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A potential origin for the circumbinary planet Delorme 1 (AB)b

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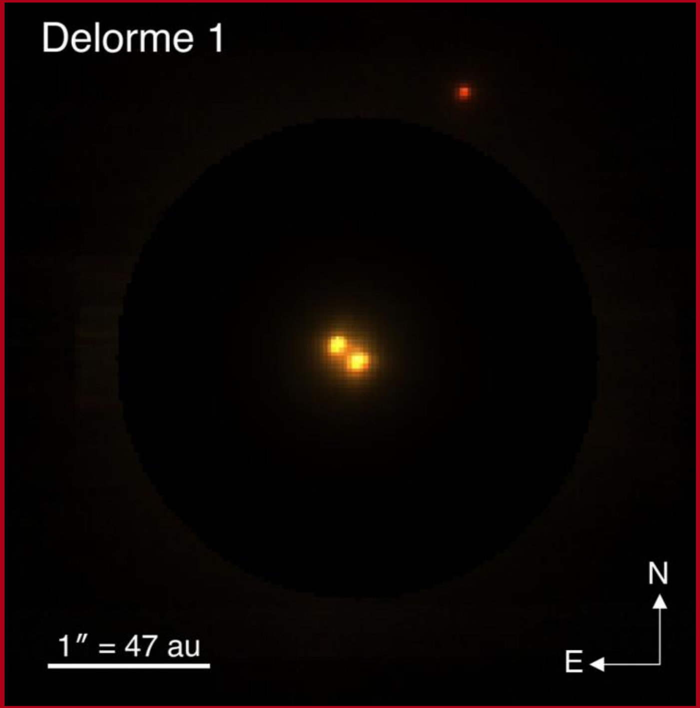
CA22133 - The birth of solar systems (PLANETS)



Credit: Eriksson et al, 2020

- Binary:
  - $M_1 = 0.19\mathrm{M}_\odot$
  - $M_2 = 0.17\mathrm{M}_\odot$
  - $\alpha_b = 12\mathrm{AU}$
- Planet:
  - $M_p = 13 \pm 5\mathrm{M_J}$
  - $\alpha_p = 84\mathrm{AU}$
  - $\dot{M} = 3.4 \times 10^{-10} - 2.0 \times 10^{-8}\mathrm{M_J yr^{-1}}$

