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ARE GRAVITATIONALLY UNSTABLE PROTOPLANETARY DISCS RARE?

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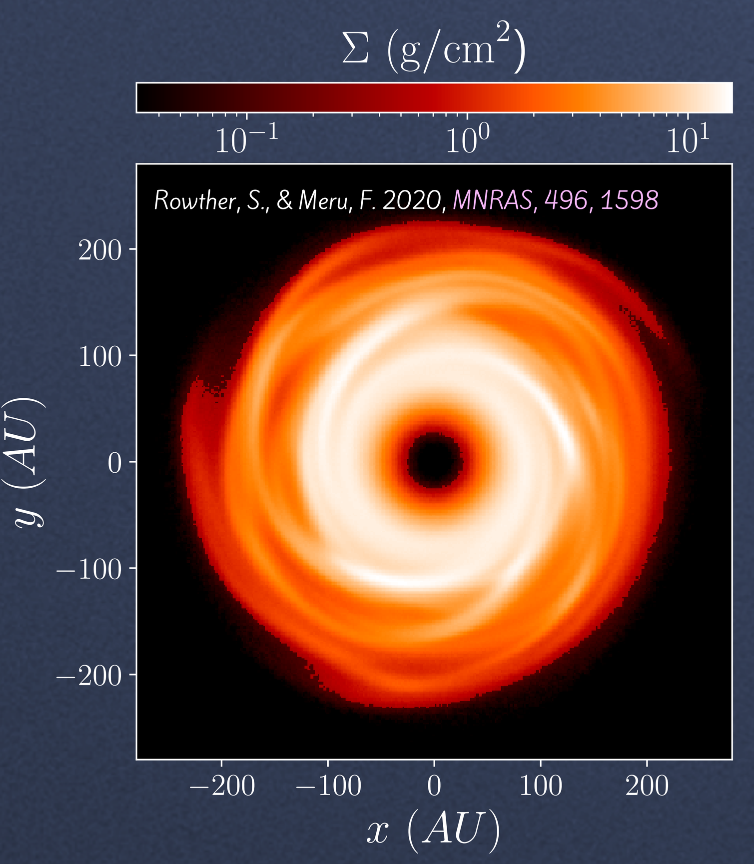
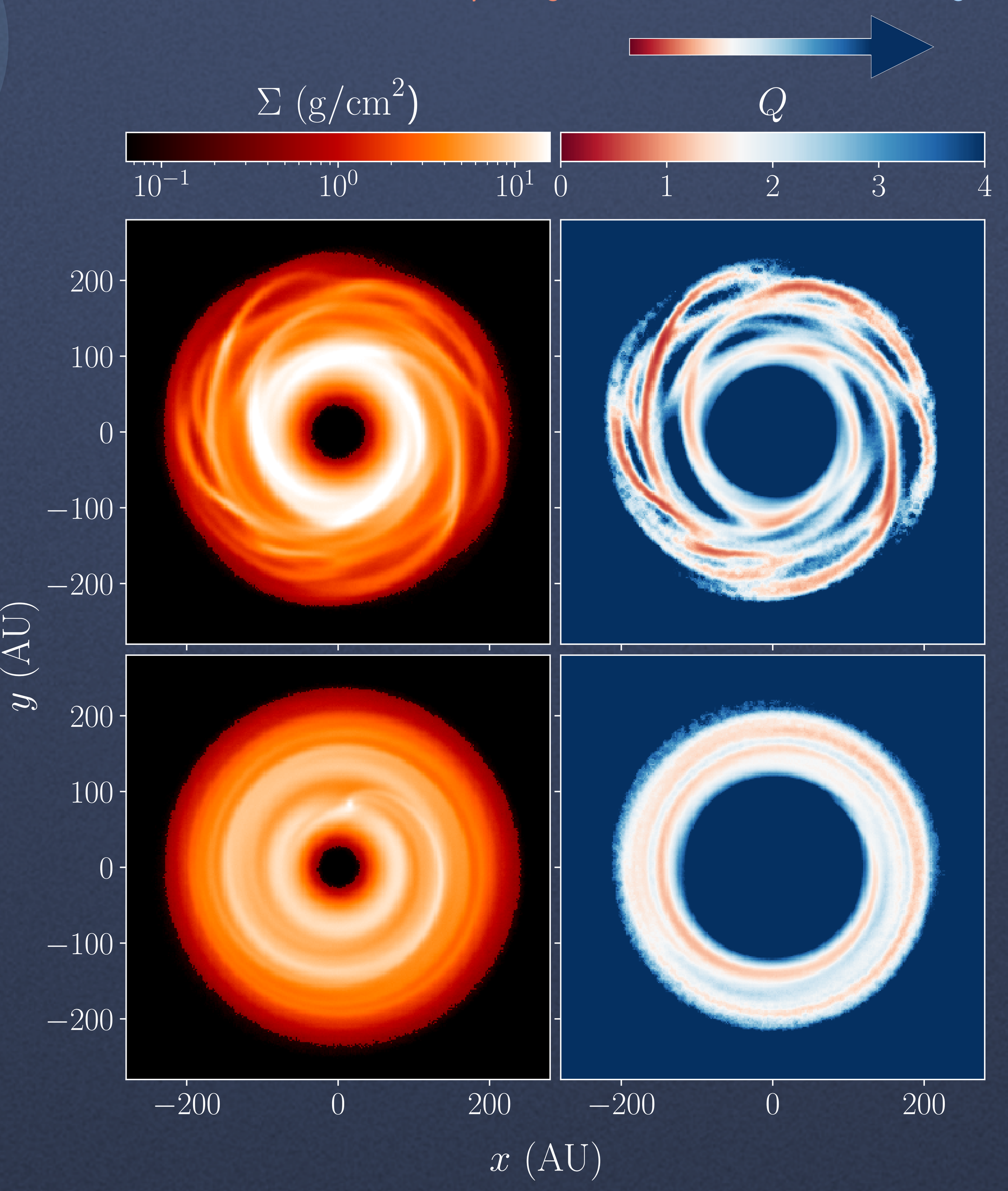
Impact of Planet on Disc Structure

