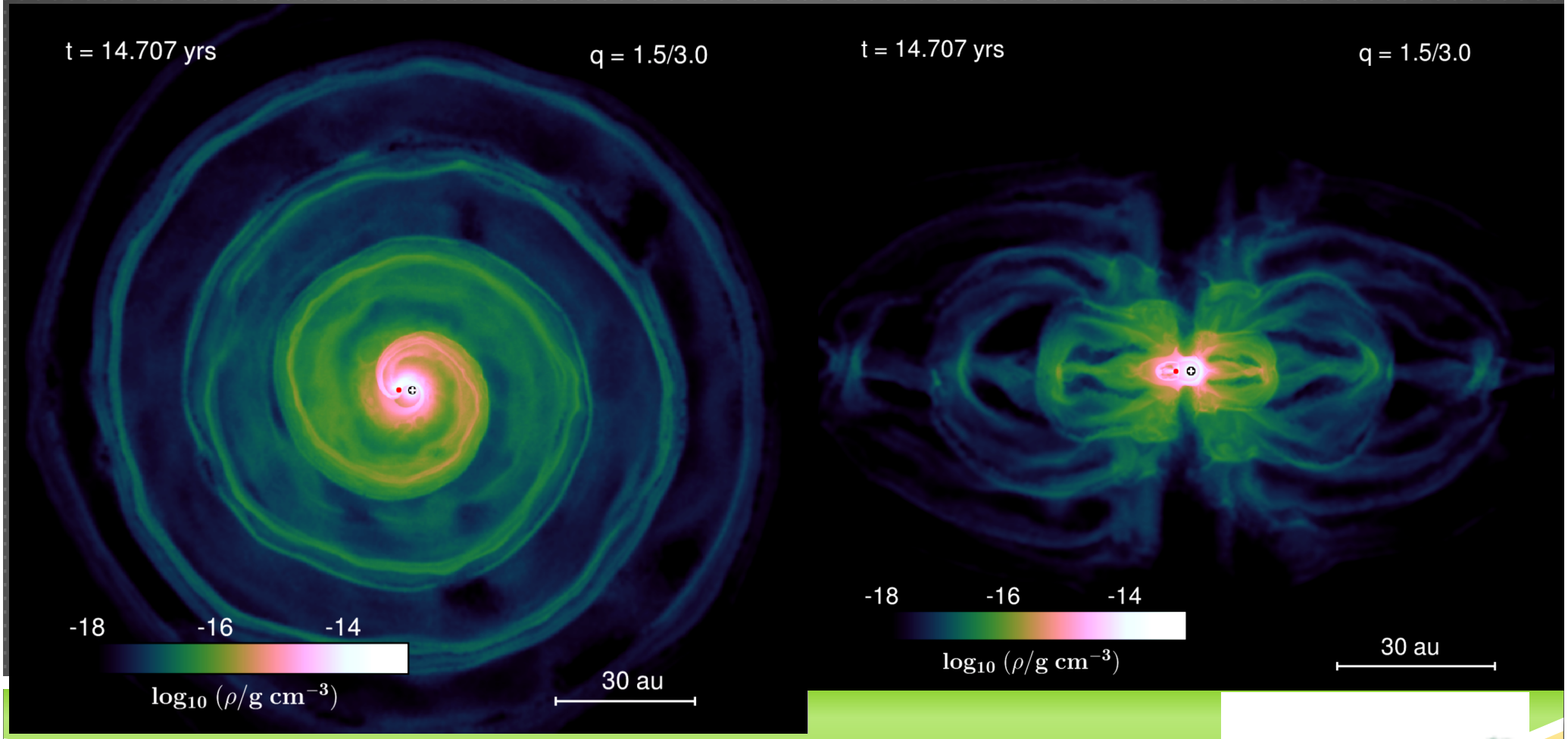
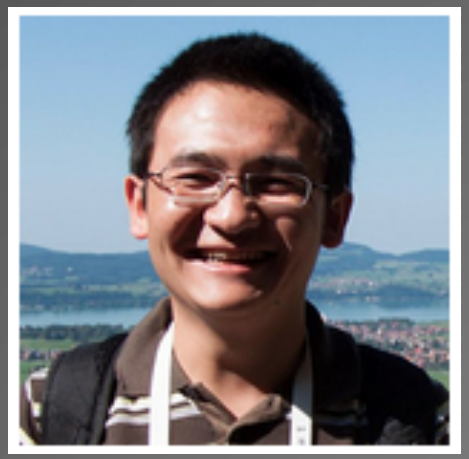
MASS AND ANGULAR MOMENTUM ACCRETION IN CEMP-S STARS



