The Mysterious Barium Stars

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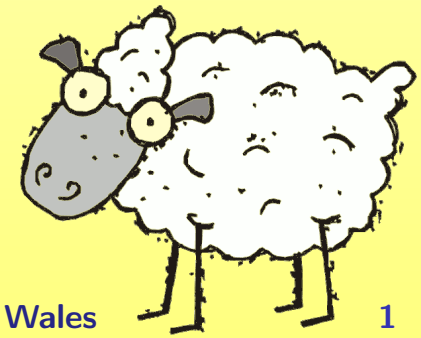
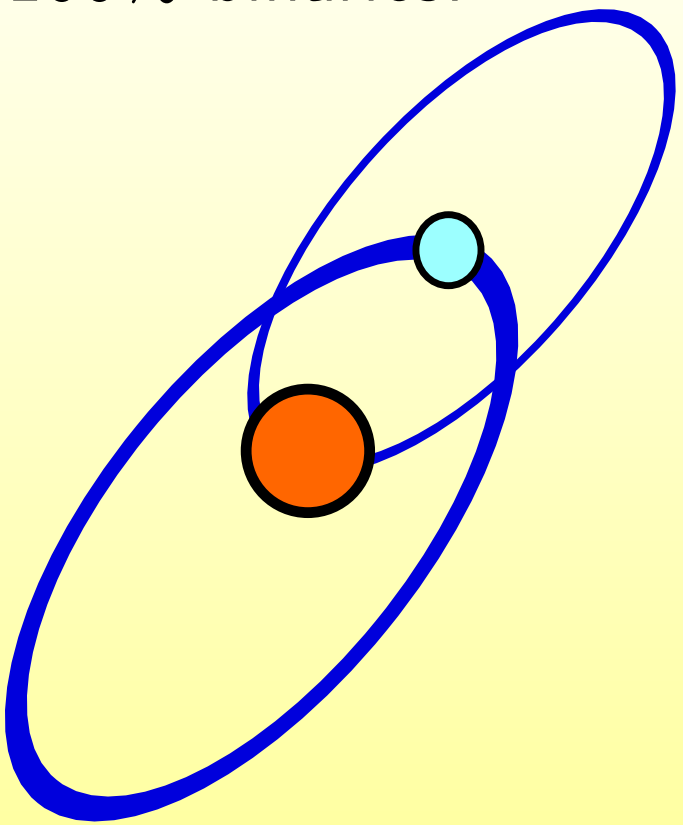
NAM UKSP • MIST



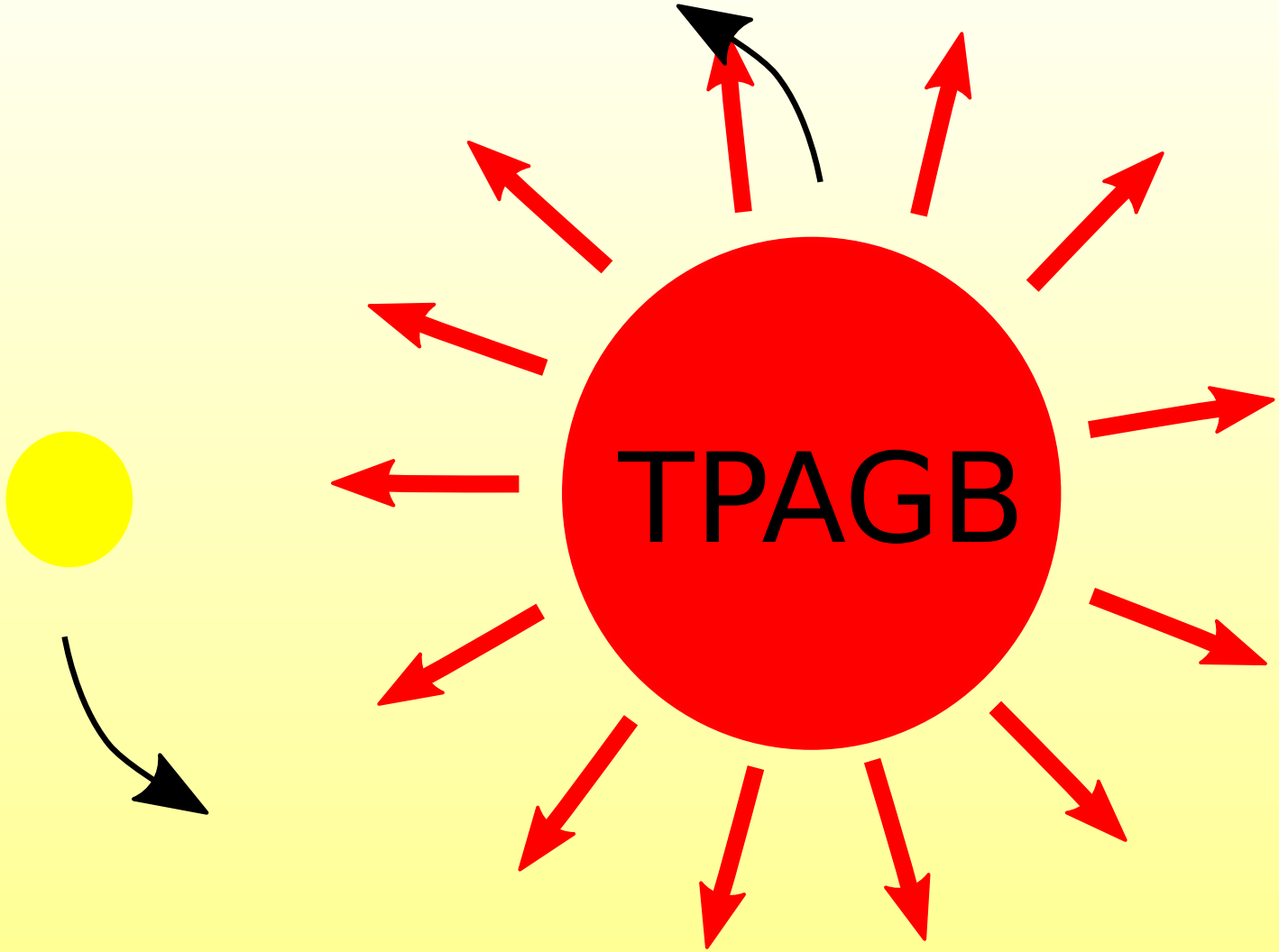
What is a barium star?

100% binaries!