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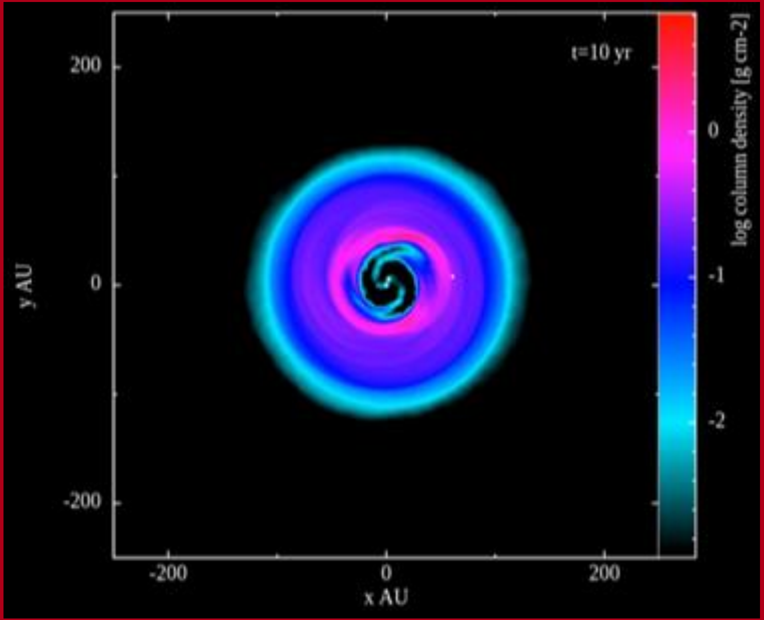
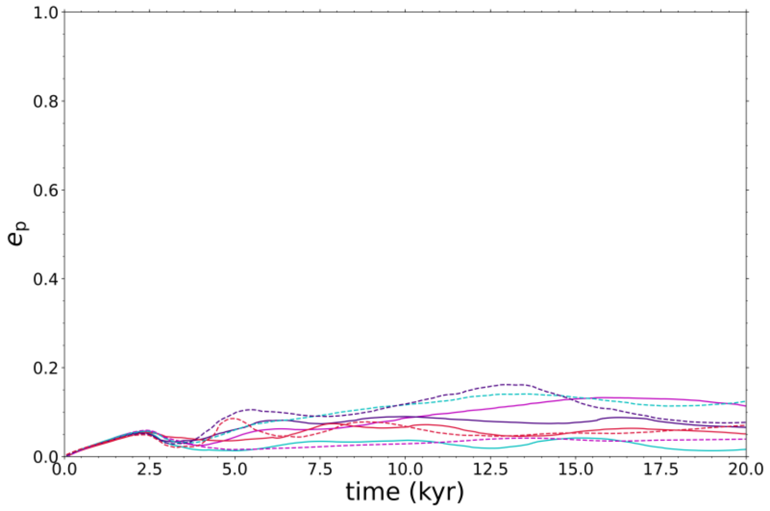
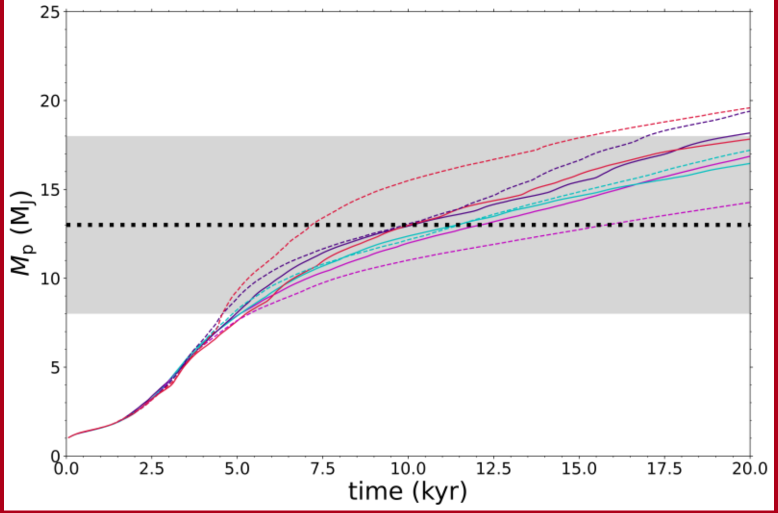
Scenario I	Scenario II	Scenario III
Gravitational Instability formation	Gravitational Instability formation	Core Accretion formation
Massive disc	Massive disc	Less massive disc
In-situ scenario	Outward migration/ scattering	Scattering



Method

- 3D Smoothed Particle Hydrodynamic code SEREN
- Relax the disc for 3kyr, then embed the planet and run for 20kyr
- $M_{\mathrm{D}} = 0.04\mathrm{M}_{\odot},\ 0.01\mathrm{M}_{\odot}$
- $\alpha_{\mathrm{b}} = 10\mathrm{AU},\ 12\mathrm{AU}$
- $\alpha_{\mathrm{p}} = 85,\ 60,\ 30\mathrm{AU}$
- $e_{\mathrm{b}} = 0.0,\ 0.2,\ 0.4,\ 0.6$