Richard J. Stancliffe

Alexander von Humboldt
Stiftung/Foundation

WITH THANKS TO…

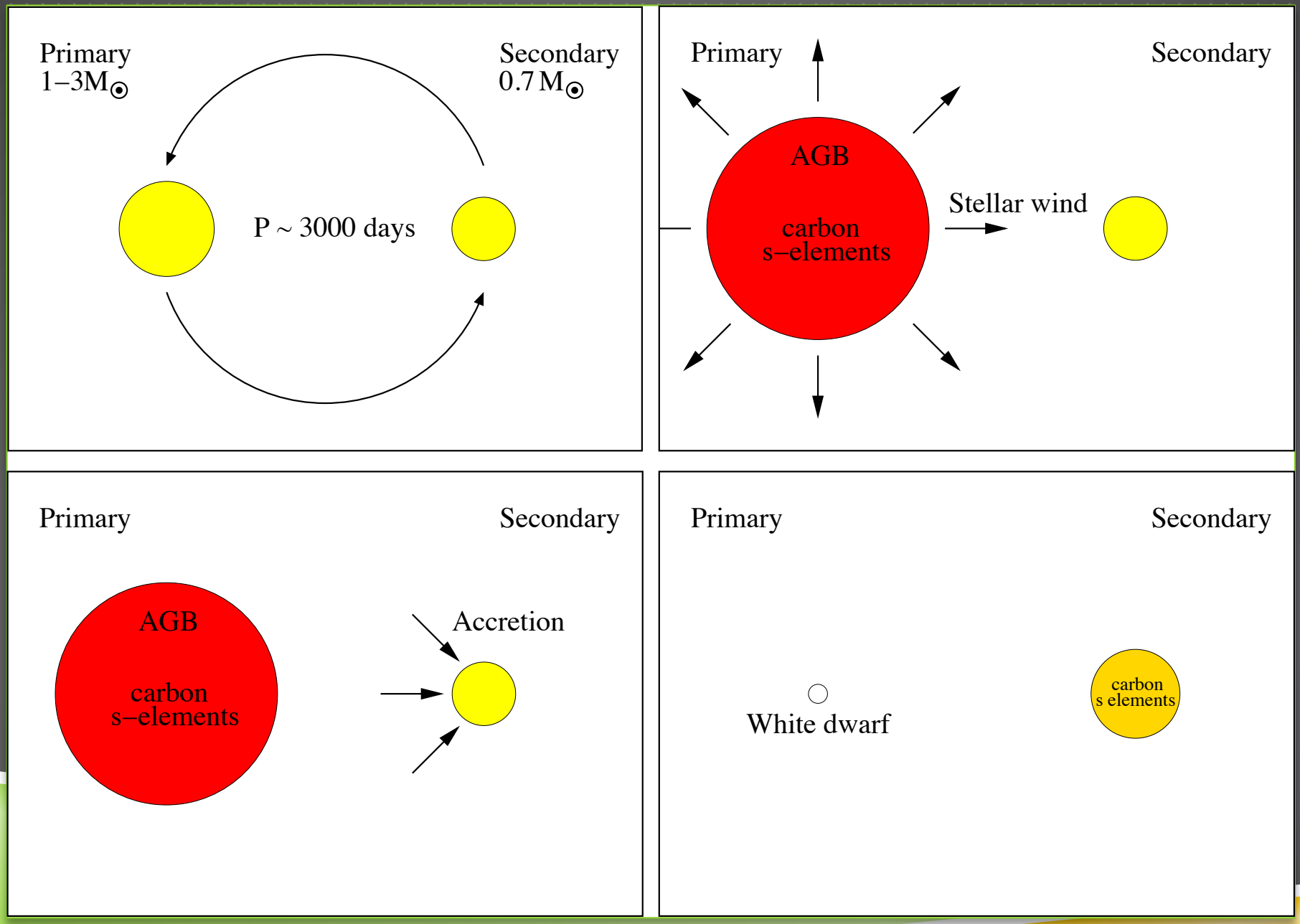


Zhengwei Liu

Elvijs Matrozis

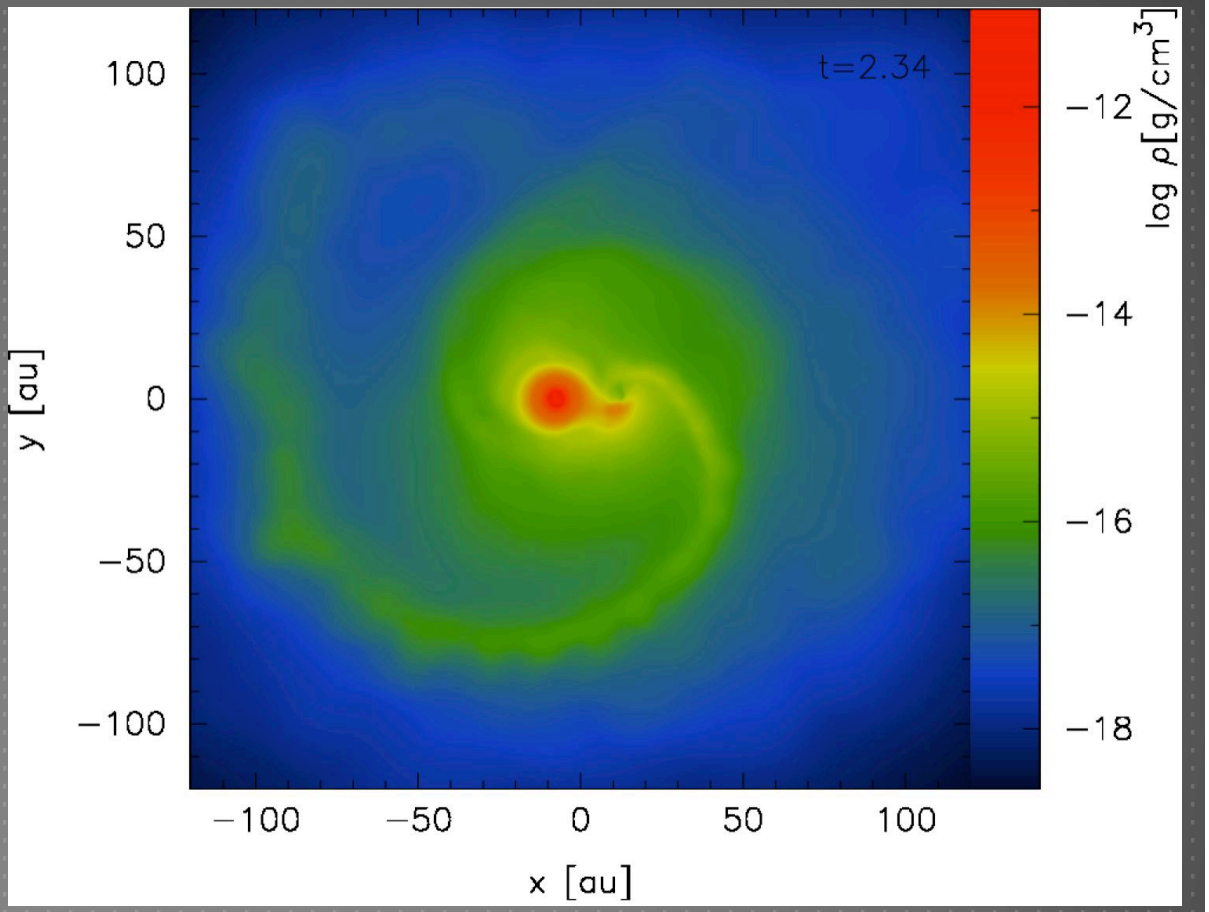
Carlo Abate

FORMATION MECHANISM

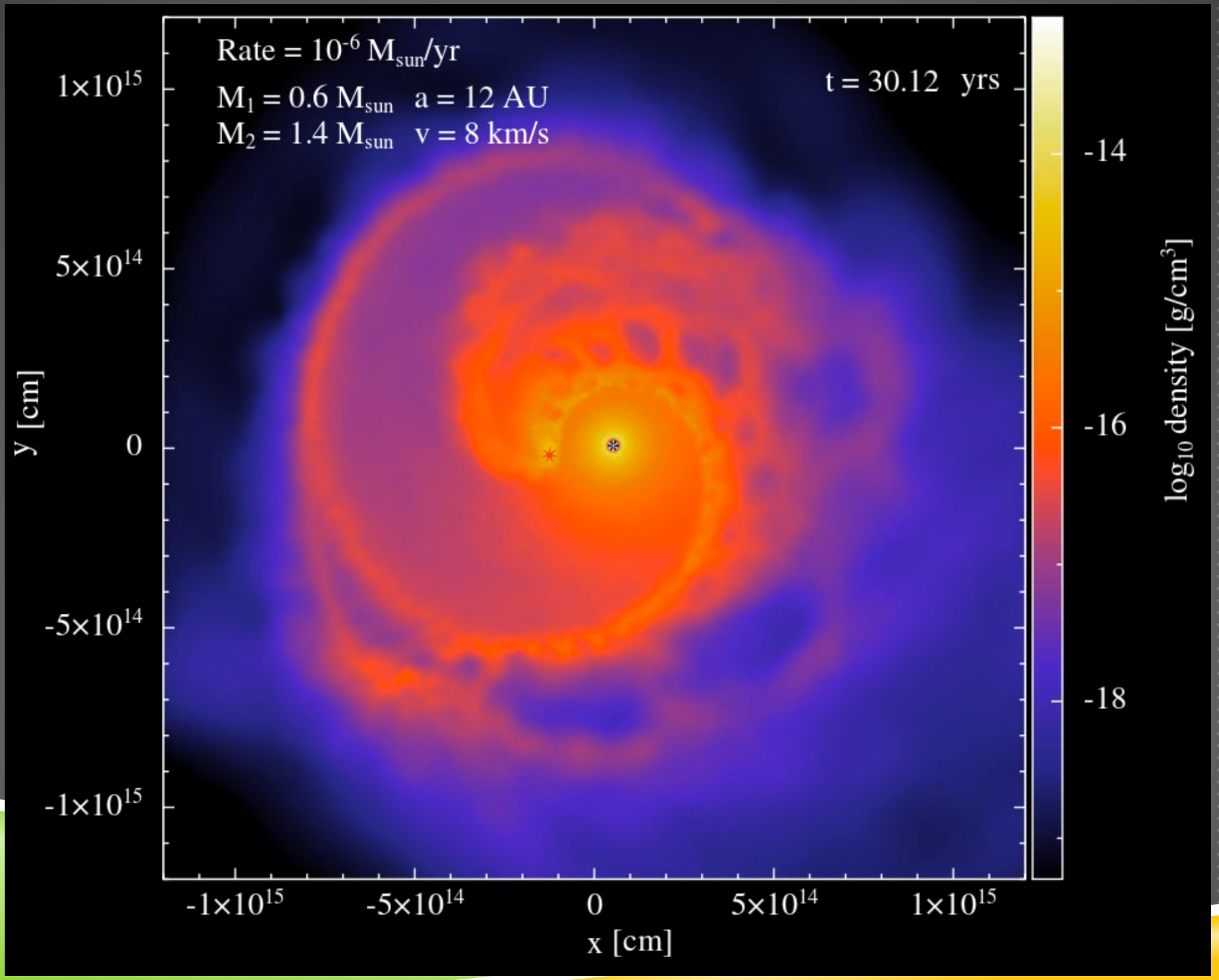


