

# Barium Stars Revisited



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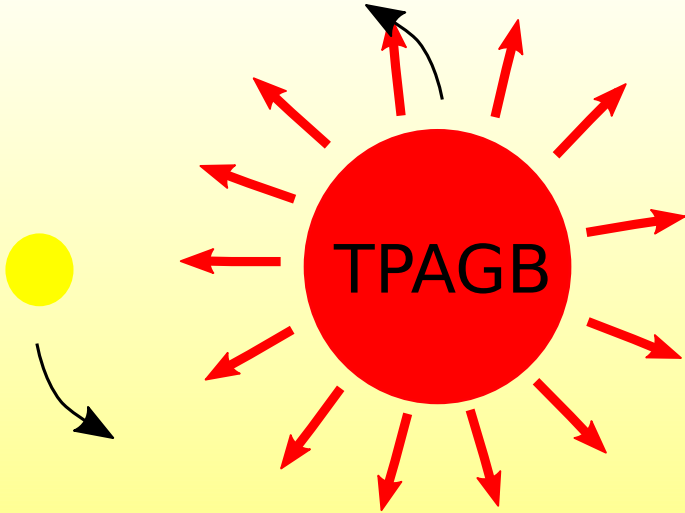
Lund Observatory



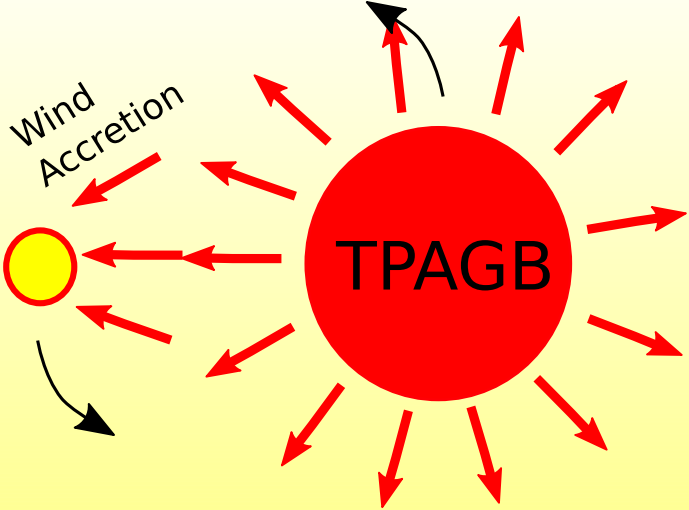
What is a barium star?



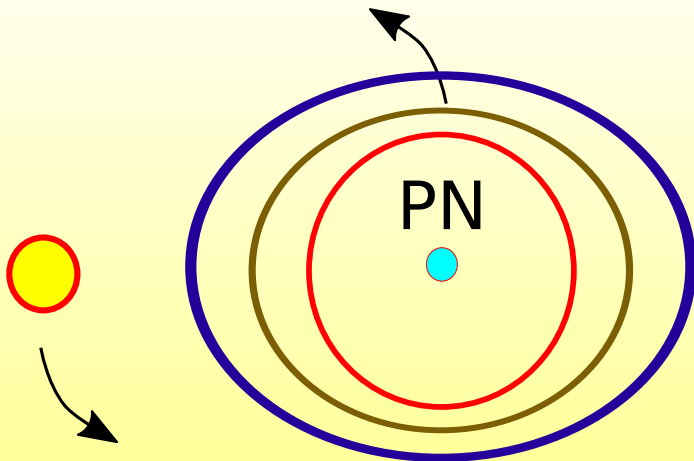
How to make a Ba star? A long time ago...



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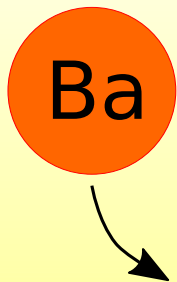


How to make a Ba star? A long time ago...