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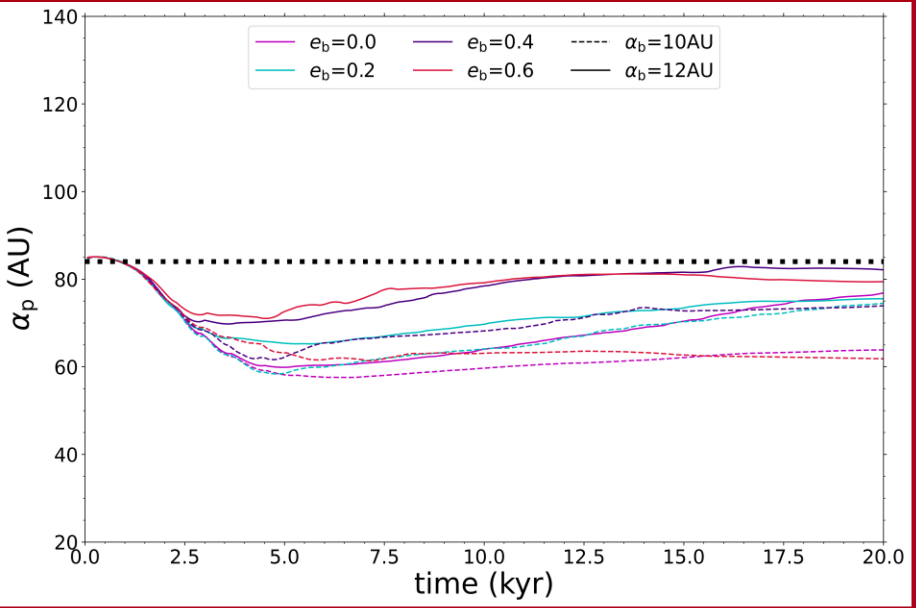
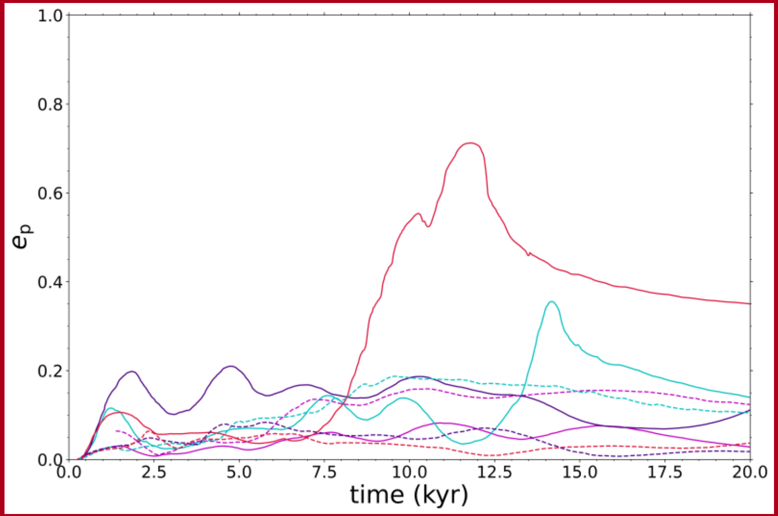
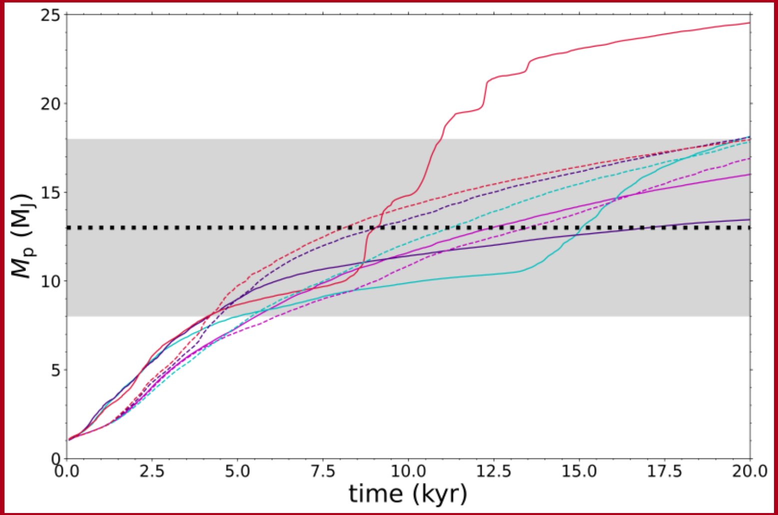
Scenario I