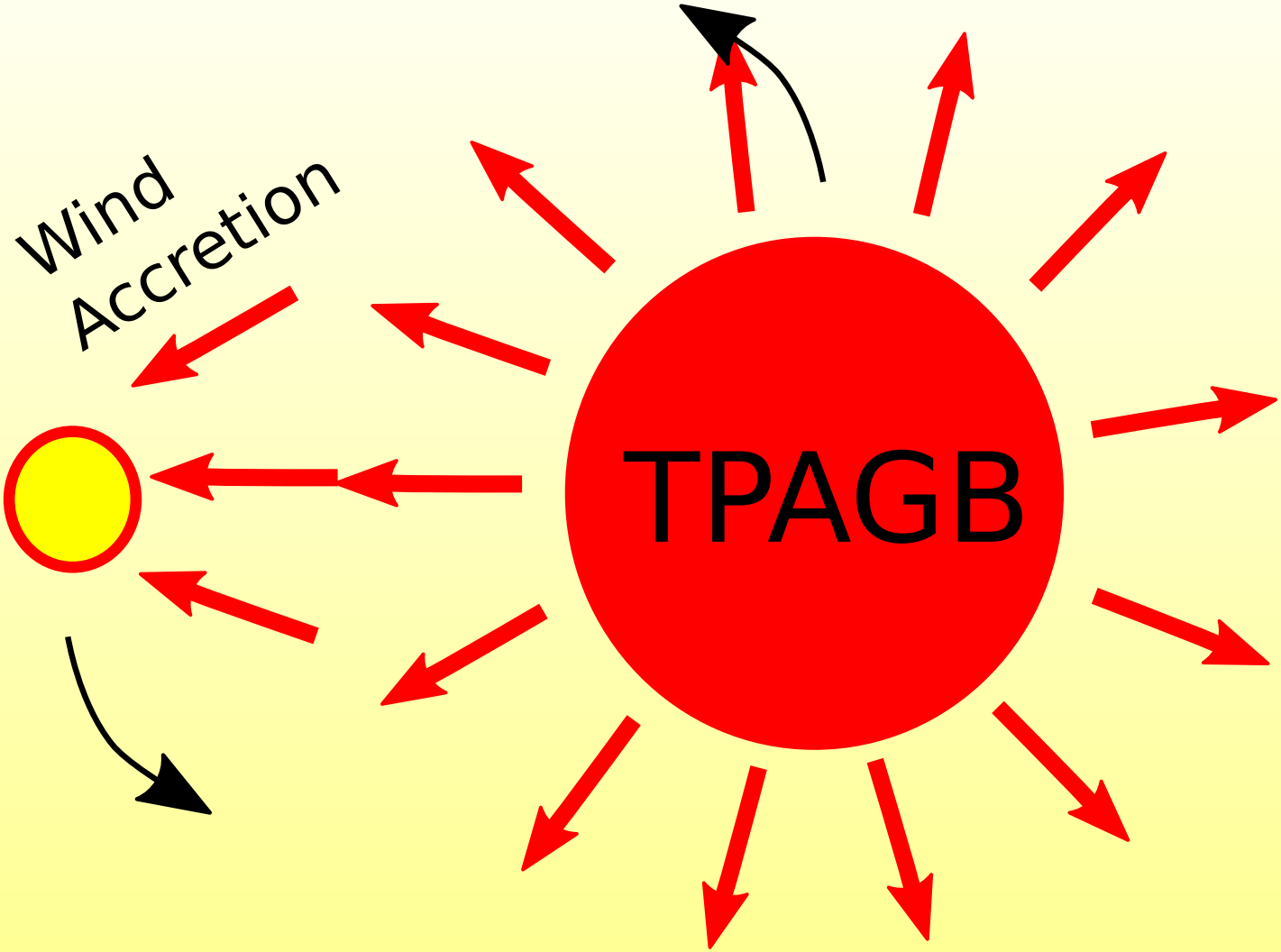


Complete observation set of periods and eccentricities

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



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



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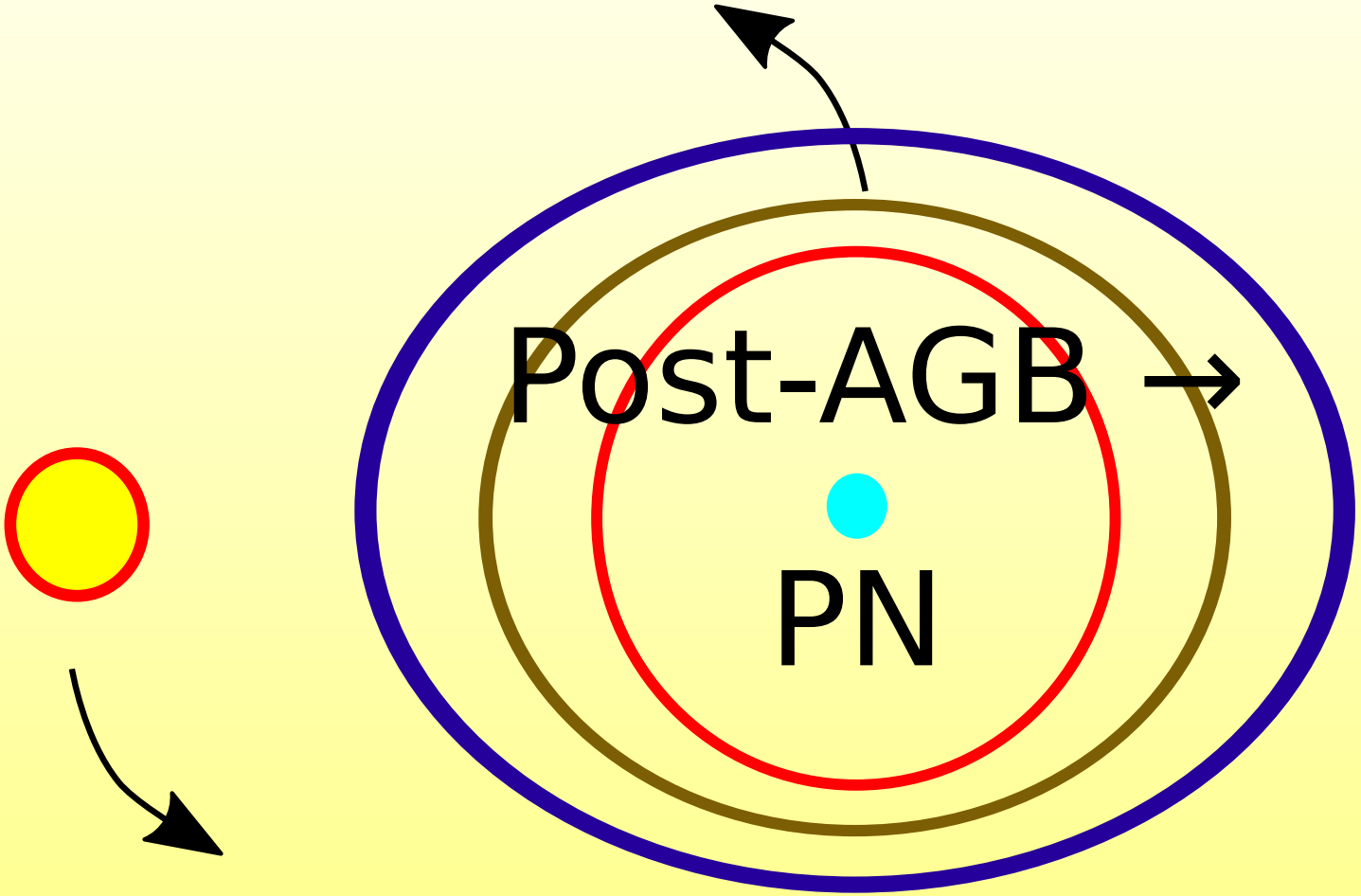
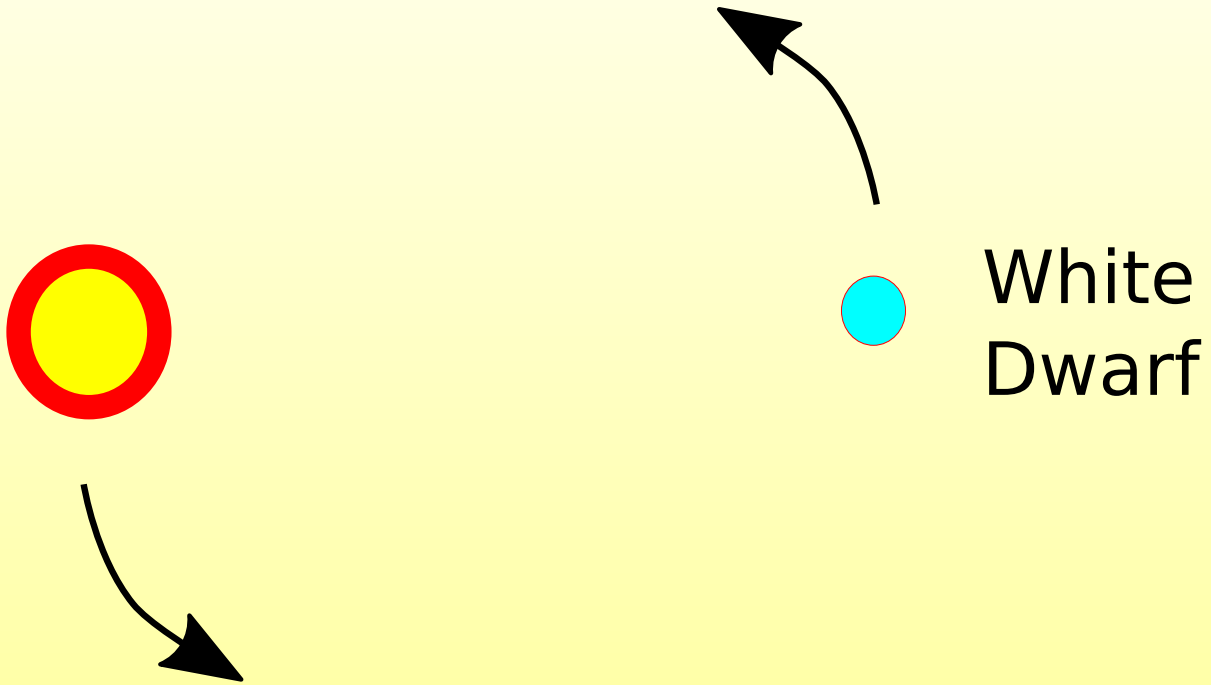
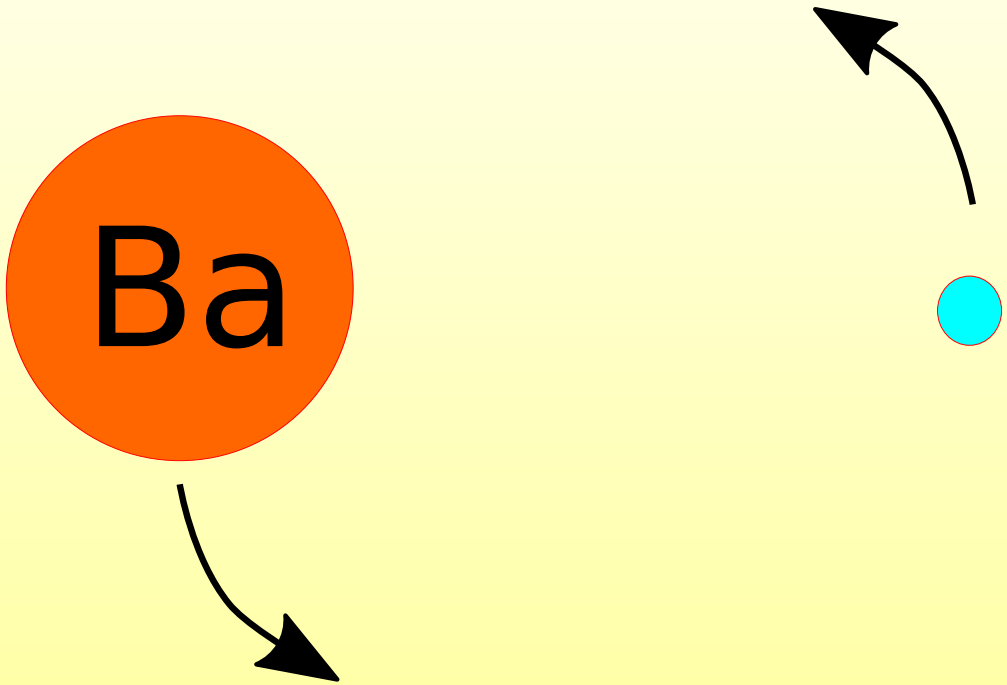


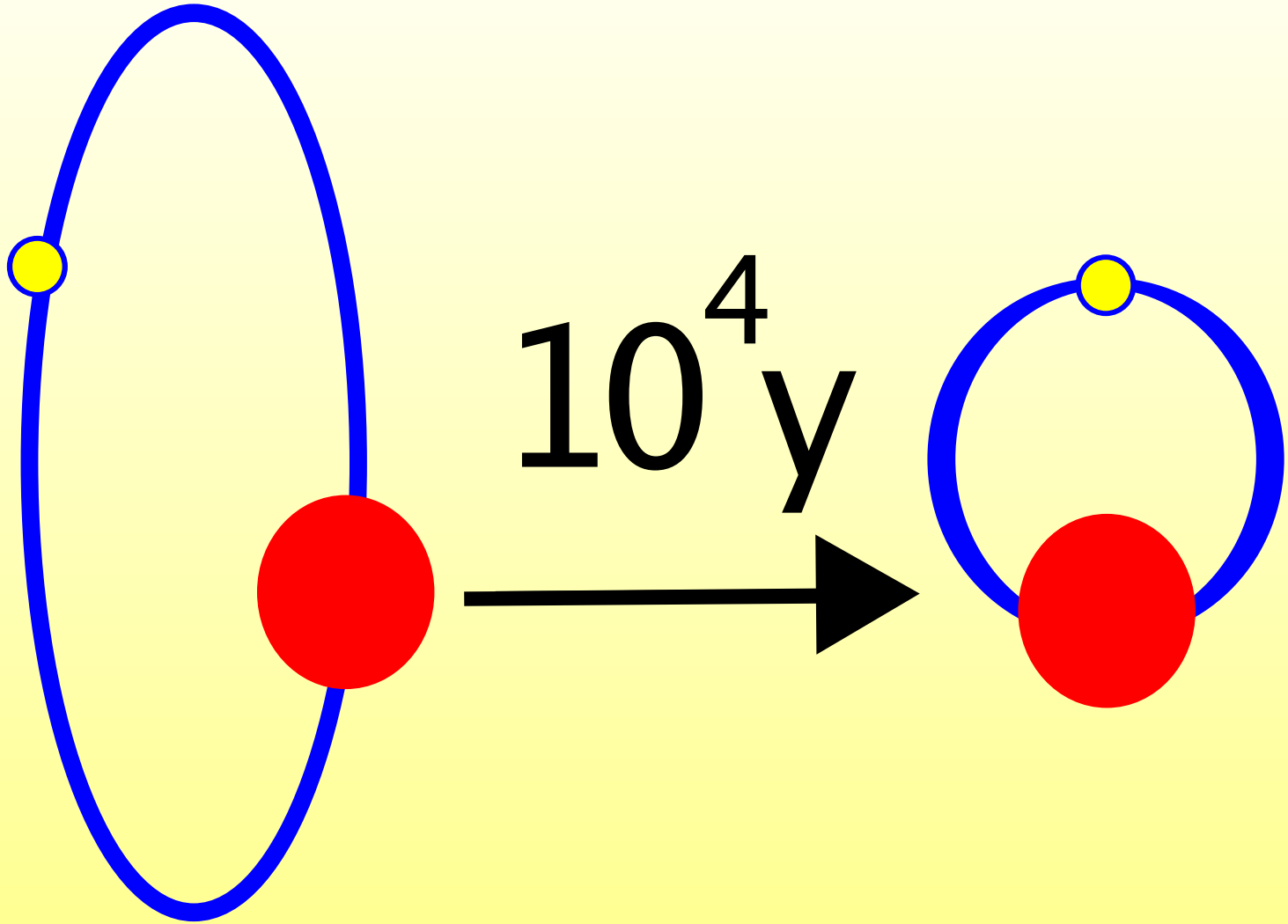
How to make a Ba star? A long time ago...



