

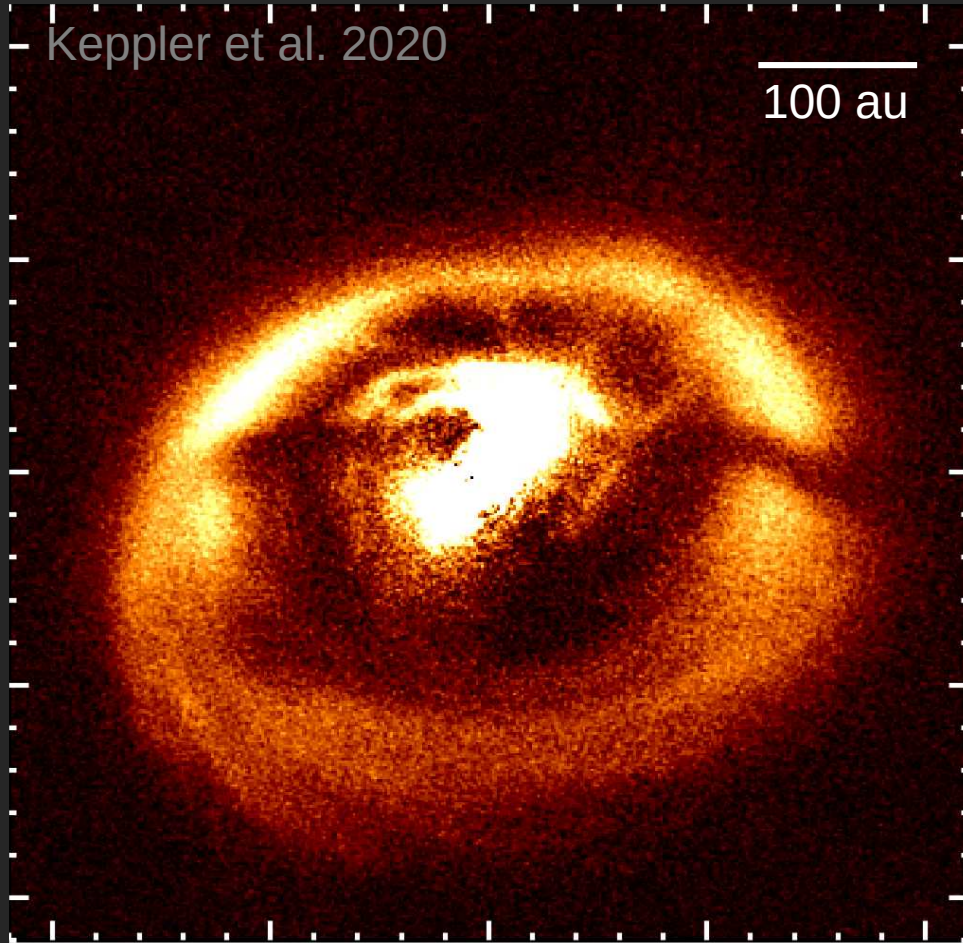


Multi-Body Hydrodynamics **Planets in Circumbinary Discs**

23.06.2026

Anna Penzlin
LMU München

Circumbinary discs

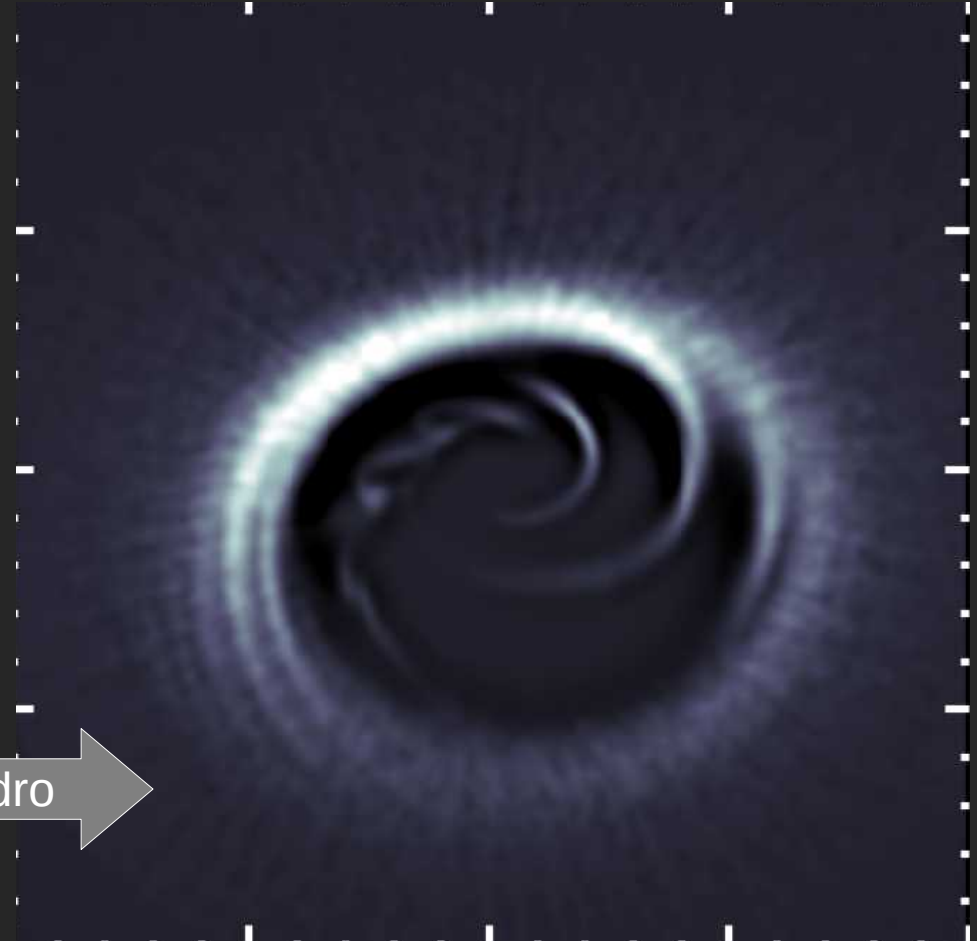
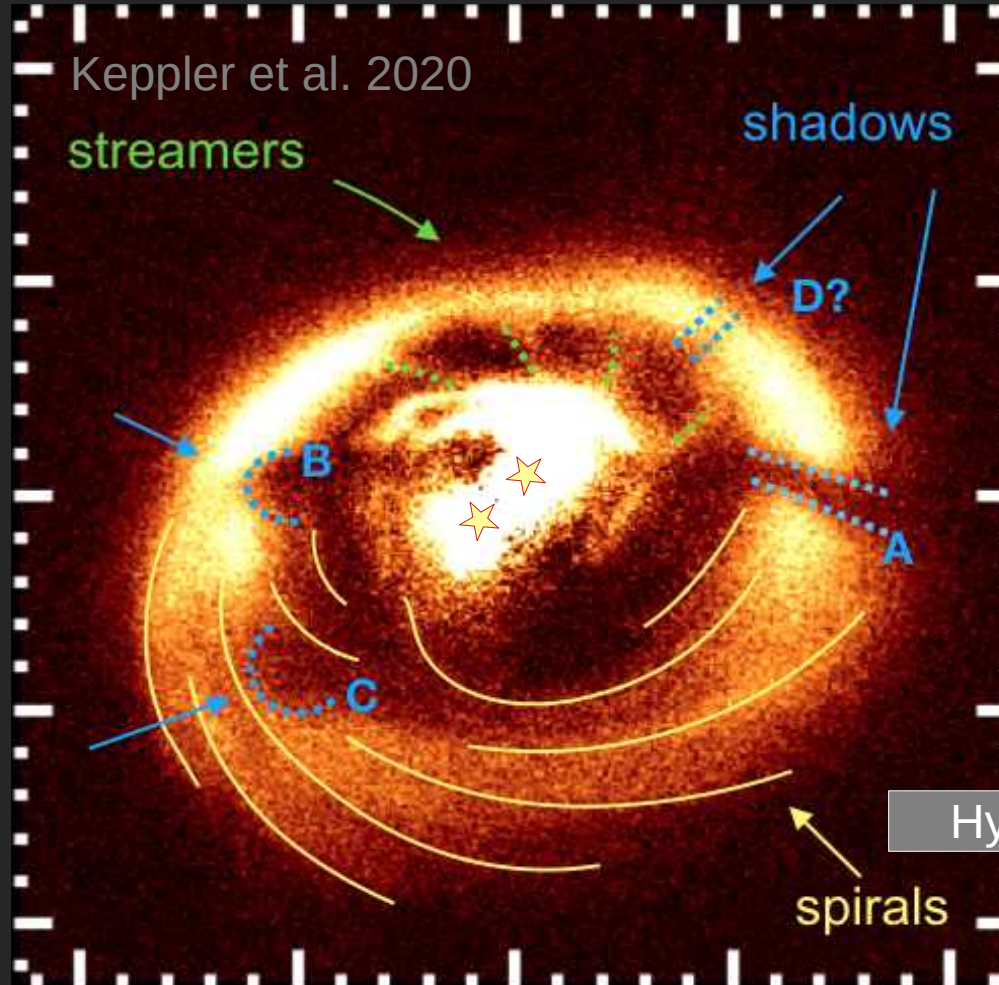


