BLAVATNIK
FAMILY FOUNDATION

Angular momentum evolution in massive binaries

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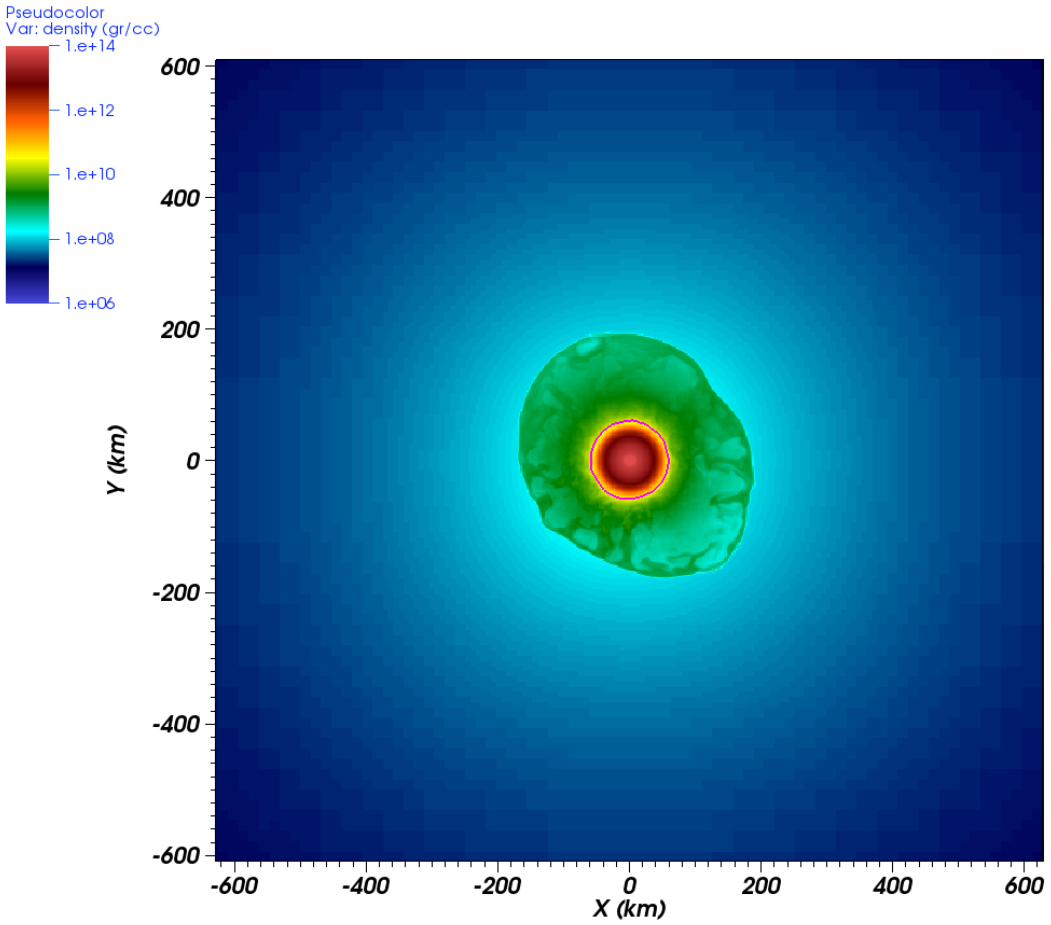
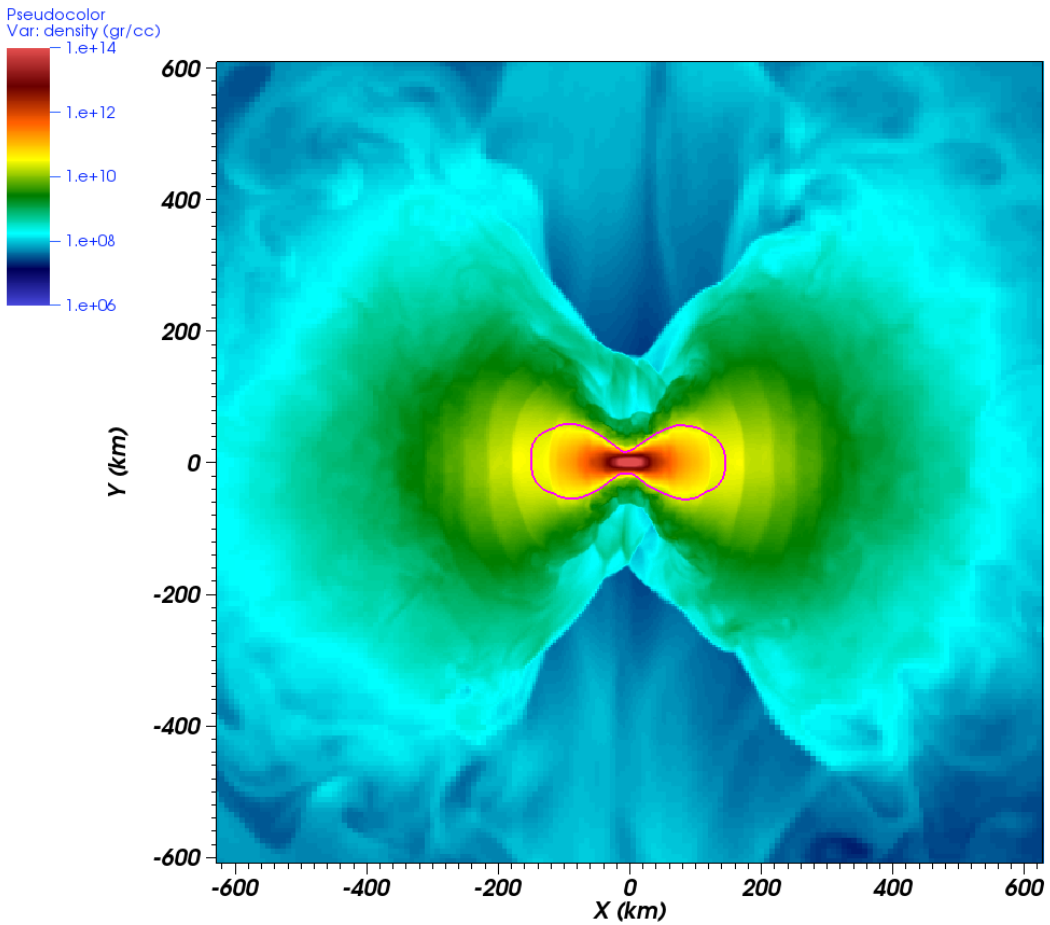
Talk outline

- Why is angular momentum important for core-collapse supernovae?
- How does the angular momentum evolve in massive binaries?