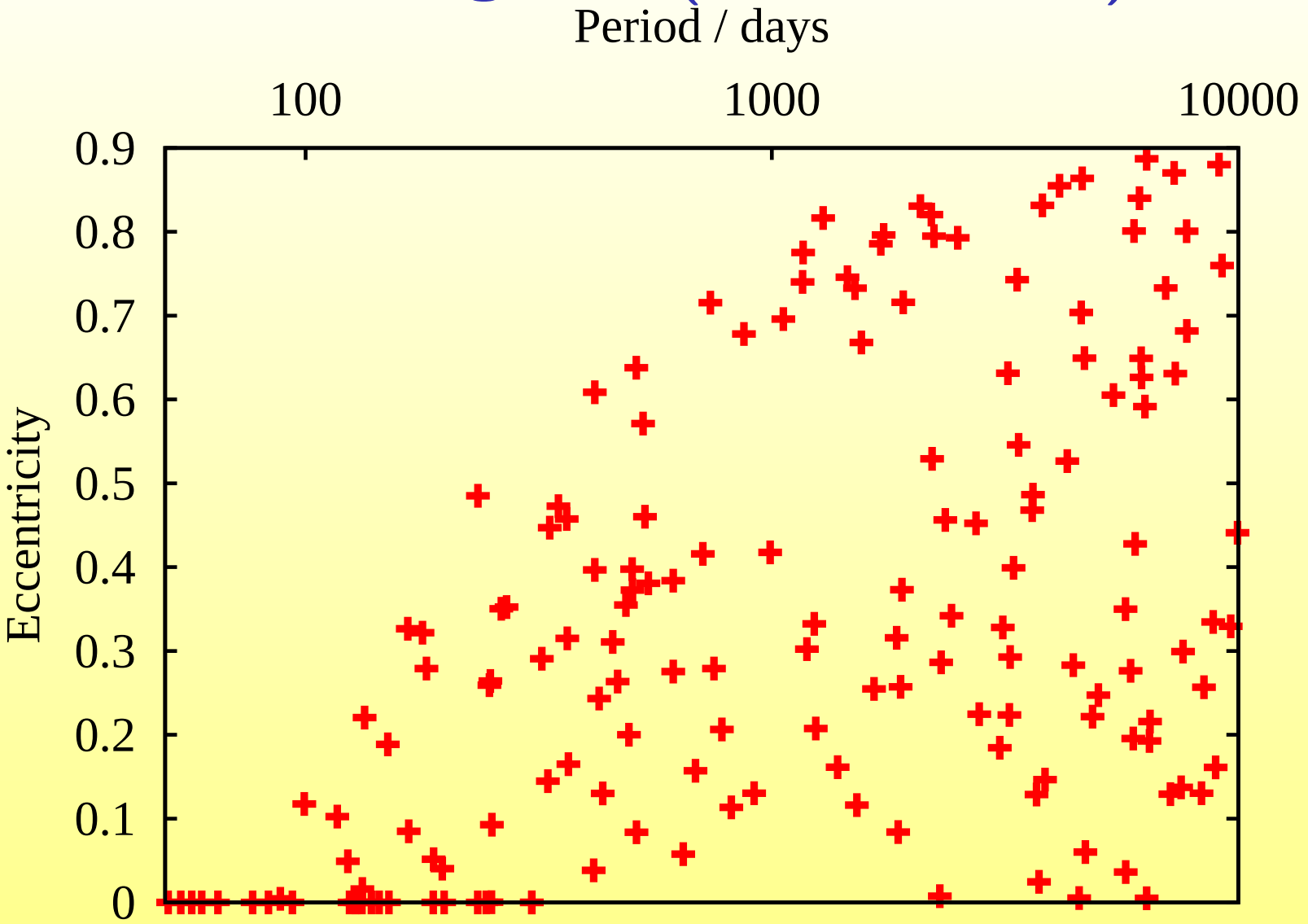
The barium star now



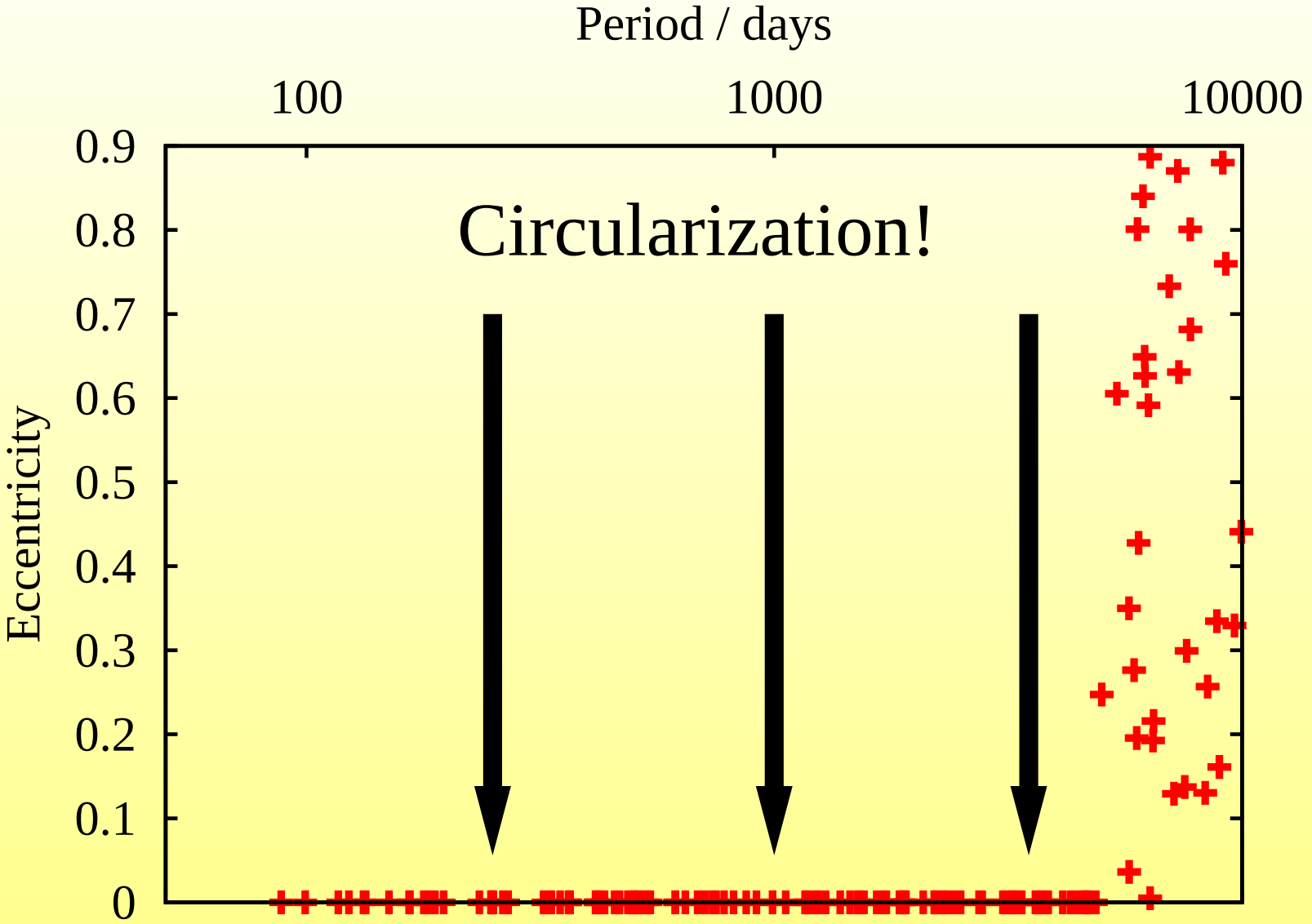
Tidal Circulari[sz]ation $\tau \sim (a/R)^8$



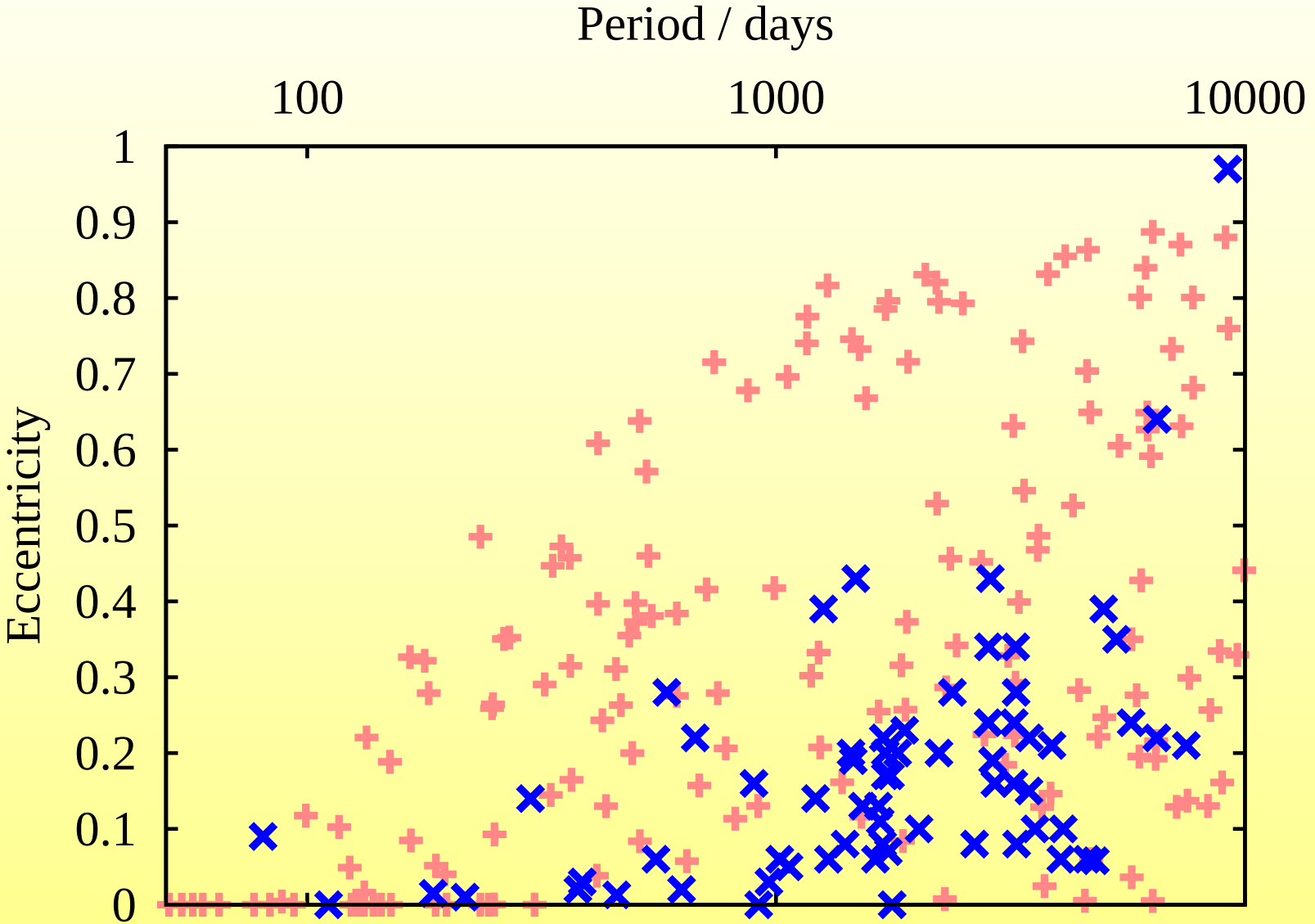
Observations: GK giants (Jorissen data)



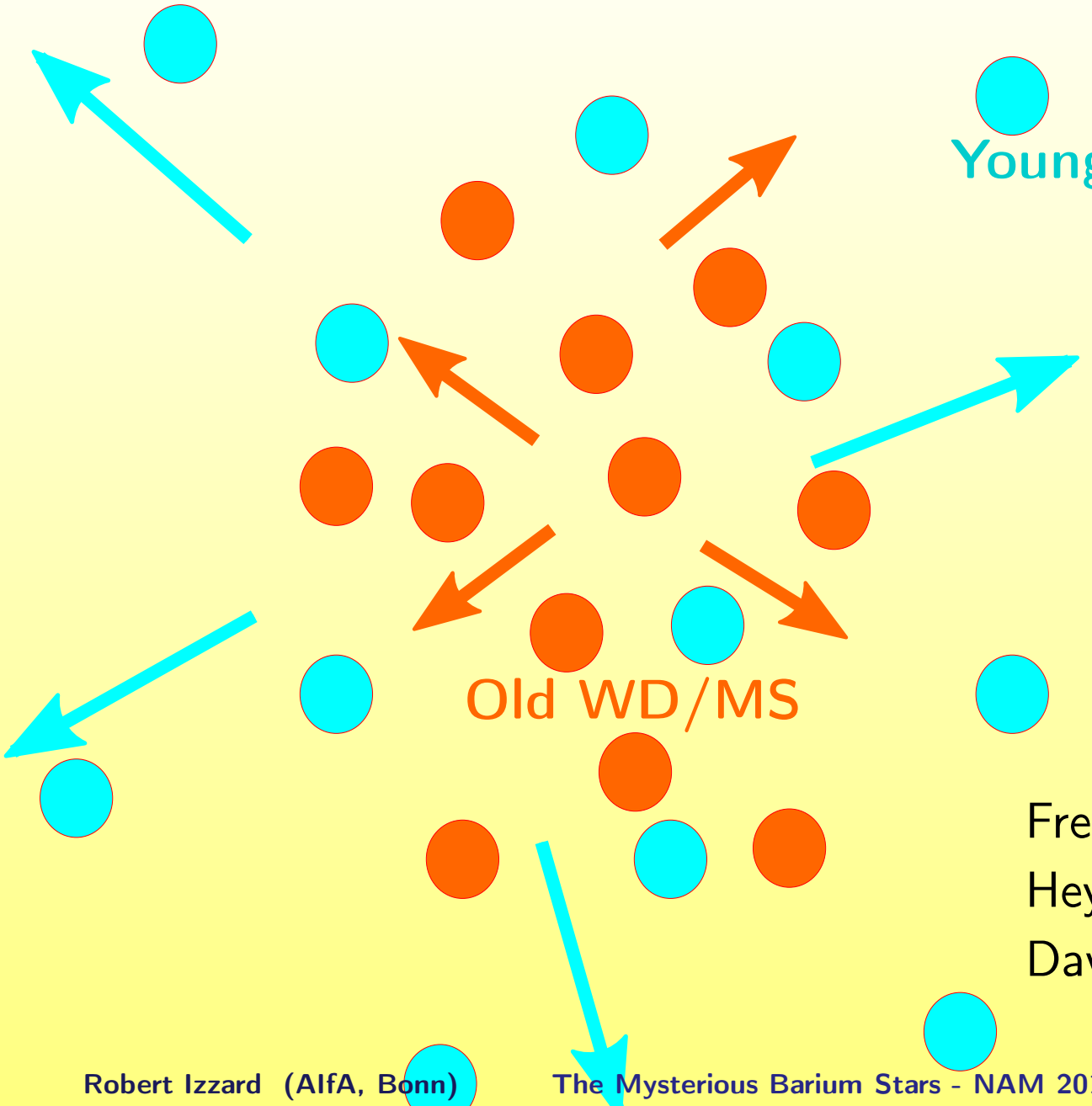
Expected result for Ba stars



Observations say otherwise!