The picture that started it all...

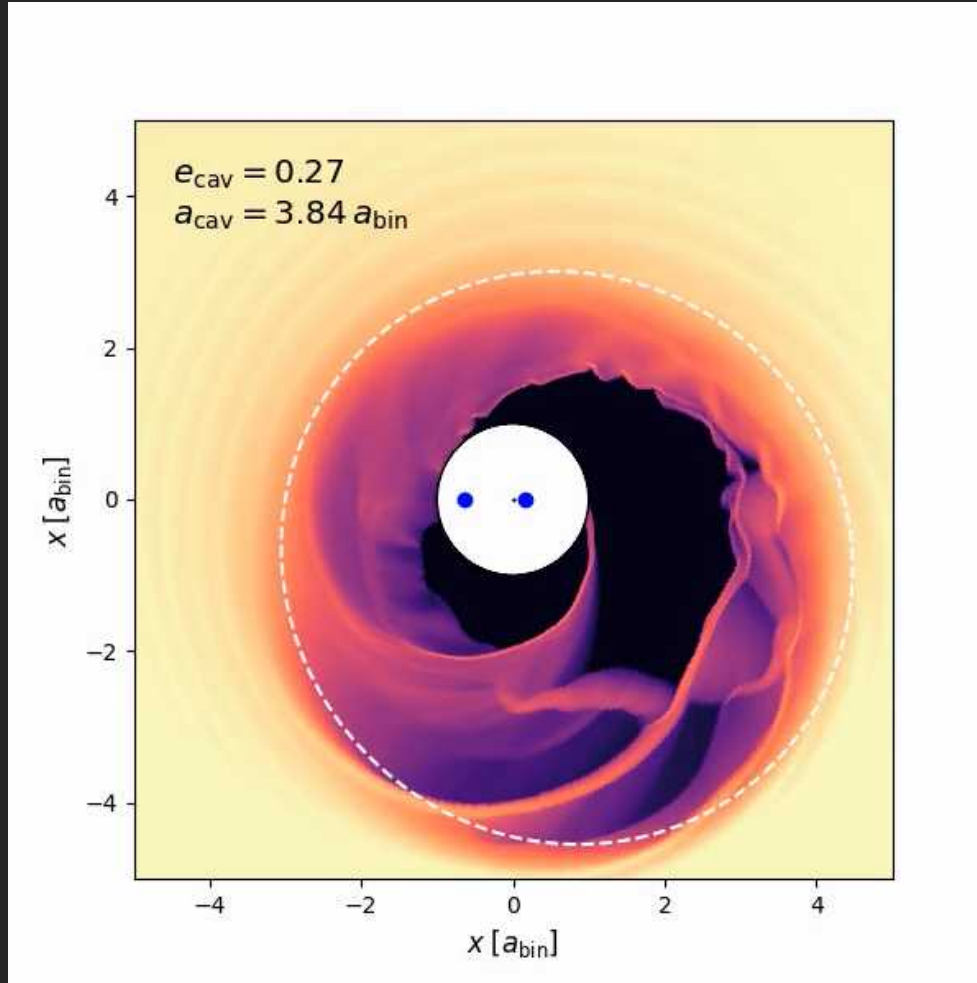


GG Tau A
VLT/SHPERE scattered light

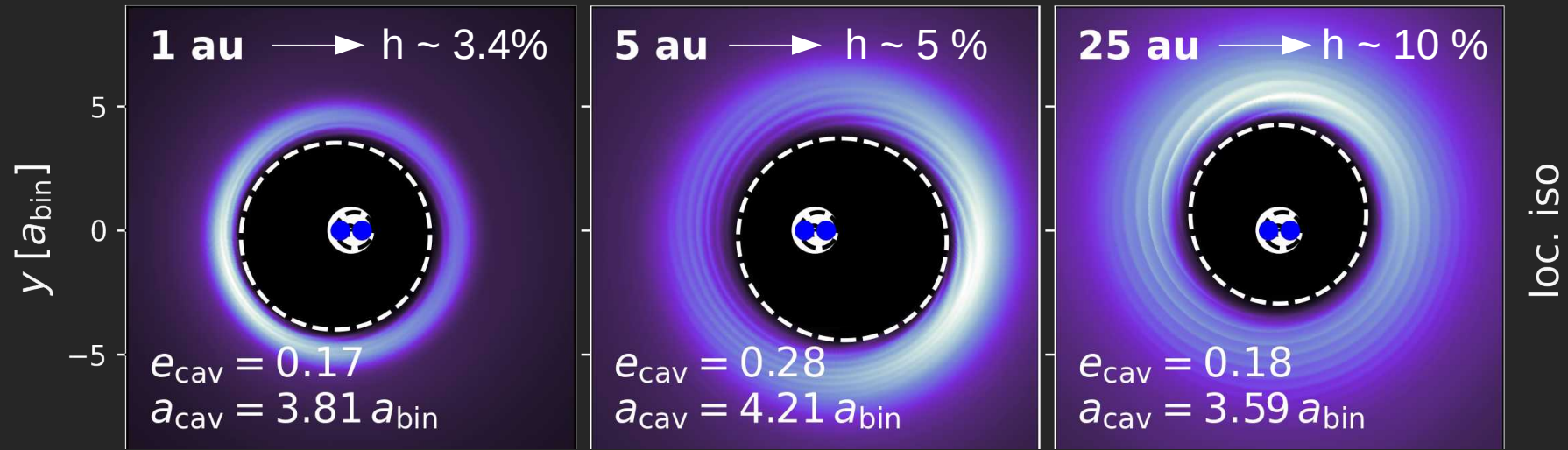
Circumbinary discs



Circumbinary disc dynamics



Circumbinary disc dynamics - isothermal



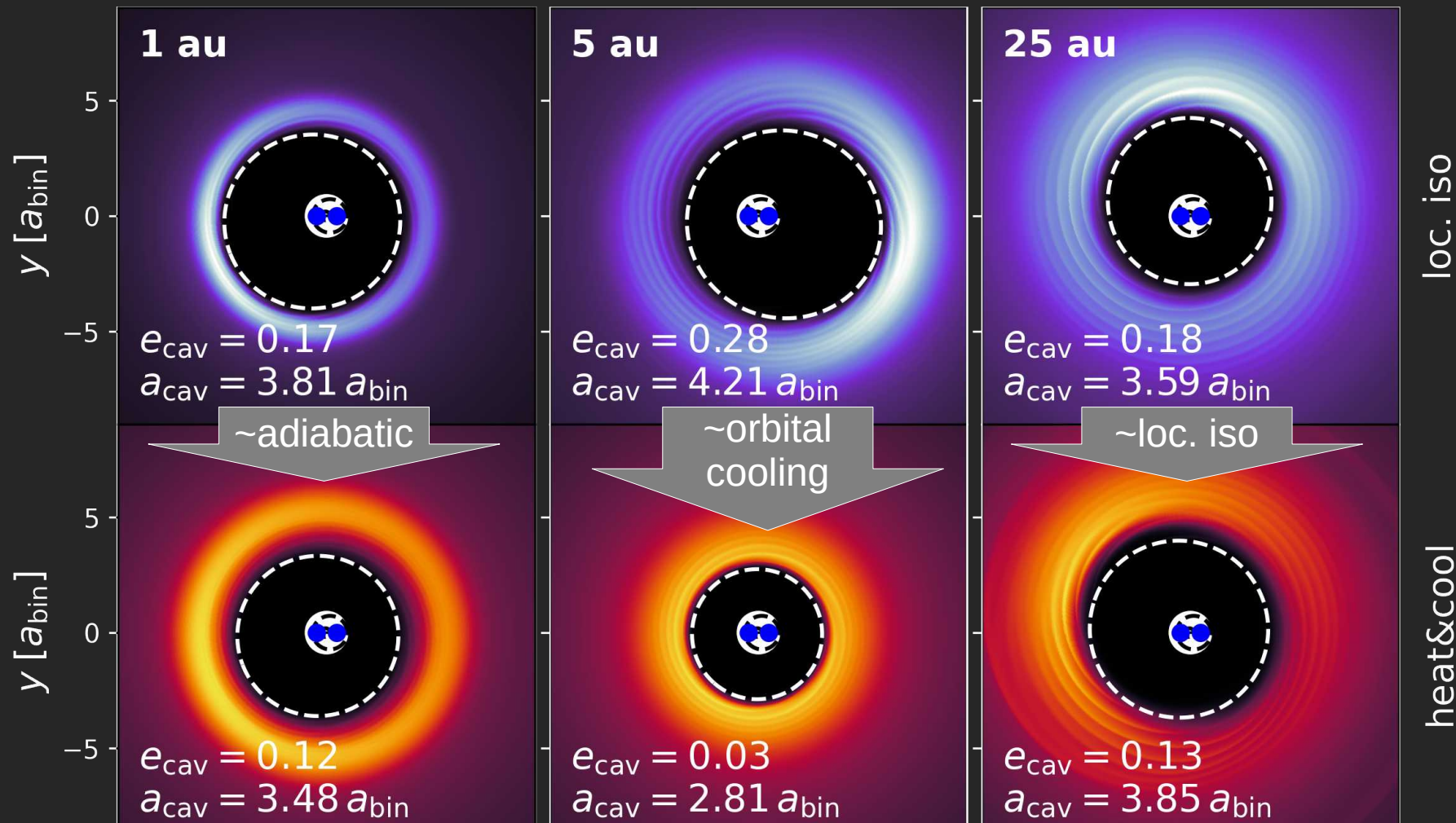
Changing the pressure scale height changes the wave winding
 → **Thicker disc have wider spirals and wider pressure maxima**