'Slow' rotation (magnetic braking)



'Fast' rotation (no magnetic braking)

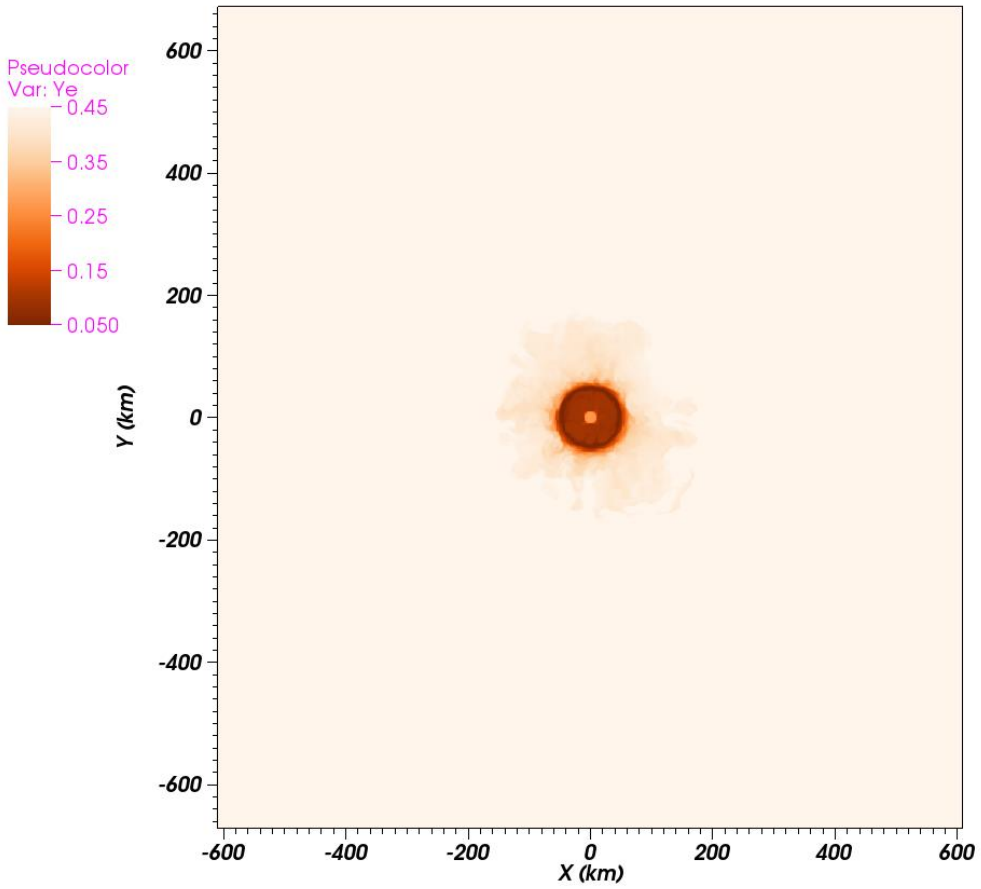


Rotation has a large effect on the collapse dynamics
(radius of pre-collapse core: approximately 2000 km)

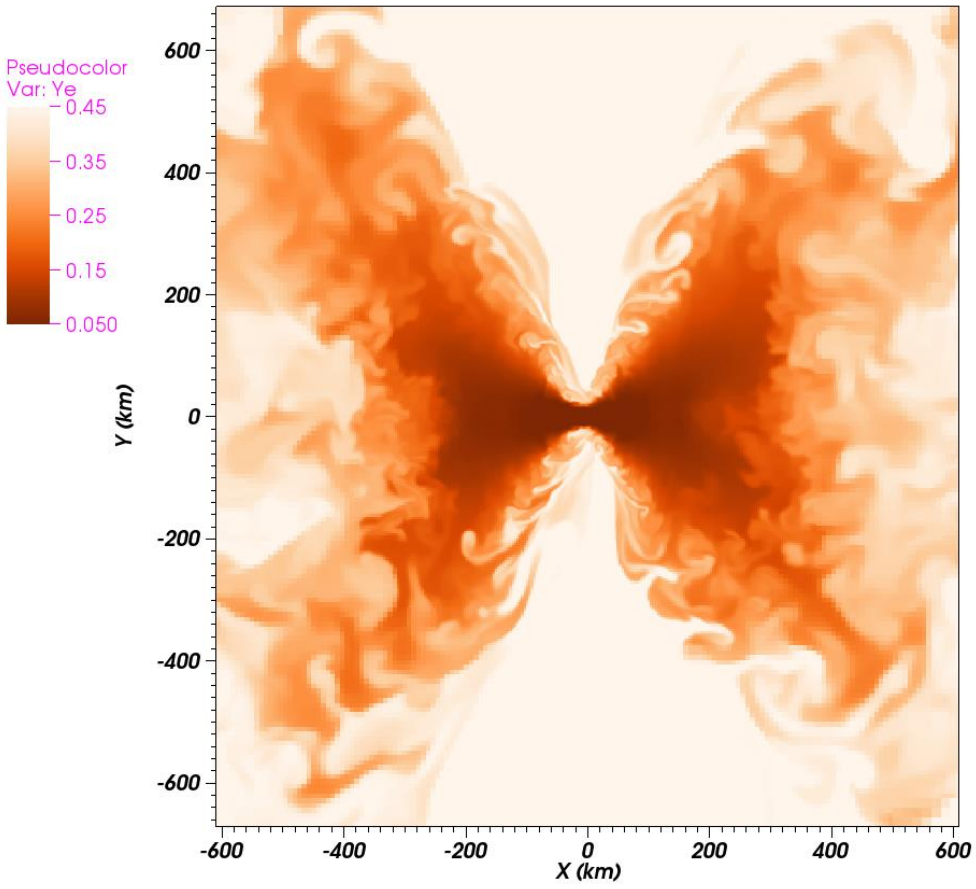
Gilkis A. 2018, MNRAS, 474, 2419

3D FLASH (Fryxell B. et al., 2000) simulations of collapsing rotating stars.

'Slow' rotation (magnetic braking)



'Fast' rotation (no magnetic braking)



Neutron-rich material is produced in a torus around the proto-neutron star for the case of fast rotation, but only in the neutron star itself for the case of slow rotation.