Thesis: Natal kick for the white dwarf



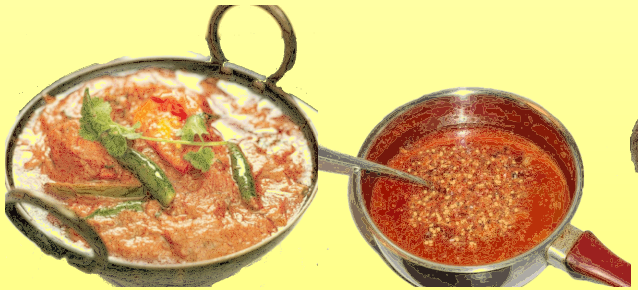
Single and binary stars!

Fregeau et al ApJ 695, 20
Heyl MNRAS 381,385 etc.
Davis et al MNRAS 383, 20

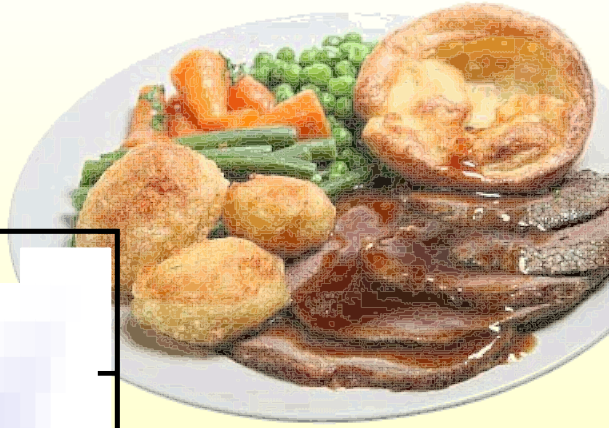
Curry Kick Scale

What is the effect on the Barium Stars?

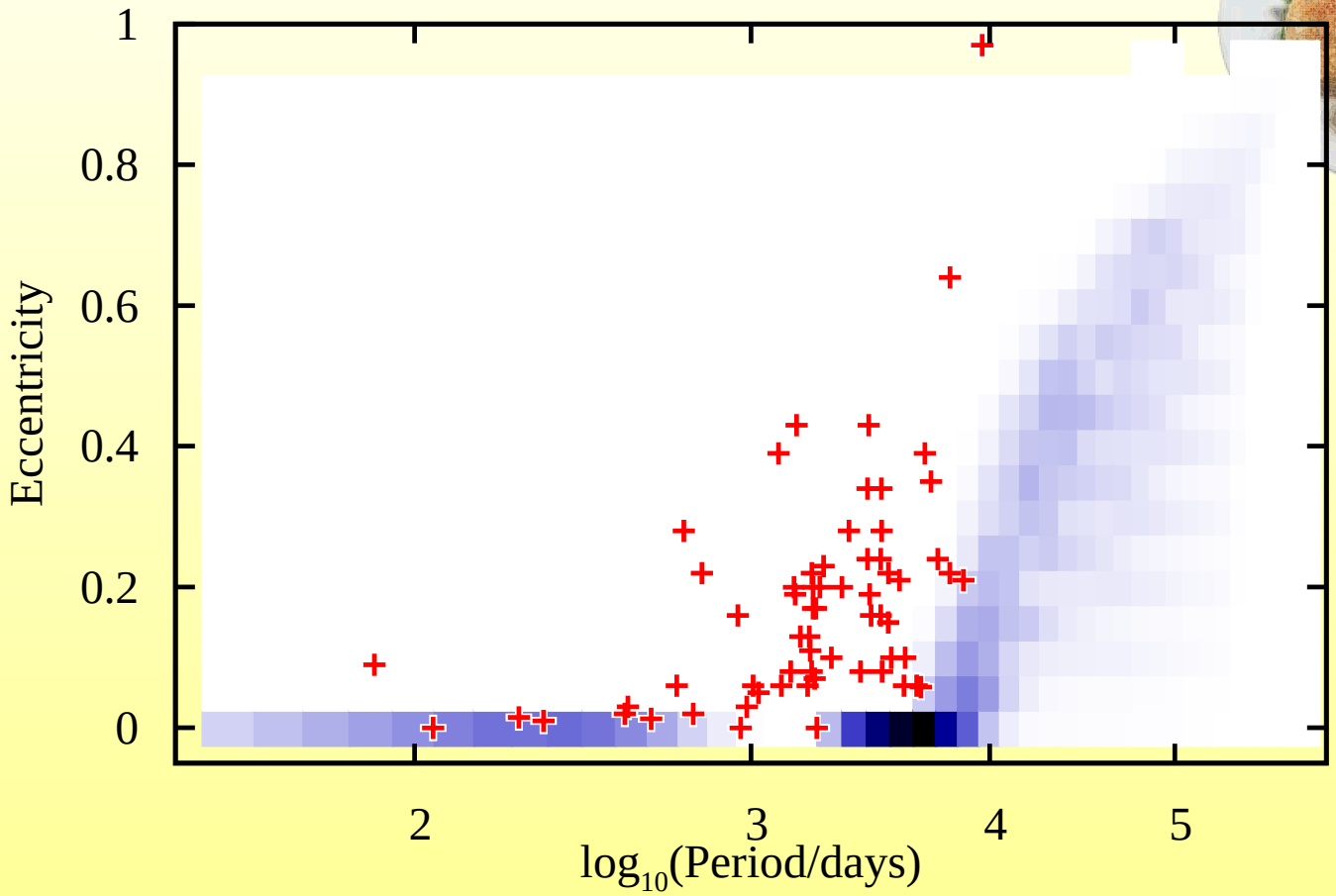
Curry	Kick Velocity/km s^{-1}
English	0
Korma	1
Dopiaza	2
Dhansak	3
Madras	4
Vindaloo	7
Phall	100



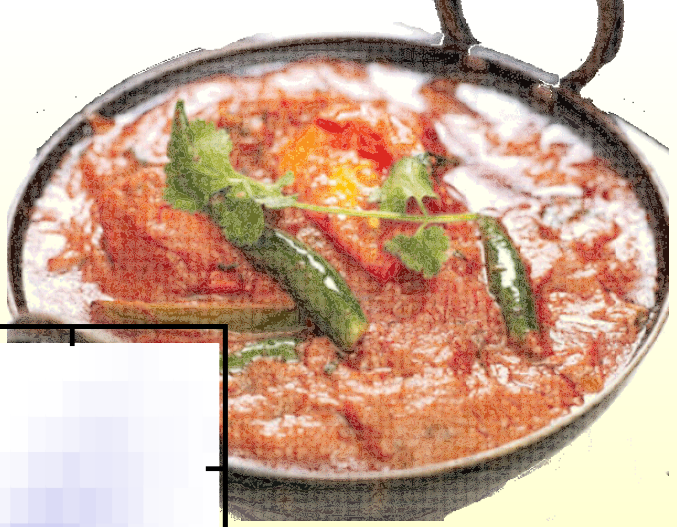

Canonical result (no kick)

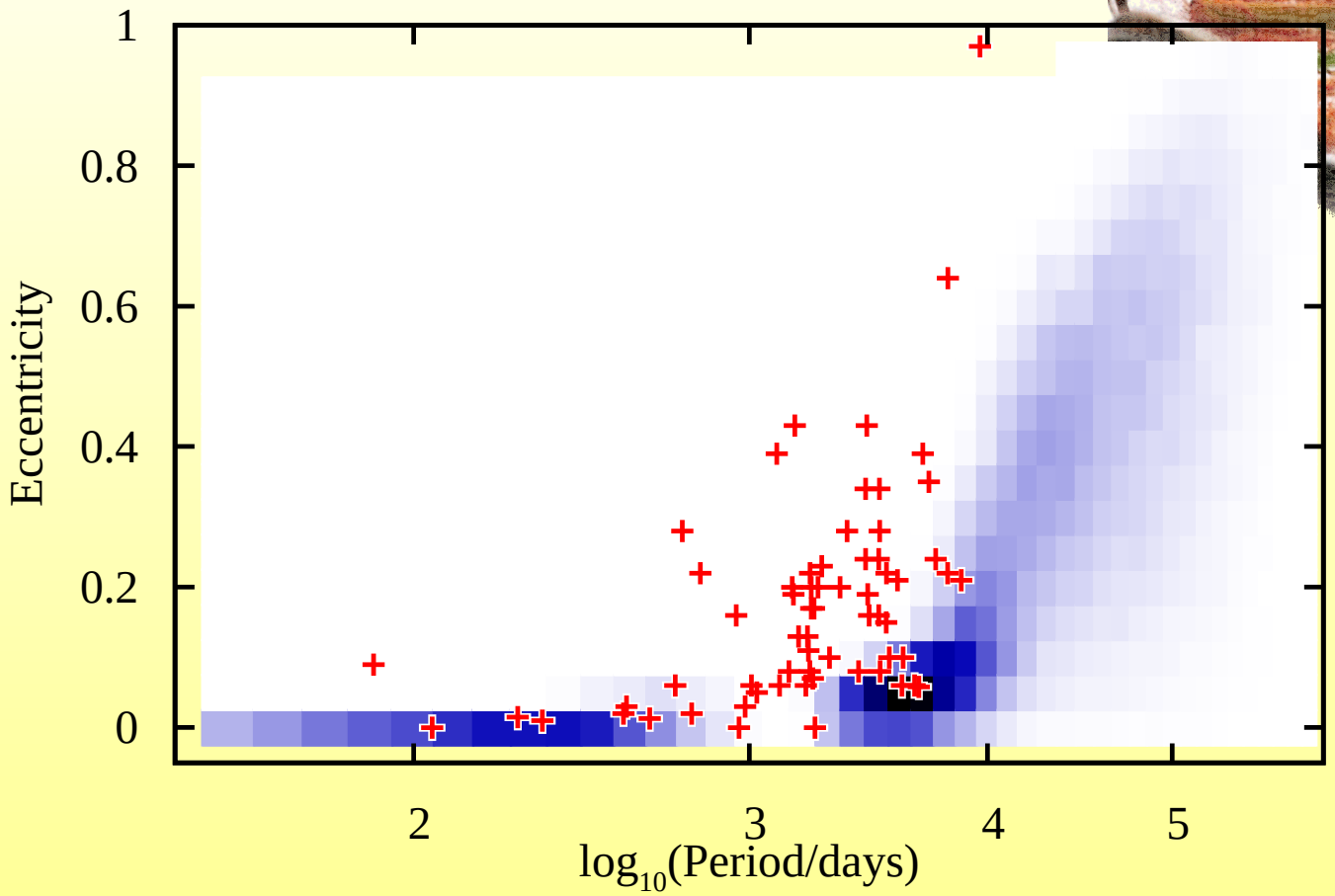


Observations: Jorissen et al (1998)