Aim: Can the rarity of gravitationally unstable discs be explained by planet-disc interactions?





Evolution without a planet

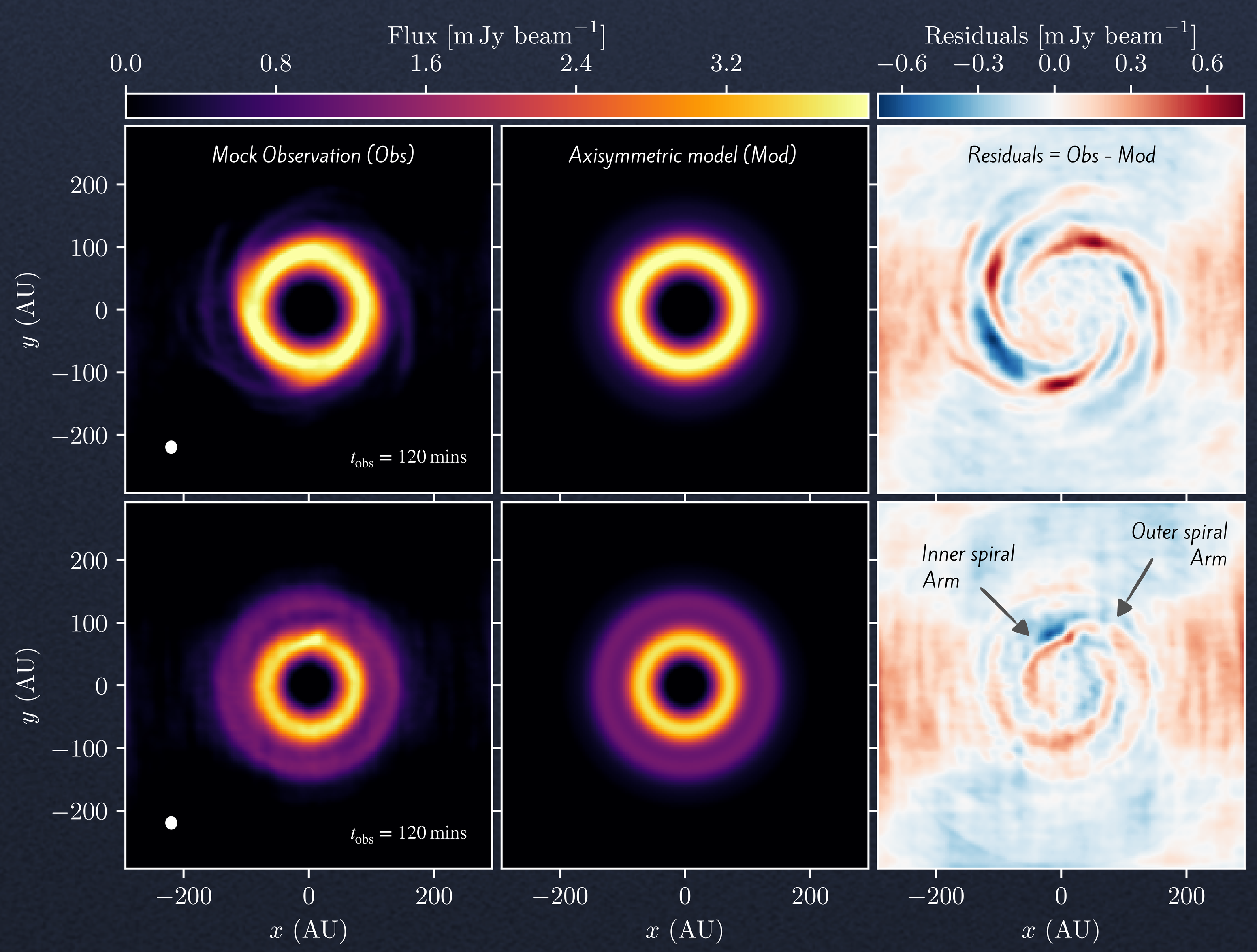
Disc remains gravitationally unstable, hence the presence of spiral structure.