Higher pressure leads to higher viscosity and “flooding” the cavity
 → **There is a viscous sweet spot for the cavity size**



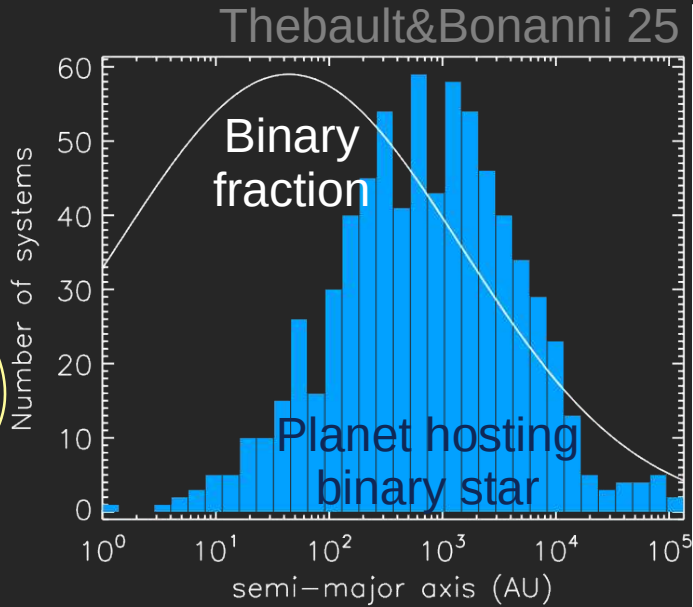
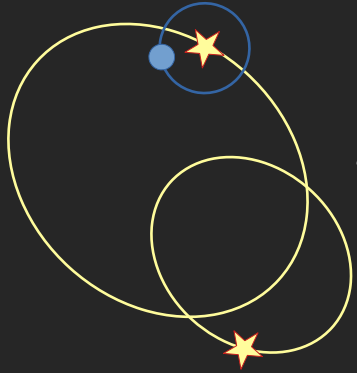
Circumbinary disc dynamics - heat&cooling

see Sudarshan+22, Penzlin+25



Circumbinary planets in observation

s-Type



- > 800 planet hosting systems
- Planet host fraction: ~ 20% of binaries
- Planet population is reduced in binaries with separation >500 au

