On dust evolution in planet-forming discs in binary systems

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Motivations

- More and more planets are detected in binaries, yet how they formed is still relatively unknown;
- Exoplanets are assembled out of the gas and dust reservoir in proto-planetary discs;
- Little theoretical work has been done on the secular evolution of the solids in planet-forming discs in binary systems.

Numerical methods

The secular evolution of the gas and the dust in circumstellar discs in binary systems is considered. Our 1D models include:

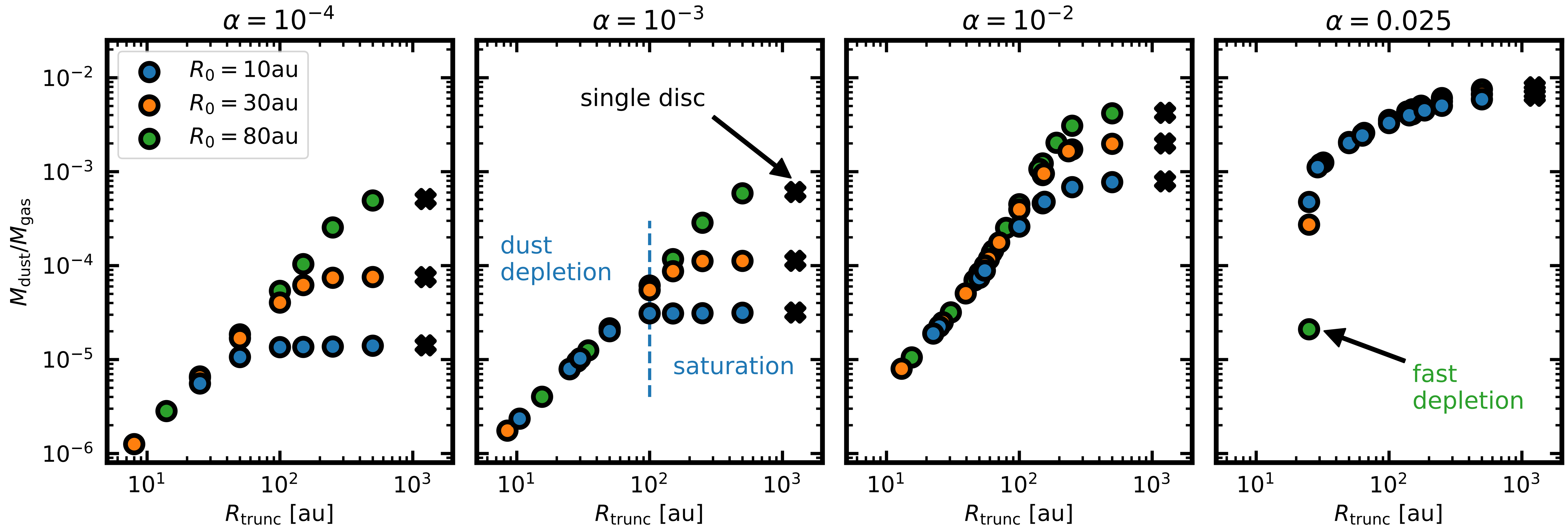
- gas viscous evolution, dust grain growth, radial drift and diffusion (as in Booth et al., 2017; Rosotti et al., 2019);
- the tidal effects of the companion imposing zero gas/dust flux at the outer edge of the disc (following Rosotti & Clarke, 2018).

As a post-processing step, we compute synthetic disc surface brightness profiles and disc sizes at ALMA wavelengths to be compared with the observations in Taurus (Manara et al., 2019) and ρ Ophiuchus (Cox et al., 2017).

