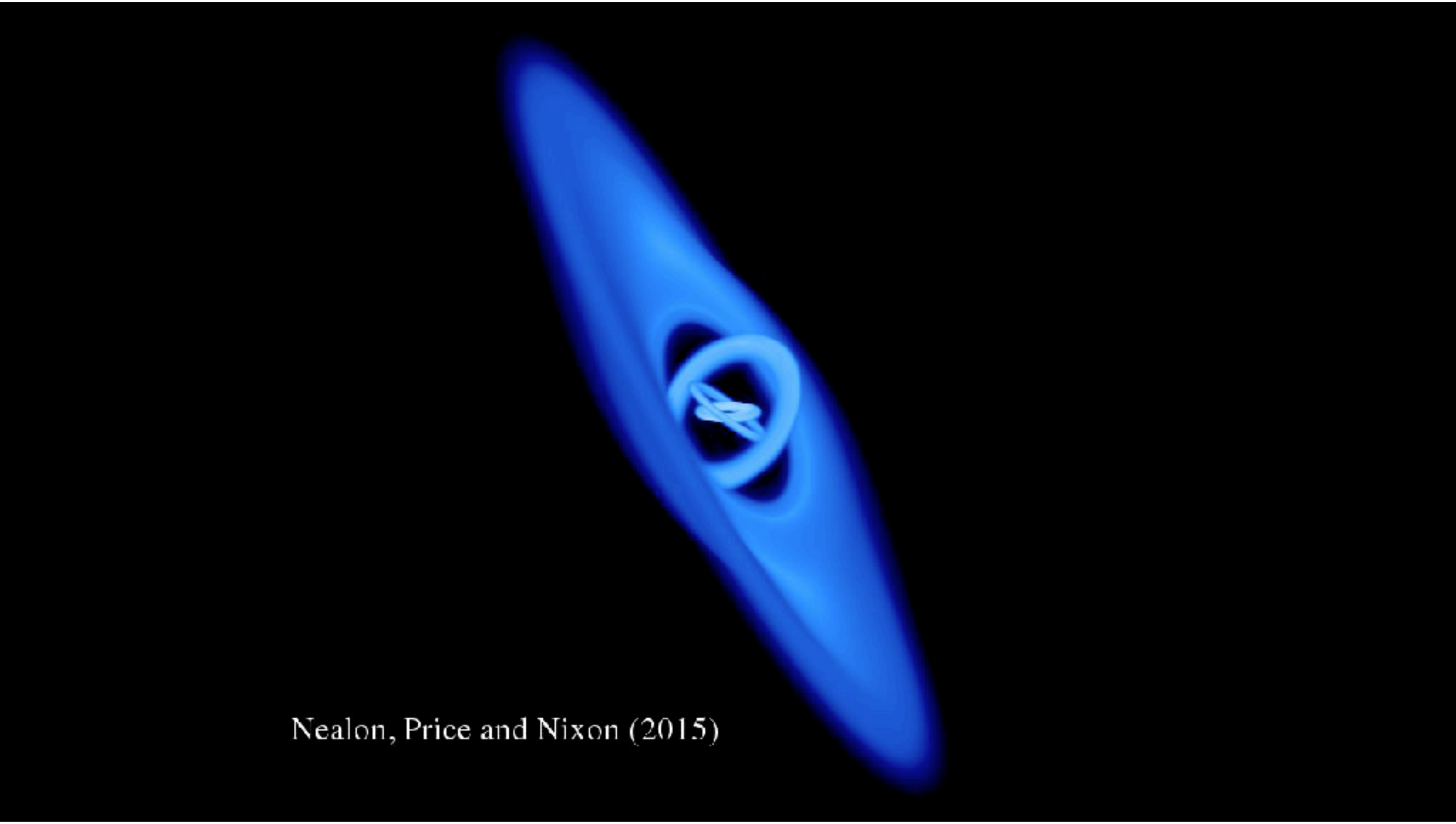


Require infall motions from cavity edge at the free-fall velocity!

LOOKING FOR CLUES

DISC TEARING?

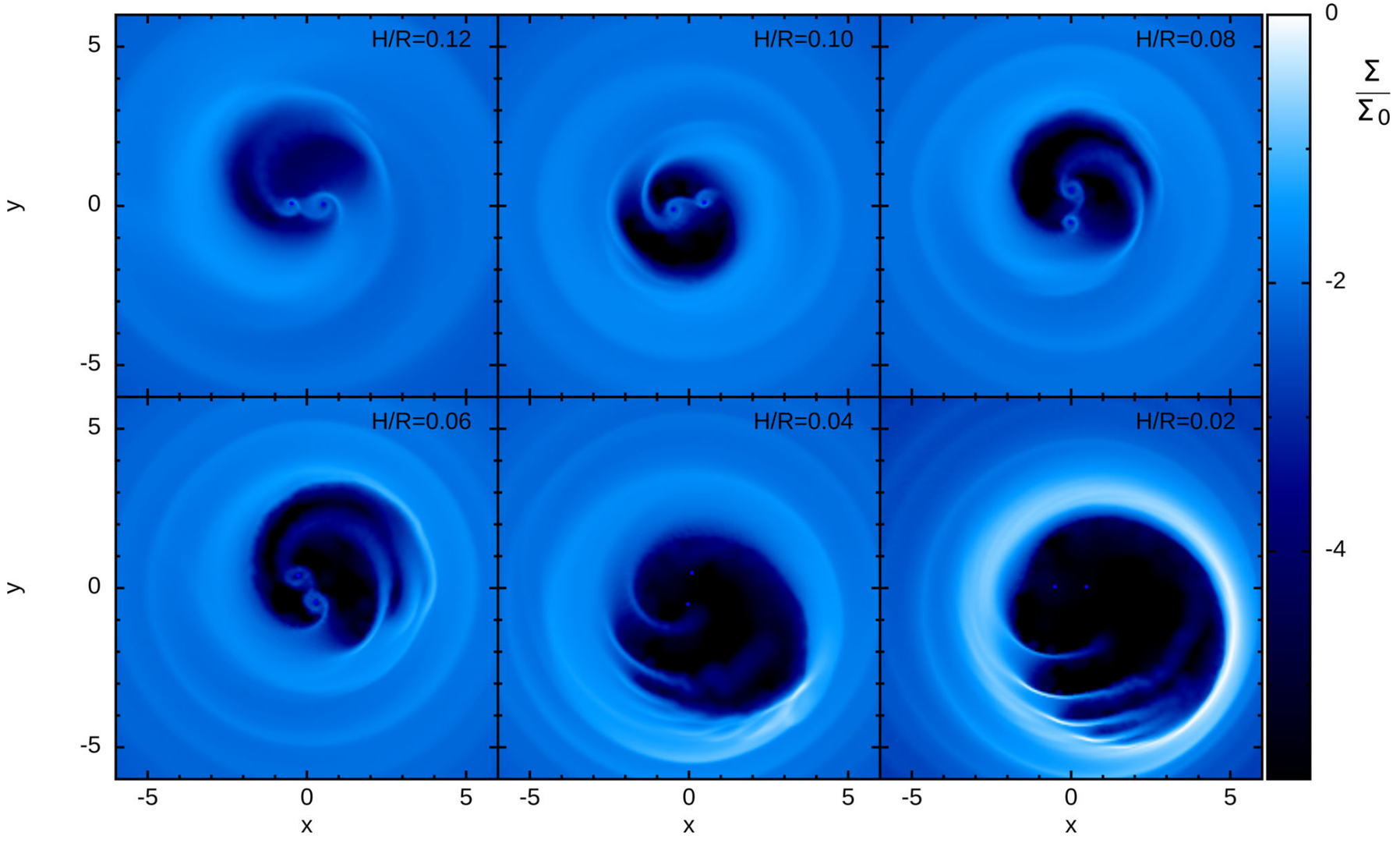
Nixon et al. (2012, 2013), Nealon et al. (2015), Dogan et al. (2015)

