Hiding Signatures of Gravitational Instability in Protoplanetary Discs: Forming Rings & Gaps

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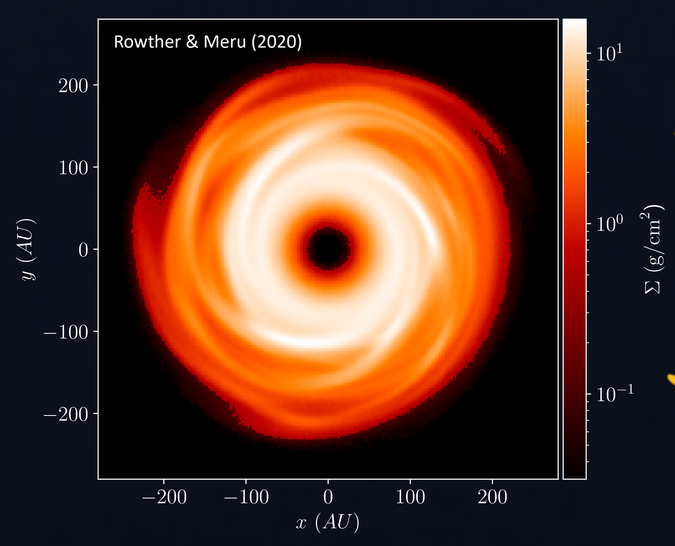
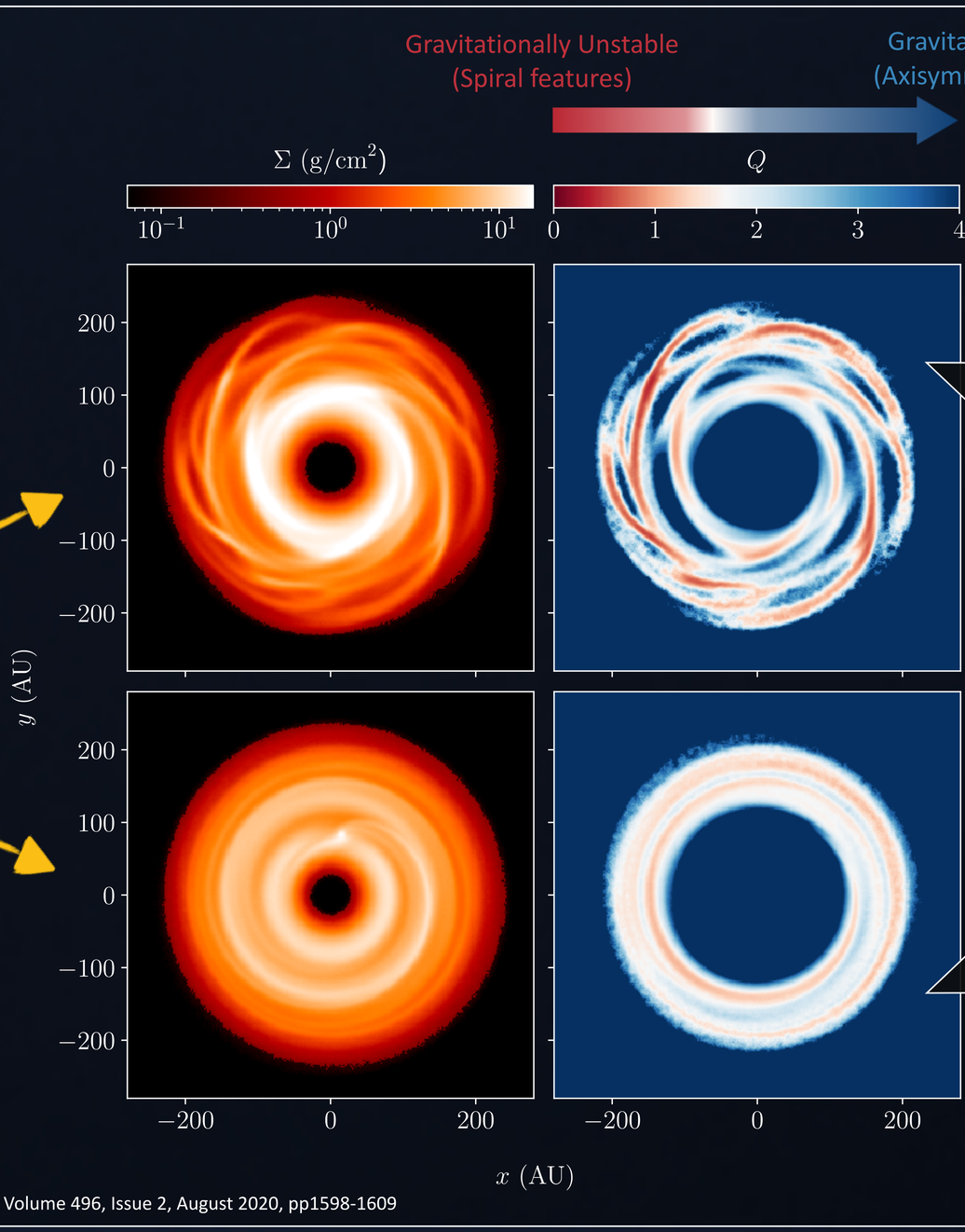
Impact of a migrating giant planet