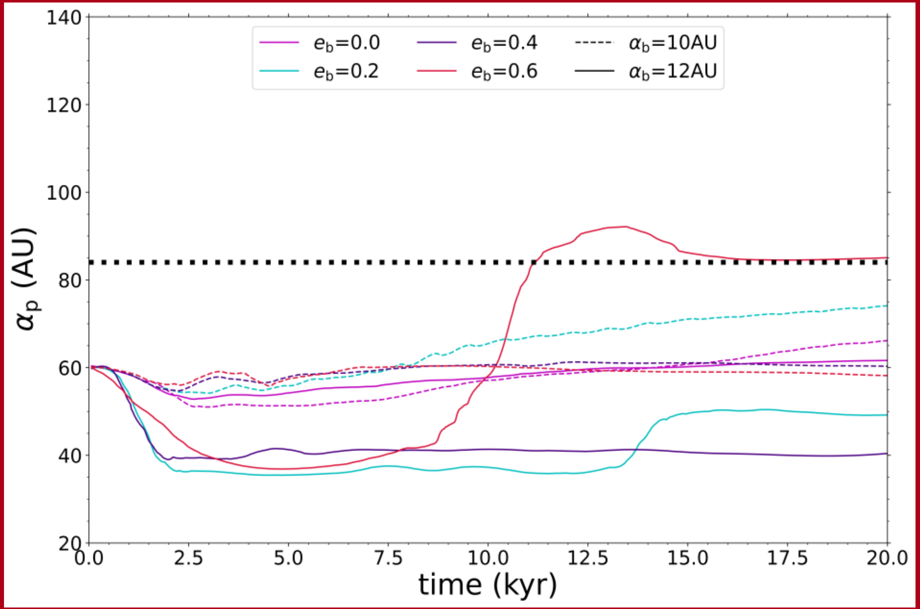


- ❖ Almost all runs reach the observed separation
- ❖ Majority are below the observed mass





Scenario II



- ❖ Almost all runs reach the observed separation
- ❖ Majority are below the observed mass