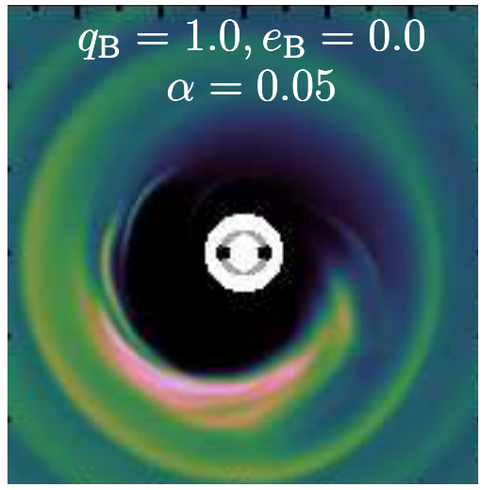


Nealon, Price and Nixon (2015)

CIRCUMBINARY DISCS = ECCENTRIC CAVITIES *Ragusa et al. (2016)*

See also: MacFadyen & Milosavljevic (2008), D'Orazio+ (2013), Farris+ (2014), Miranda+ (2016)

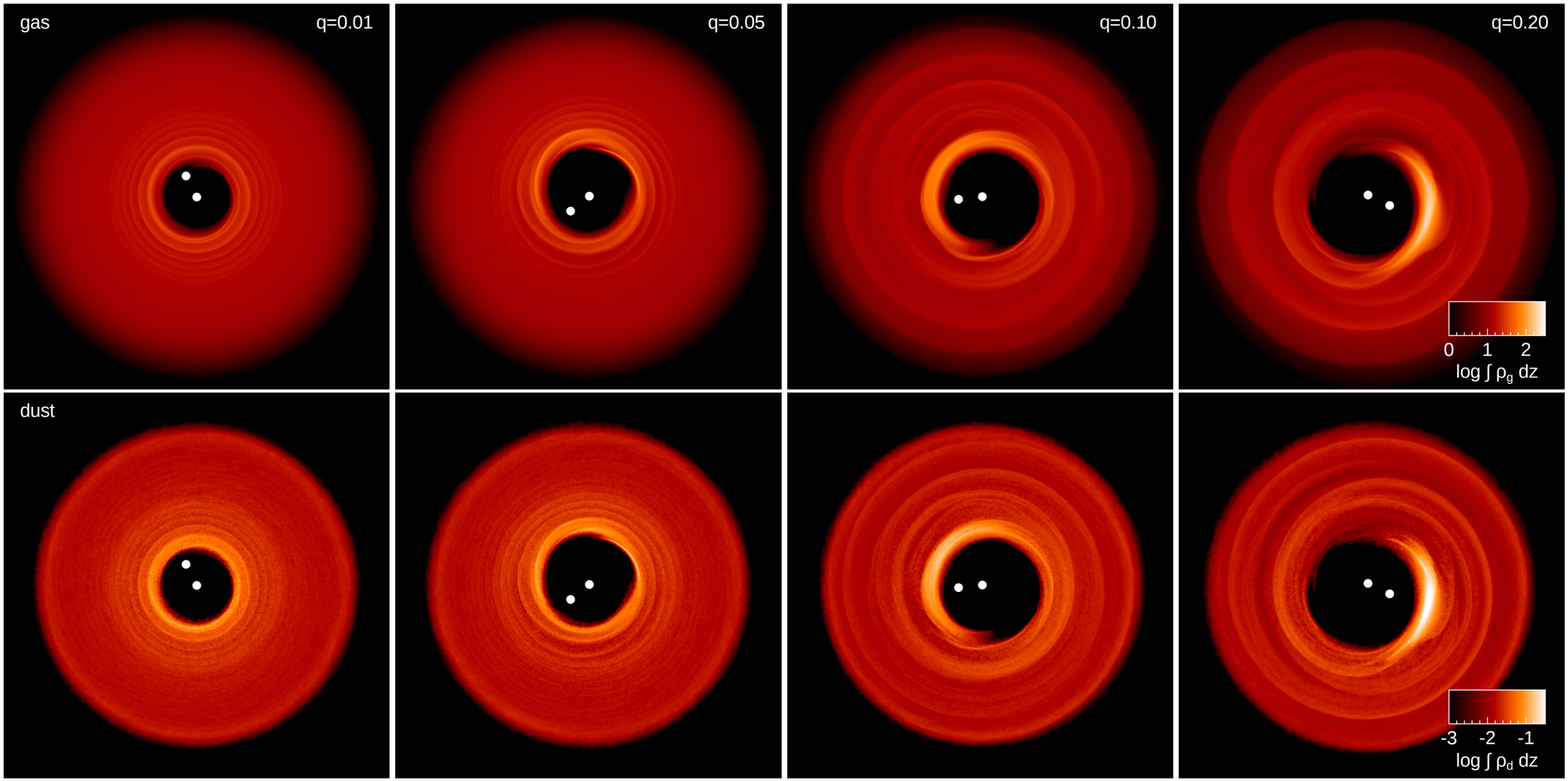




Miranda+2016

HORSESHOES IN TRANSITIONAL DISCS

Ragusa+ (2017)



See also Lyra & Lin (2013), Zhu & Stone (2014), Mittal & Chiang (2015), Zhu & Baruteau (2016), Baruteau & Zhu (2016)