1

Are gravitationally unstable discs rare or hidden by planet-disc interactions?





Evolution without a planet

Disc remains gravitationally unstable, hence spiral structure.

Evolution with a planet

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

Spirals – A characteristic feature of gravitational instability, but rarely seen in observations.

Rings and gaps – More commonly observed.

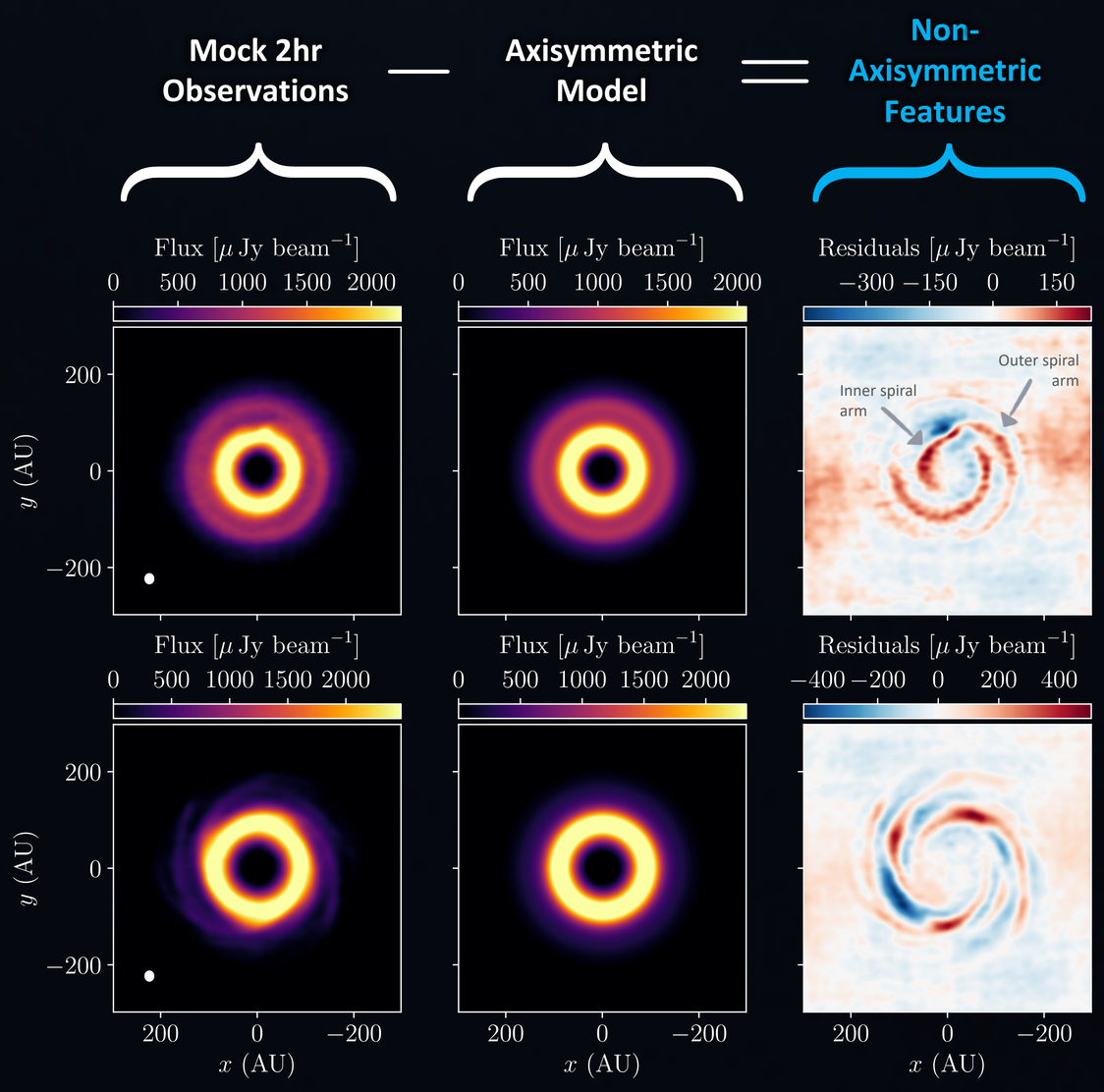
Rowther & Meru (2020) , "Planet Migration in Self-Gravitating Discs: Survival of Planets". MNRAS, Volume 496, Issue 2, August 2020, pp1598-1609