Gilkis A. 2018, MNRAS, 474, 2419

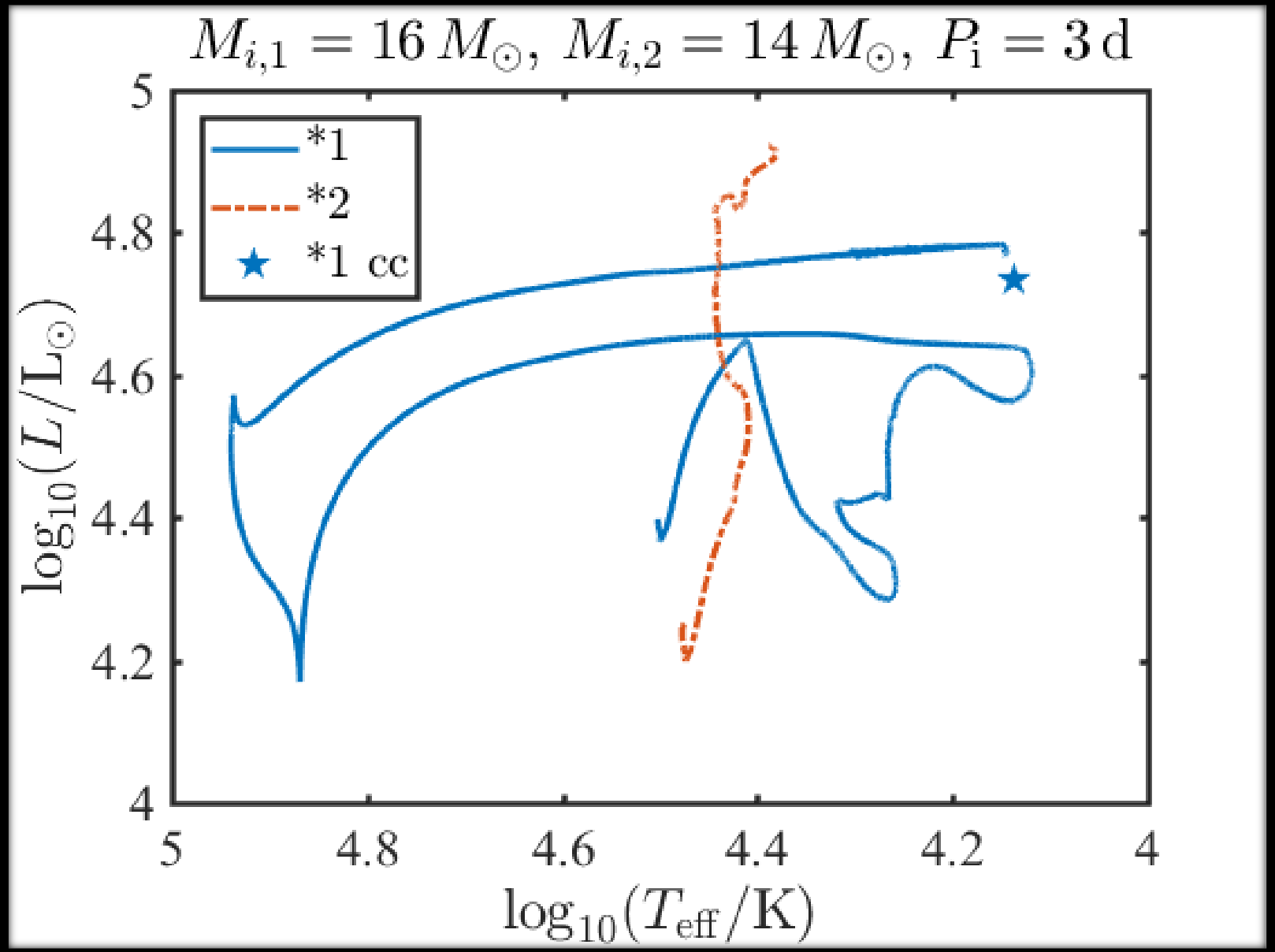
3D FLASH (Fryxell B. et al., 2000) simulations of collapsing rotating stars.

MESA

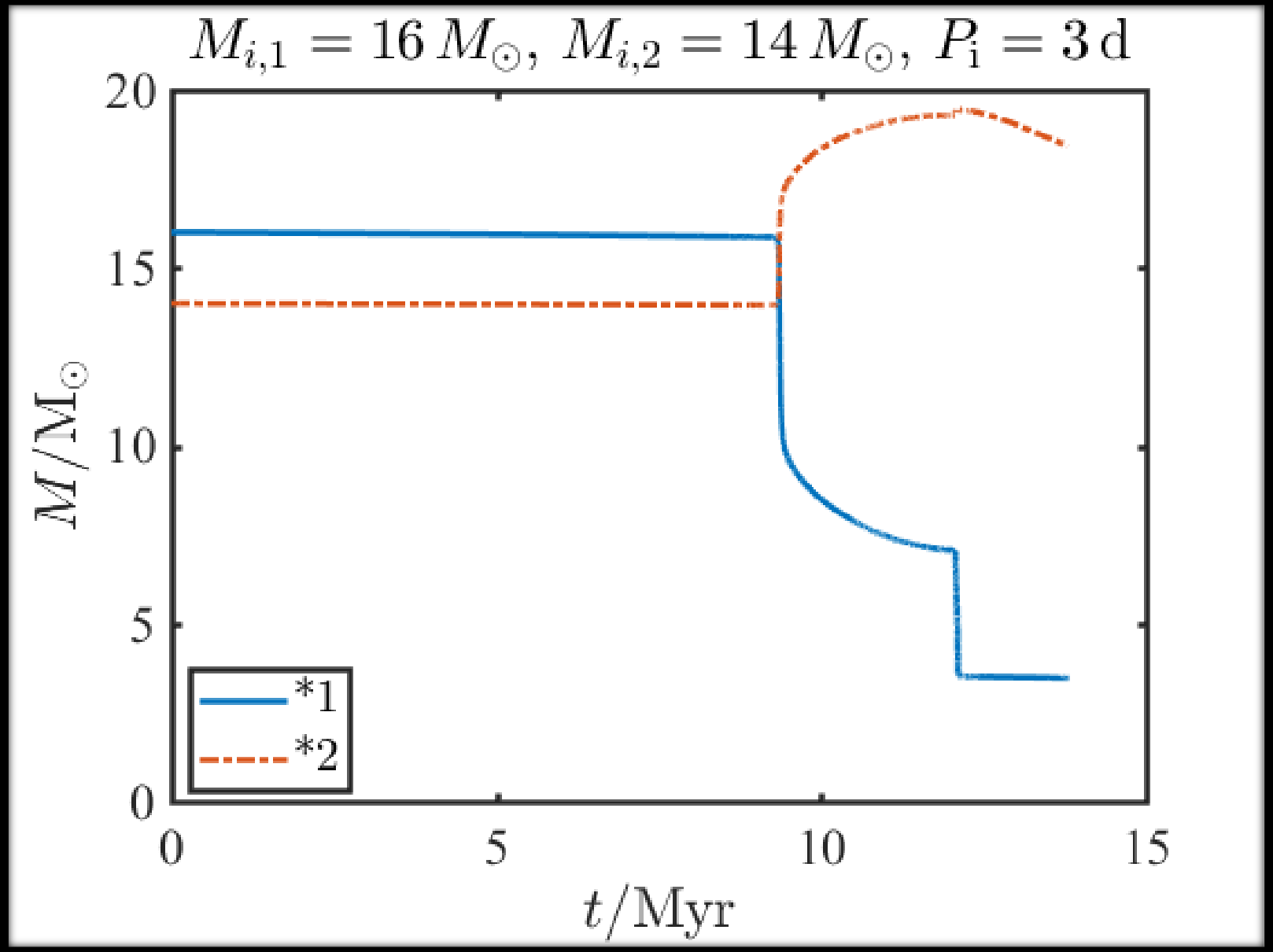
(Modules for Experiments in Stellar Astrophysics – Paxton B. et al., 2011,2013,2015,2018)