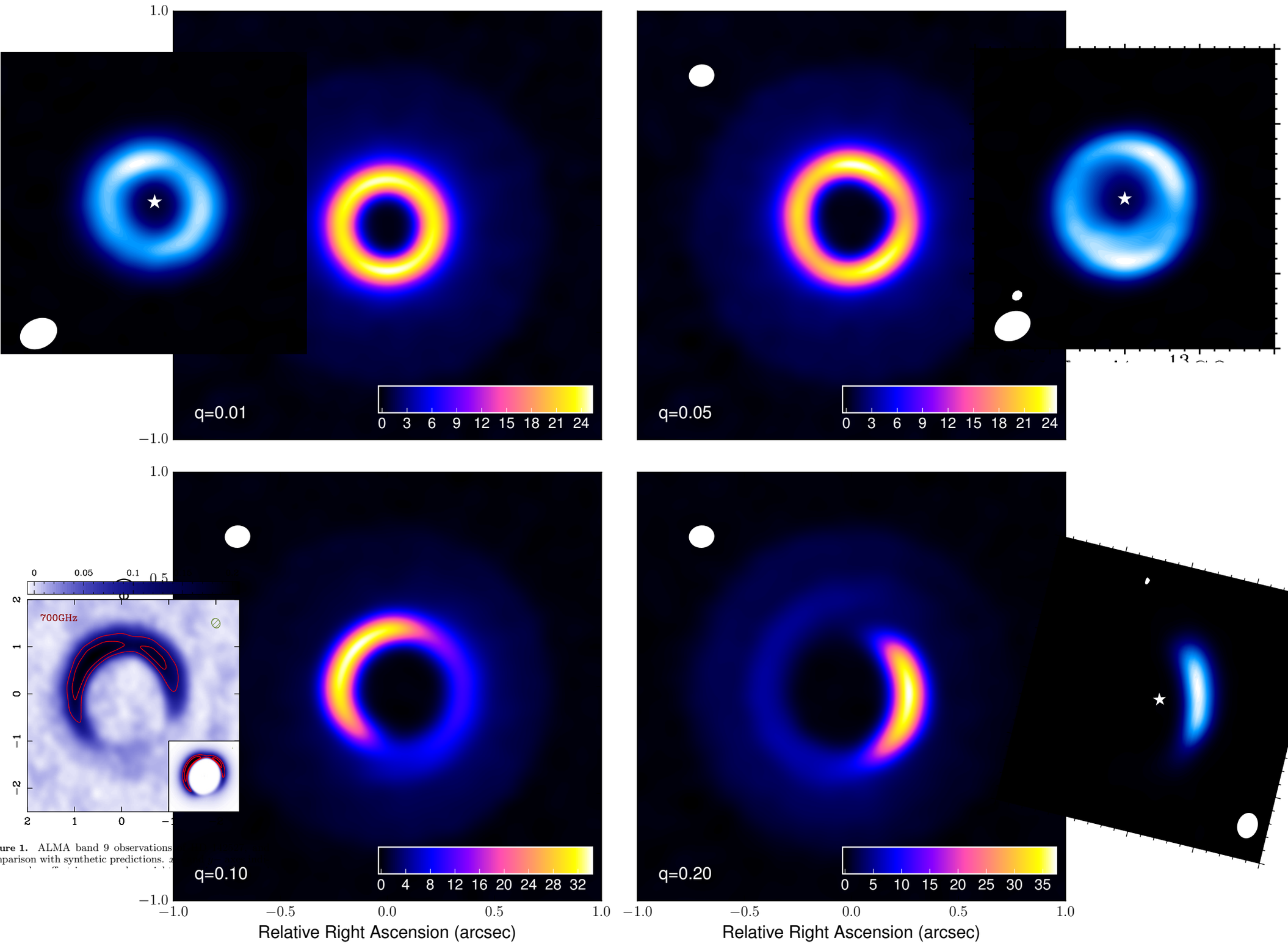
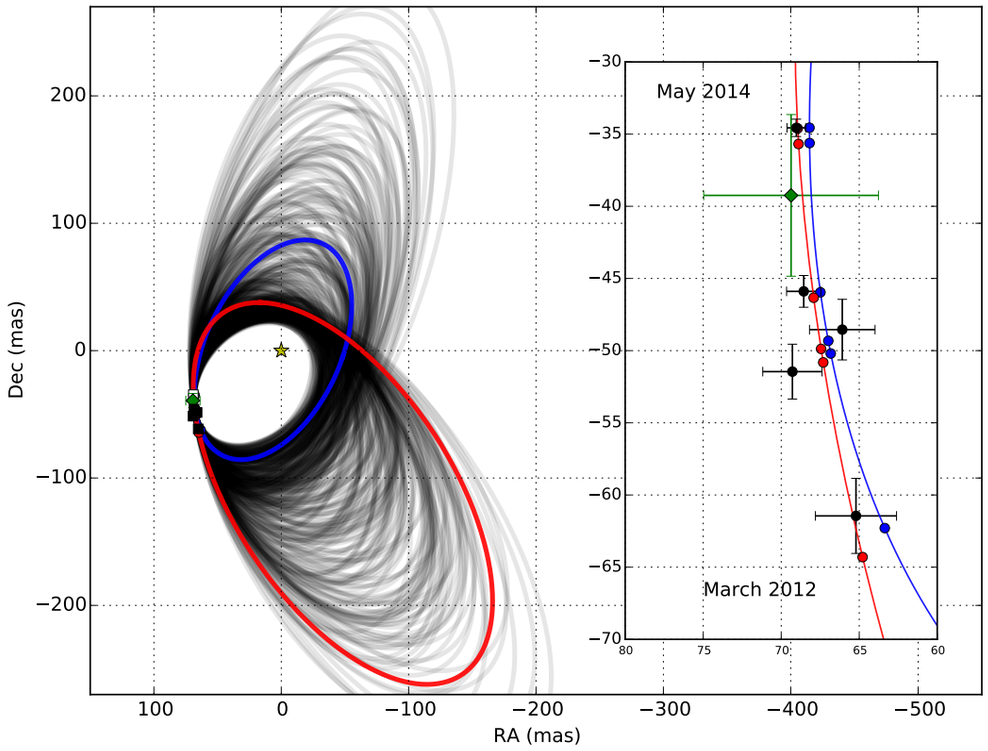


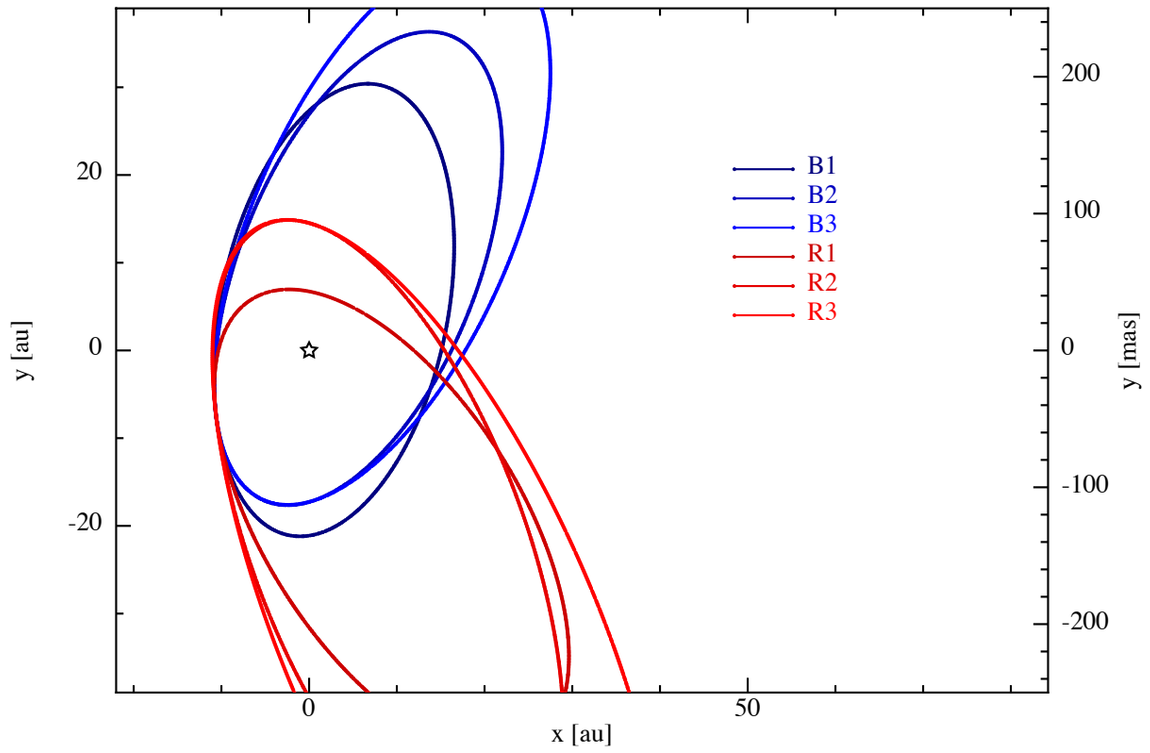
Figure 2. Comparison of ALMA simulated observations at 345 GHz of disc models with a mass ratio $q = 0.01$ (upper left), $q = 0.05$ (upper right), $q = 0.1$ (bottom left) and $q = 0.2$ (bottom right). Intensities are in mJy beam^{-1}. The white colour in the filled ellipse in the upper left corner indicates the size of the half-power contour of the synthesized beam: 0.12×0.1 arcsec ($\sim 16 \times 13$ au at 130 pc.).