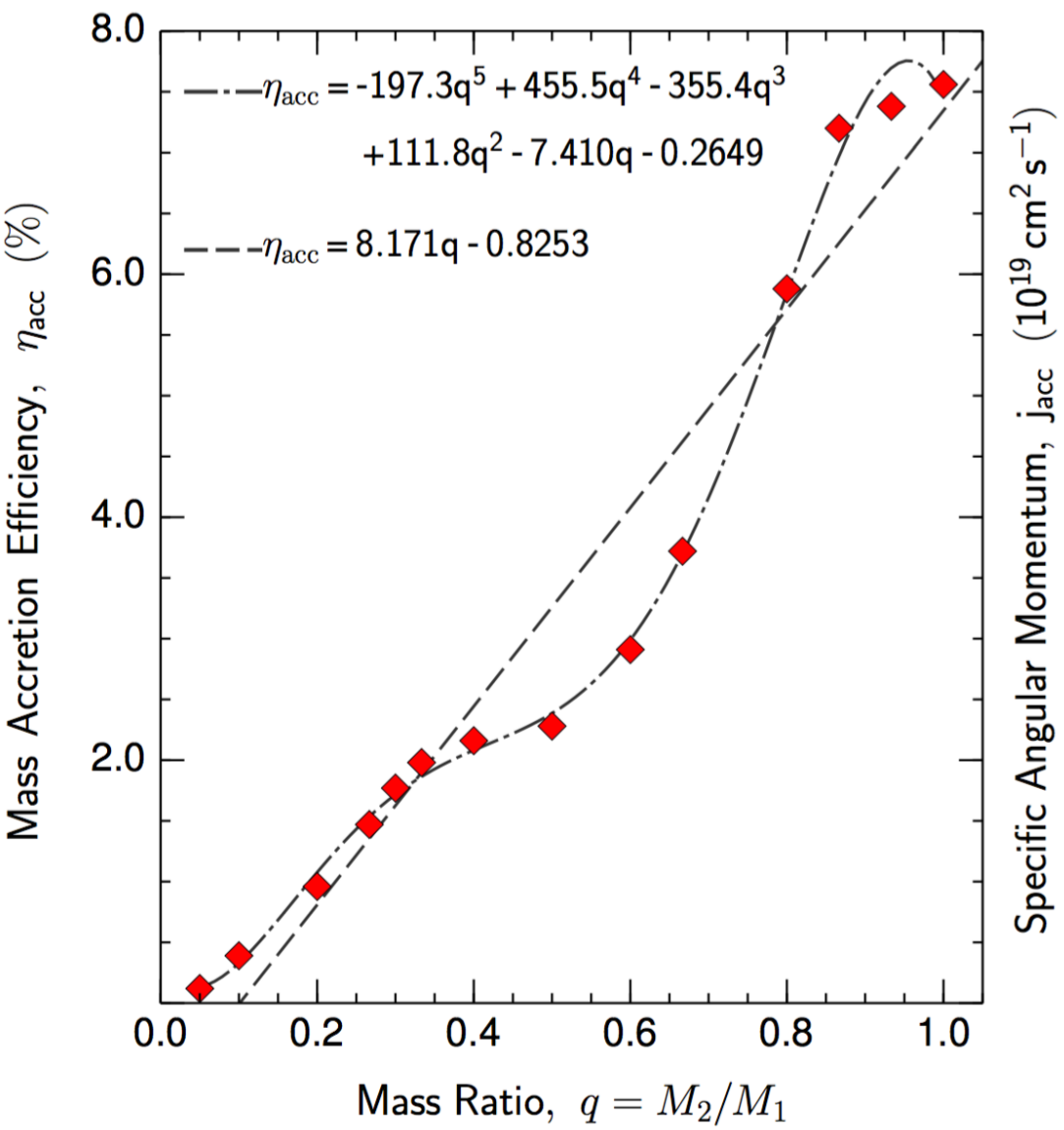
MASS TRANSFER

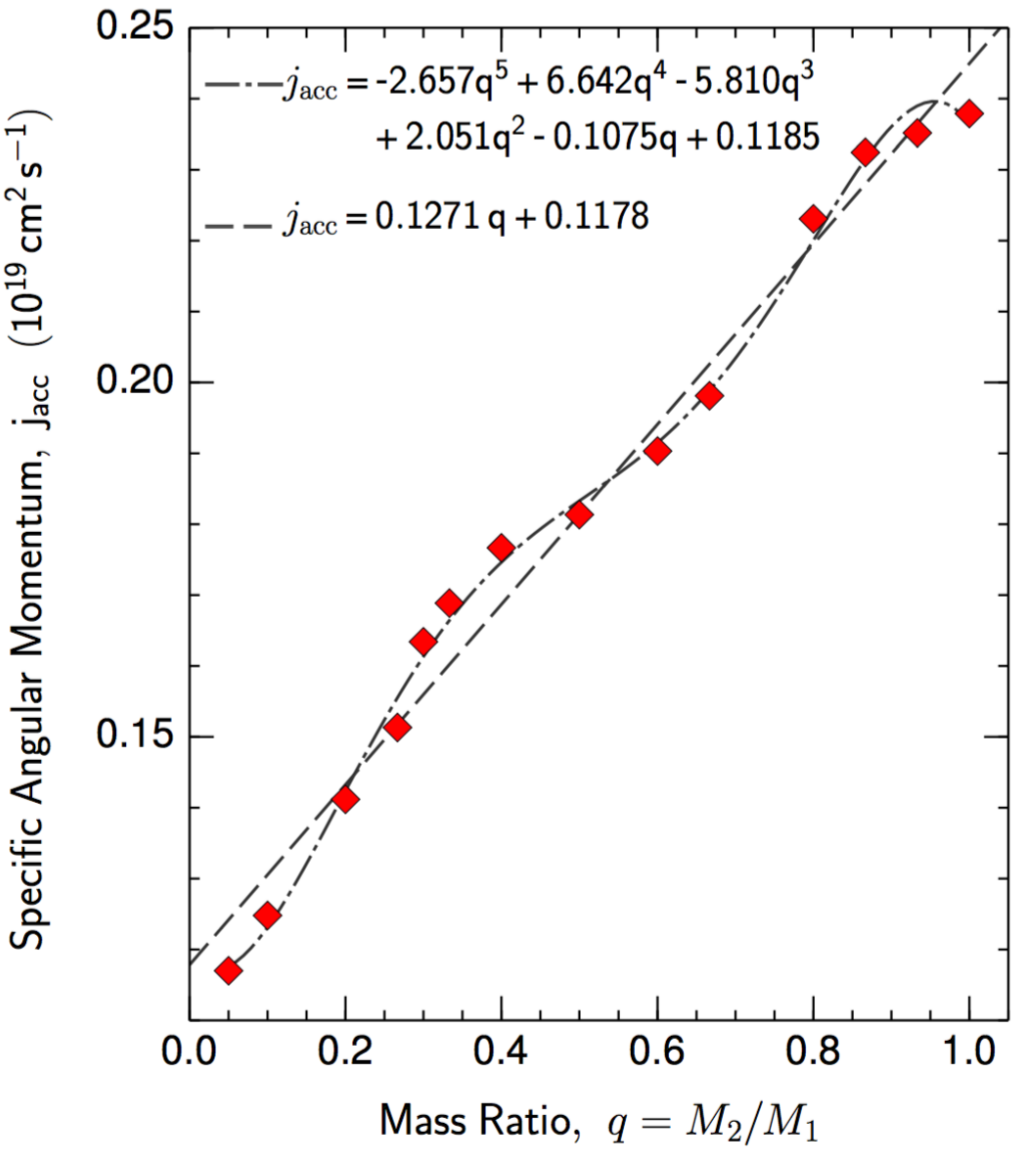
- Typically assume Bondi-Hoyle accretion from wind
- But AGB winds are slow (10 km/s)
- For wide binaries, the orbital speed is similar
- Accretion is not so simple…
- Need hydro to help!