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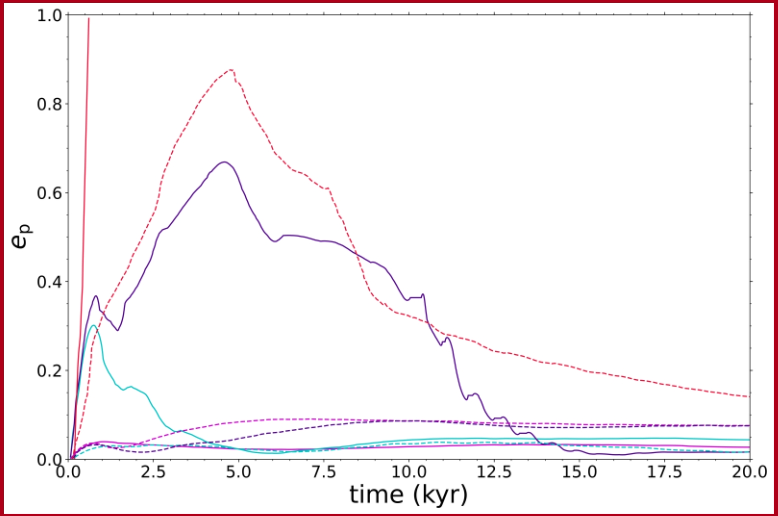
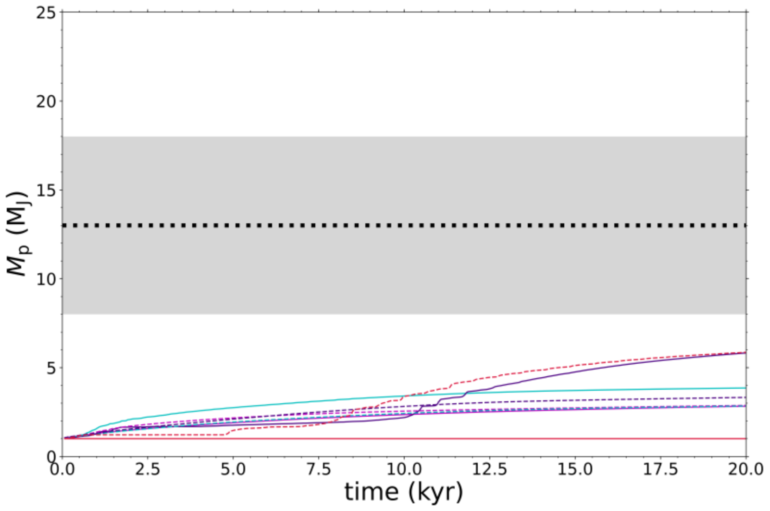
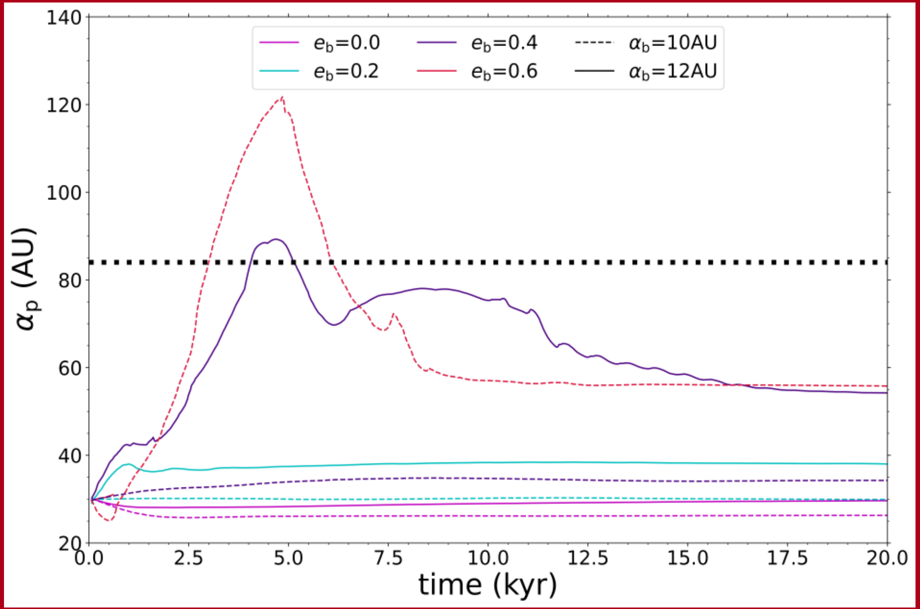
Scenario III







- No run is able to reach the observed separation
- All runs remain below the observed planet mass

Simulations vs observations

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Scenario I

- $\dot{M}_{\rm p}^{\rm 40Myr} = (1.9 - 4.6) \times 10^{-8}{\rm M_J yr^{-1}}$
- $M_{\rm p}^{\rm 40Myr} = (49 - 87){\rm M_J}$

Scenario II

- $\dot{M}_{\rm p}^{\rm 40Myr} = (1.8 - 4.8) \times 10^{-8}{\rm M_J yr^{-1}}$
- $M_{\rm p}^{\rm 40Myr} = (22 - 91){\rm M_J}$

Scenario III

- $\dot{M}_{\rm p}^{\rm 40Myr} = 3.8 \times 10^{-10} - 4.4 \times 10^{-9}{\rm M_J yr^{-1}}$
- $M_{\rm p}^{\rm 40Myr} = (4 - 17){\rm M_J}$

Observed

- $\dot{M}_{\rm p}^{\rm 40Myr} = (0.8 - 3.0) \times 10^{-8}{\rm M_J yr^{-1}}$
- $M_{\rm p}^{\rm 40Myr} = 13 \pm 5{\rm M_J}$

Conclusions

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- We presented three formation scenarios for this object:
  - (I) an in situ formation in a massive disc
  - (II) a closer in formation than Scenario I and outward migration in a massive disc
  - (III) formation closer to the binary in a lower mass disc

- We are able to replicate the observed separation in Scenario I and Scenario II.
- By the end of the simulation runtime, the majority of planet masses are consistent with the observed value.
- At 40Myr, we find Scenario I and II are most consistent with the observed mass accretion rate although the planet mass is above the observed value.
- We find all models may explain specific features of the observations but not all.