Evolution with a planet

Presence of a giant planet results in an axisymmetric disc which is no longer gravitationally unstable.

- Rings & gaps (axisymmetric) are very common.
- Spirals (non-axisymmetric), a characteristic of gravitational instability, however are rarely seen.

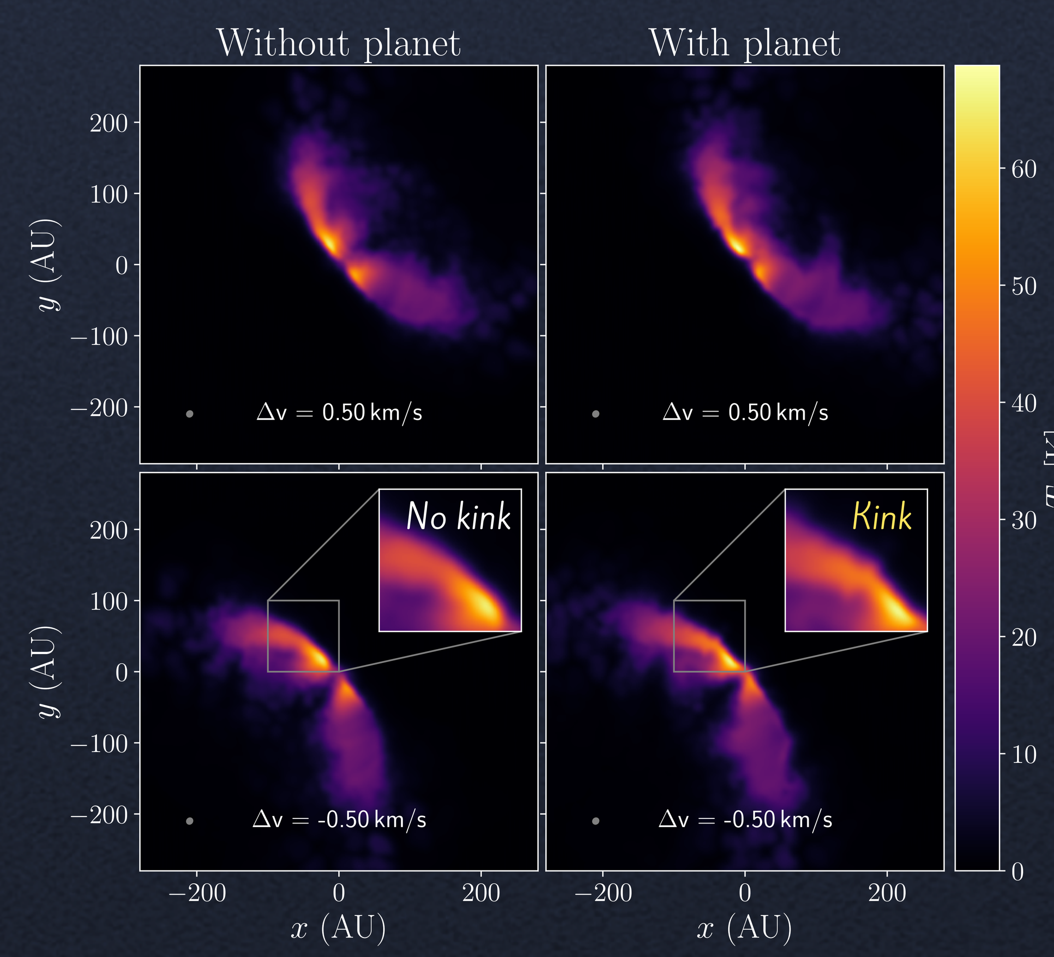
Mock ALMA Continuum Observations



- Without a planet (top row) - spiral arms due to gravitational instability are seen.
- With a planet (bottom row) - Axisymmetric apart from the spiral arms caused by the planet.

CO Kinematics

- Dominated by Keplerian rotation.
- The spiral waves generated by the embedded planet can cause localised deviations in the Keplerian flow of the disc (Pinte+ 2019, 2020).
- These deviations can be detected as kinks in the gas channel maps.



Synthetic channel maps

- $^{13}C^{16}O$.
- J = 3-2 transition line.
- Kink only seen with a planet in the $\Delta v = -0.5$ km/s channel.
- Can exclude large scale perturbations as kink is not seen in the opposite channel.

Conclusion

We show that in a massive gravitationally unstable protoplanetary disc, a giant planet can yield an axisymmetric disc by suppressing the spiral structure that would have otherwise been present.

References -
Pinte, C., van der Plas, G., Ménard, F., et al. 2019, Nature Astronomy, 3, 1109
Pinte, C., Price, D. J., Ménard, F., et al. 2020, ApJL, 890, L9

Tools used:
- MCFOST - Pinte, C., Ménard, F., Duchêne, G., & Bastien, P. 2006, A&A, 459, 797 ; Pinte, C., Harries, T. J., Min, M., et al. 2009, A&A, 498, 967
- Phantom - Price, D. J., Wurster, J., Tricco, T. S., et al. 2018, PASA, 35, e031