Mohamed & Podsiadlowski (2007)

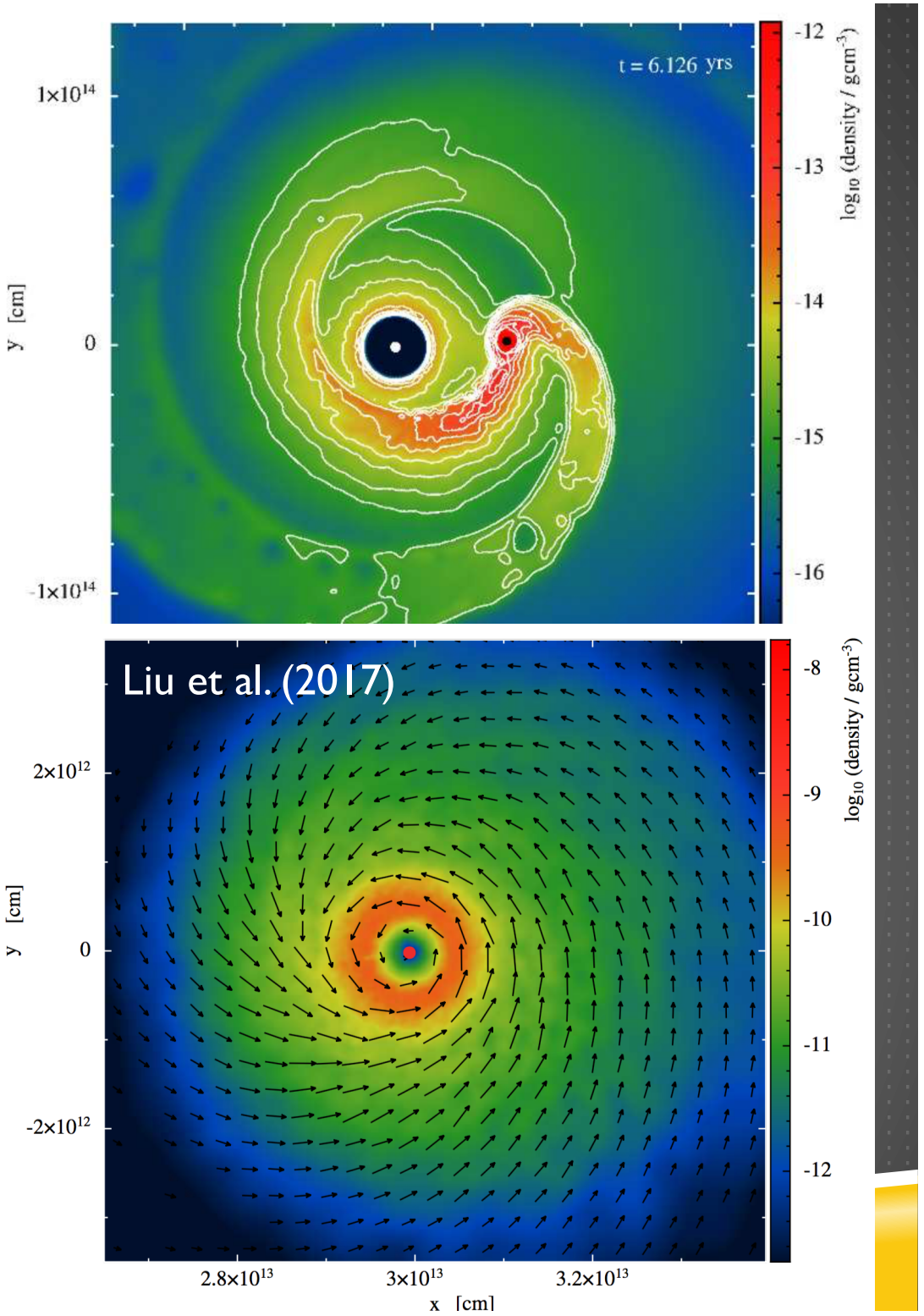

Rate = 10^{-6} M_{sun}/yr
M_1 = 0.6 M_{sun} a = 12 AU
M_2 = 1.4 M_{sun} v = 8 km/s
t = 30.12 yrs
1×10^15
5×10^14
0
-5×10^14
-1×10^15
y [cm]
-1×10^15
-5×10^14
0
5×10^14
1×10^15
x [cm]
-14
-16
-18
log10 density [g/cm^3]


η_{acc} = -197.3q^5 + 455.5q^4 - 355.4q^3
+111.8q^2 - 7.410q - 0.2649
η_{acc} = 8.171q - 0.8253
Mass Accretion Efficiency, η_{acc} (%)
Mass Ratio, $q = M_2/M_1$

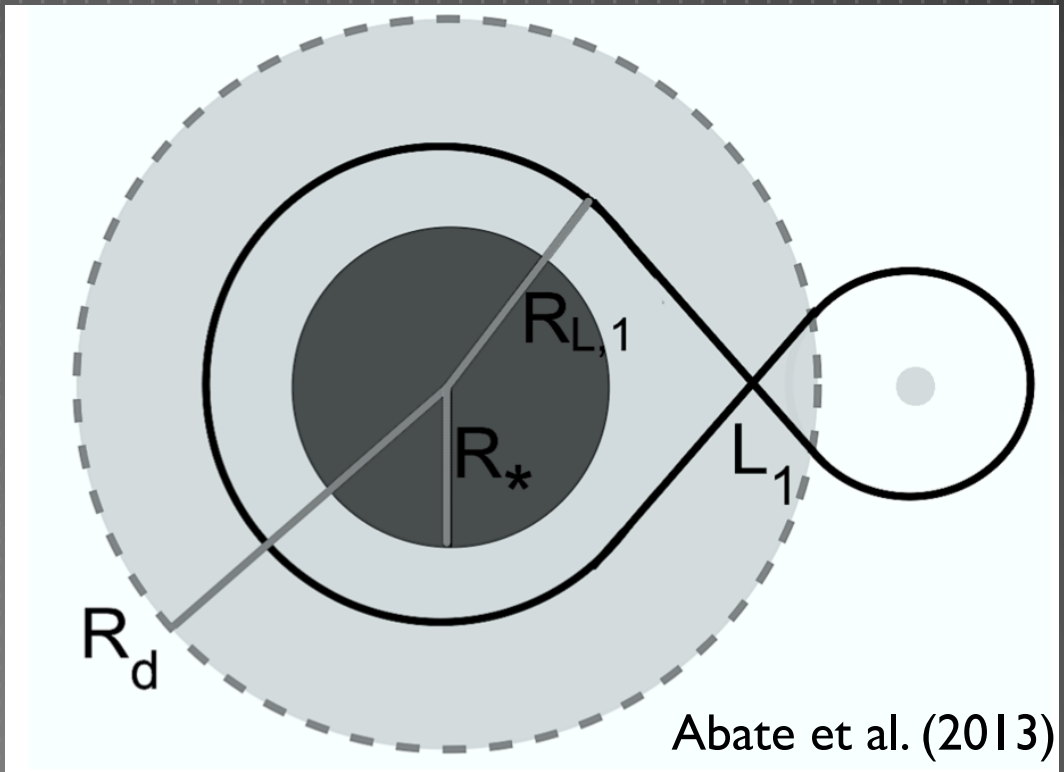

j_{acc} = -2.657q^5 + 6.642q^4 - 5.810q^3
+ 2.051q^2 - 0.1075q + 0.1185
j_{acc} = 0.1271 q + 0.1178
Specific Angular Momentum, j_{acc} (10^{19} cm^2 s^{-1})
Mass Ratio, $q = M_2/M_1$