- Additions/changes:
  - Rotation + structure
  - Tidal synchronization
  - Mass transfer + angular momentum
  - Accretion + mixing
  - Winds

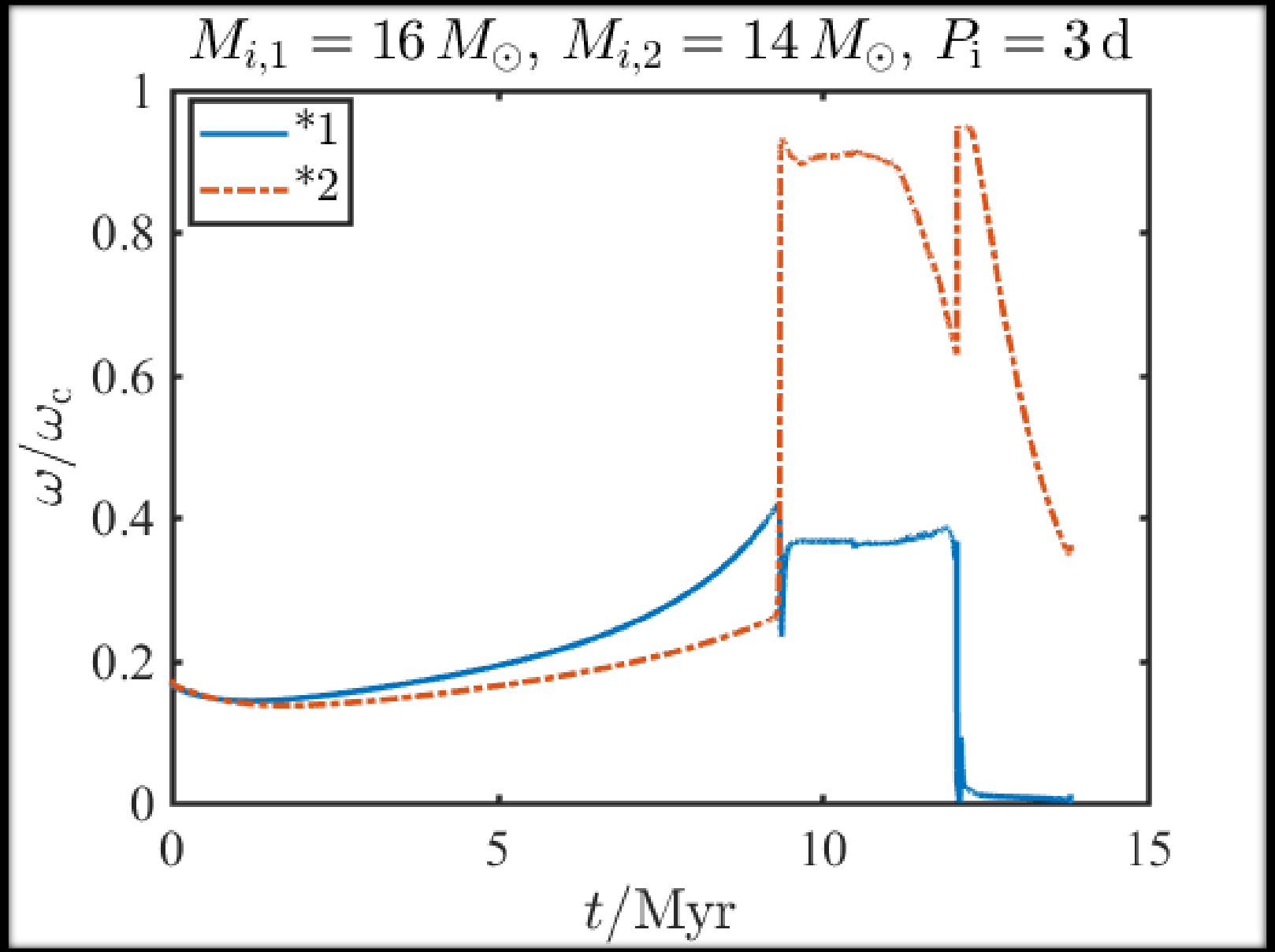
The secondary gains mass and becomes more luminous, while the primary loses almost all of its hydrogen.