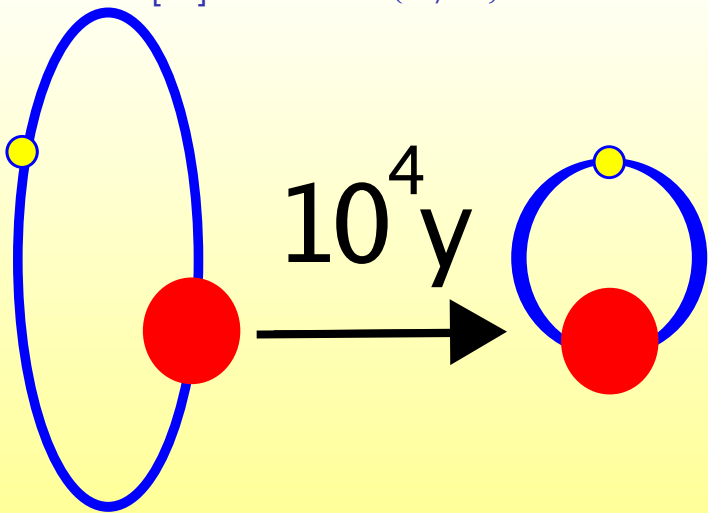


White  
Dwarf

The barium star now

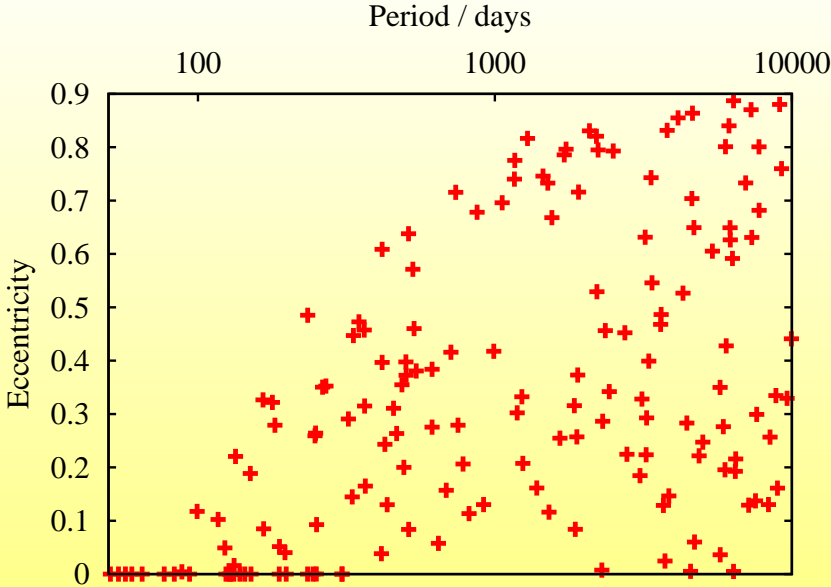


Tidal Circularization  $\tau \sim (a/R)^8$

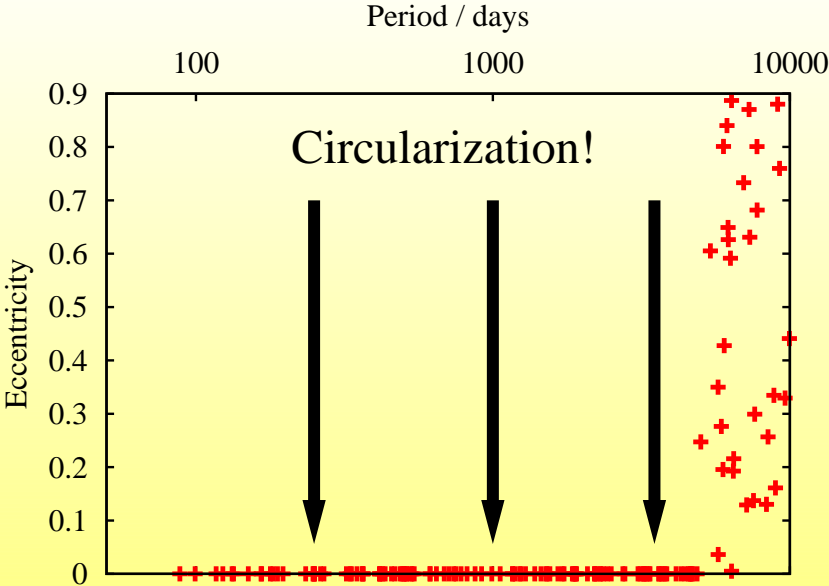




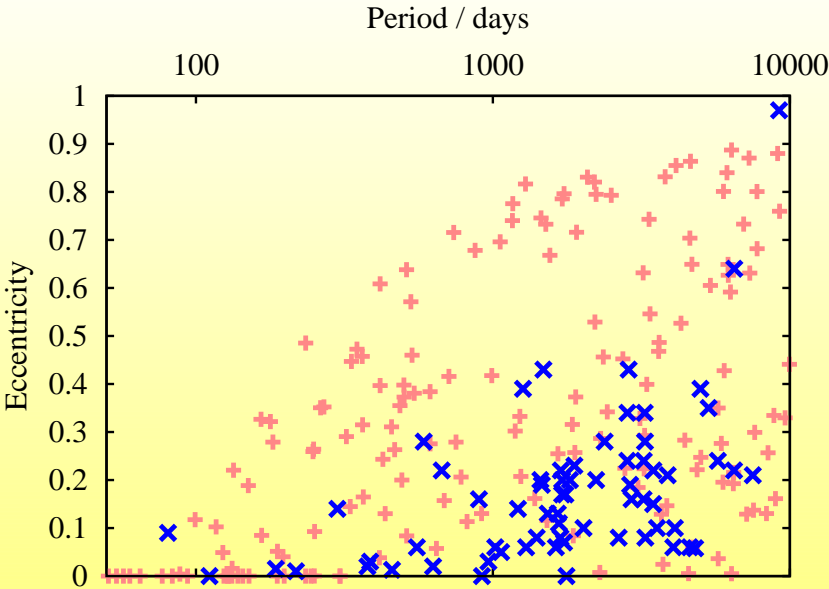
# Observations: GK giants (Jorissen data)