CAVEATS

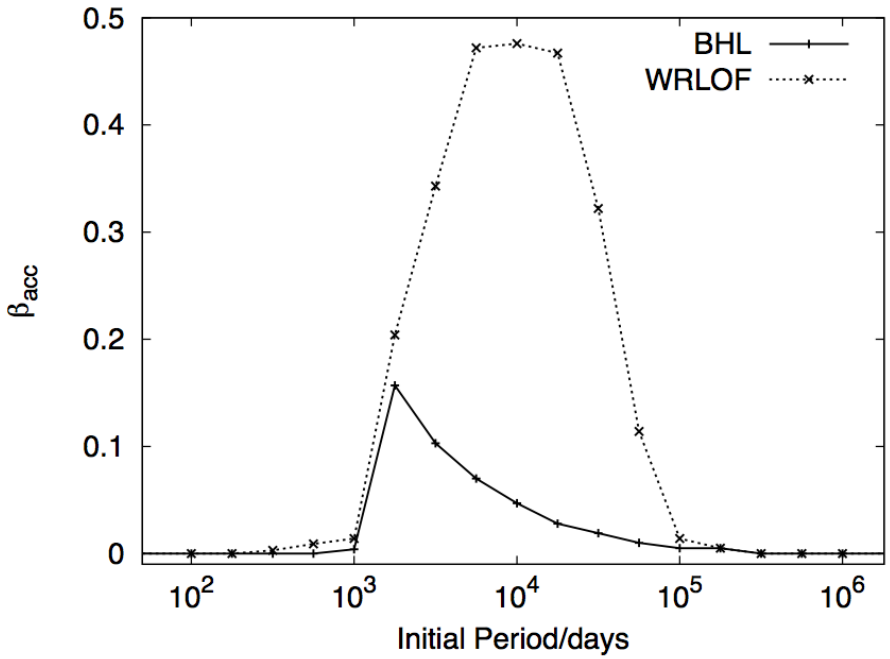
- Simulations are still pretty basic
- Isothermal gas leads to accretion disc
  - Consistent with others (Chen et al. 2017, Saladino et al., in prep)
- More sophisticated treatment of winds needed



- Dust acceleration radius, R_d is key
- If this lies outside the Roche Lobe efficient mass transfer can occur
- Wind Roche Lobe Overflow
- Could be about 5 times as efficient as Bondi Hoyle wind accretion
- Needs to be followed up with detailed sweep of binary configurations

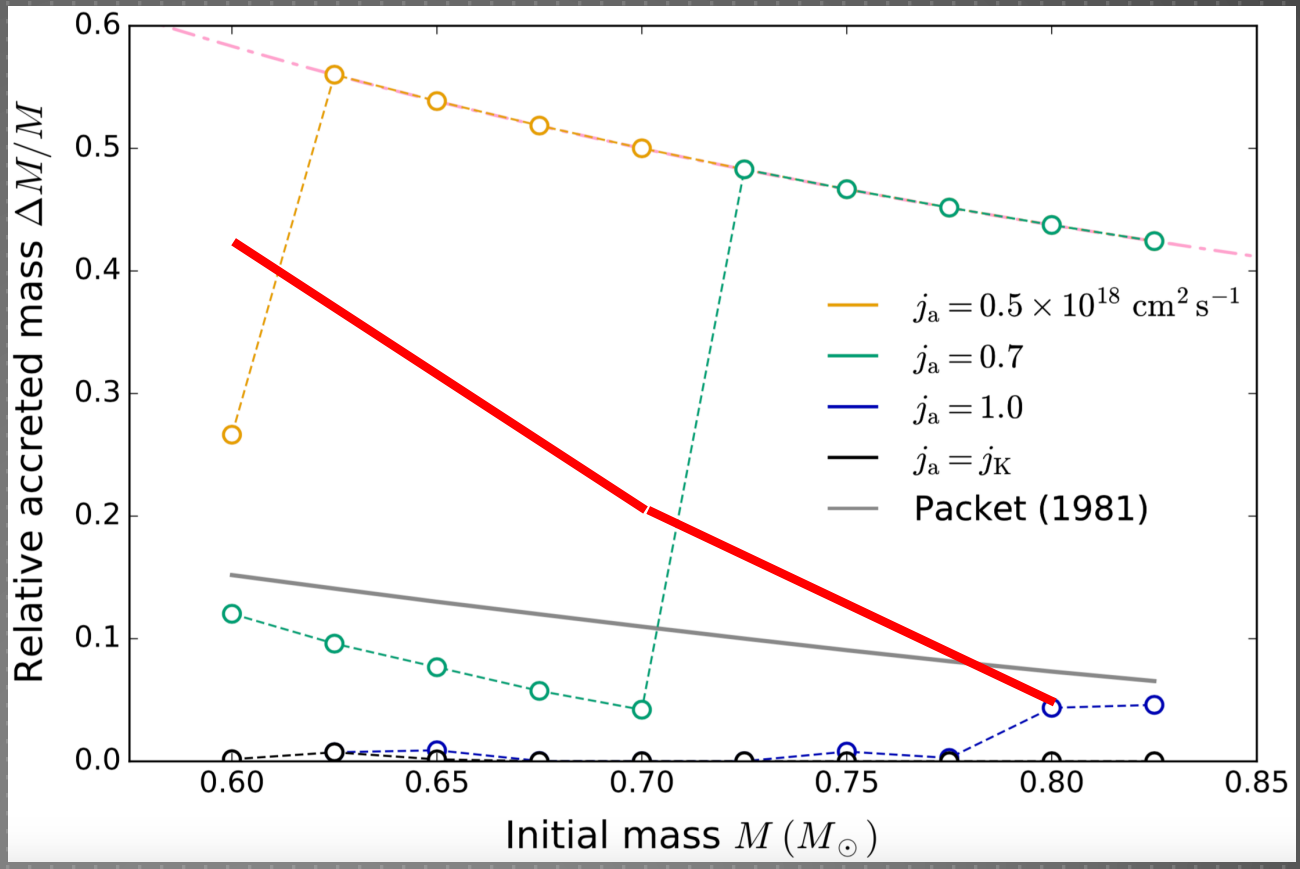


Abate et al. (2013)



ANGULAR MOMENTUM LIMITS ACCRETION

- How much mass can be accreted before critical rotation is reached?
- We want to make secondaries around 0.85Msun
- Too much AM is a problem!



Matrozis, Abate & Stancliffe (2017)