Mock observations

2

Top: No spiral arms due to gravitational instability are seen for a disc with a migrating giant planet. However, spiral arms (annotated below) from the planet are seen.

Bottom: Three spiral arms due to gravitational instability are seen for a disc evolved without a giant planet.

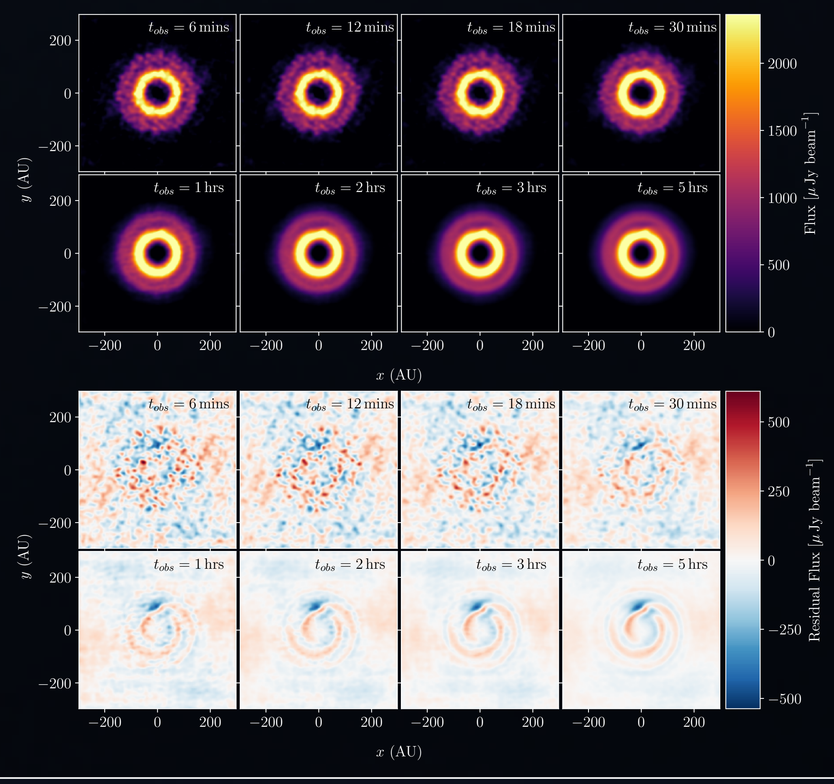


Implications on observational times

3

Short observation times (<1hr): Difficult to detect non-axisymmetric features, such as the spiral arms caused by the planet.

Long observation times (>1hr): More likely to see plausible evidence of planet-disc interaction.



Conclusions

4

Planet-disc interactions can hide signatures of gravitational instability in a protoplanetary disc, giving the appearance of an axisymmetric disc.

Possible evidence of planet-disc interactions becomes more apparent at longer than typical observation times (>1hr).

Software used: Phantom - Price, Daniel J. et al. (2018). "Phantom: A Smoothed Particle Hydrodynamics and Magnetohydrodynamics Code for Astrophysics". Publications of the Astron. Soc. of Australia 35, e031.
MCFOST – Pinte et al. (2006). "Monte Carlo Radiative Transfer in Protoplanetary Discs". Astronomy and Astrophysics, Volume 459, Issue 3, December I 2006, pp.797-804