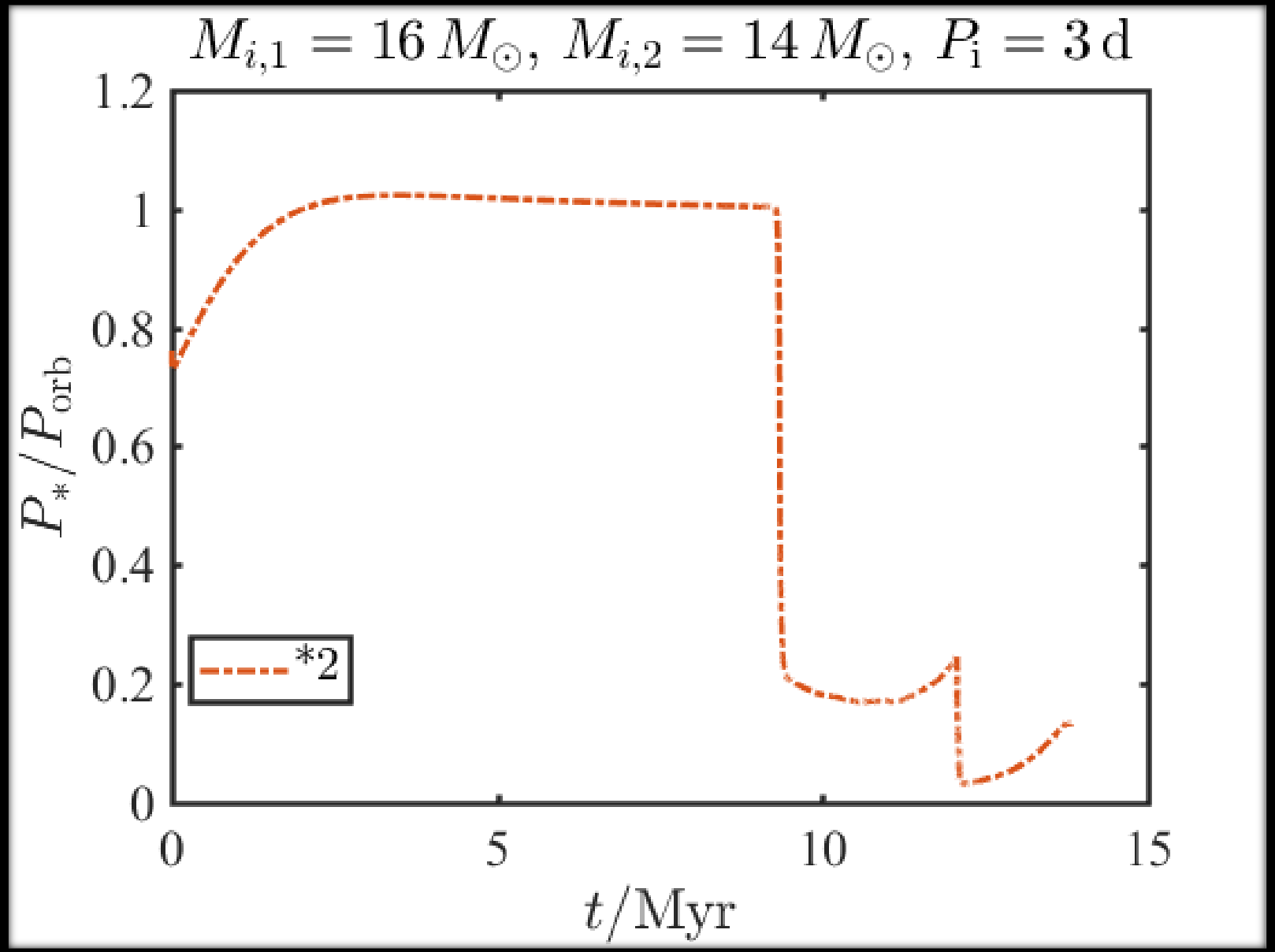
The secondary becomes significantly more massive during mass transfer, avoiding critical rotation thanks to tidal spin-down.



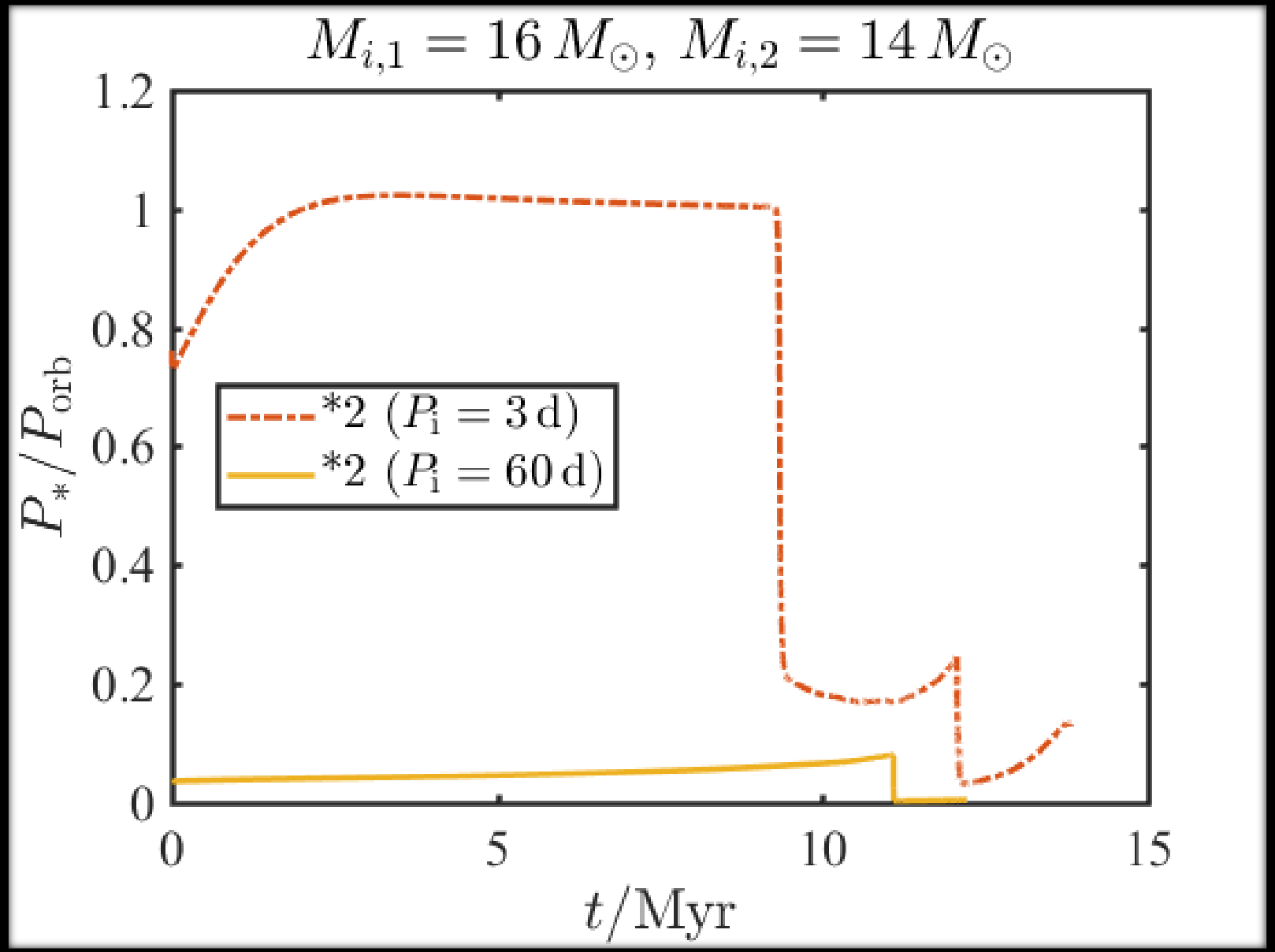
The secondary spins up after rapid mass accretion phases.