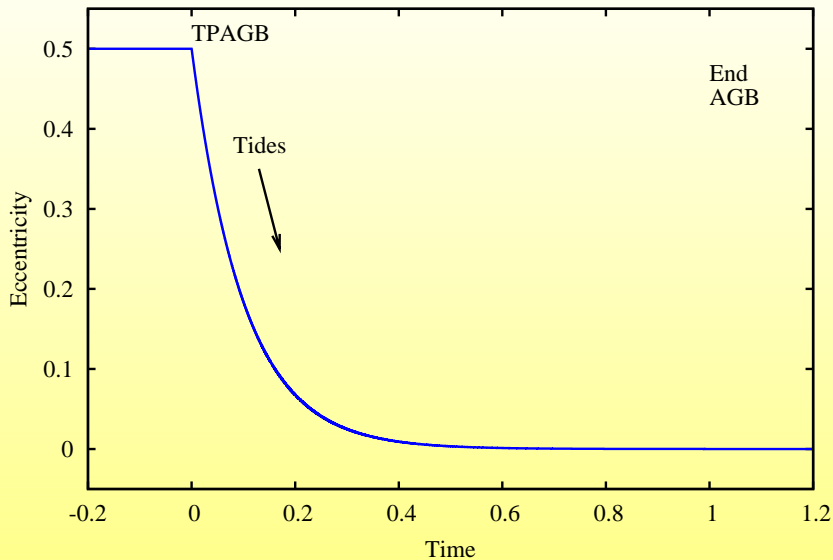
# Expected result for Ba stars



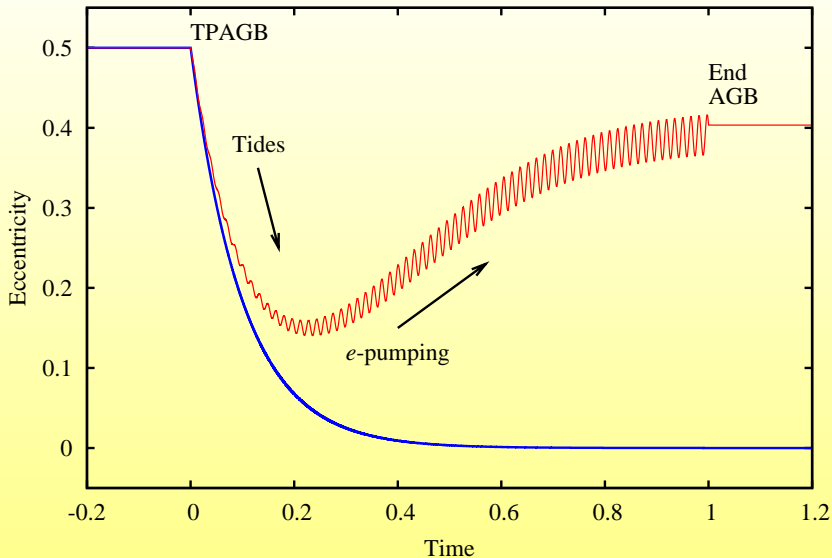
But it doesn't/mayn't happen!



