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Destroying the sites of planet formation

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Introduction

- Planetary systems form from protoplanetary discs (PPDs) – discs around young stars made of gas and dust.
- Planets are made up of this dust.
- A process called photoevaporation results in most of the dust leaving the PPD.
- This is inconsistent with planet formation; dust is the main component of planets.

Photoevaporation

- Gas and dust can escape the disc due to an external radiation field from a nearby star.
- This starts at the transition radius.

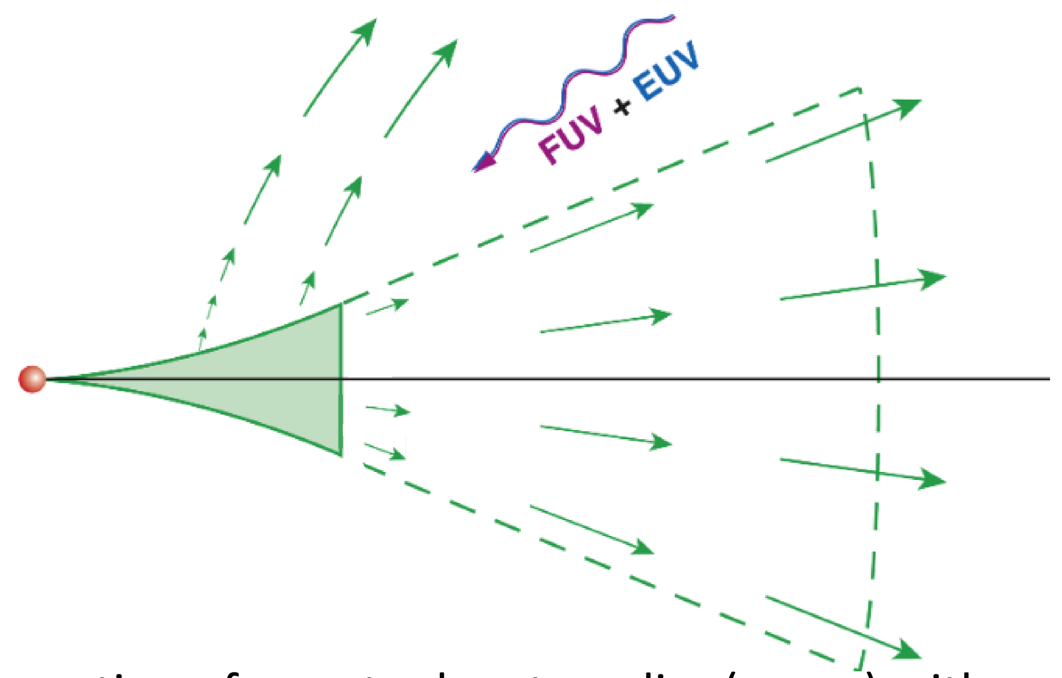

Fig: cross section of a protoplanetary disc (green) with photoevaporative flow leaving from the outer edge (arrows) [1].

- Most of the dust escapes with the gas – the slim disc model will give a more accurate dust-gas coupling, which could preserve dust populations.

[1] *Adams F. C. et al, 2004, ApJ, 611, 360*
[2] *Abramowicz M. A. et al, 1988, ApJ, 611, 360*
[3] *Popham R., Narayan R., 1992, ApJ, 394, 255*
[4] *Takeuchi T., Lin D. N. C., 2002, ApJ, 581, 1344*

Slim Disc Model

- Current PPD models assume a thin disc; we expect this assumption to breakdown in the photoevaporating part of the disc.

