PLANETARY SYSTEMS IN THE MAKING: INTERACTIONS BETWEEN MULTIPLE PLANETS AND THEIR PARENT DISC

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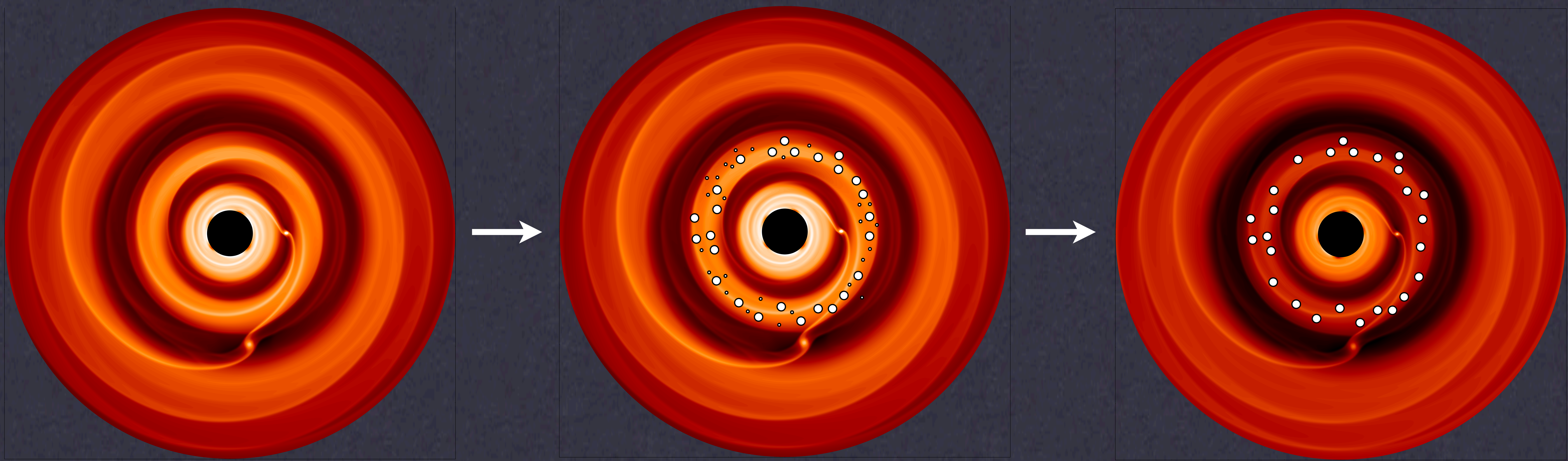
ABSTRACT

We propose a mechanism by which dust rings in protoplanetary discs can form and be long-lasting. We perform 2D gas hydrodynamical simulations of two giant planets embedded in protoplanetary discs. The planets may open deep or partial gaps but we place them sufficiently far apart such that they do not open a common gap. We find that a ring of material forms in between the planets where the surface mass density is higher than either side of the ring. The ring is a region of pressure maximum where we expect large grains, which are marginally coupled and would otherwise be subject to radial drift, to collect. We then infer the likely behaviour of dust in the ring as the gas disc evolves by considering how the Stokes number, St $\propto 1/\Sigma$, would change as the gas surface mass density, Σ, evolves. Over time the gas surface density in the ring decreases which may cause the larger trapped particles to begin to decouple. Consequently, these particles are expected to stay in a ring formation longer than the gas ring.

THE PROPOSED MECHANISM



1. Two planets open deep or partial gaps

2. Ring of gas forms in between

3. Ring is a region of pressure maximum where dust particles that would otherwise be subject to radial drift can be trapped.

4. Gas surface density decreases over time, increasing the Stokes numbers of the dust particles.

5. Small dust flows with the gas. Large particles may start decoupling from the gas, and remain in a ring structure.

IMPLICATIONS

- This mechanism is scale-free i.e. for any disc model there is always *some* particle size for which this mechanism will operate, provided the planets are sufficiently far apart such that a ring of material exists in between.
- Dust rings may be longer lived than gas rings
- Applied to the MMSN, the millimetre and centimetre-sized grains in the outer O(10) au would be affected by this mechanism
- Provides a possible location for further planet growth
- Observing in different wavelengths may show different ring widths since the disc forms a steep pressure gradient on both sides of the ring. The strength of the pressure gradient is different for different sized particles.
- Ring structures are observed in the HD100546 [1] and HD169142 [2] protoplanetary discs. These discs also consist of two protoplanetary candidates each [3,4,5,6]. These discs may be candidates for this mechanism.

References:

[1] Pineda et al (2014)

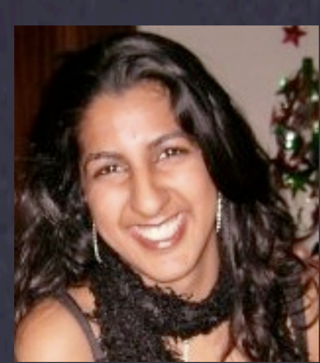
[2] Quanz et al (2013a)

[3] Quanz et al (2013b)

[4] Brittain et al (2013)

[5] Regianni et al submitted

[6] Osorio et al submitted



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