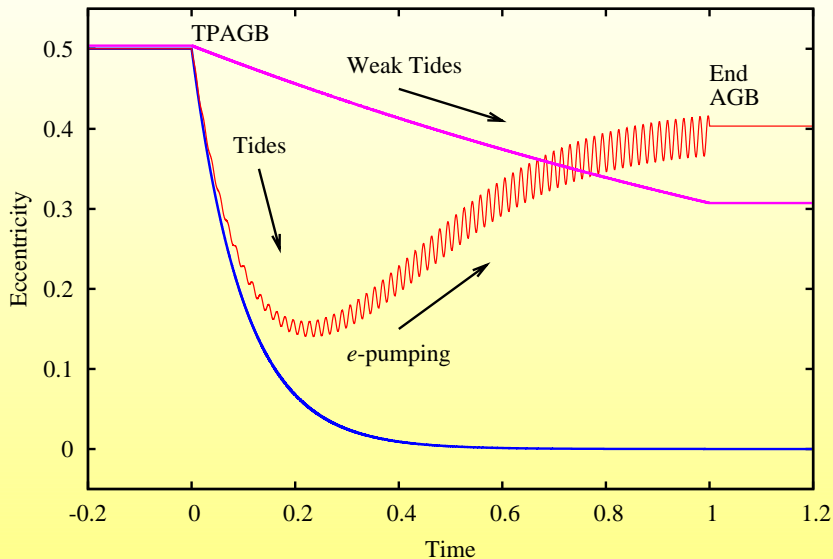
# What is happening?



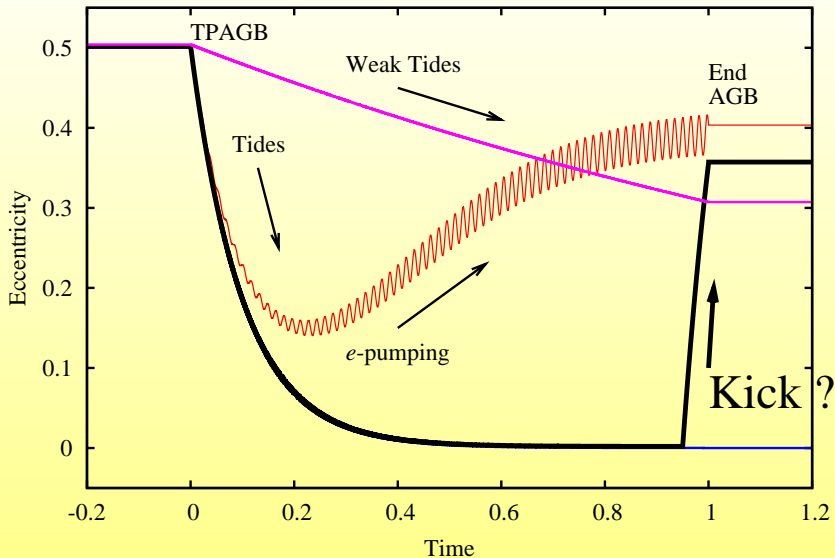
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## Curry Kick Scale

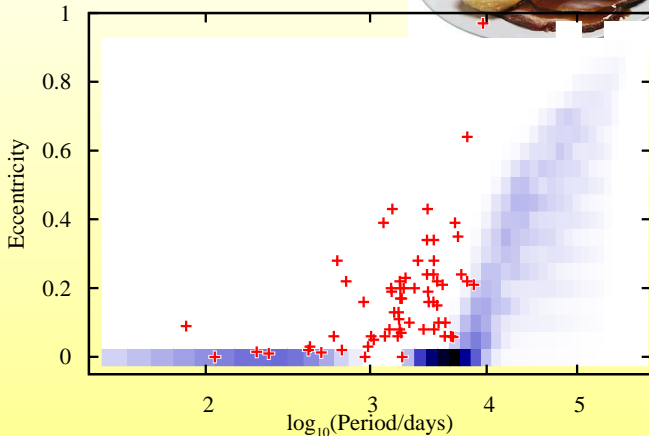
**What is the effect on the Barium Stars?**

Curry	Kick Velocity/ $\text{km s}^{-1}$
English	0
Korma	1
Dopiaza	2
Dhansak	3
Madras	4
Vindaloo	7
Phall	100