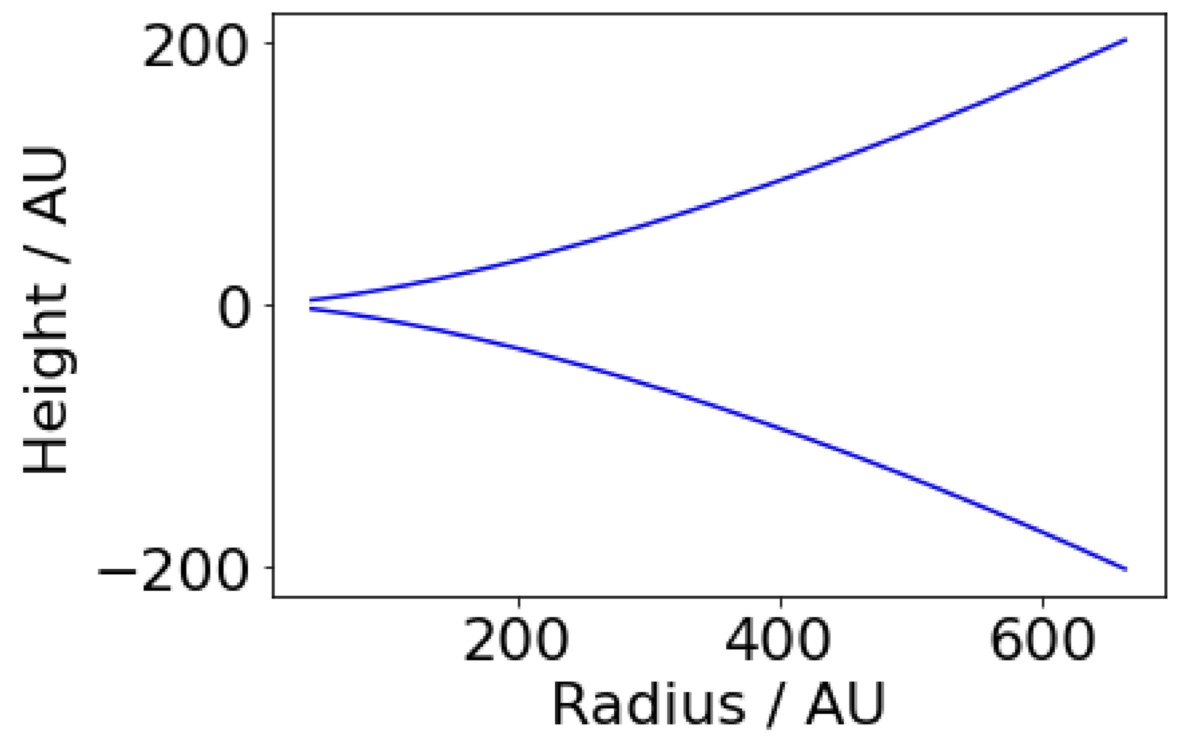

Fig: the cross section of the disc modelled – the critical radius is at 44 AU. The height is no longer negligible.

Method

1. We solve the coupled steady state equations governing the evolution of the angular and radial velocities of the gas between the transition radius and the sonic radius [2, 3]. The shooting method is used to solve the two-point boundary value problem.
2. The dust-gas coupling is then calculated using dust evolution equations to find the equivalent solutions for dust [4].

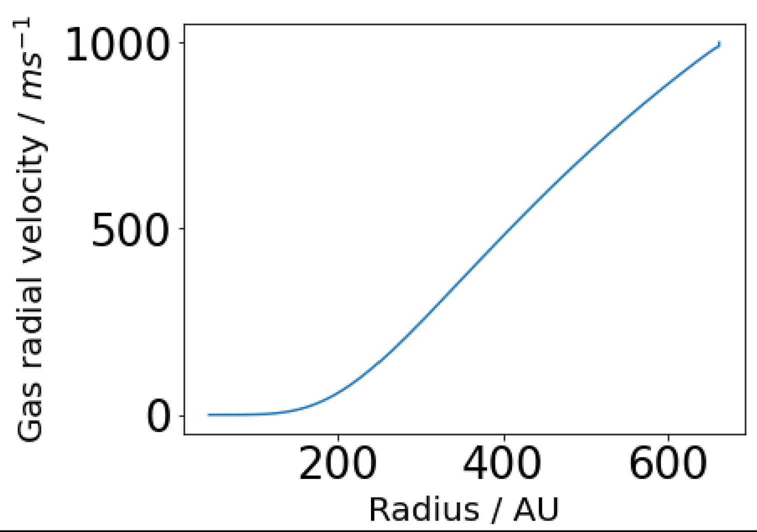

Fig: the radial gas velocity as a function of radius.