MODELLING HD142527

Price et al. (2018)



Lacour et al. (2016)

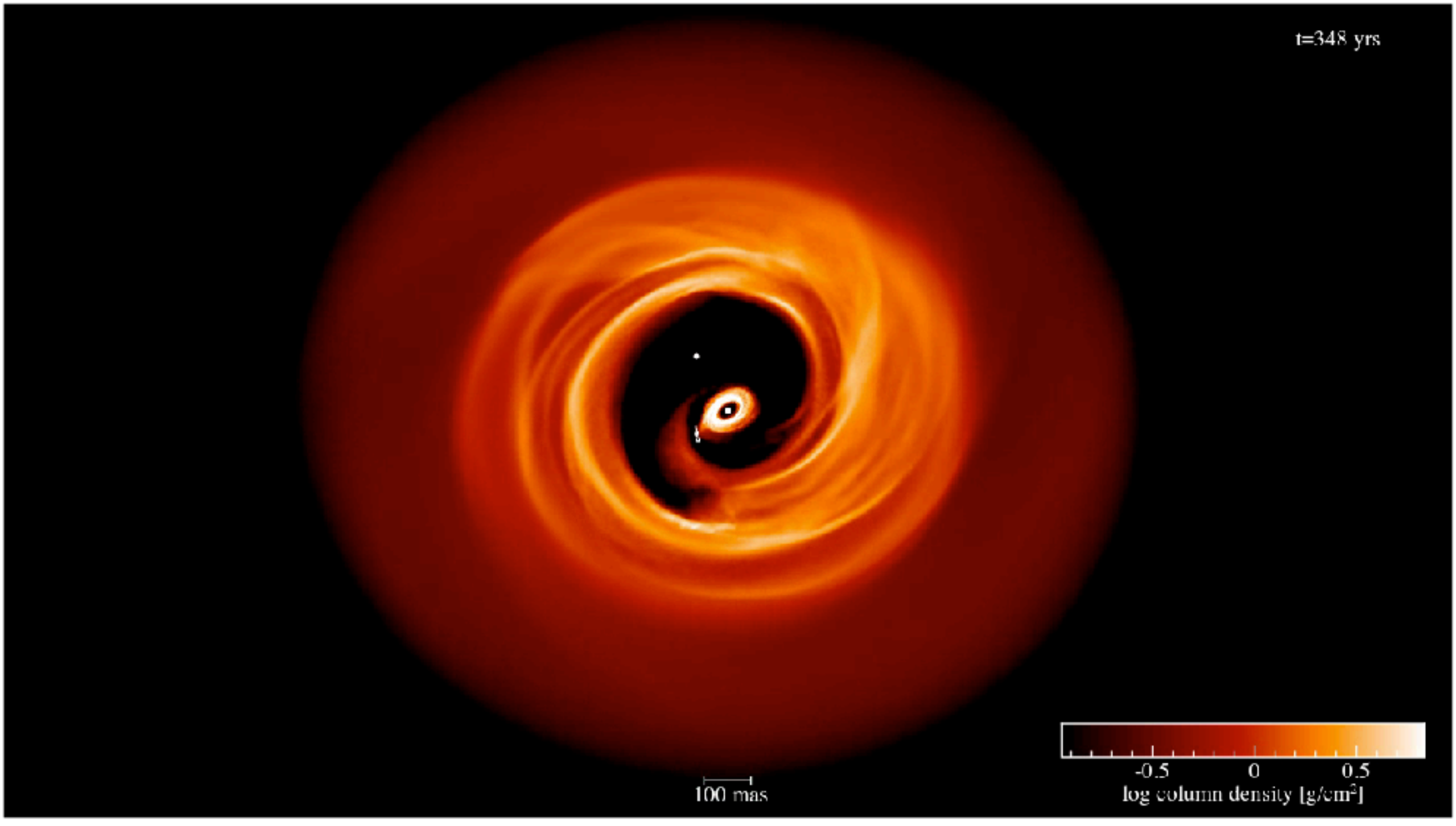


Orbital arc fits using IMORBEL (Pearce, Kennedy & Wyatt 2015)

	a	e	i	Ω	ω	f
Orbit B1	26.5	0.24	119.9	349.7	218.0	25.93
Orbit B2	28.8	0.40	120.4	340.3	201.5	33.78
Orbit B3	34.3	0.50	119.3	159.2	19.98	35.04
Orbit R1	31.4	0.74	131.3	44.95	27.88	249.3
Orbit R2	38.9	0.61	120.3	19.25	354.0	268.3
Orbit R3	51.3	0.70	119.3	201.4	173.3	270.4