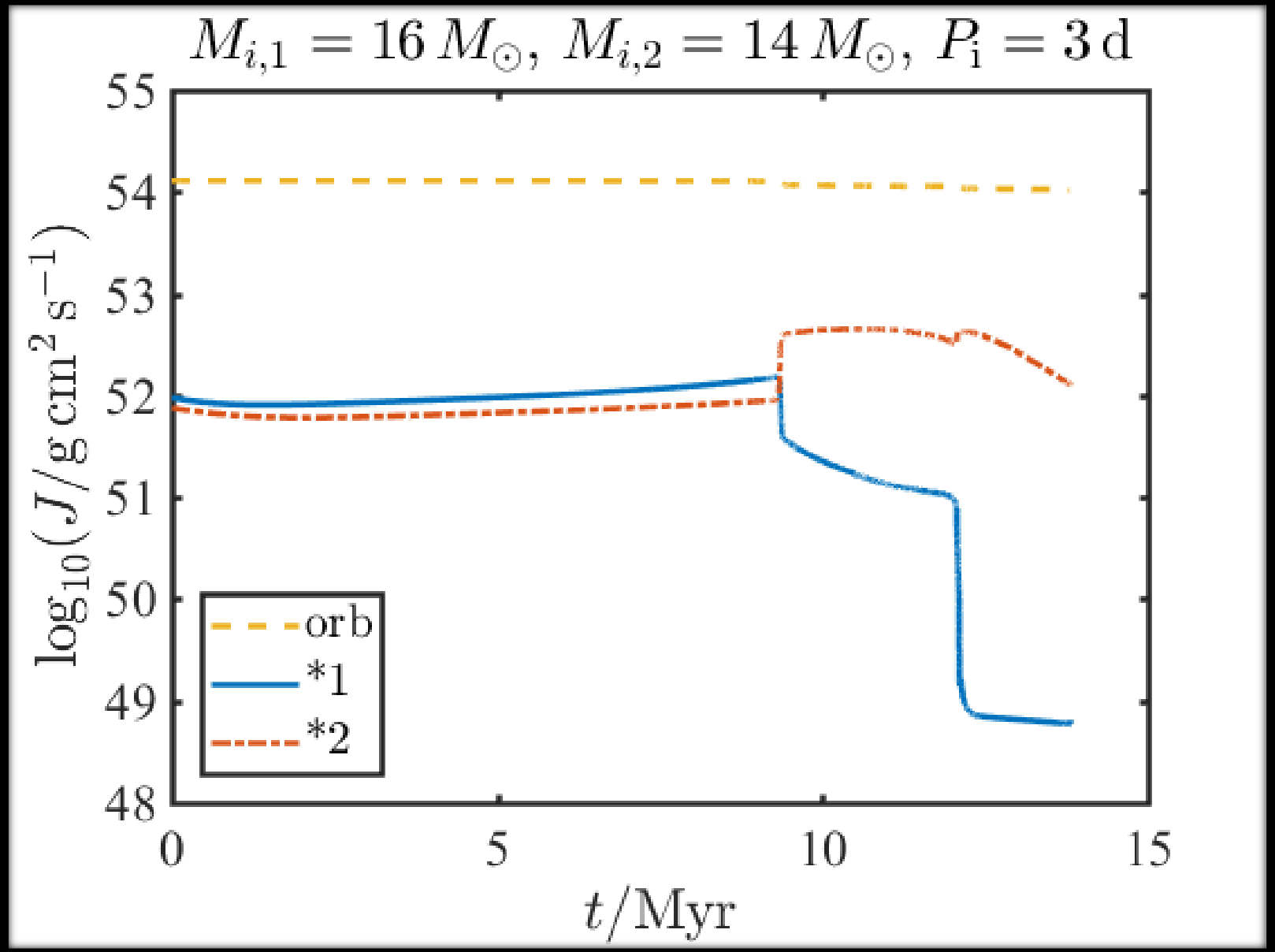
The secondary becomes tidally synchronized before mass transfer, and later spins super-synchronously.