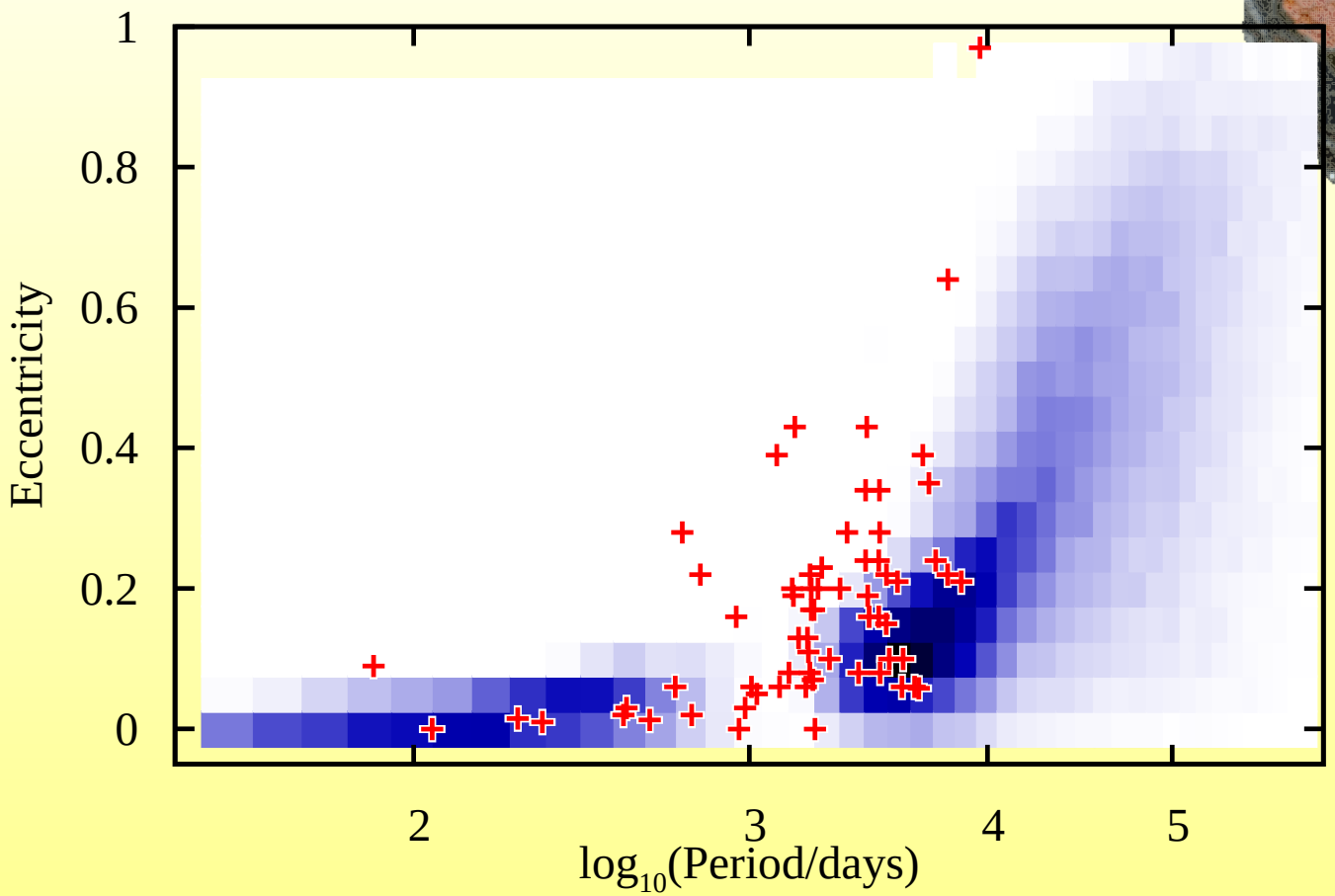


Korma kick $1\,\mathrm{km\,s^{-1}}$

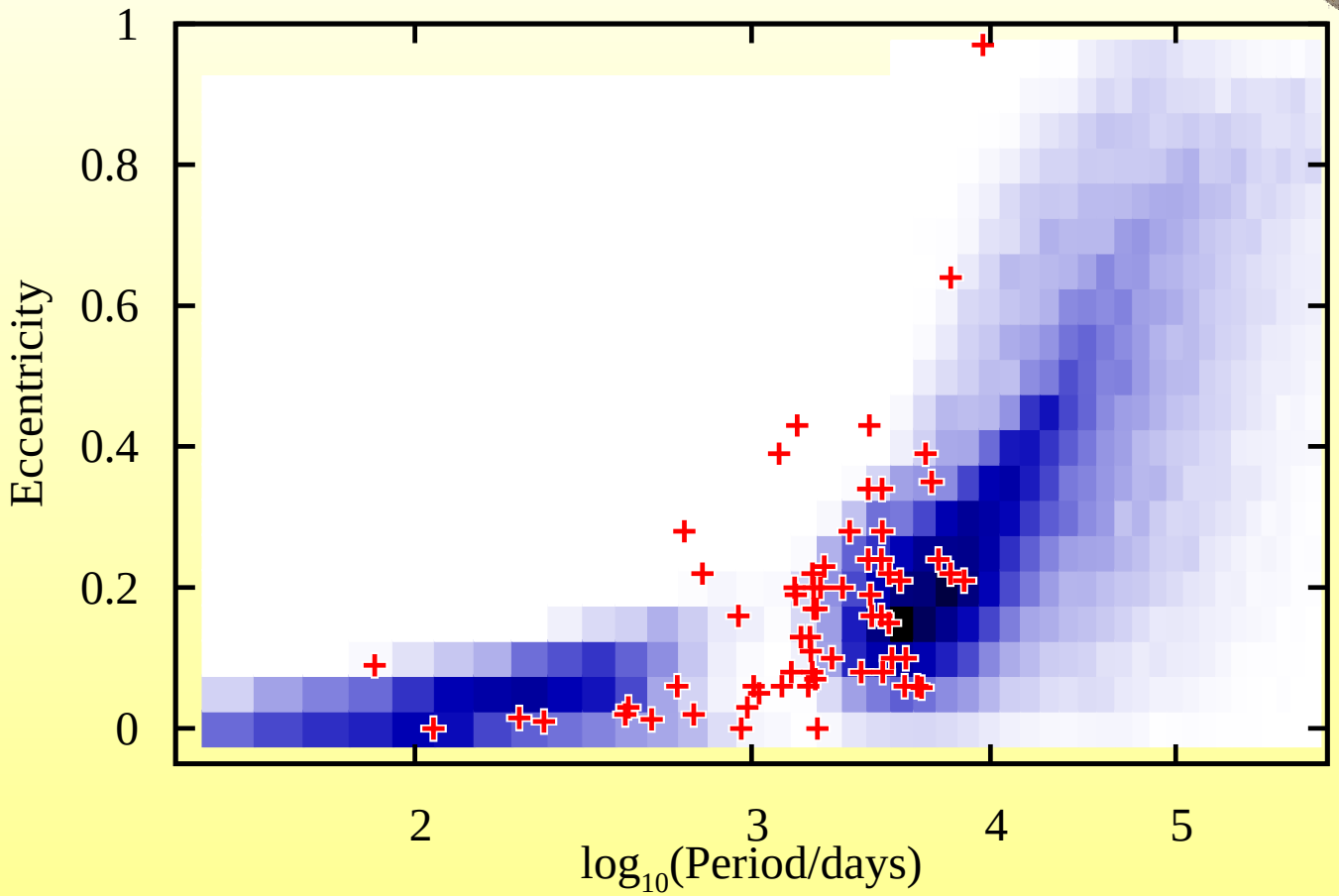




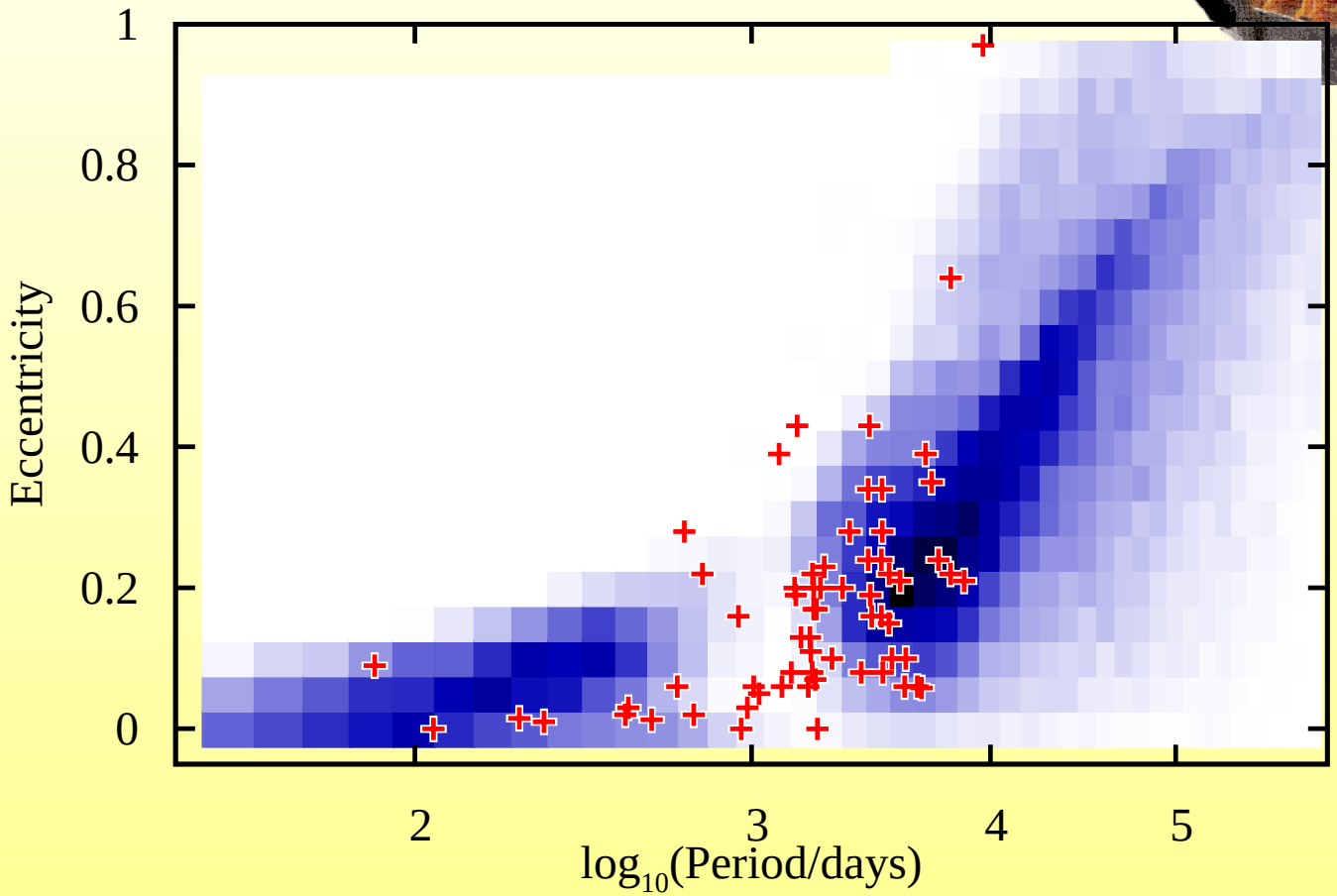
Dopiaza kick $2\,\mathrm{km\,s^{-1}}$



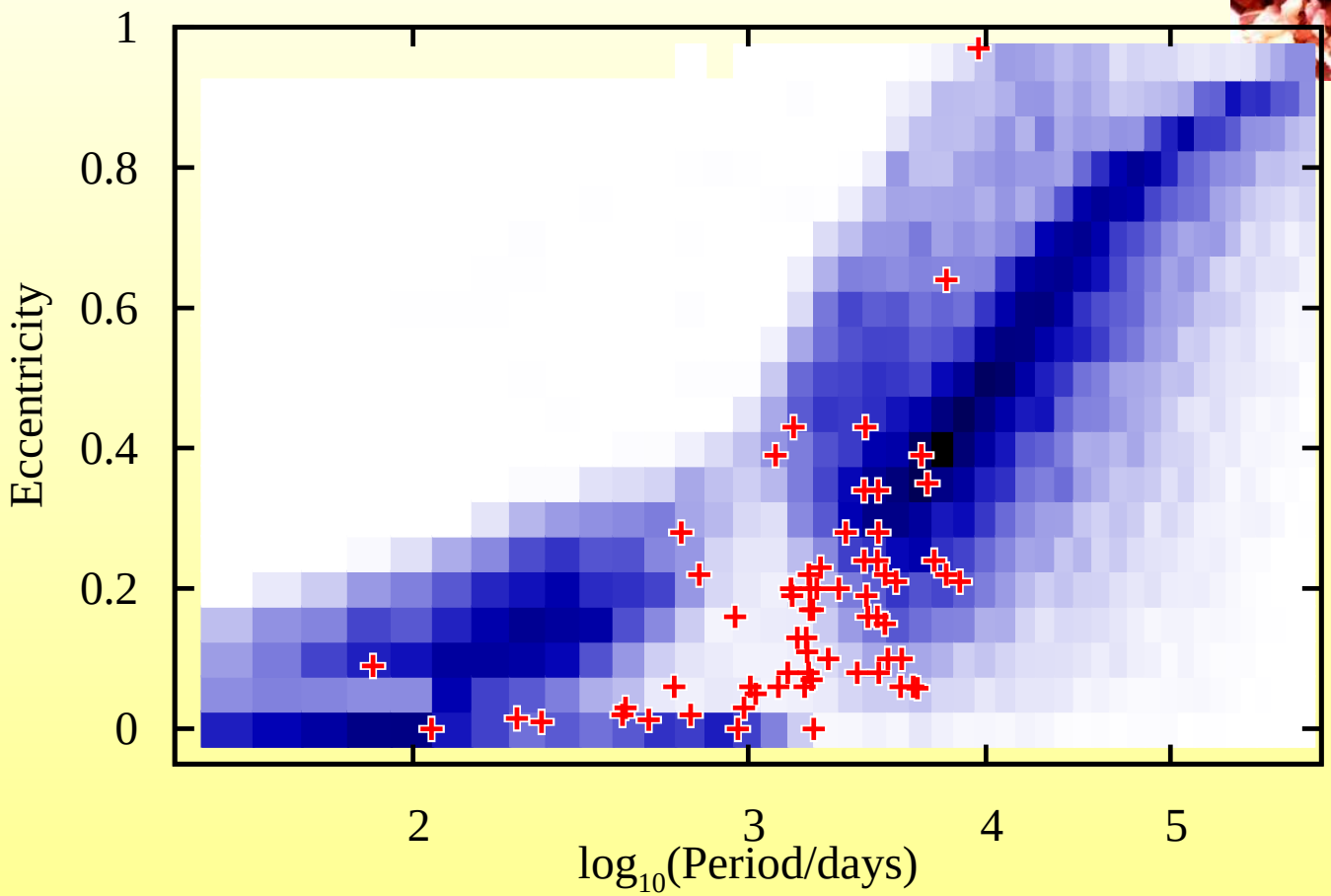
Dhansak kick $3\,\mathrm{km\,s^{-1}}$



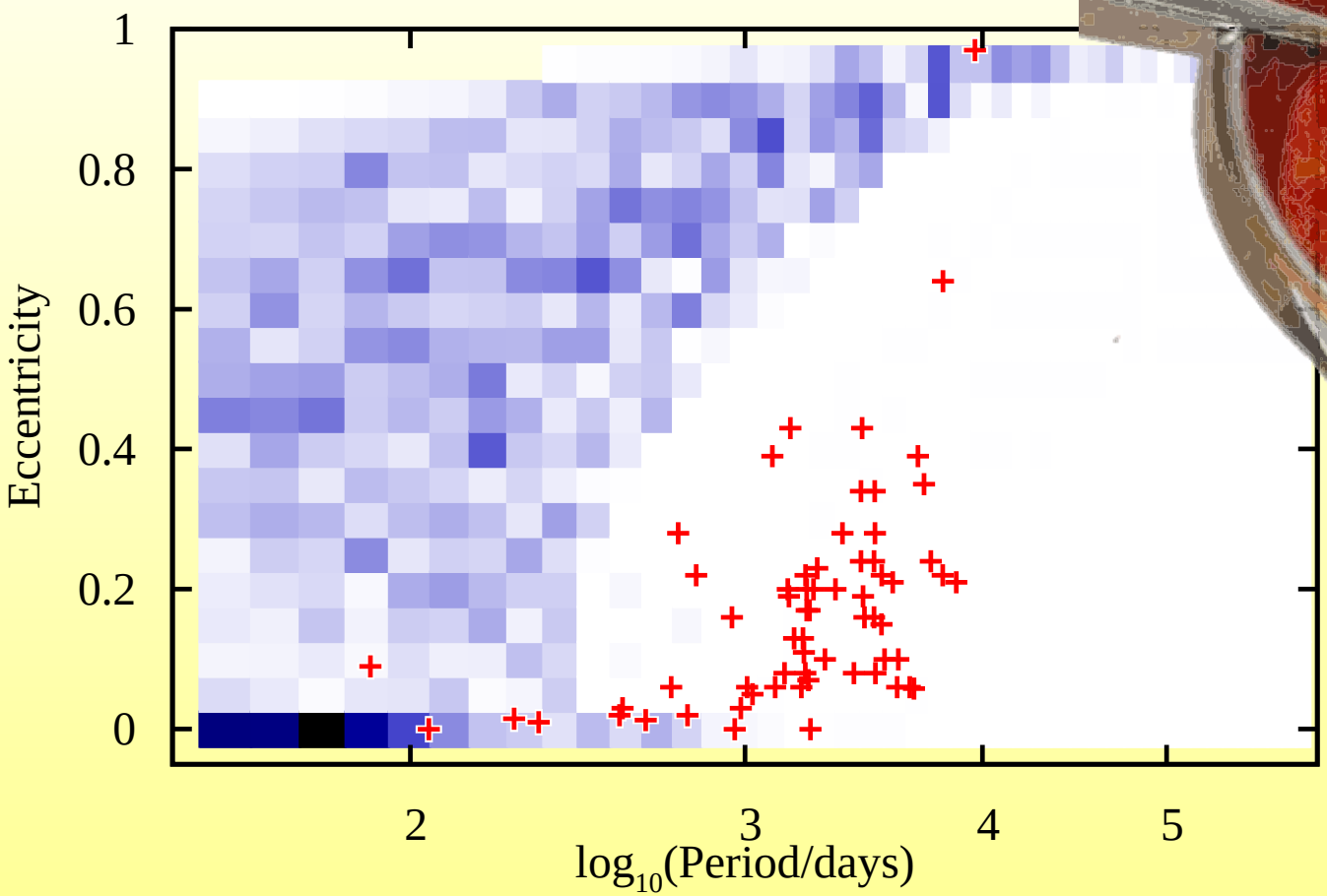
Madras kick $4\,\mathrm{km\,s^{-1}}$



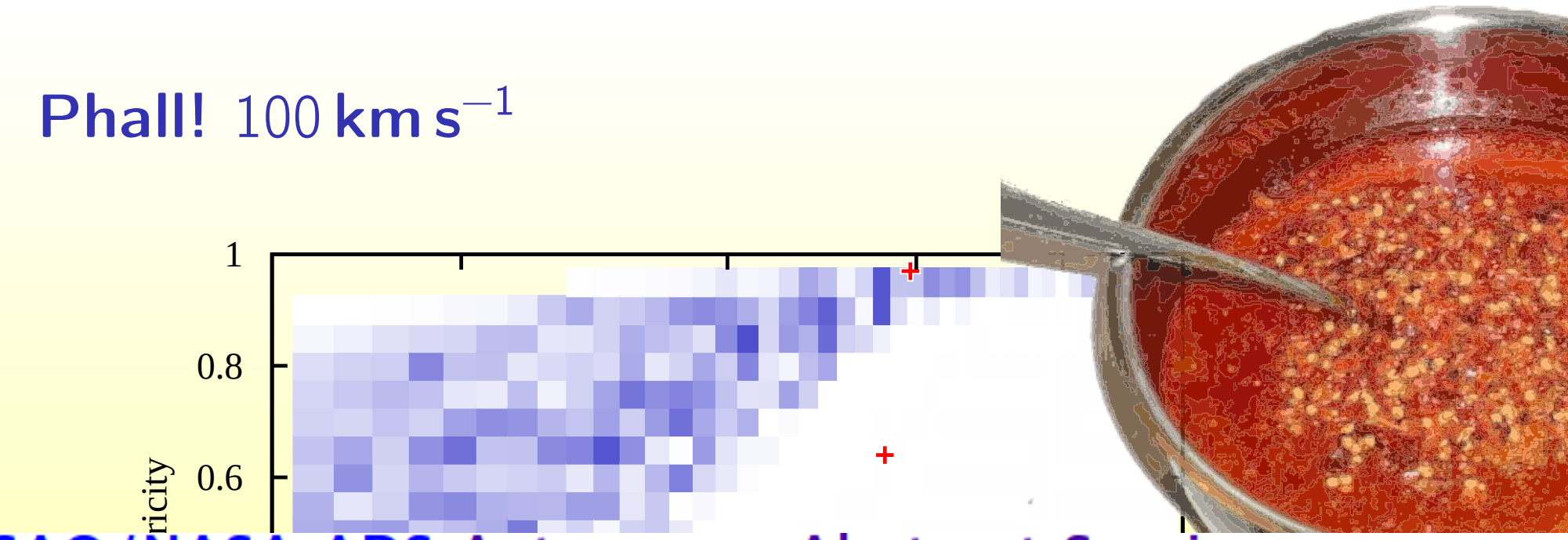
Vindaloo kick $7\,\mathrm{km\,s^{-1}}$



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



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



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Title: The rise and phalli of barium stars

Authors: Izzard, R. G.; Dermine, T.; Church, R. P.

Publication: Asymmetric Planetary Nebulae 5 conference, held
U.K., 20 – 25 June 2010, A. A. Zijlstra, F. Lykou, I

Madras please! ($4\,\mathrm{km\,s^{-1}}$) Still Problems!

Long-P tail

Period gap!