Results

- The dust radial velocity is determined by a variety of parameters, the key parameter being the grain size.
- We see that dust grains smaller than 0.08 cm are entrained in the wind.

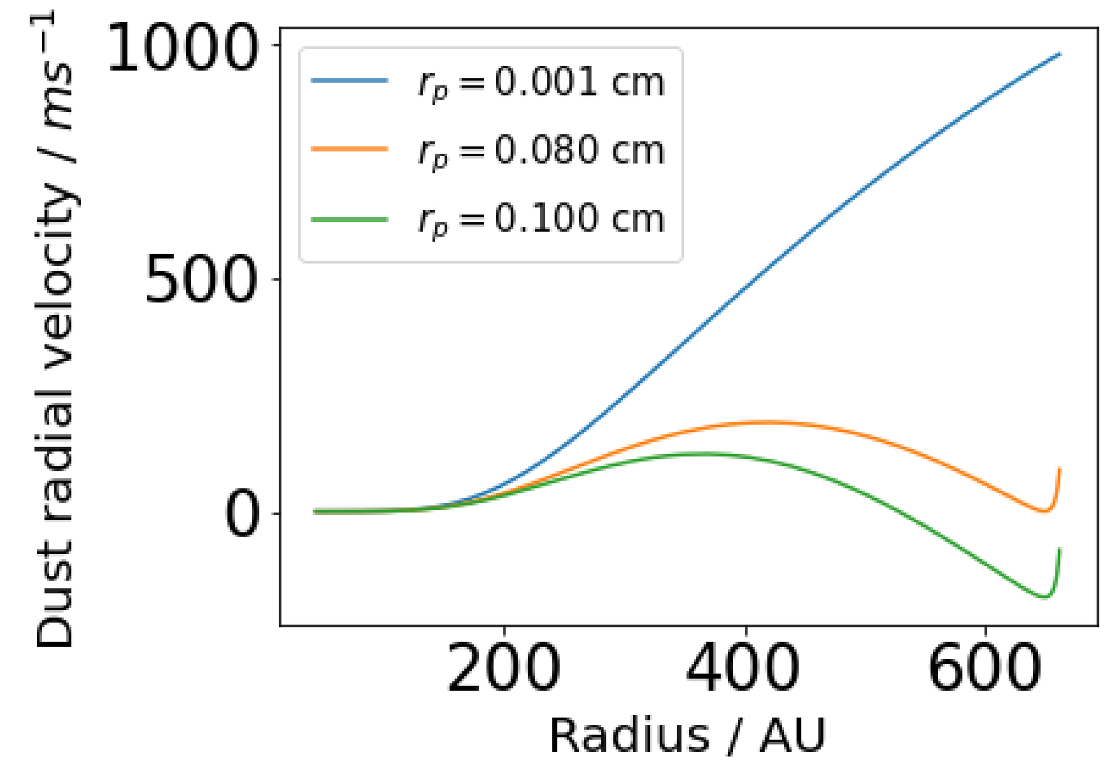

Fig: the radial velocity of dust as a function of radius. Negative velocities indicate dust moving inwards in the PPD.

Conclusion

- For the given parameterisation, we conclude that **dust loss is negligible**.
- The dust growth timescale is two orders of magnitude lower than the disc depletion lifetime; almost all the dust will remain trapped in the disc.
- Further investigation must be done to explore how the model holds up to different parameterisations, particularly those with a higher viscosity.