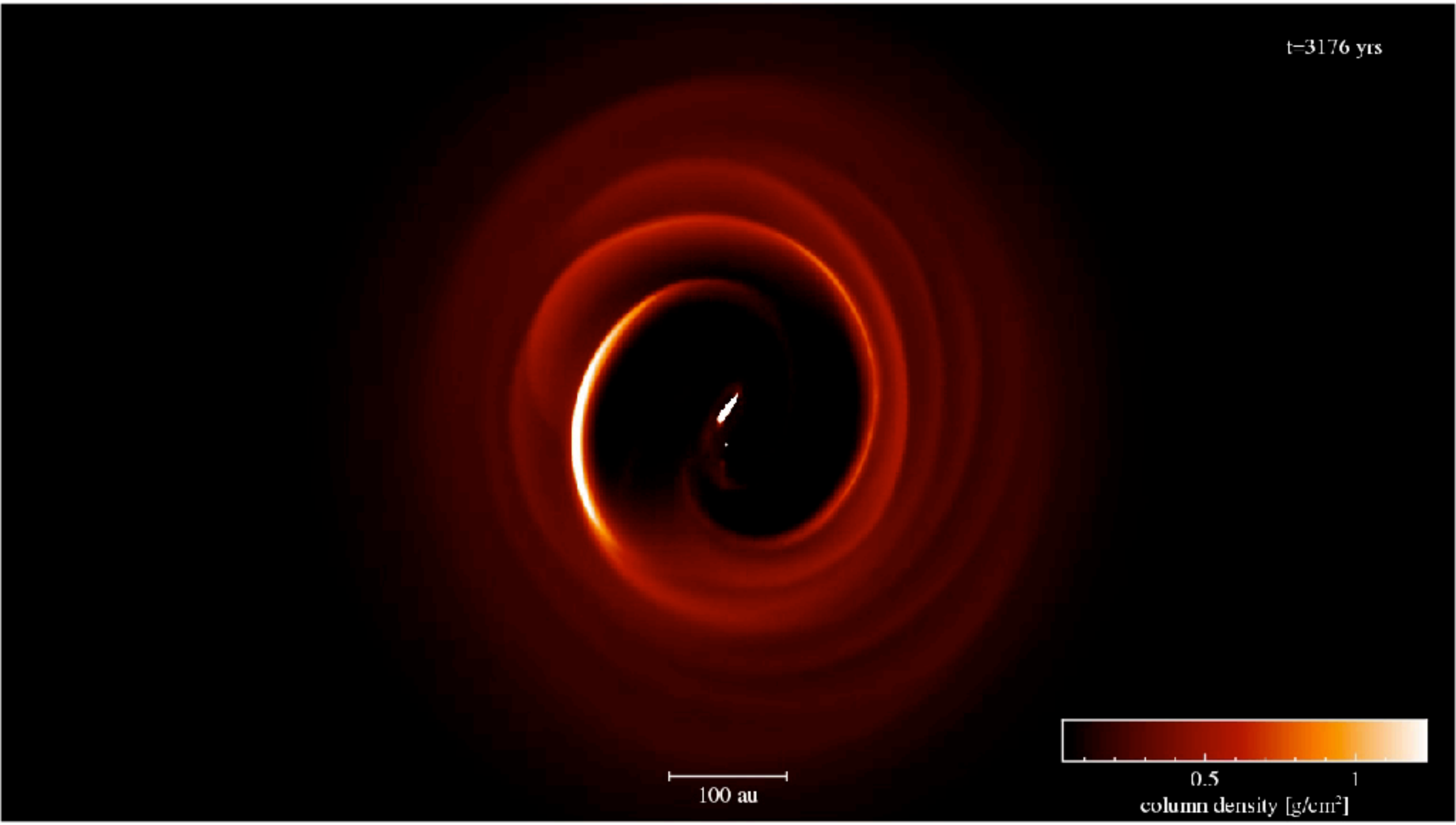
BLUE ORBIT

Price et al. (2018)



RED ORBIT

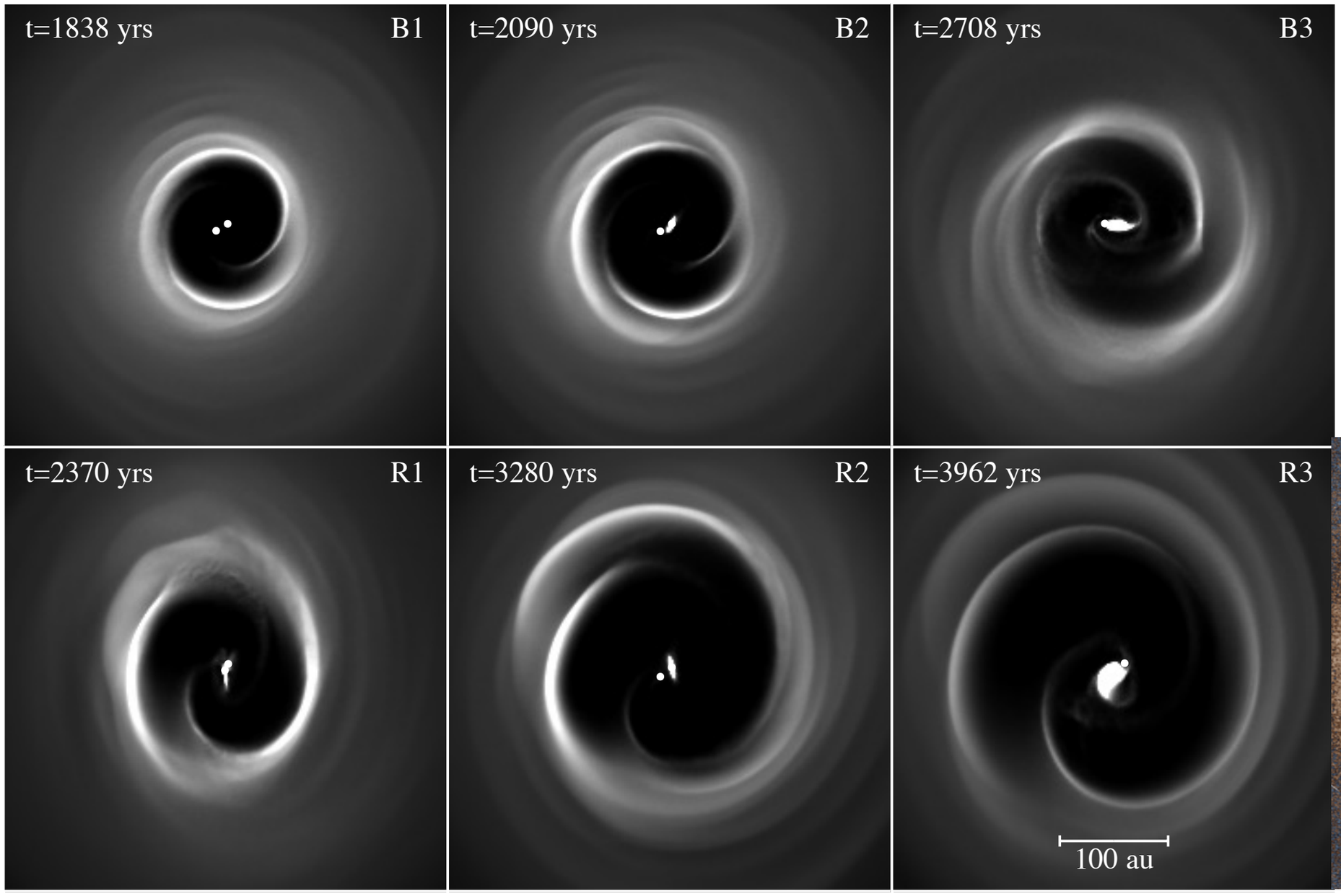
Price et al. (2018)

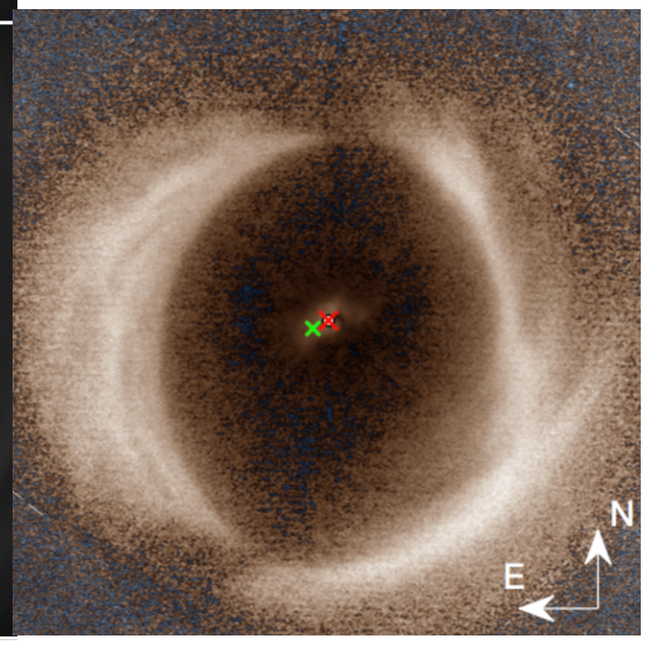


See almost polar alignment of binary to disc, c.f. Aly et al. (2015), Martin & Lubow (2017)

SPIRALS

See also Ogilvie & Lubow (2002), Rafikov (2002), Fung & Dong (2015)