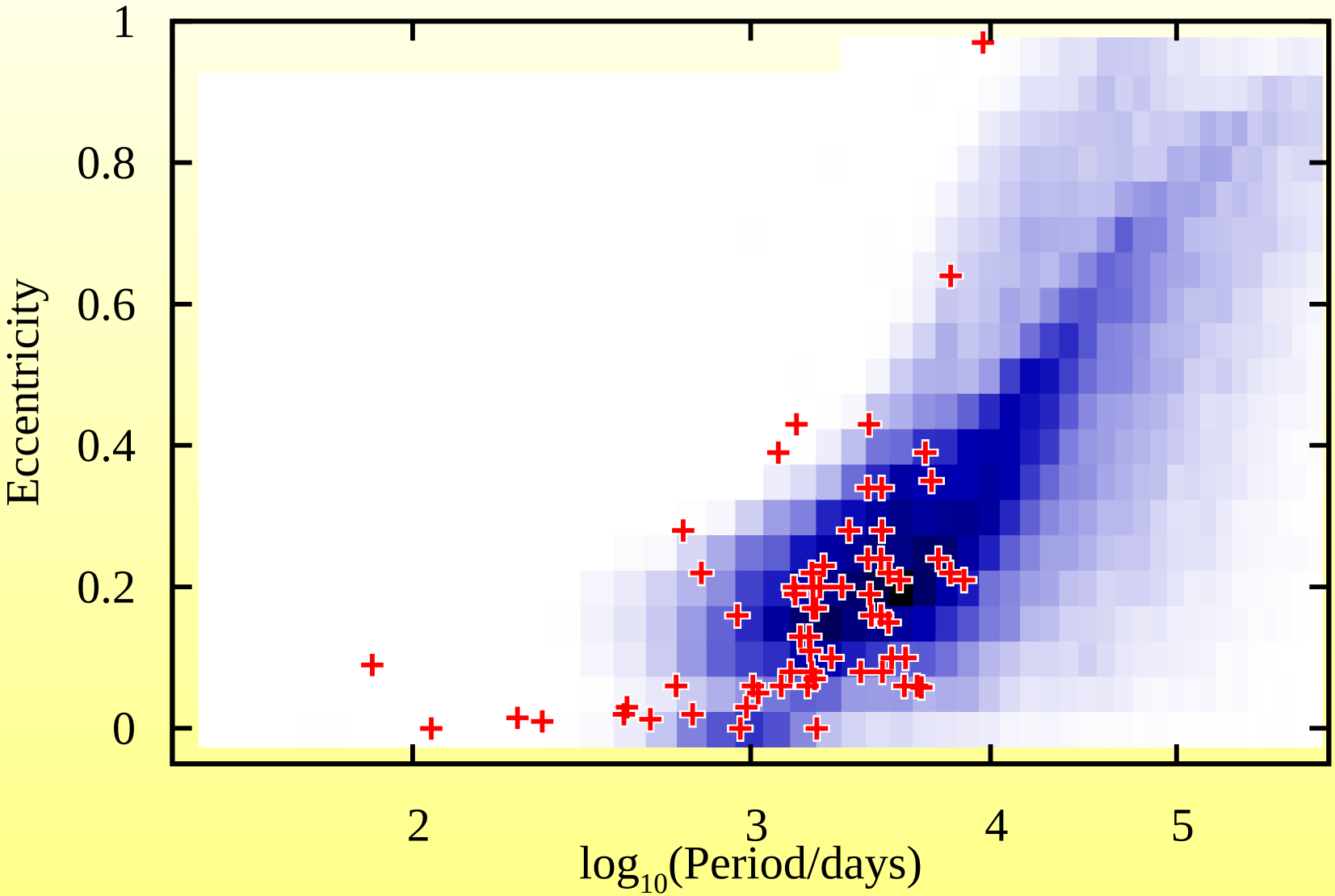
Eccentricity

1
0.8
0.6
0.4
0.2
0

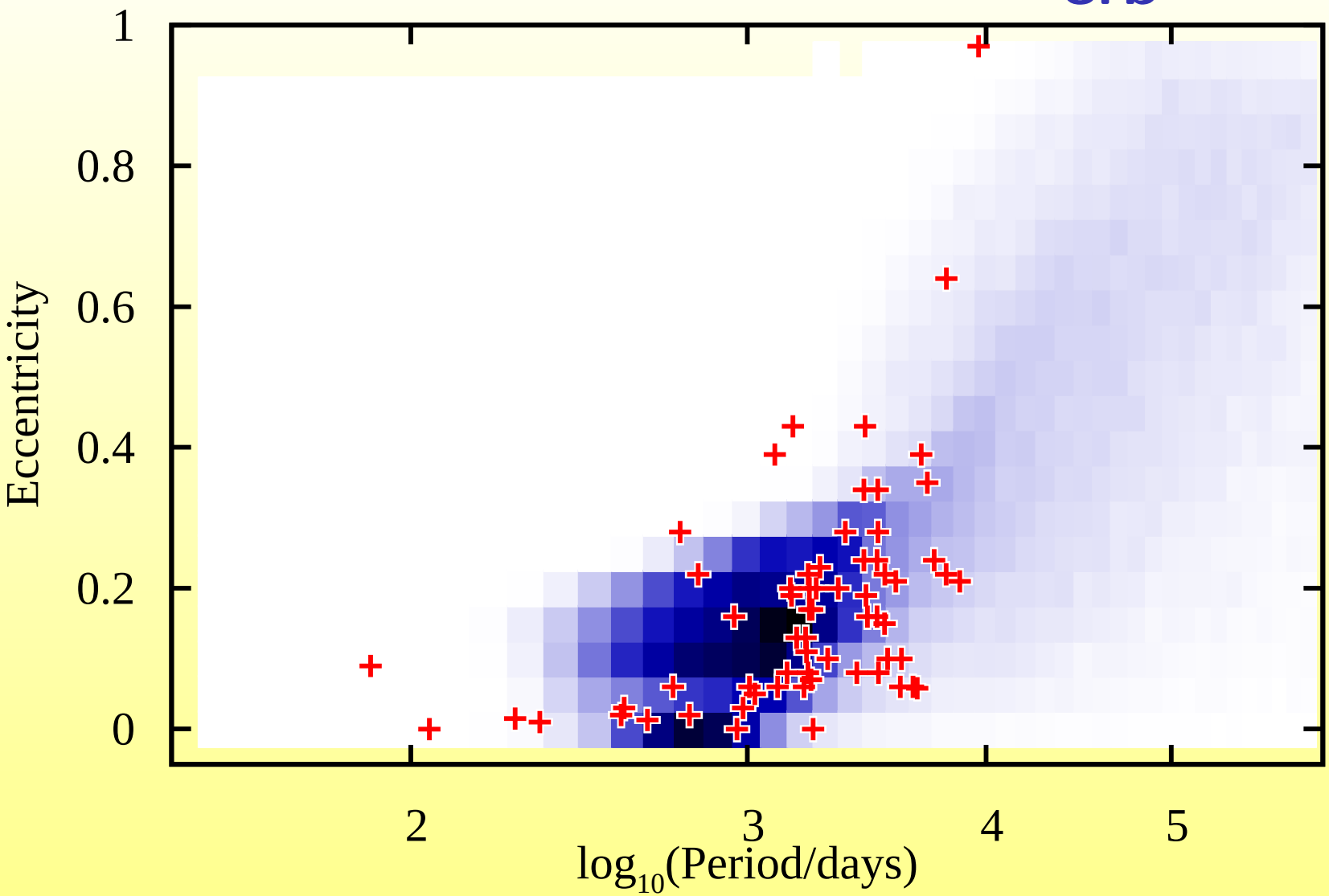
2
3
4
5

$\log_{10}$(Period/days)

4km/s kick+efficient CE ejection (bad curry?)



4km/s kick + efficient CEE and j_{orb}



Izzard, Dermine & Church (2010) A&A 523, 10

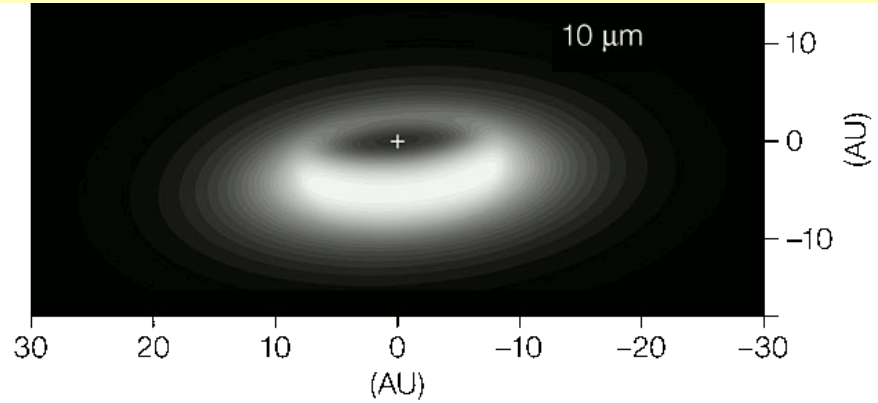
Newsflash! Circumbinary Discs!