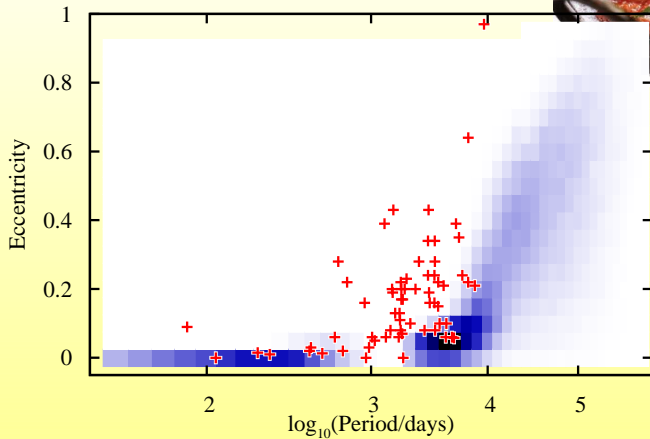


# Canonical result (no kick)

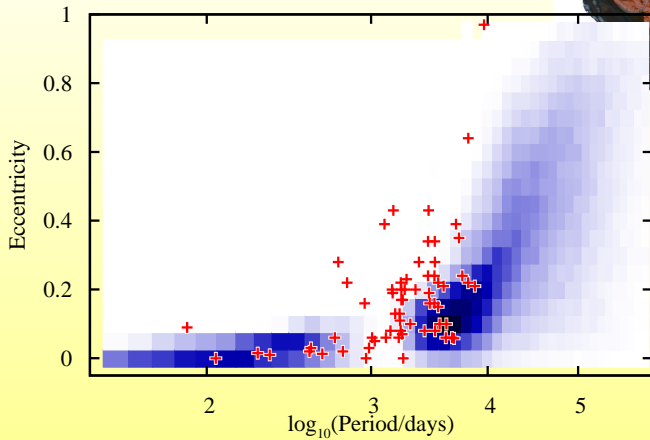
Observations: Jorissen et al (1998)