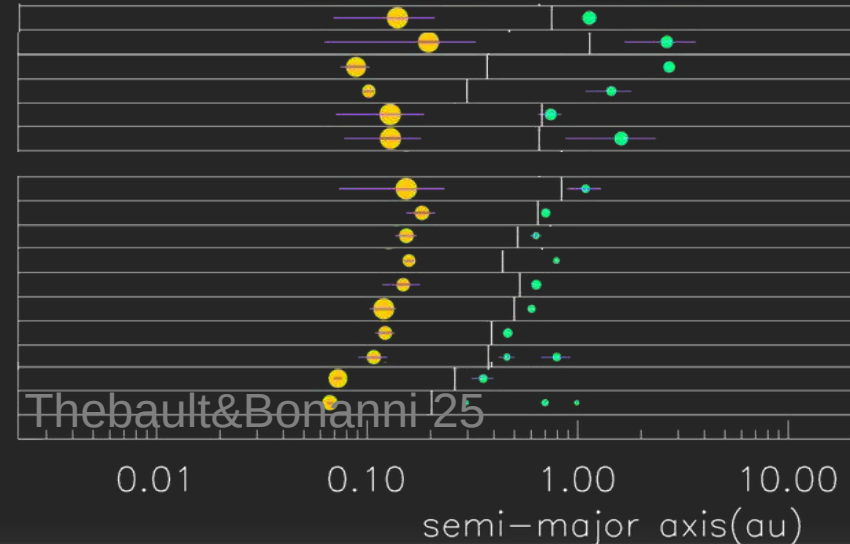
p-Type



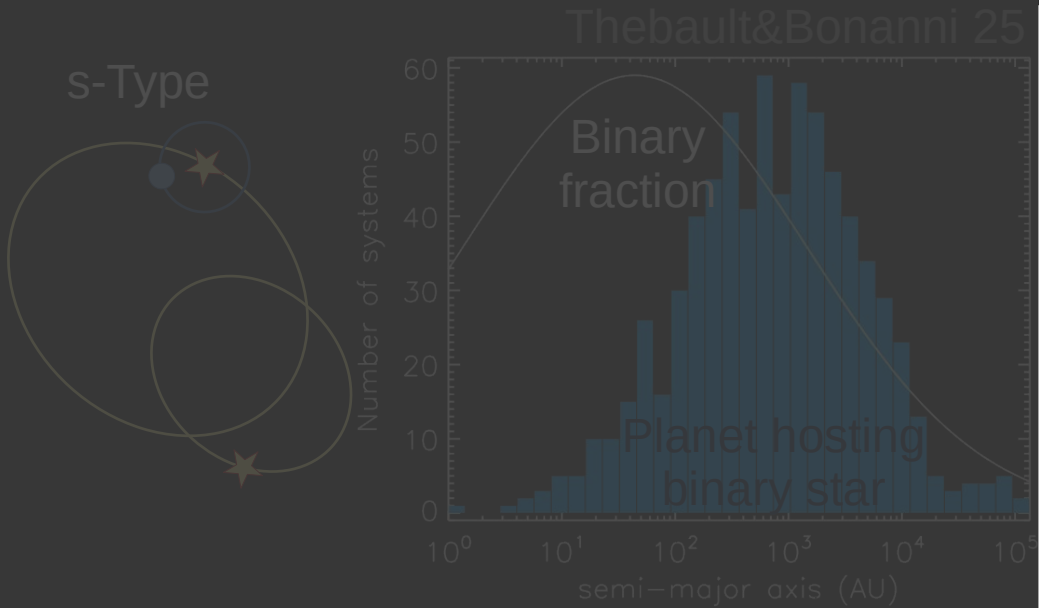
≤ 30 planets confirmed

Kepler1660
KIC7821010
Kepler1647
BEBOP-3
TIC172900988
KIC7177553•

Kepler34
Kepler16
Kepler1661
Kepler453
Kepler64•(PH1)
Kepler35
Kepler38
TOI1338
Kepler413
Kepler47



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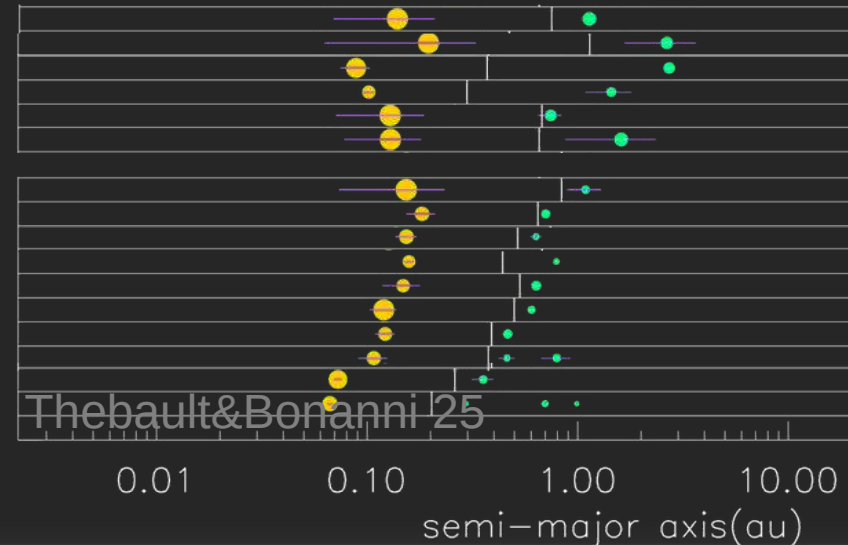
In this talk:



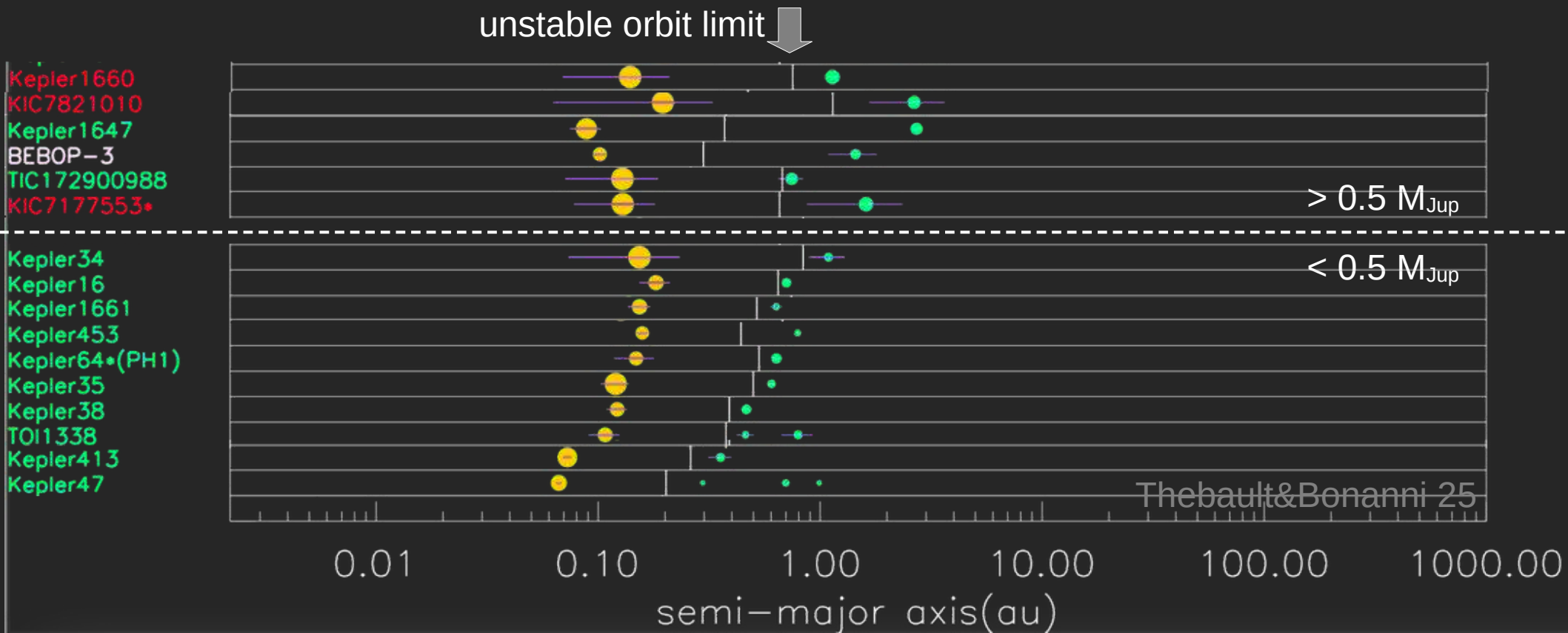
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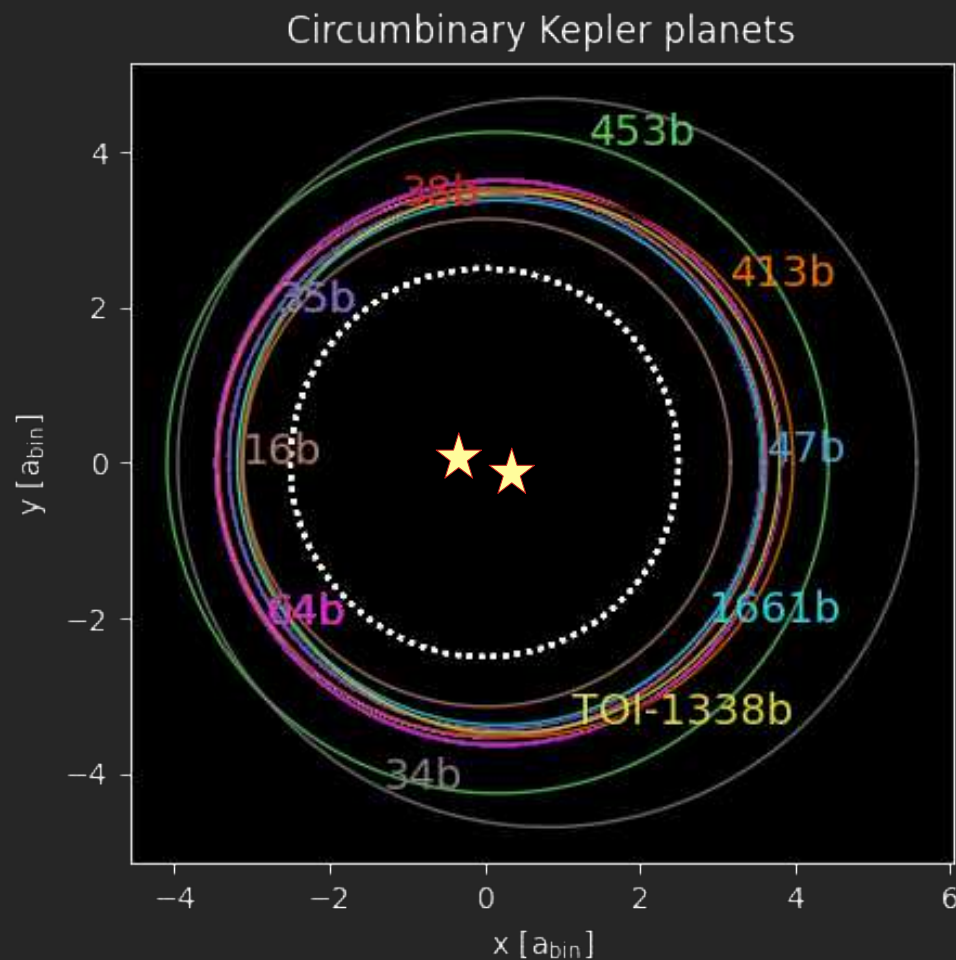
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Circumbinary planets in observation – p-Type