Results: stellar multiplicity hastens disc evolution

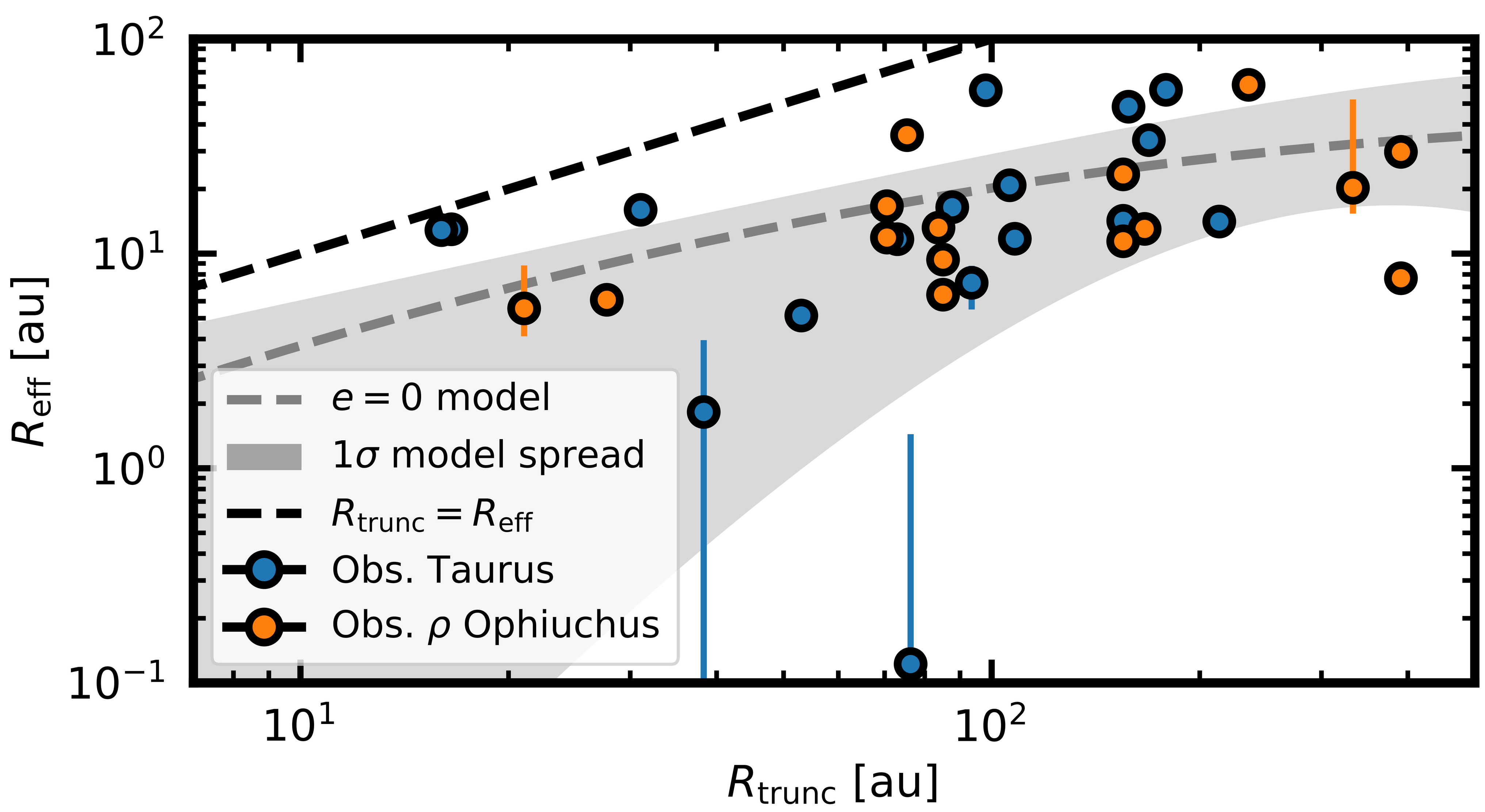
The dust-to-gas mass ratio ($M_{\rm dust}/M_{\rm gas}$) is plotted as a function of the truncation radius ($R_{\rm trunc}$) for different values of the disc scale radius (R_0) and viscosity (α) after $t = 1$Myr. Two different behaviours can be identified:

- small α: if $R_{\rm trunc} \lesssim 100$au binary discs (dots) retain less dust than the single-star ones (crosses), regardless of R_0. Otherwise the dust-to-gas mass ratio is not affected by the presence of a companion within the first mega year;
- large α: saturation occurs for $R_{\rm trunc} \gtrsim 500$au. Even if more dust is retained than in the low viscous case, discs disperse more rapidly.



Results: disc dust sizes do not trace $R_{\rm trunc}$

Manara et al. (2019) found that the observed disc sizes are too small to be explained without invoking very high eccentricities. Our zero eccentricity ($e = 0$) models naturally explain why disc dust sizes (the 68-per-cent-flux radius, $R_{\rm eff}$) are smaller than the truncation radius ($R_{\rm trunc}$) once dust radial drift is taken into account.



Conclusions

- Gas and dust evolve faster in binaries than in single-star discs: radial drift is more efficient in removing solids;
- For planet formation to be viable in multiple stellar systems, planetesimals must form early (within a mega year);
- The observed disc dust sizes are compatible with zero eccentricity models and do not trace the position of $R_{\rm trunc}$.

References

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Any questions? Contact me at fz258@cam.ac.uk