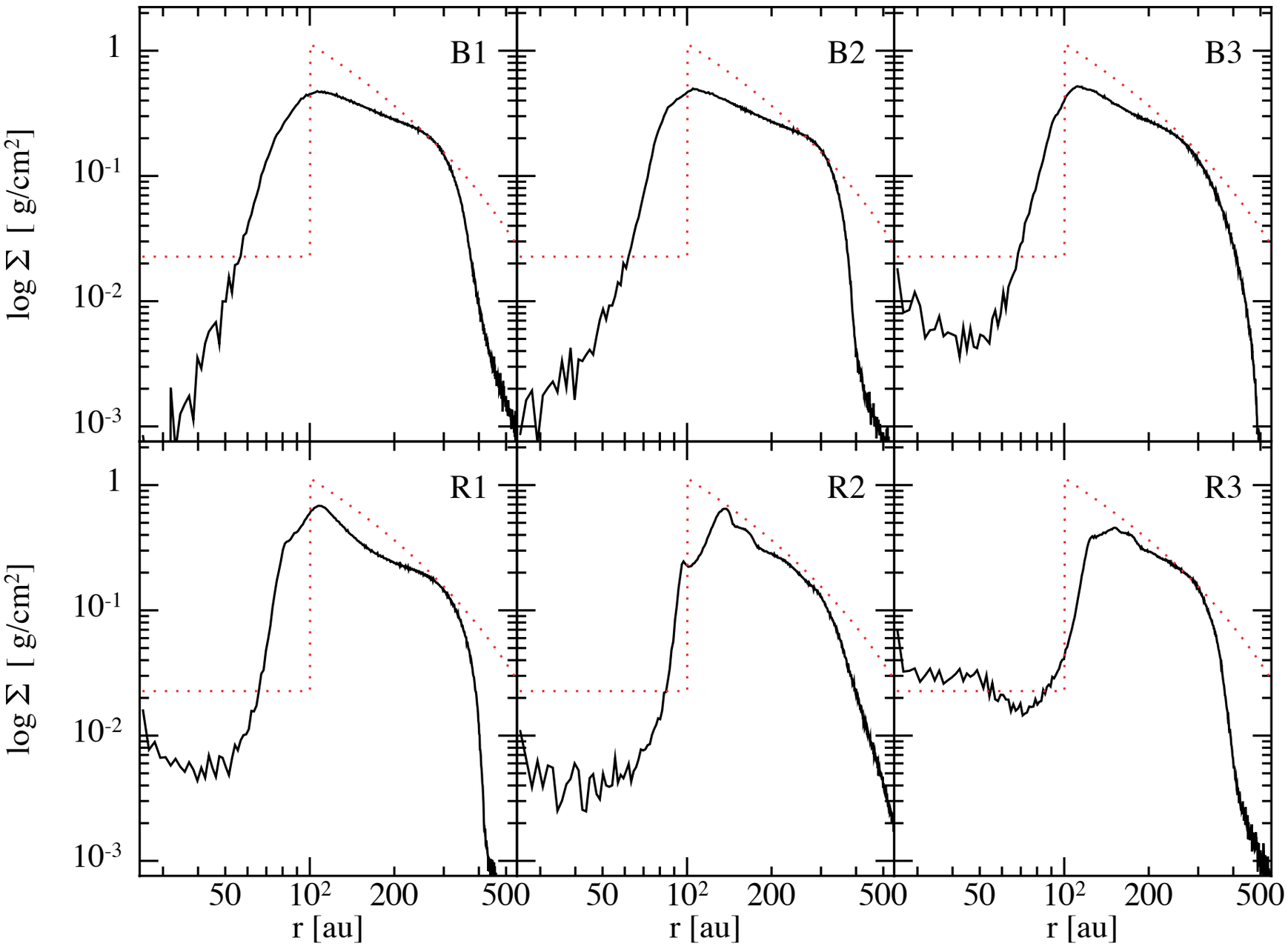


Price et al. (2018)

Binary must be on RED orbit!

CAVITY SIZE *Perez+(2015)*

an axisymmetric disk. The total mass of gas surviving inside the cavity is high $(1.7 \pm 0.6) \times 10^{-3}\ M_{\odot}$.