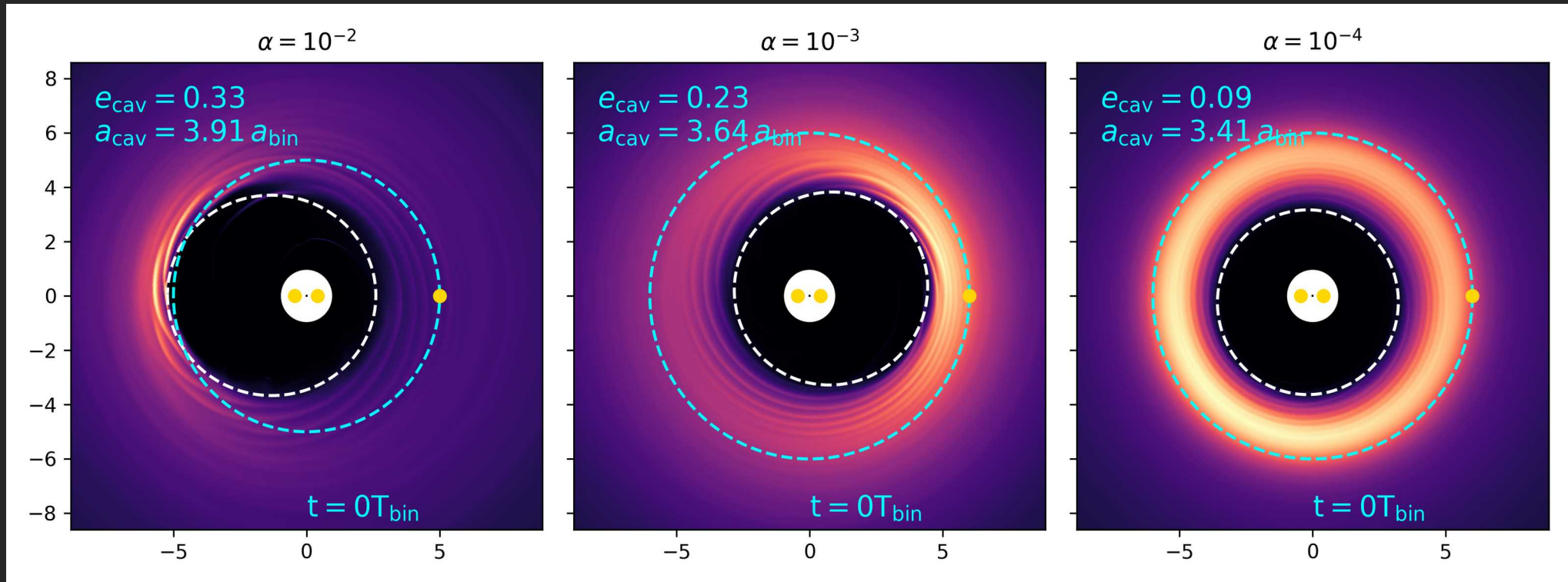


Circumbinary planets in observation – p-Type



Migration of circumbinary planets – sub-Jupiters

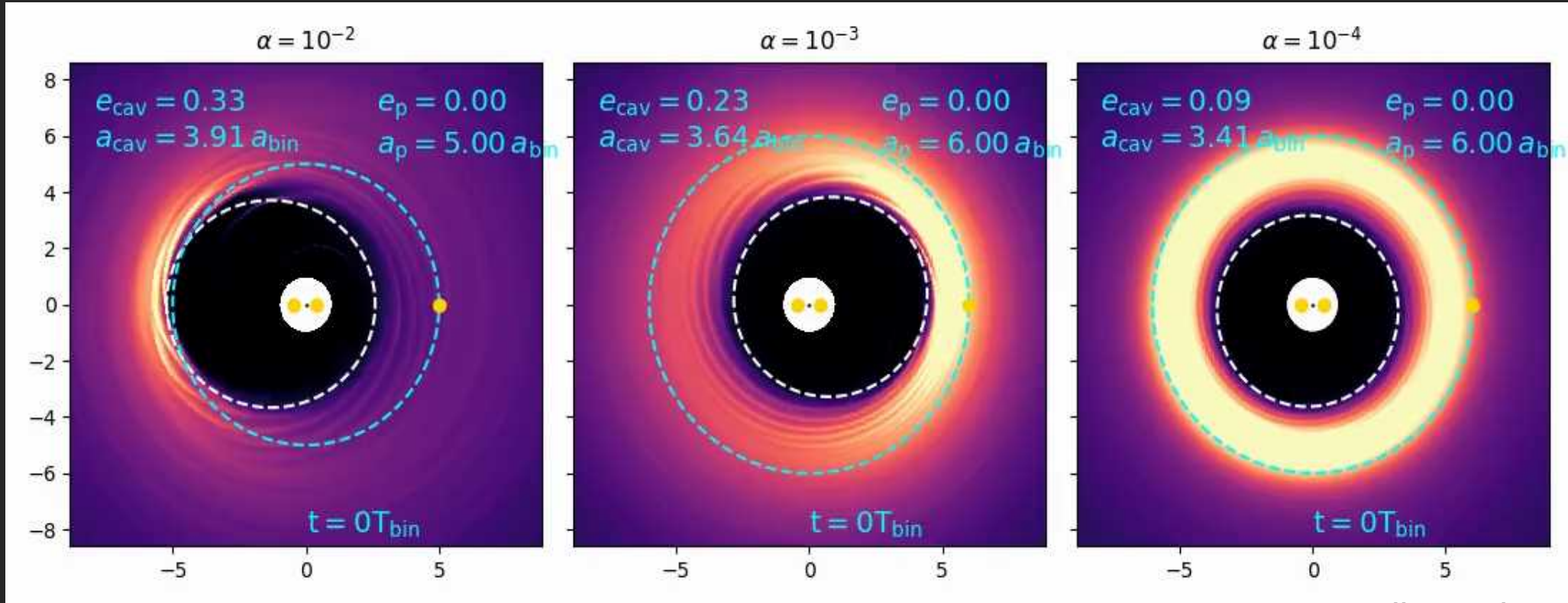
The turbulent viscosity reshapes the disc



Penzlin et al. 21

Migration of circumbinary planets – sub-Jupiters

The turbulent viscosity reshapes the disc



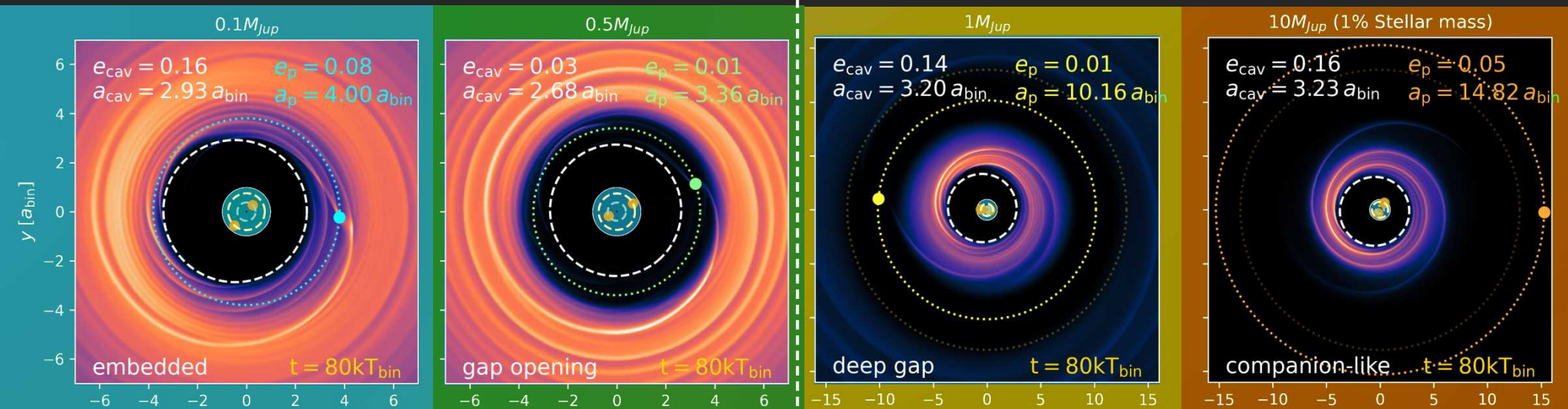
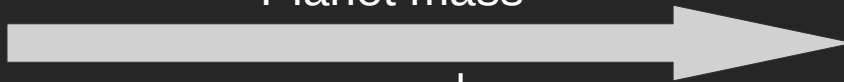
It changes the migration environment and the gap-opening planet mass