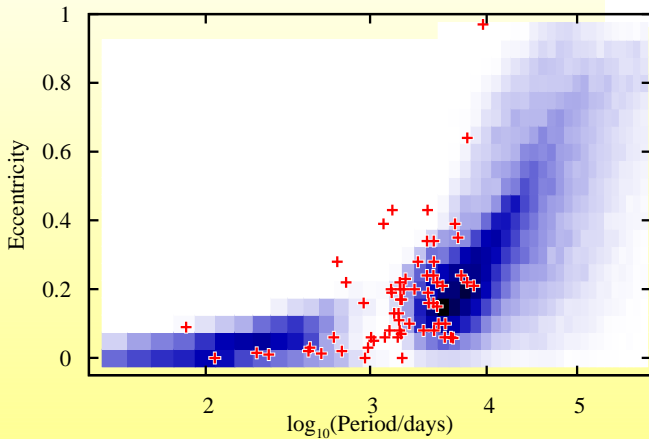
Korma kick  $1 \text{ km s}^{-1}$



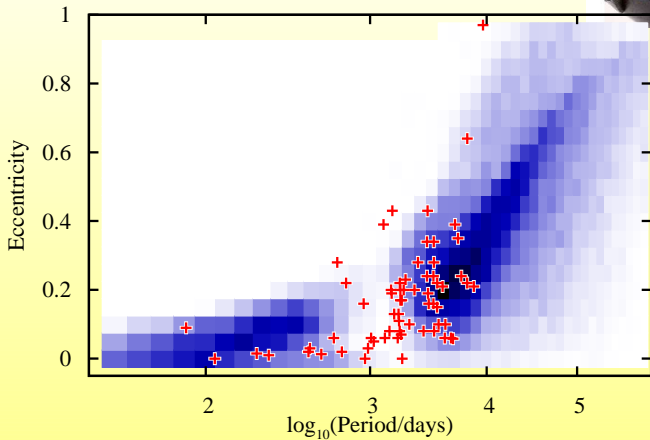
Dopiza kick  $2 \text{ km s}^{-1}$



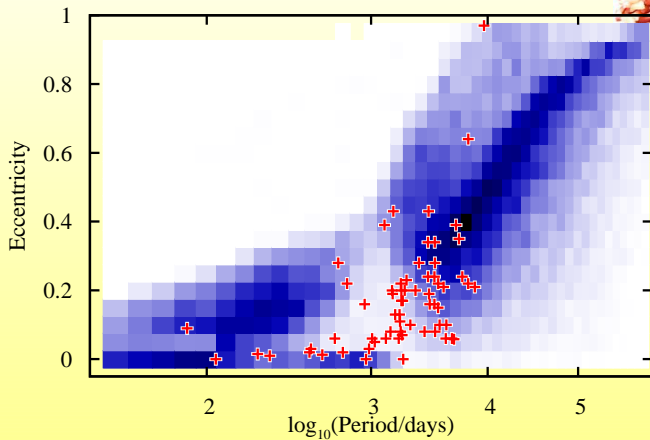
Dhansak kick  $3 \text{ km s}^{-1}$



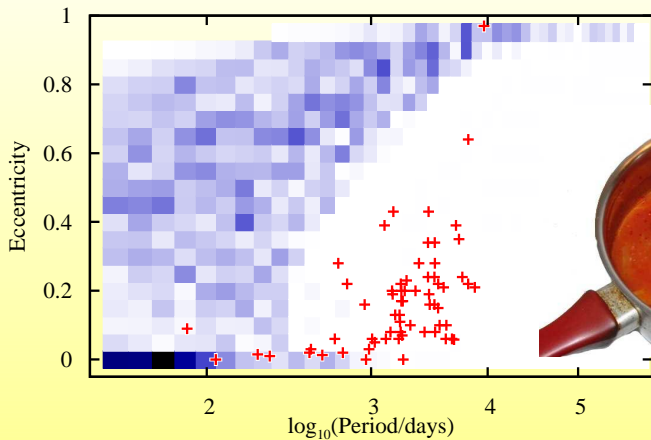
Madras kick  $4 \text{ km s}^{-1}$



Vindaloo kick  $7 \text{ km s}^{-1}$

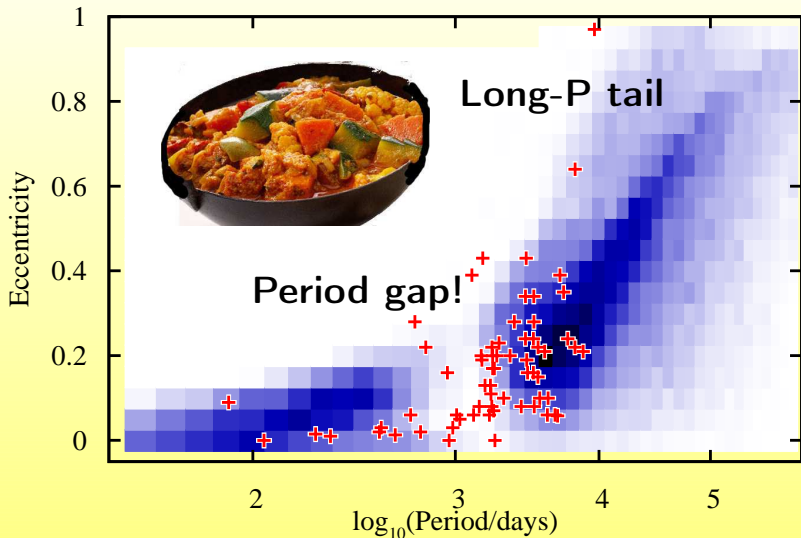


Phall!  $100 \text{ km s}^{-1}$



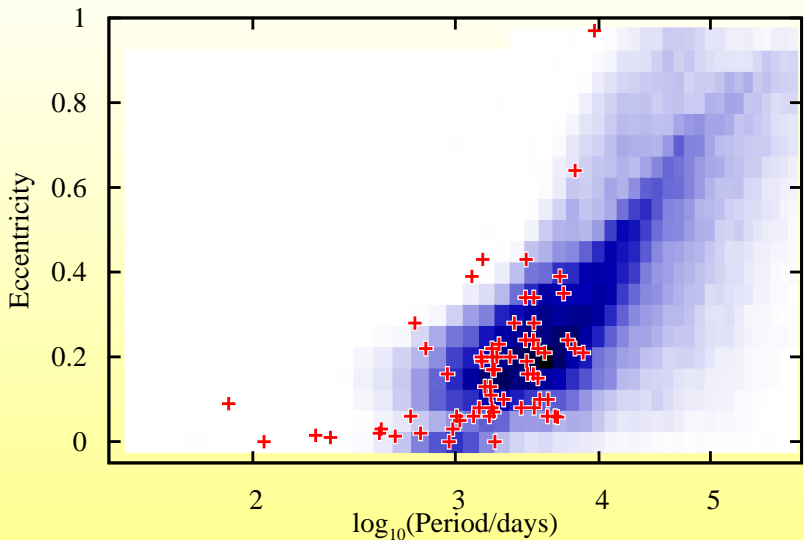
Madras please! ( $4 \text{ km s}^{-1}$ )

Still Problems!