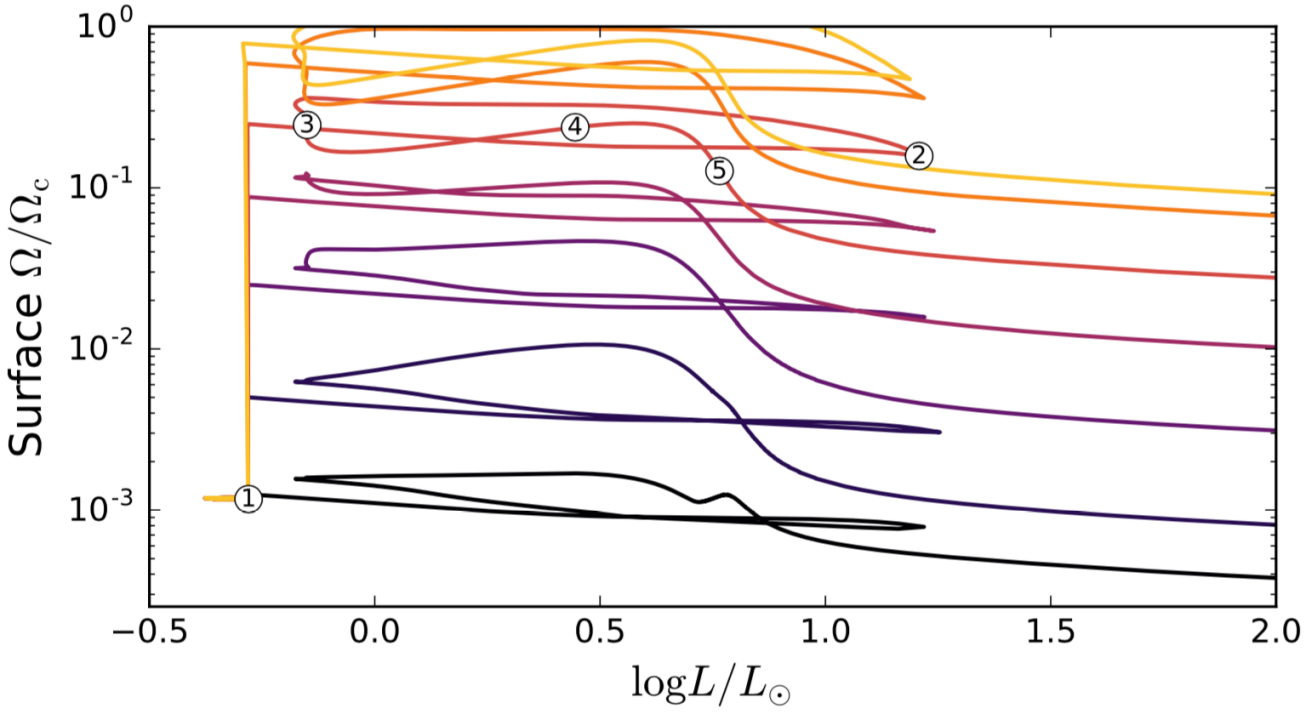
0.75 Msun + 0.05 Msun

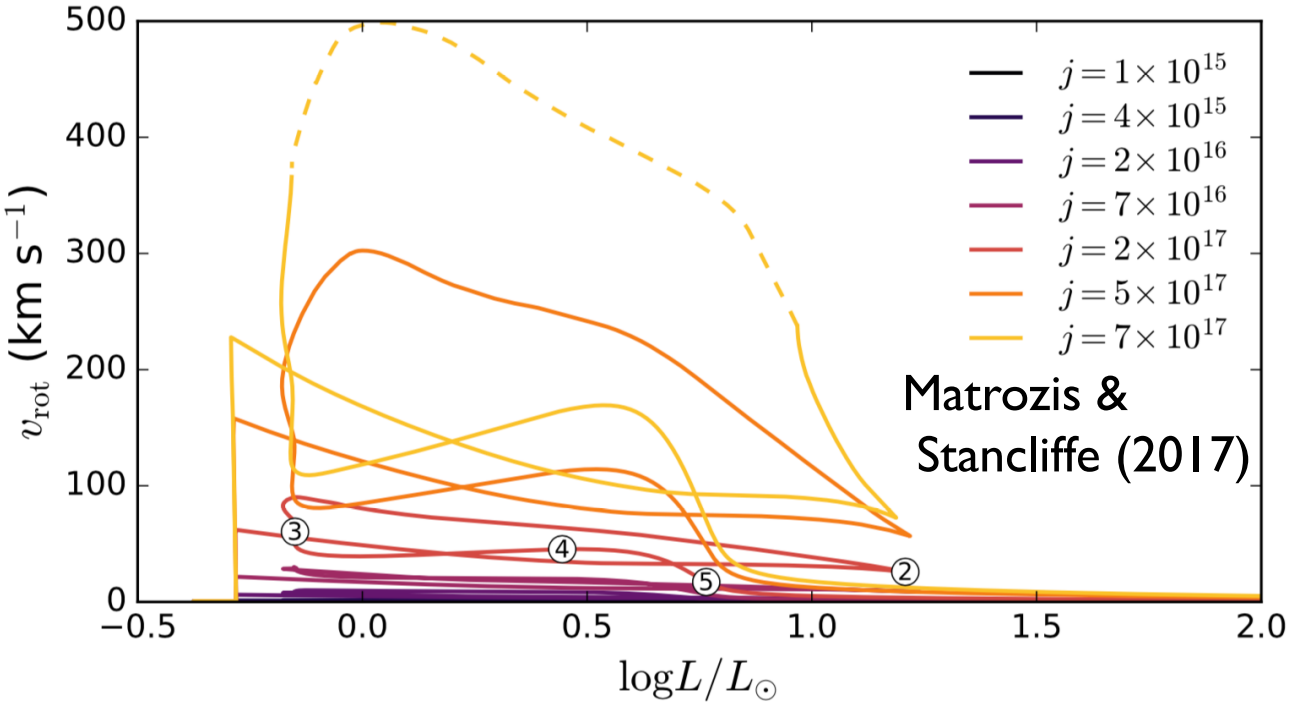
Initially spin up outer layers

Too much AM and we hit critical rotation during accretion

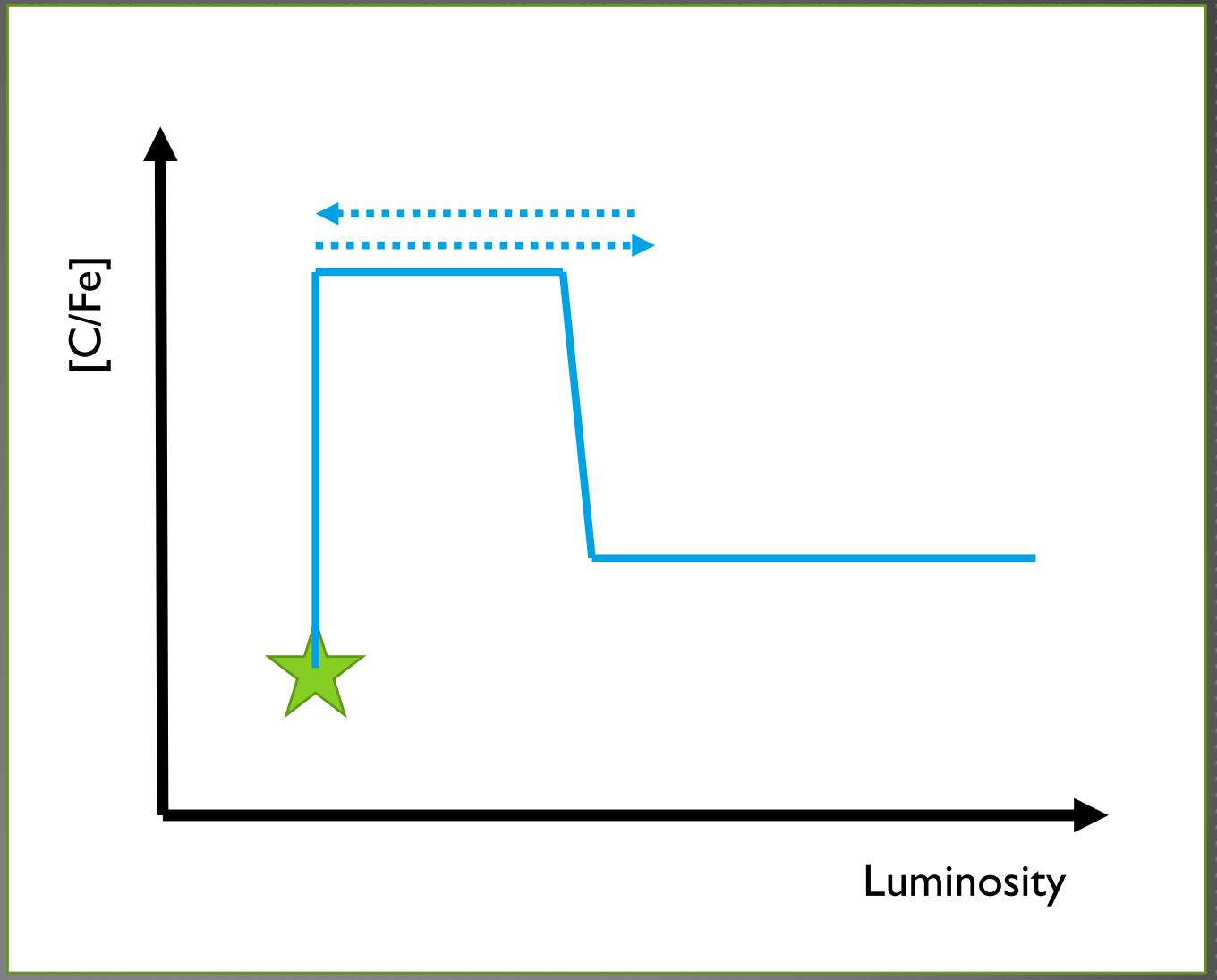
Transport some AM into the interior

CEMP-s rotate at 5-10 km/s

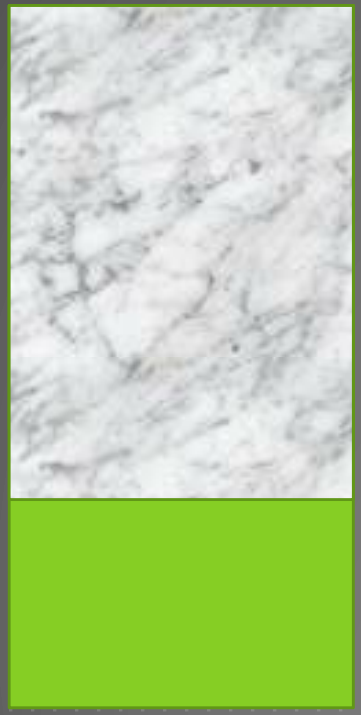