Penzlin et al. 21

For sub-Neptune planets, low viscosities are needed to reach the inner cavity

Migration of circumbinary planets – Giants

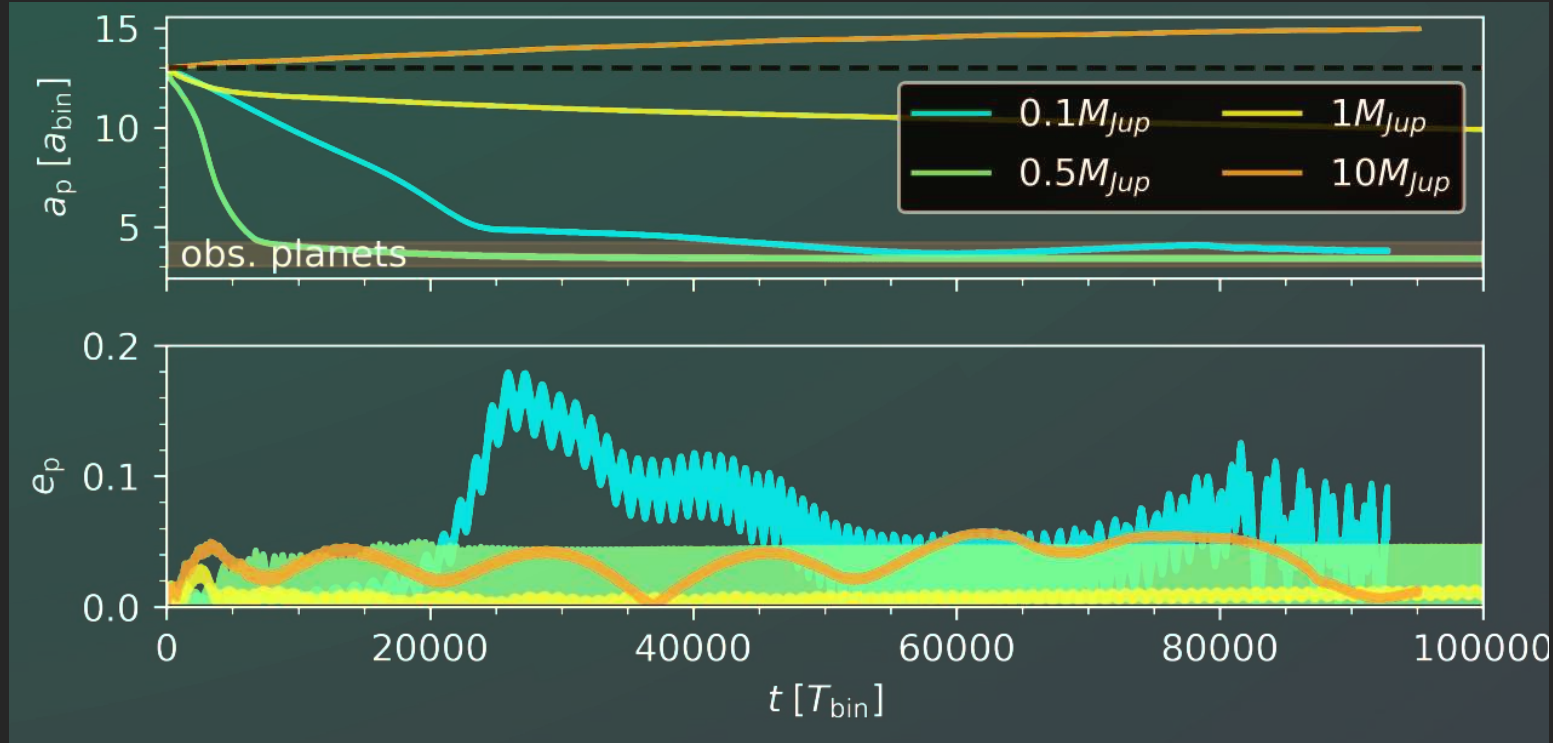
Planet mass



Planets connected to the disc

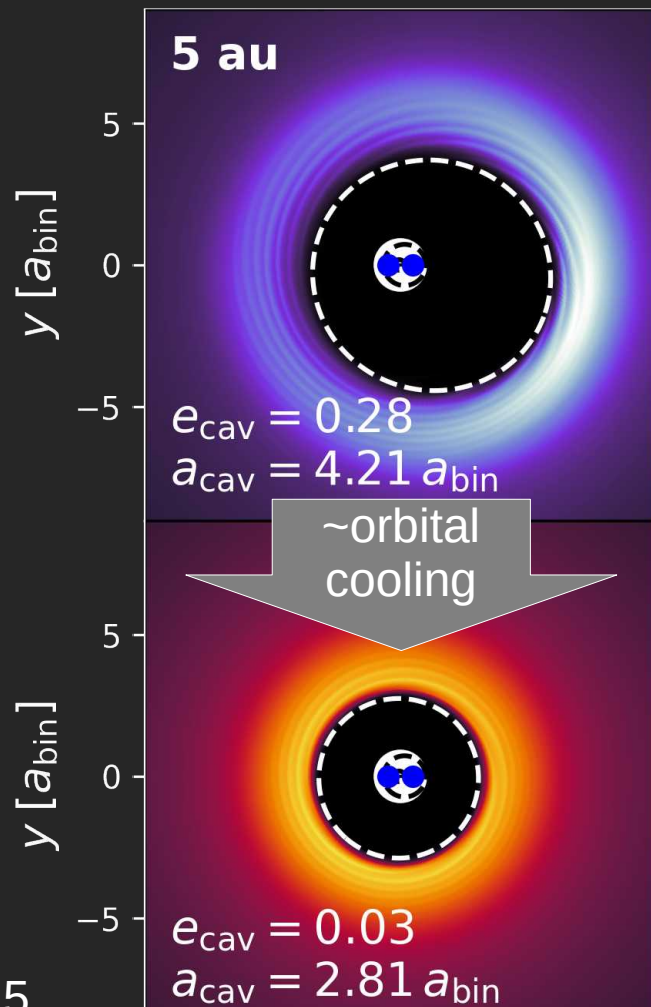
Planets in extremely deep gaps

Migration of circumbinary planets – Giants



$> 1 M_{\text{Jup}}$ planet can migrate outwards (also in non-binary discs)
(Pierens+08, Dempsey+21)

Migration of circumbinary planets – Larger systems



For cavities of ~ 40 au,
 the thermodynamic interaction
 damps the wakes and shrinks
 the cavity.