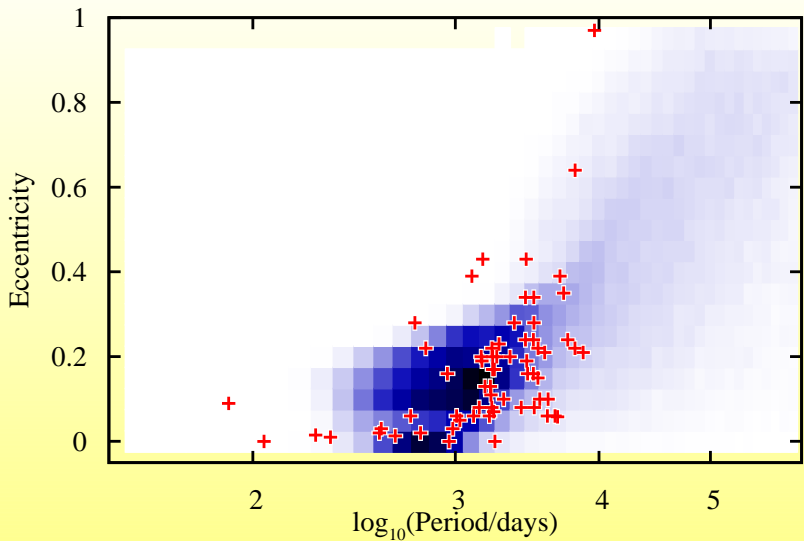




# 4km/s kick+efficient CE ejection (dodgy curry!)



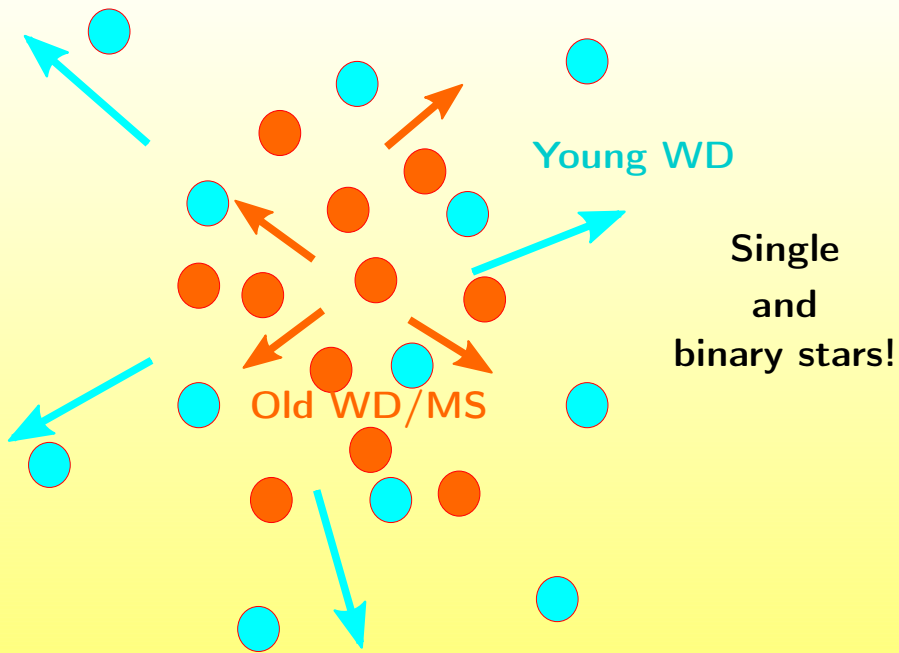
4km/s kick + efficient CEE and  $\dot{J}_{\text{orb}}$



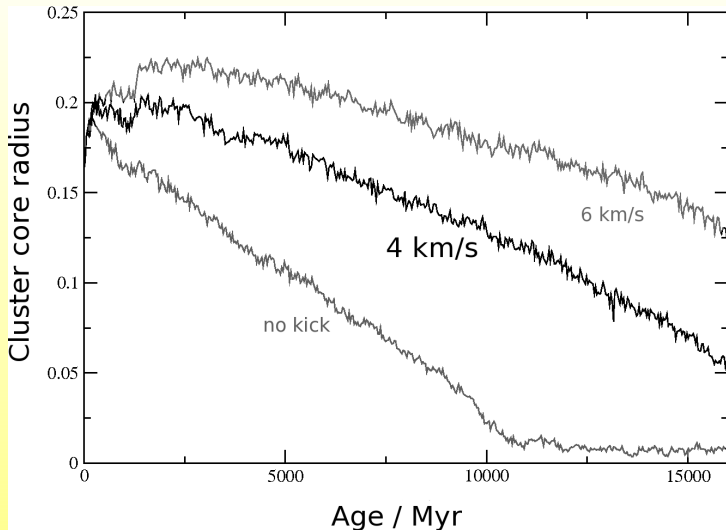
# Do Kicks Really Happen?

1. Globular cluster evidence
2. Do we expect to see a kick in PNe?
3. YOU ARE THE EXPERTS!

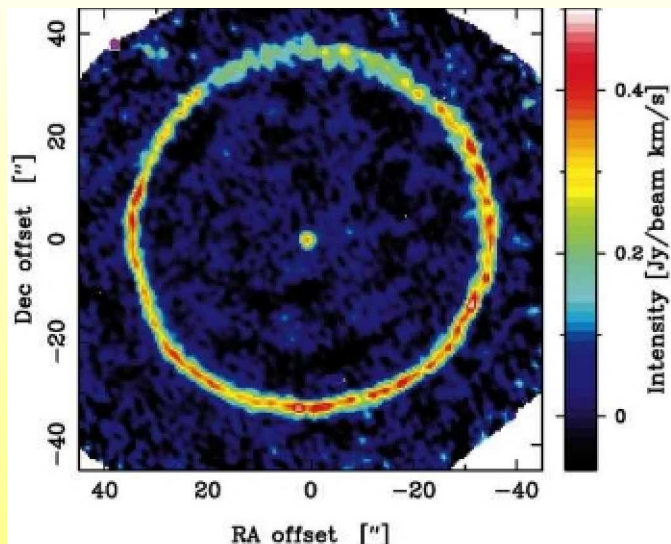
# Independent evidence from GCs (Davis et al.)