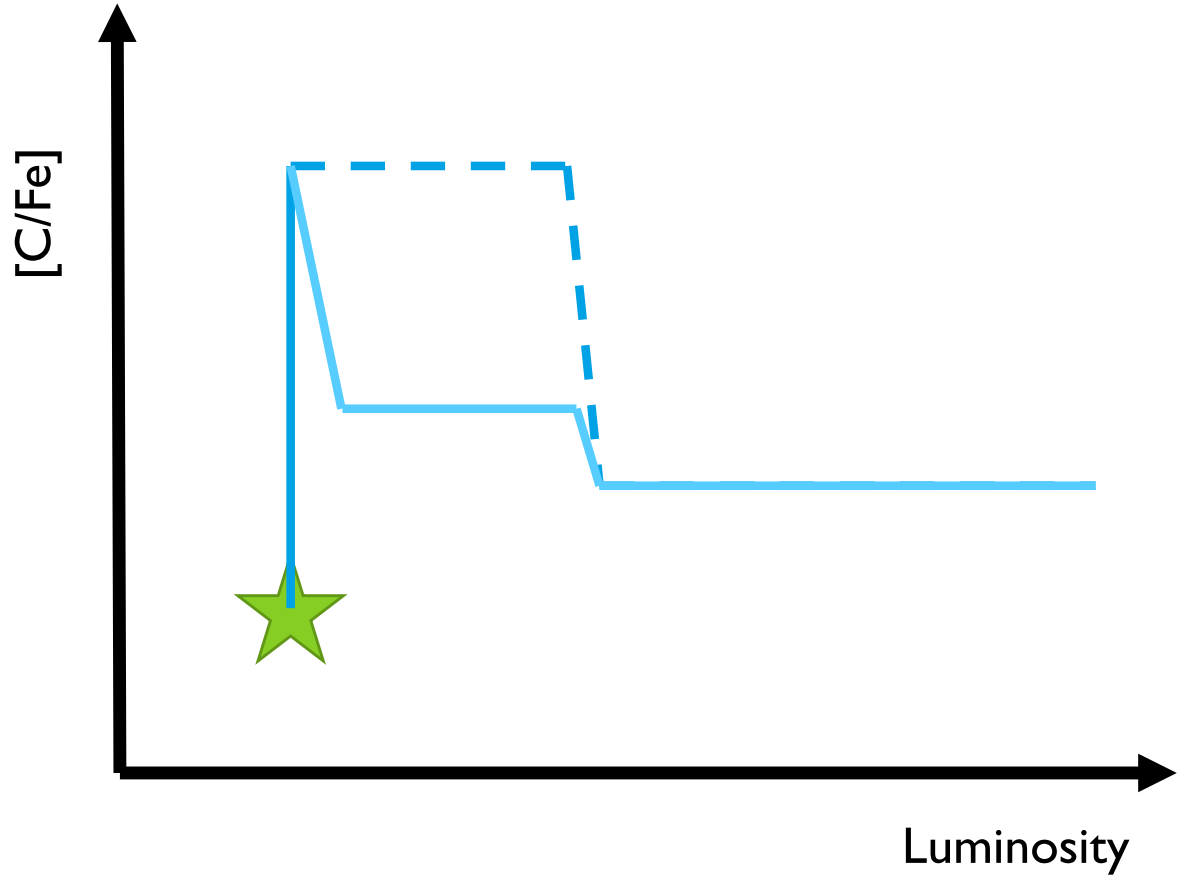
FATE OF ACCRETED MATERIAL



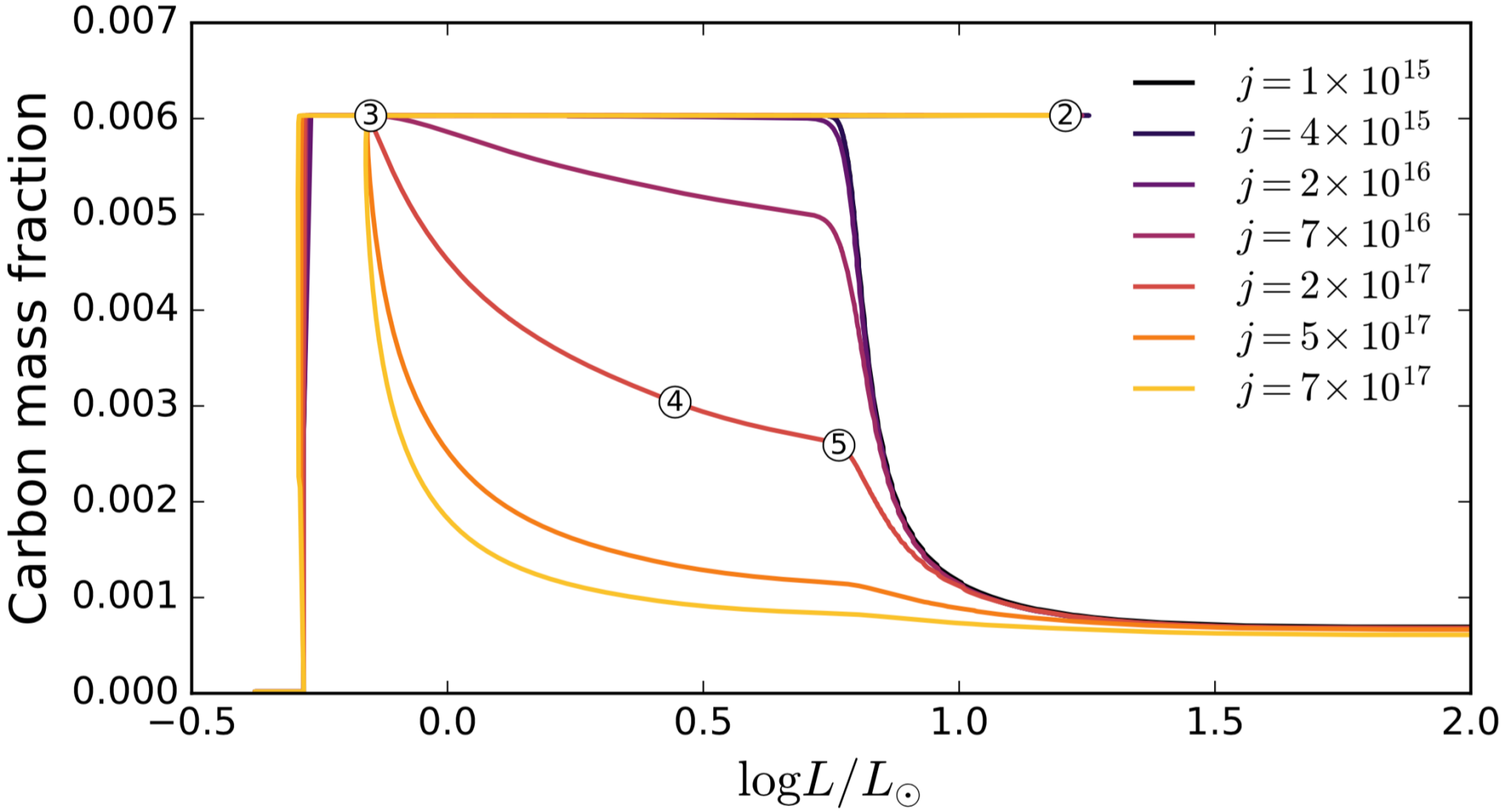
FATE OF ACCRETED MATERIAL II



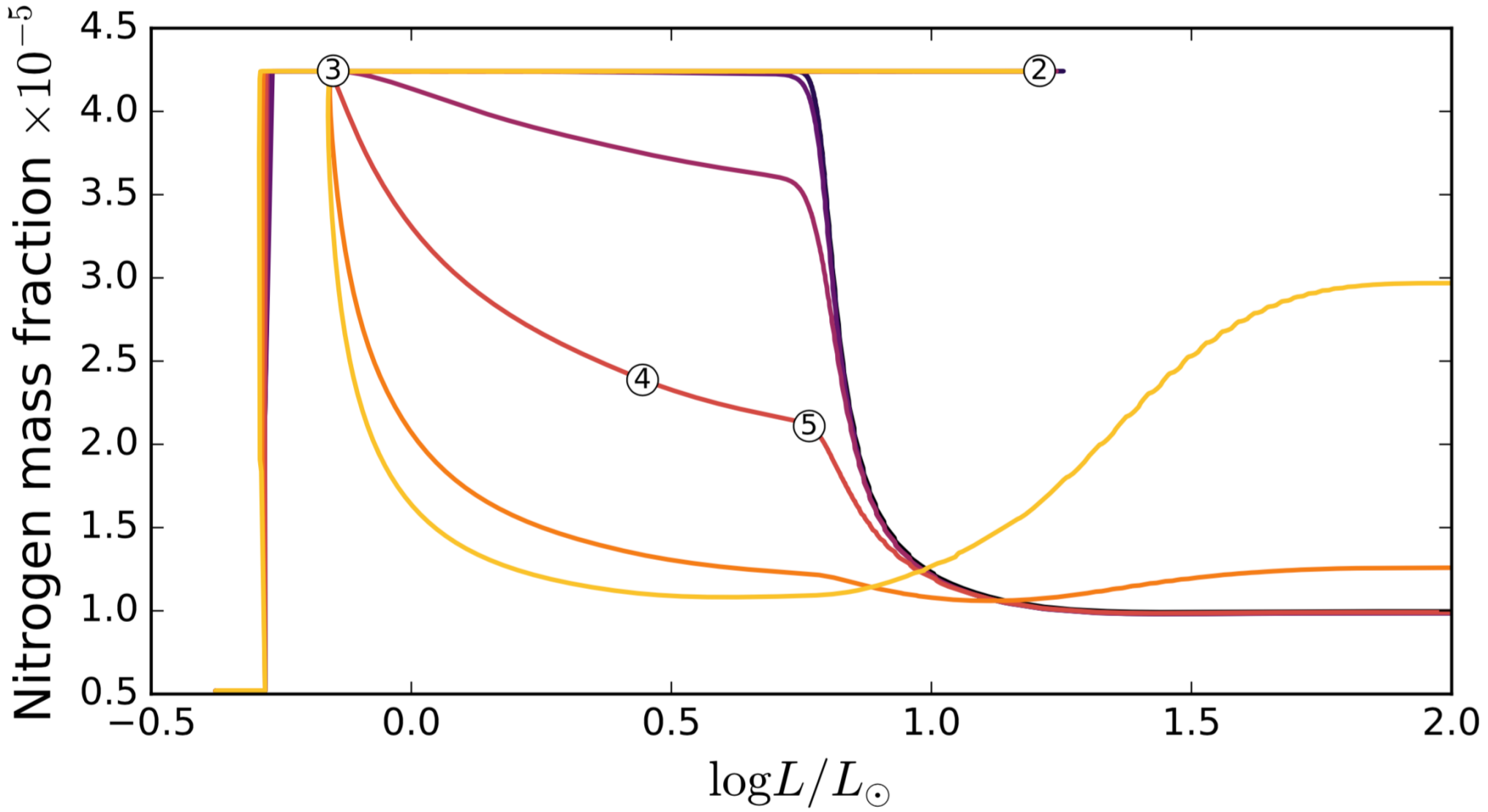
Thermohaline mixing (see Stancliffe et al. 2007)



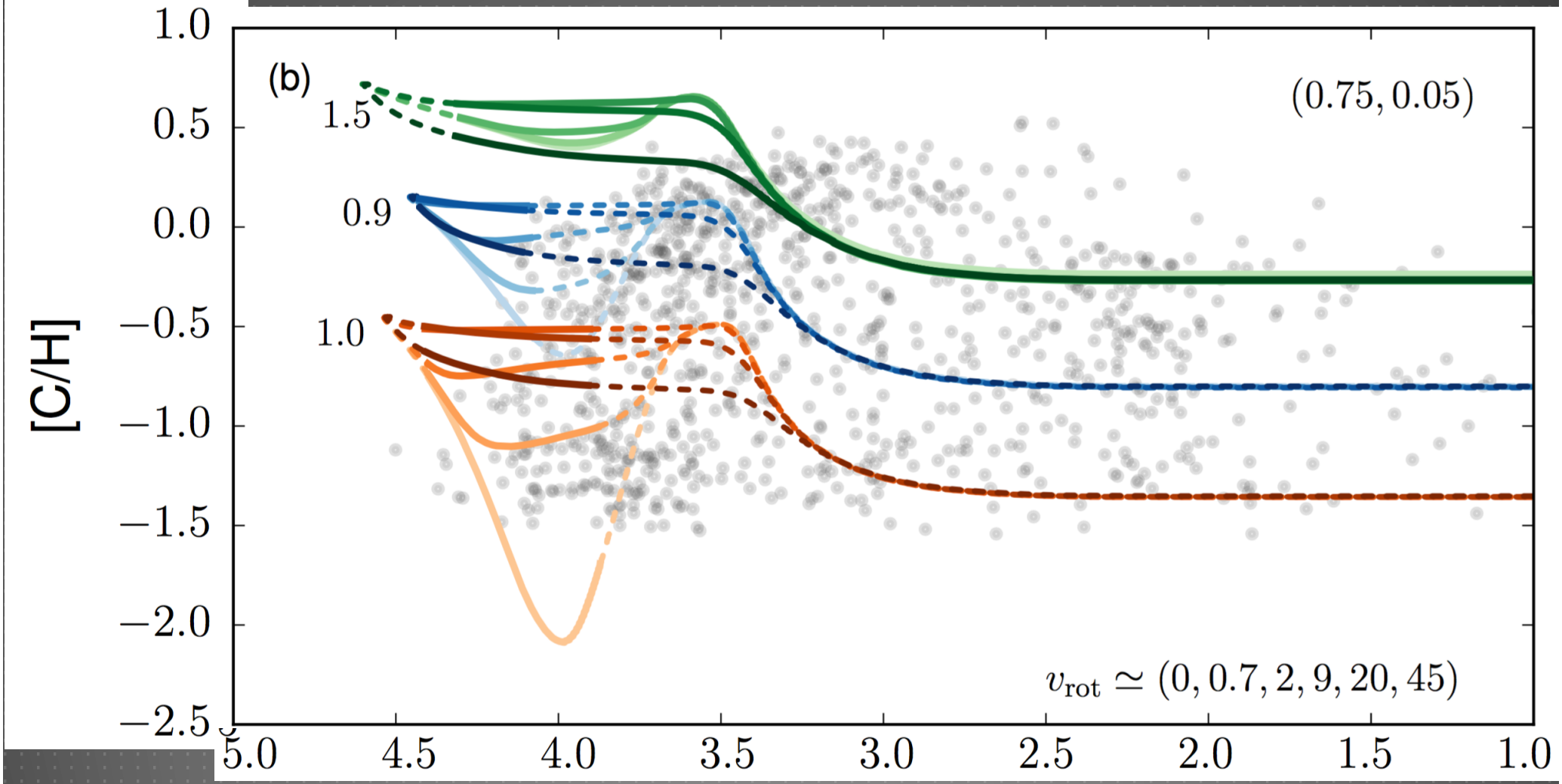
Matrozis & Stancliffe (2017)



Matrozis & Stancliffe (2017)



Matrozis & Stancliffe (2017)



Rotation + settling

SDSS data from Lee et al. (2013)

CONCLUSIONS

- Mass transfer via stellar winds is complicated
- Hydro simulations are extremely useful!
  - Still lots need to be done
- Too much angular momentum reaches the secondary!
  - Can't accrete enough mass before critical rotation
- Rotation may affect surface abundances
  - Inhibits settling, may cause mixing