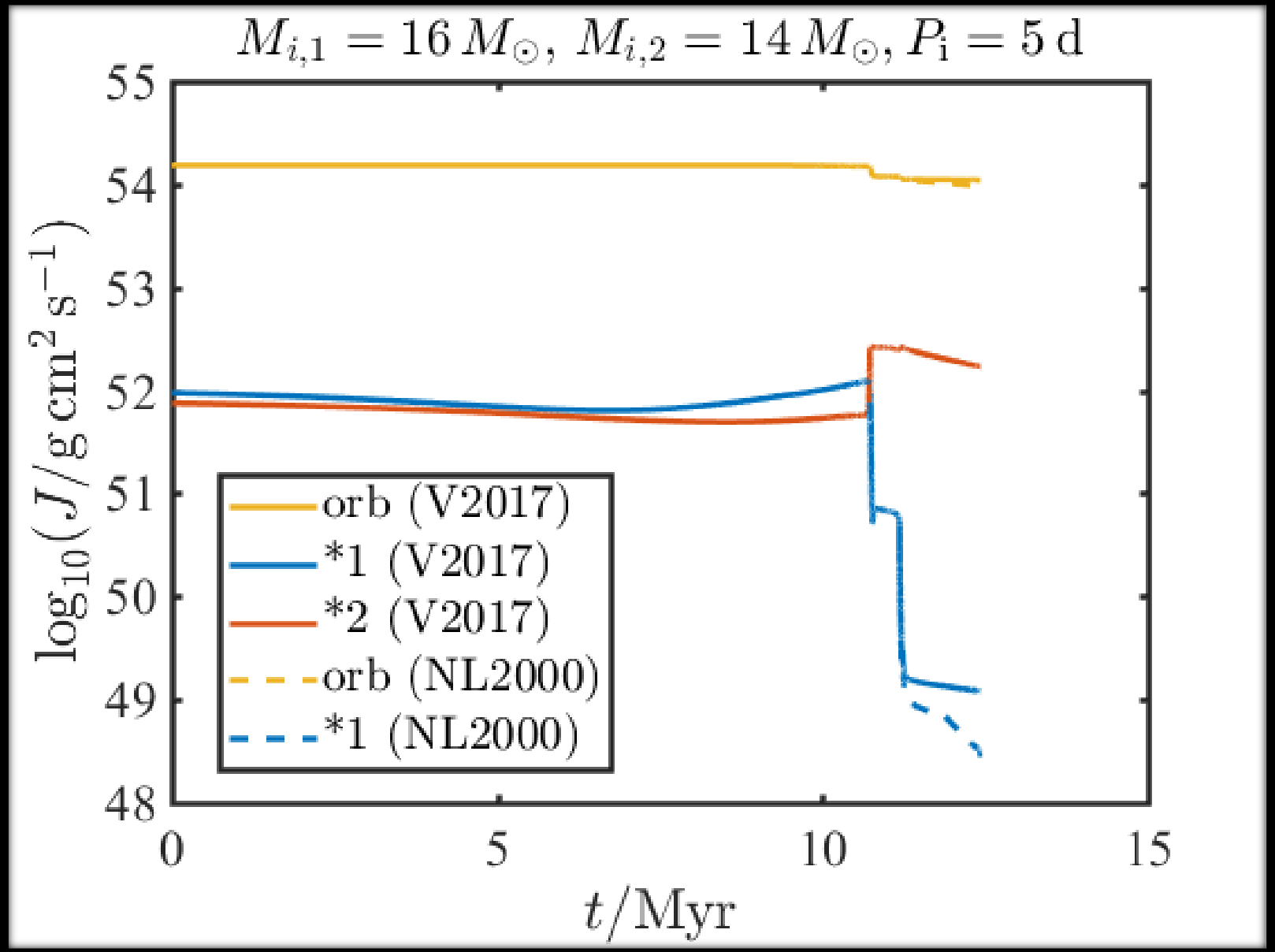
Tides are less important for longer initial periods.



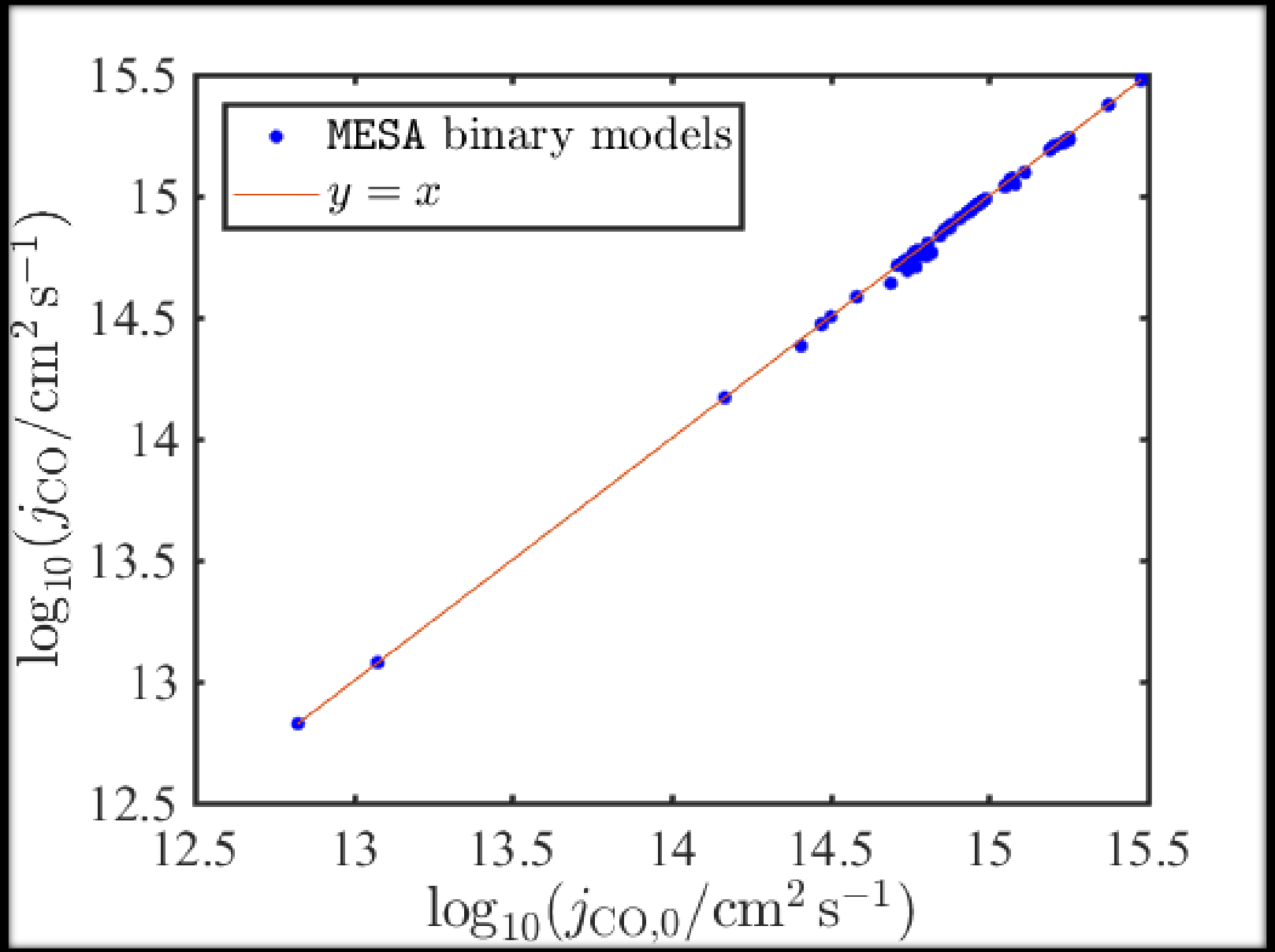
Most of the angular momentum is in the orbit, but relatively large changes in the angular momentum of the two stars occur, owing to mass transfer and wind mass loss.