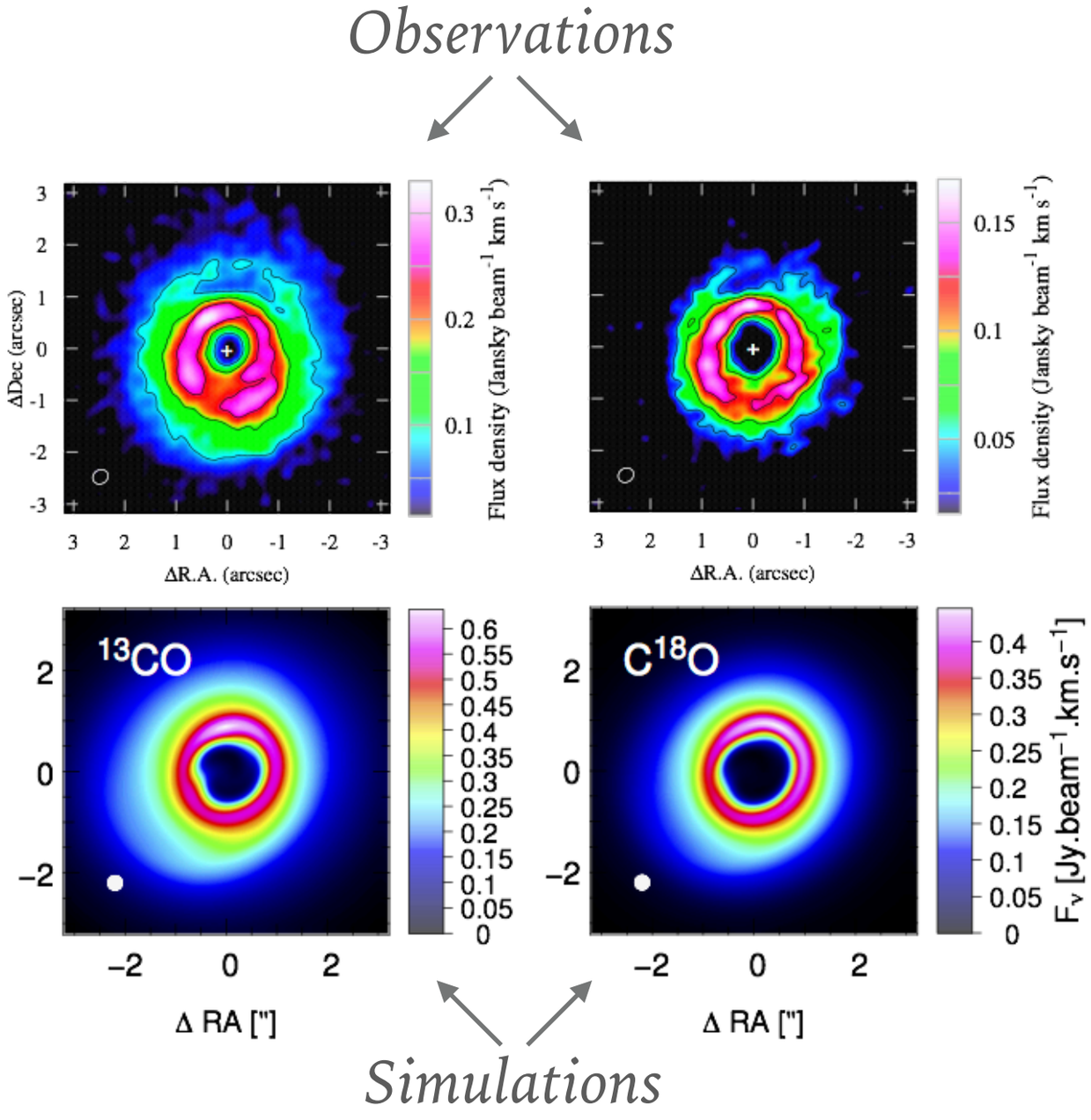


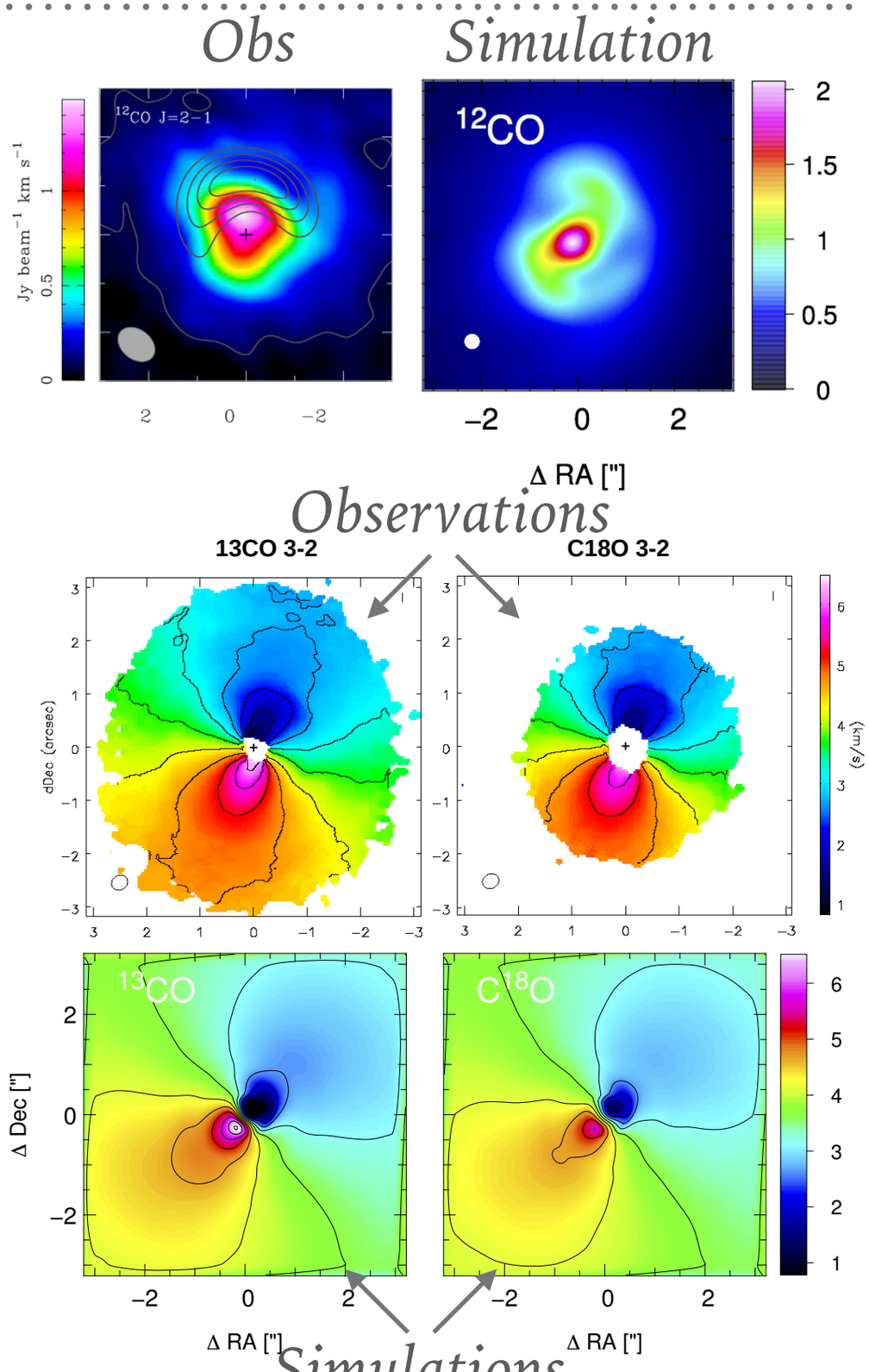
Mass inside the cavity:

Disc	M<90 au
B1	2 x 10^{-3}
B2	1.9 x 10^{-3}
B3	1.6 x 10^{-3}
R1	2.1 x 10^{-3}
R2	1.5 x 10^{-3}
R3	1.4 x 10^{-3}

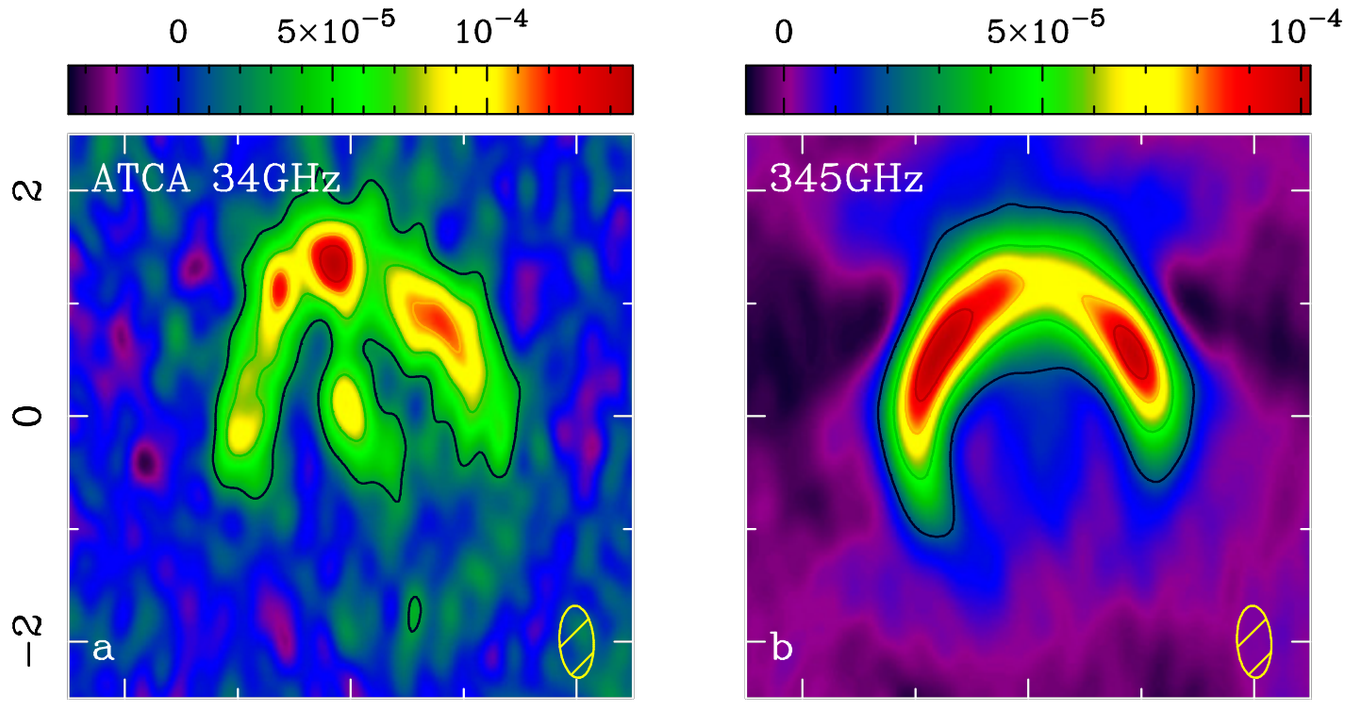
Red = Best fit model used in Perez + (2015) to fit the observed data!