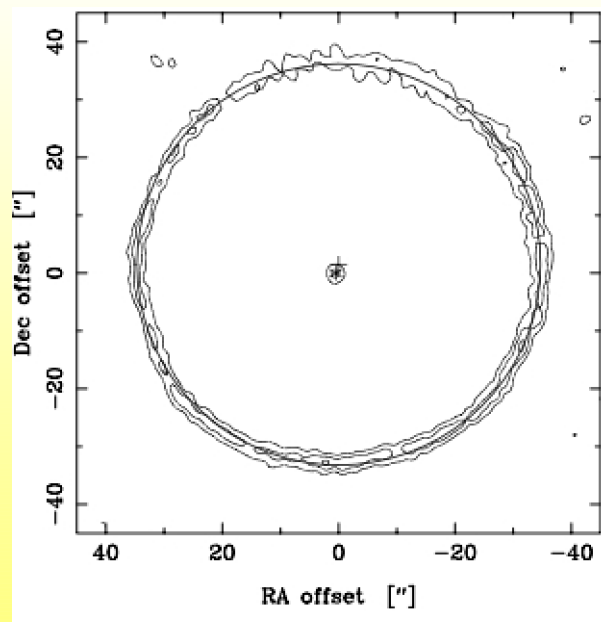
# Independent evidence from GCs (Fregeau, Heyl)



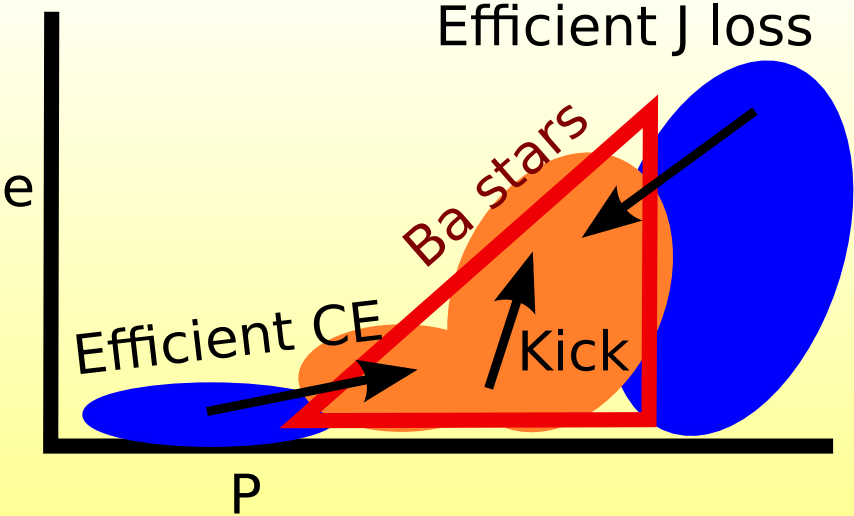
# Kick Implications: PNe (TT Cygni in CO)



# Kick Implications: PNe (TT Cygni in CO $v \sim 0.6 \text{ km s}^{-1}$ )



# Conclusion: How To Make Ba Stars...?





.....

# Efficient common envelope ejection?

- ▶ *As if we have a clue?!*
- ▶ Envelope weakly bound
- ▶ Even with  $\alpha = 1$  only a few % of envelope's recombination energy is required
- ▶ Nelemans/Tout  $\gamma$  prescription  $\rightarrow$  similar!
- ▶ Only for  $P \lesssim 2000$  days

# Angular momentum?

- ▶ Huang 1956:
  - ▶ *when the lost mass is collected by the secondary component, the major axis will decrease*

$$\dot{J}_{\text{orb}} \propto \left( -|\dot{M}_1| - \frac{M_2}{M_1} |\dot{M}_2| \right)$$

- ▶ Second term **large** for efficient accretion!

$$\dot{J}_{\text{orbit}} = l \frac{J_{\text{orbit}}}{M_1 + M_2} (\dot{M}_1 + \dot{M}_2)$$

$(l \gtrsim 2)$

- ▶ Alternatively:
  - ▶ magnetic braking
  - ▶ disc mass loss?

## Efficient accretion: Mira

