Exploring Planet Formation around Host Stars of Different Masses

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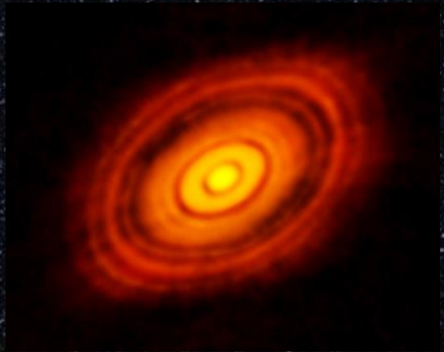


***Fig 1 -** Protoplanetary disk – the home of planet formation – around young stellar object HL Tau (ALMA, 2014).*

Introduction

Context: Planetary and stellar formation are inherently linked: the physical and chemical compositions of protoplanetary disks (Fig 1) are responsible for the resultant planetary conditions.

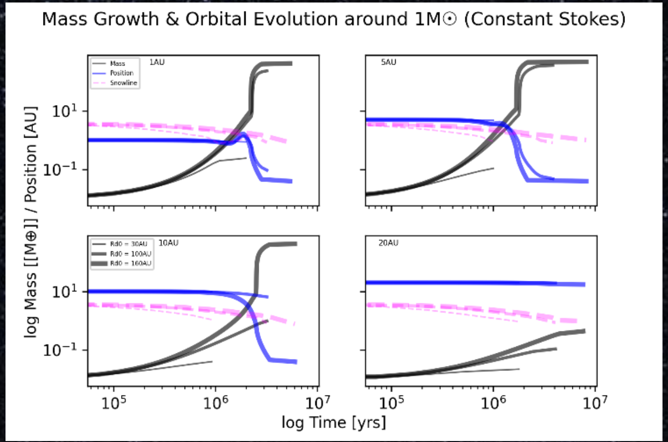
Aims: To examine how stellar hosts and their surrounding protoplanetary disks affect the formation and migration of planets.

Methods

Adapting and utilising code developed by Liu et al. in (2019), and expanding on the findings to include host stars in the range of 1-3$M_{\odot}$ and investigate the impact that different conditions – *e.g.* disk size, accretion rate, stellar mass, grain growth rate, and migration – have on planetary growth. By diversifying the stellar host properties defined in the simulation, we hope to recreate the wide range of exoplanets seen in the observations.

Results

Fig 2 a) & b) illustrates planet growth and orbital evolution in varying disk sizes at various initial locations around a 1$M_{\odot}$ & 2.5$M_{\odot}$, respectively. Water-ice line (magenta) is pushed to greater radial distances with a larger (more luminous) star. Protoplanets formed near this boundary experience pebble accretion due to enhanced surface density and thus capable of accreting gas sooner, while more gas material is available.



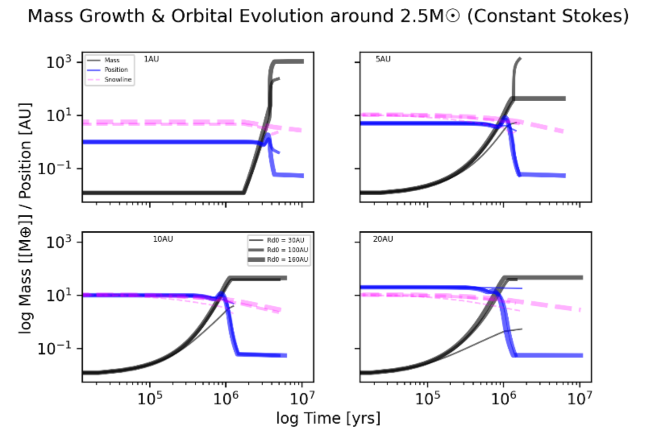


***Fig 2a & b –** Planetary mass growth (black) and orbital evolution (blue) over time with the planetesimal starting at radial distances from the 1M⊙ (a) and 2.5M⊙ host stars (1, 5, 10, 20 AU). The dashed magenta line denotes the water ice-line for each star/disk combination.*

Discussion & Conclusion

The gas giants formed in the simulation all migrate inwards - a hallmark of the close-in orbits of hot Jupiters that over-saturate our current observational capabilities. While planets in the inner disk region (<5AU) have the most successful chance of becoming gas giants, they also inhabit arguably the most dynamic region of the disk while the host star is still accreting addition material. Conversely, there are stark differences between planet formation in 1$M_{\odot}$ & 2.5$M_{\odot}$ stars: the isolation mass – the point at which a protoplanet can begin gas accretion – scales linearly with stellar mass. To conclude; protoplanets with a 2.5$M_{\odot}$ host star have - in general - less gas content than those born in a 1$M_{\odot}$ system and are more likely to be terrestrial. This may be due to the need for additional gas budget for the star due to its increased mass, however more investigation into disk dissipation factors in intermediate-mass stars is required.

References:

Brogan, C., Saxton, B. & ALMA (2014) A protoplanetary disc has formed around the young star HL Tau.

Liu, B., Lambrechts, M., Johansen, A. and Liu, F., (2019) Super-Earth masses sculpted by pebble isolation around stars of different masses. Astronomy & Astrophysics, 632, p.A7.

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