CO EMISSION (USING MCFOST RT CODE, PINTE ET AL. 2006)

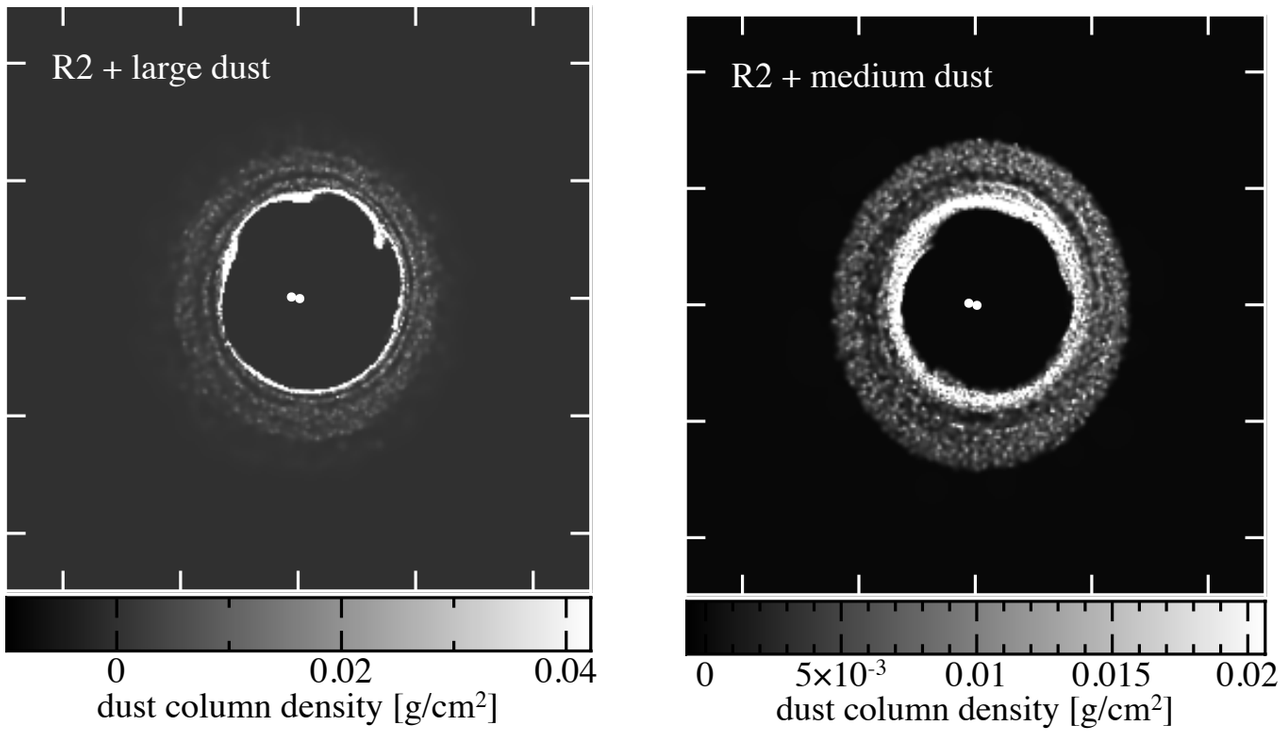




HORSESHOE



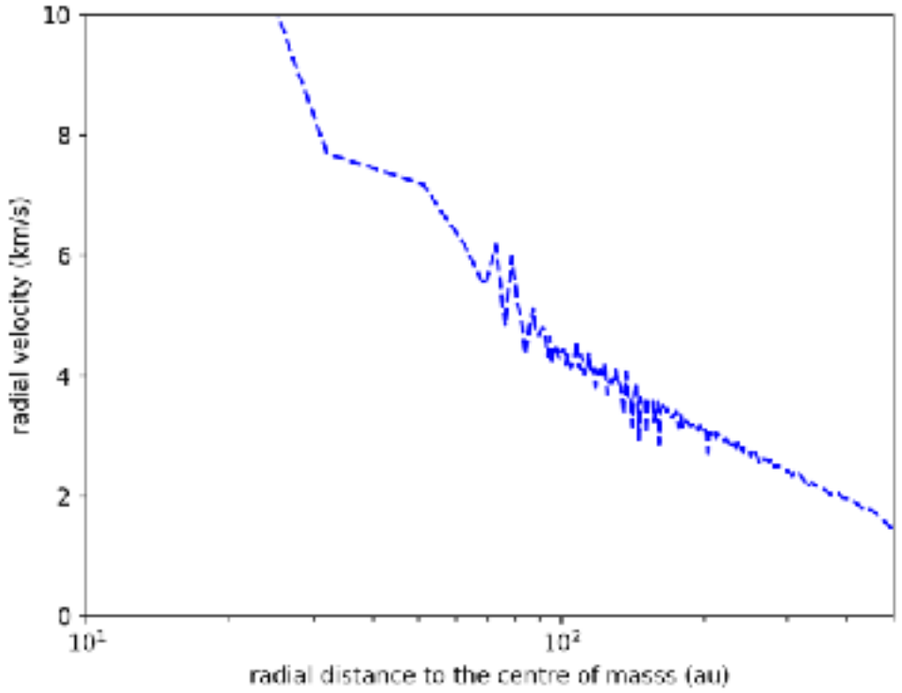
Observations

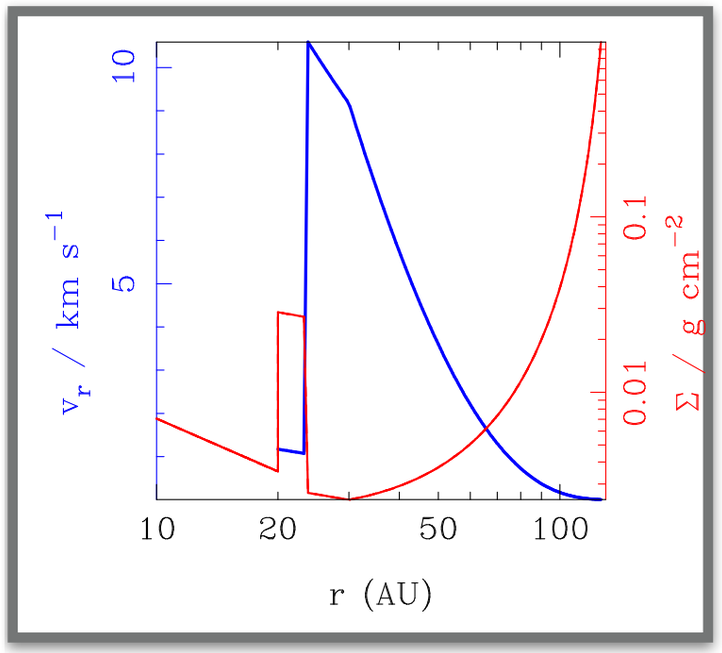


Simulations

FAST RADIAL FLOWS

Price et al. (2018)





WE HAVE THE CULPRIT

SUMMARY

- All the main observational features in HD142527 can be explained by the presence of the binary companion
- Suggests circumbinarity may be the origin of many features seen in transitional discs (c.f. LkCa15; Sallum et al. 2015)
- Are all transitional discs circumbinary?