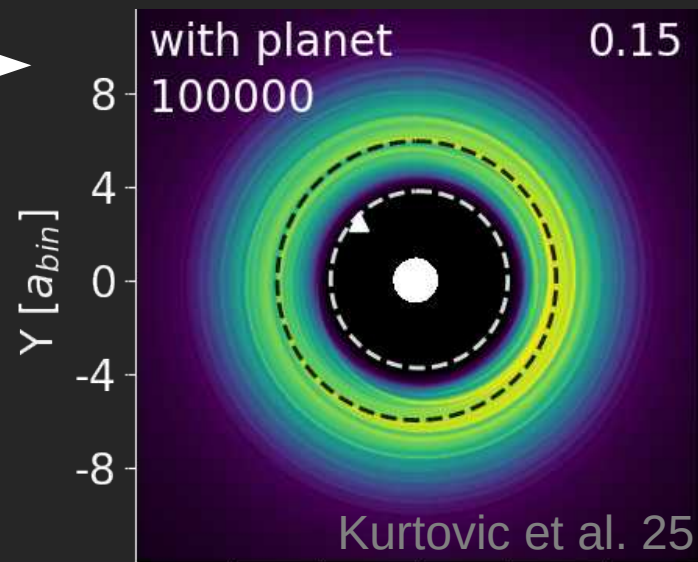
loc. isothermal with planet →

&

← **Systems with heat/cooling
 are degenerate**

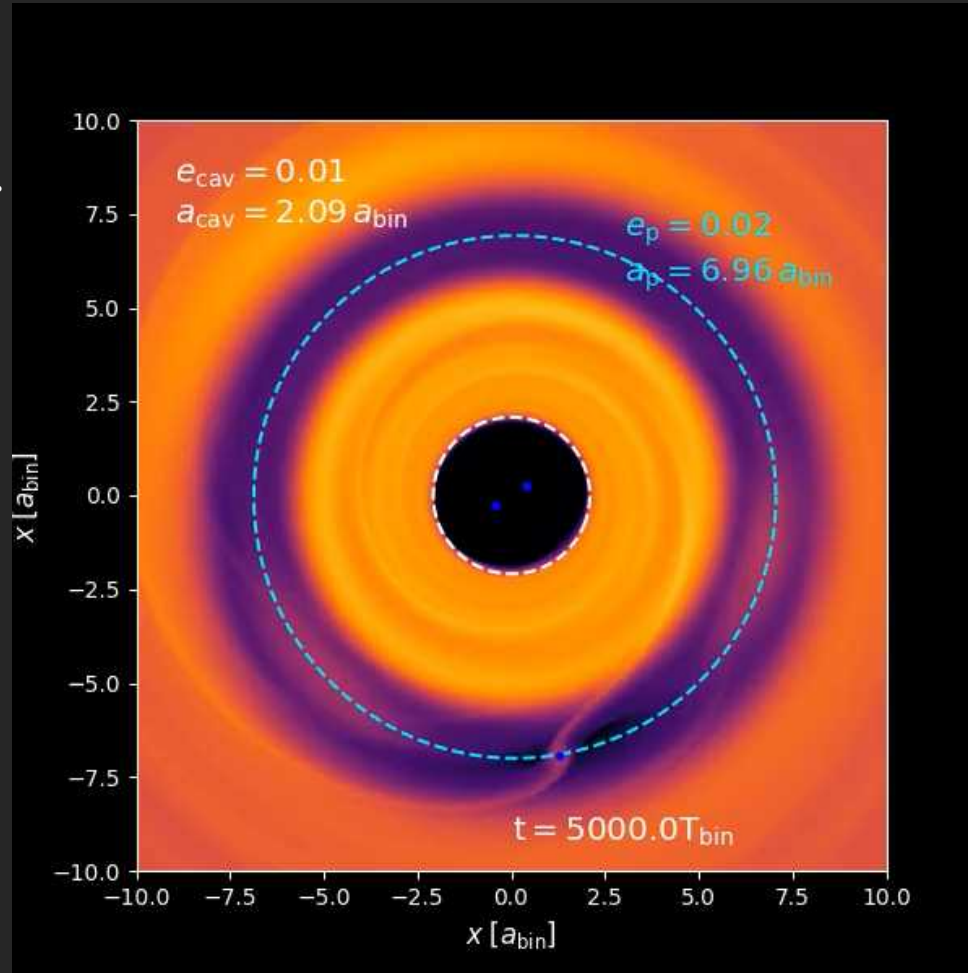
**What happens if both is
 combined?**

Planets can circularize the
 disc beyond their orbit.



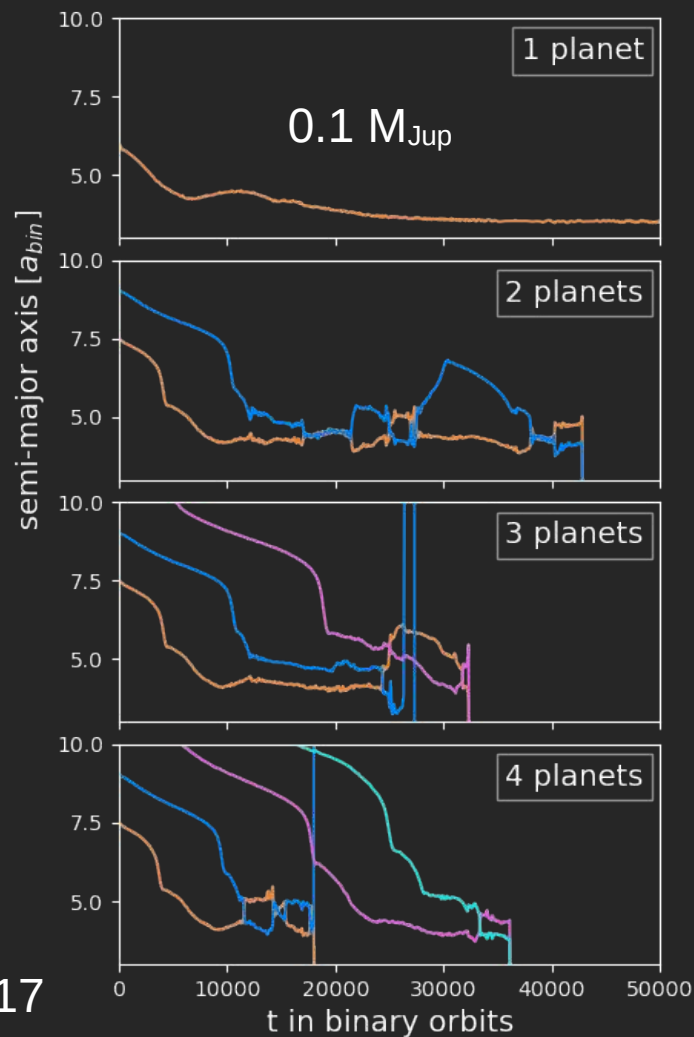
Migration of circumbinary planets – Larger systems

Planet migration
in heat/cooling system.



- 1) Planet migrates in a circular disc
- 2) Planet depletes inner region and changes thermal condition
- 3) Inner disc is pushed back and planets stall further out.

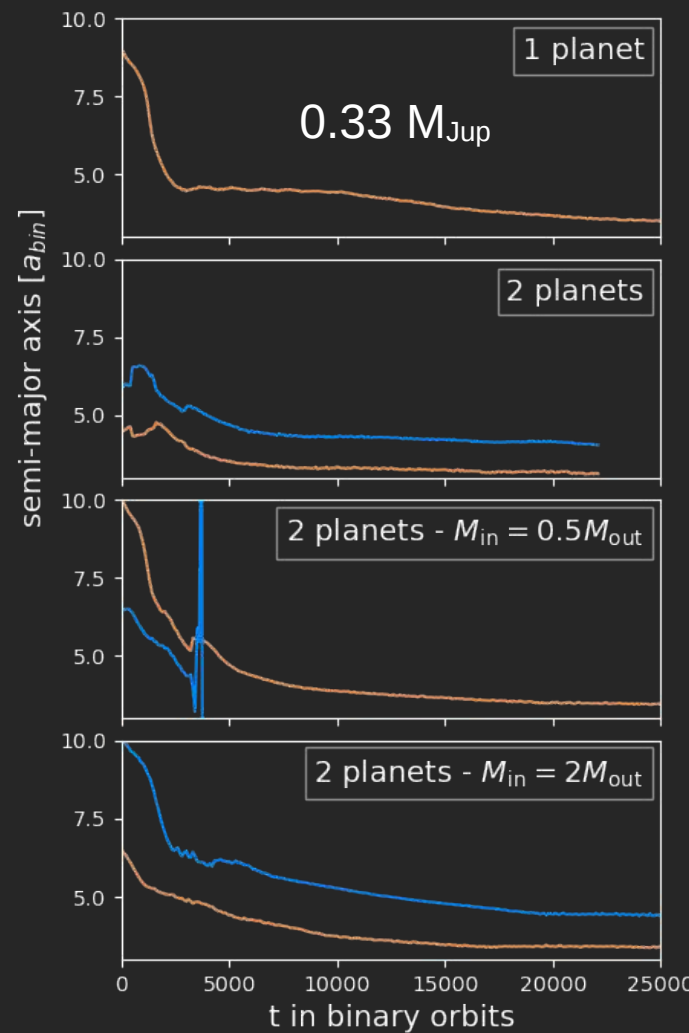
Migration of circumbinary planets – Multi-planets



Planet migration slows near the inner edge.

Planet chain can catch up then and interacted in there orbits.

When no fully stable resonance is formed planets in the disc destabilized each other eventually.



Circumbinary planets – Summary

Binaries drive continuously excitation into their common disc

- Planet formation around 1 host star with a 100 au companion is normal.
- Planet formation around 2 host stars piles up at 3.5 binary separations (near instability).

Planets are effective in forming in the inner disc.

- The observed sub-Jupiter planets must be gap carving.
- The observed super-Jupiter must stall in deep gaps.

Viscosity is as low as 10^{-4} .

- Orbital cooling can circularize orbits just like planets.
- Planets can change the thermal conditions and disc eccentricity.

Planets and thermodynamics can be degenerate.

- Smaller planets can destabilize each other.
- Planets in gaps can migrate in stable resonances.

Planet formation around binaries is harder.