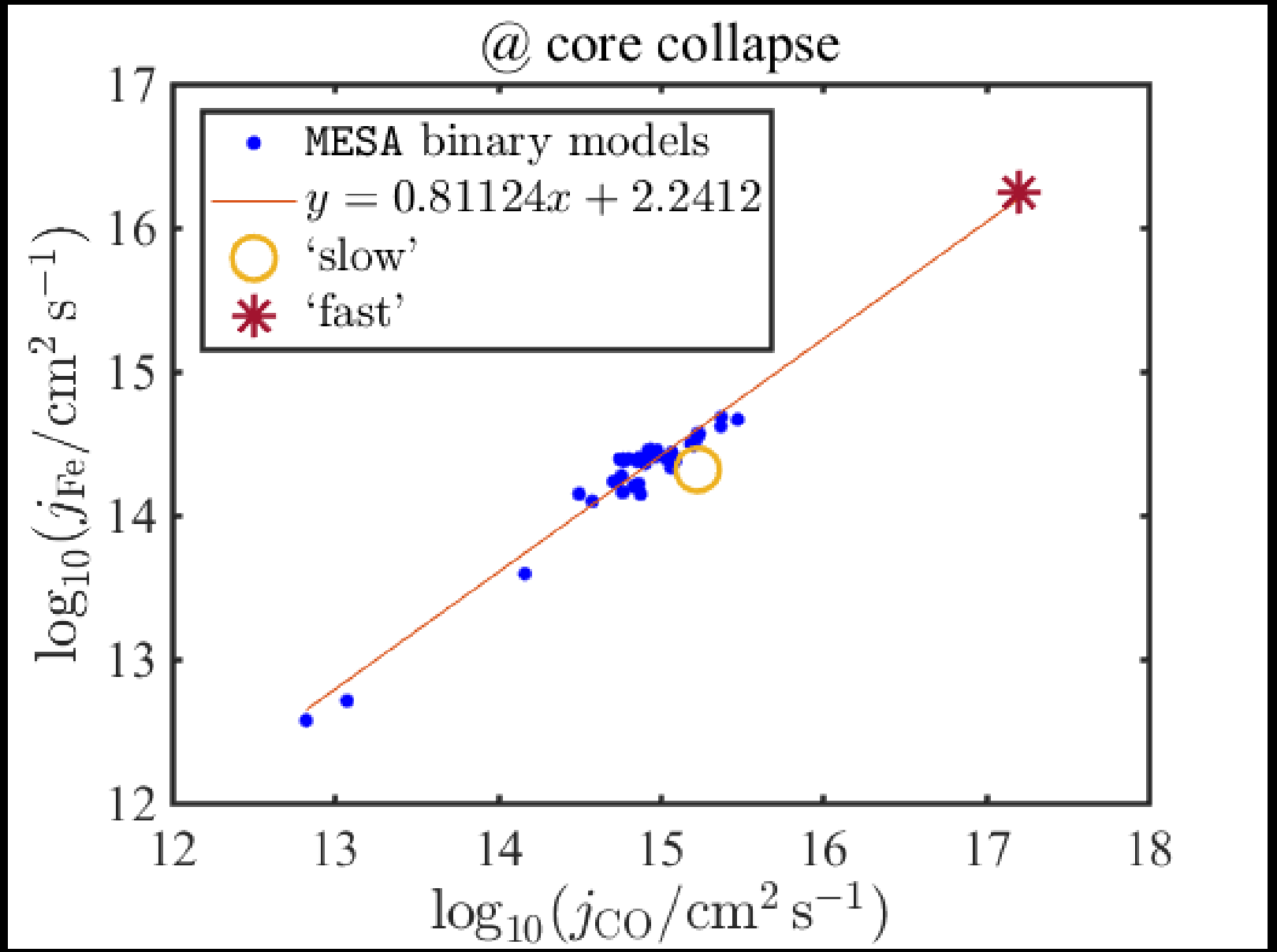
Different mass-loss prescriptions (Nugis & Lamers 2000; Vink 2017) affect the angular momentum loss.



The angular momentum of the CO core is essentially unchanged from the end of core carbon burning until the point of iron core collapse.

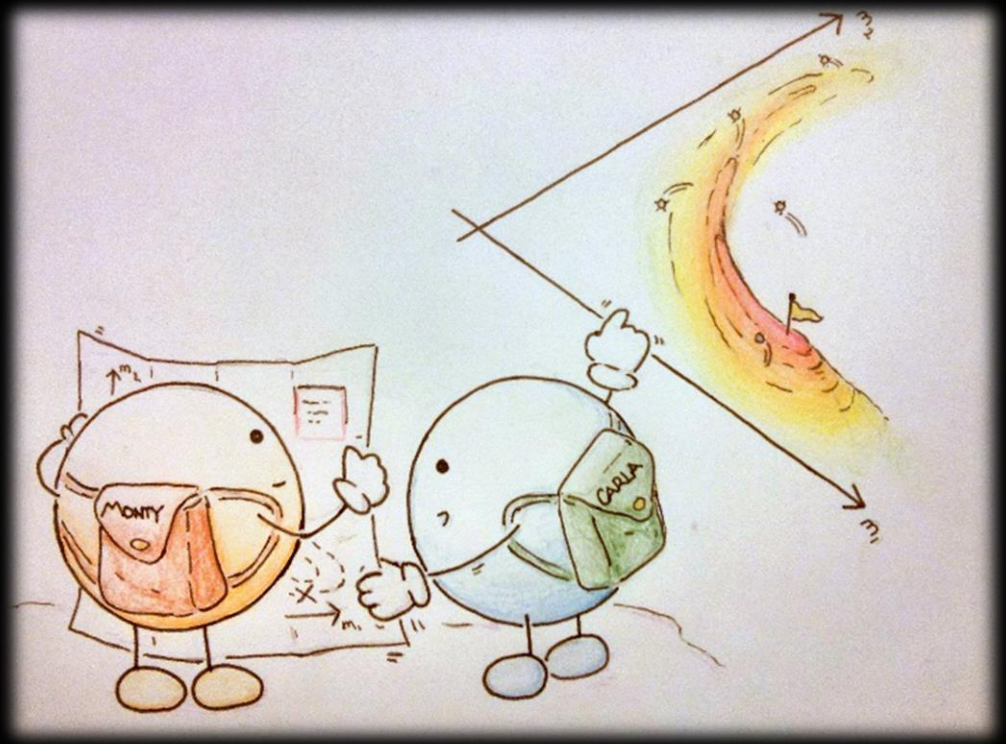


The average specific angular momentum in the iron core correlates with the average specific angular momentum of the CO core.



Summary

- Angular momentum:
  - is important for core collapse dynamics;
  - impacts the evolution;
  - is affected by winds, but the core is relatively insensitive, when considering the effects of magnetic braking.
- Next:
  - further explore the binary star parameter space.



(Image from: cplberry.com)