Post-AGB = Ba progenitor

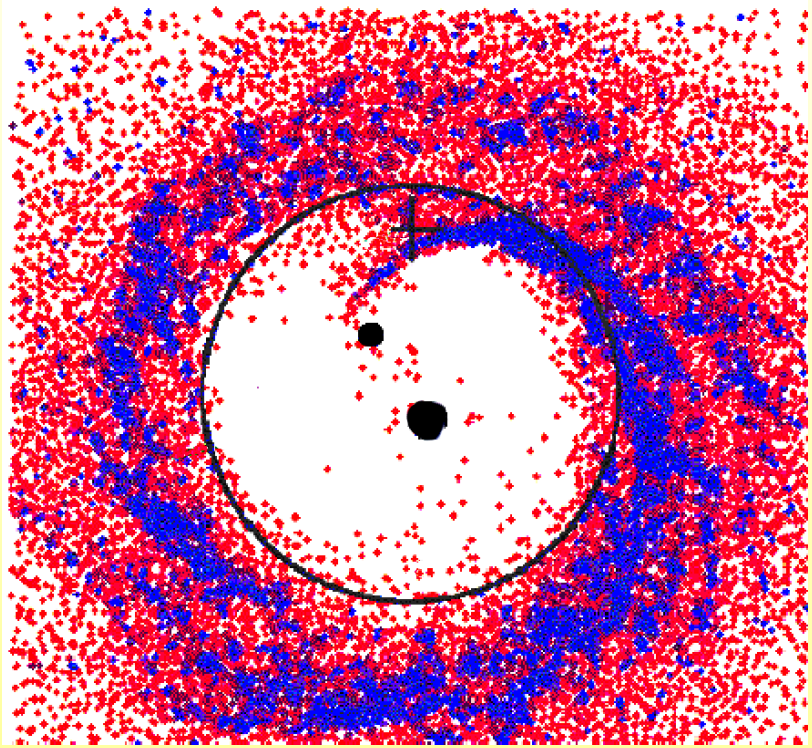
25% are binaries

these *all* have CB Discs

Tyl Dermine is modelling these

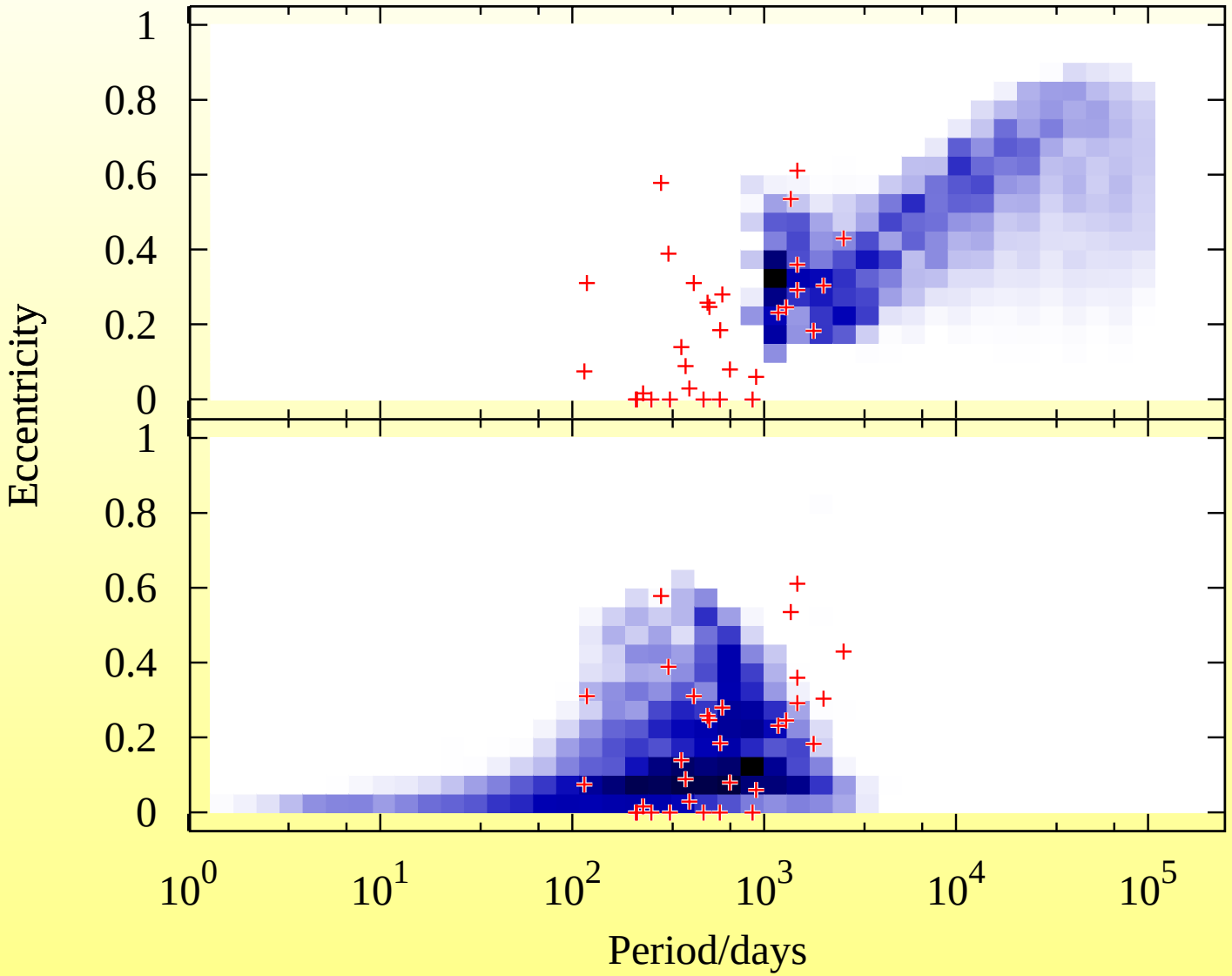


Deroo et al. 2007

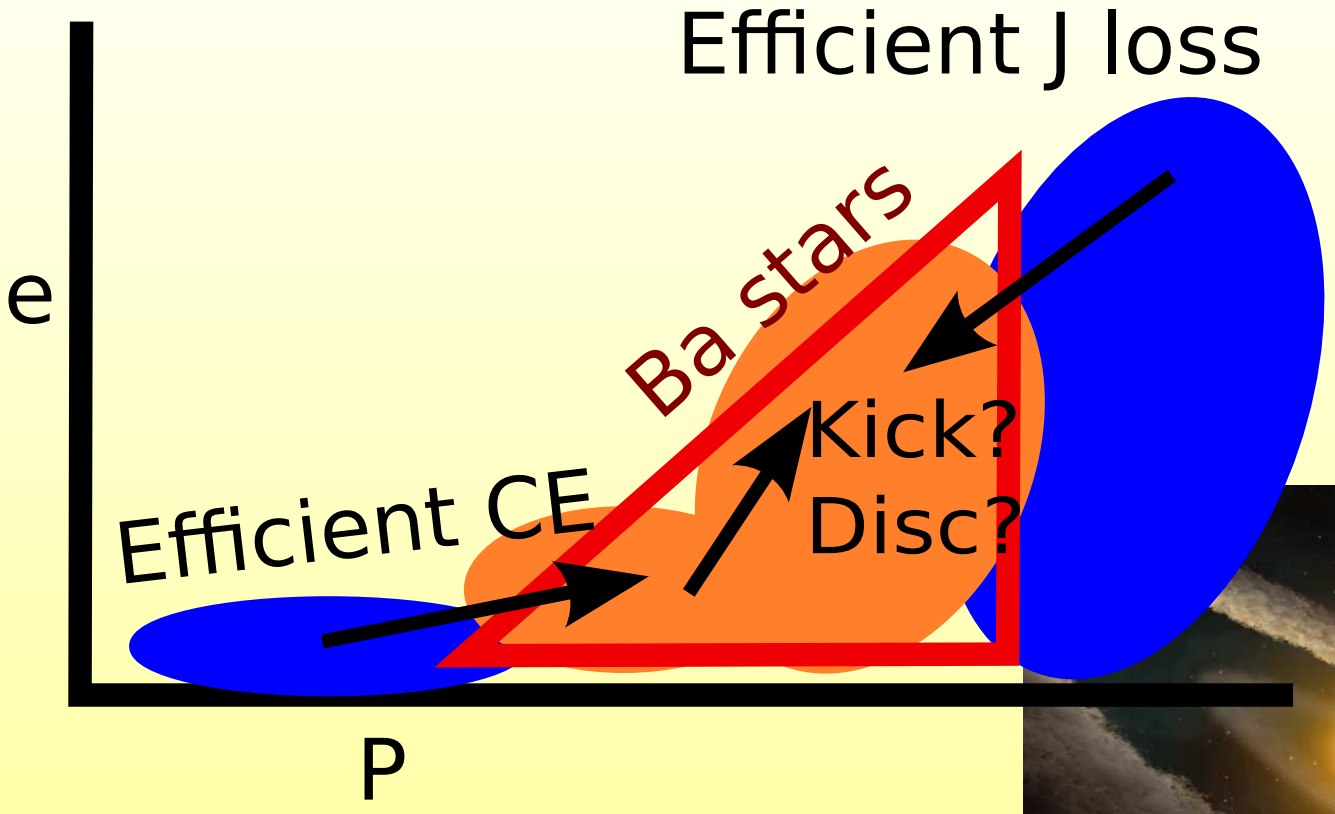


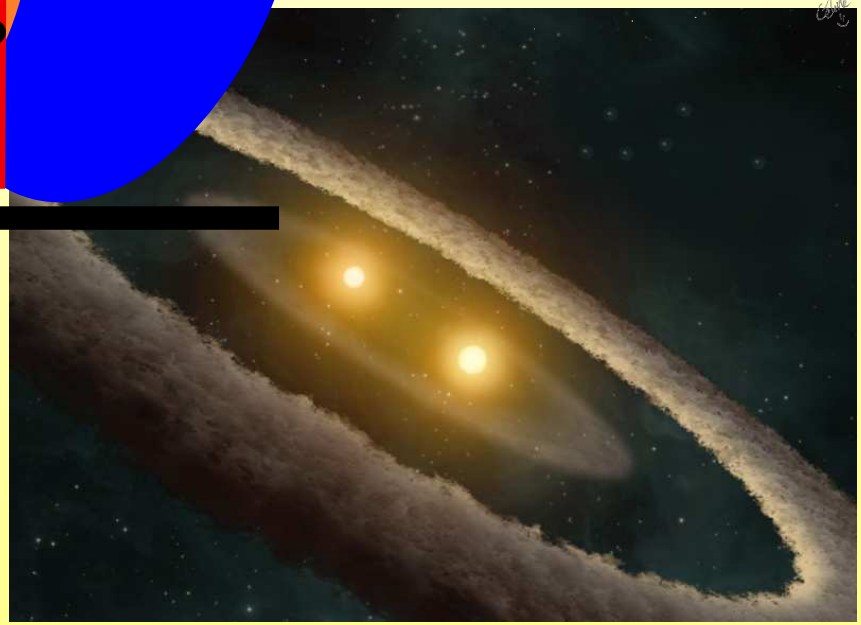
Artymowicz & Lubow 1996

CB Disc Models for post-AGB stars



Conclusion: How To Make Barium Stars. . . ?





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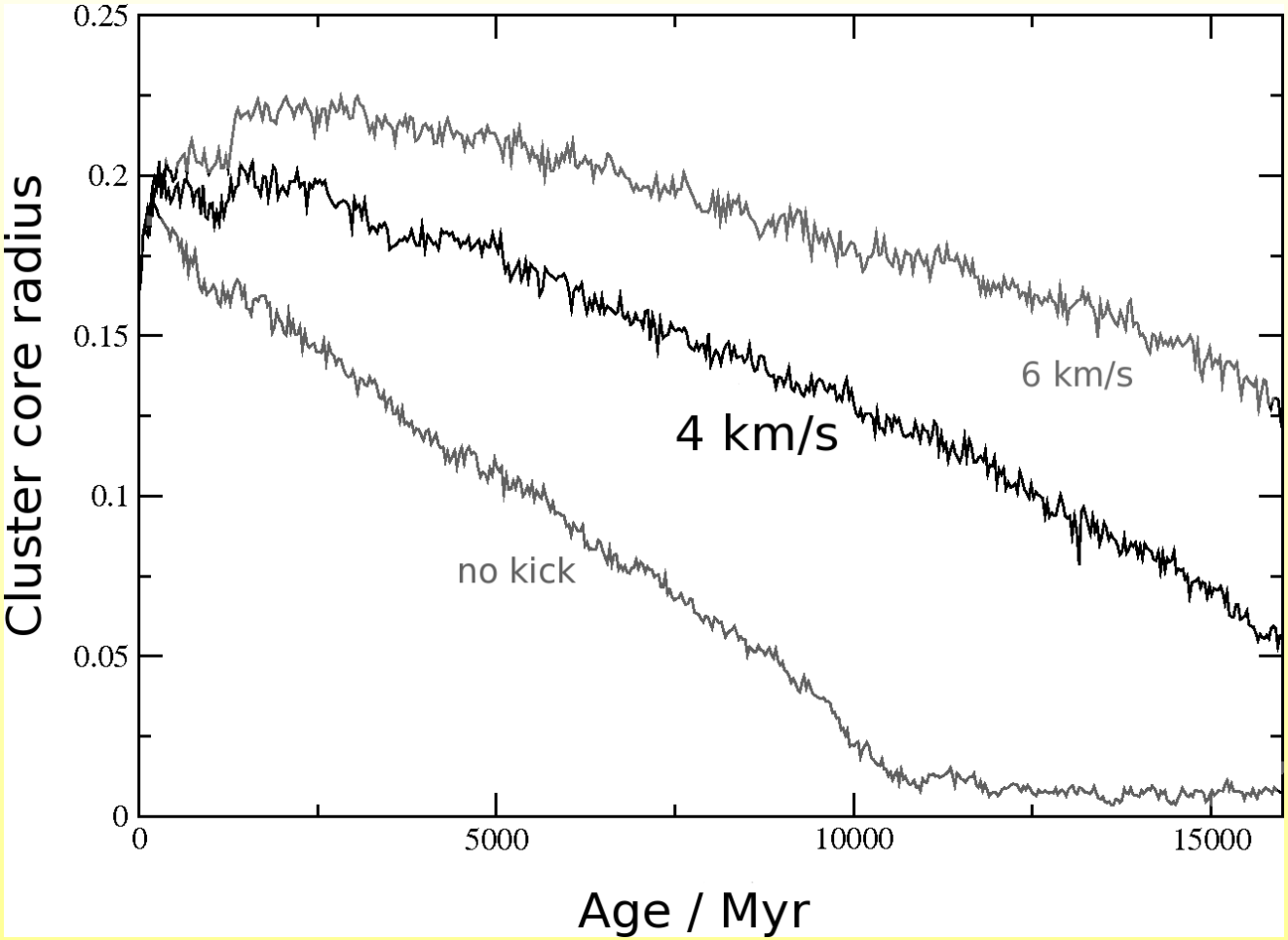
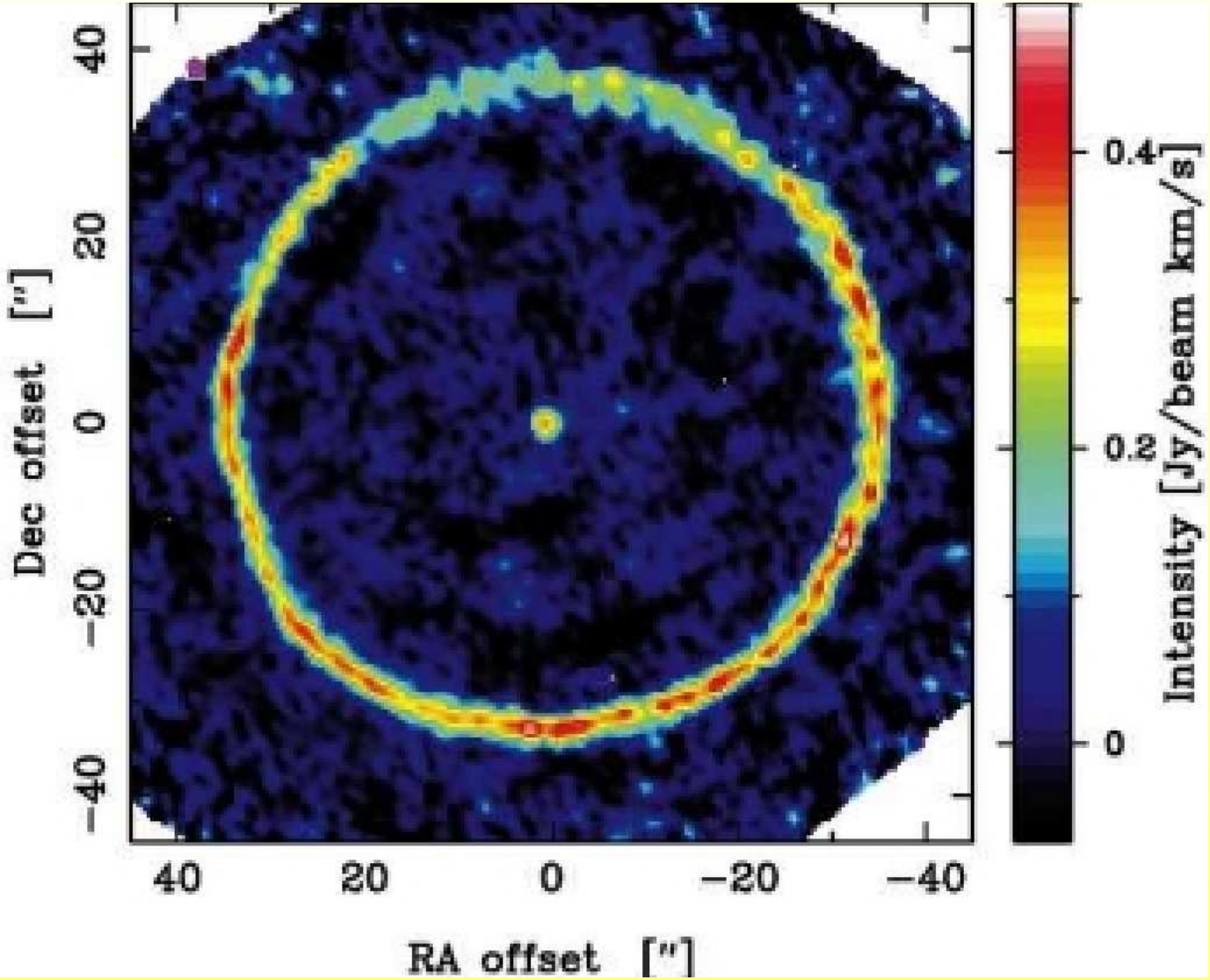
Many thanks!

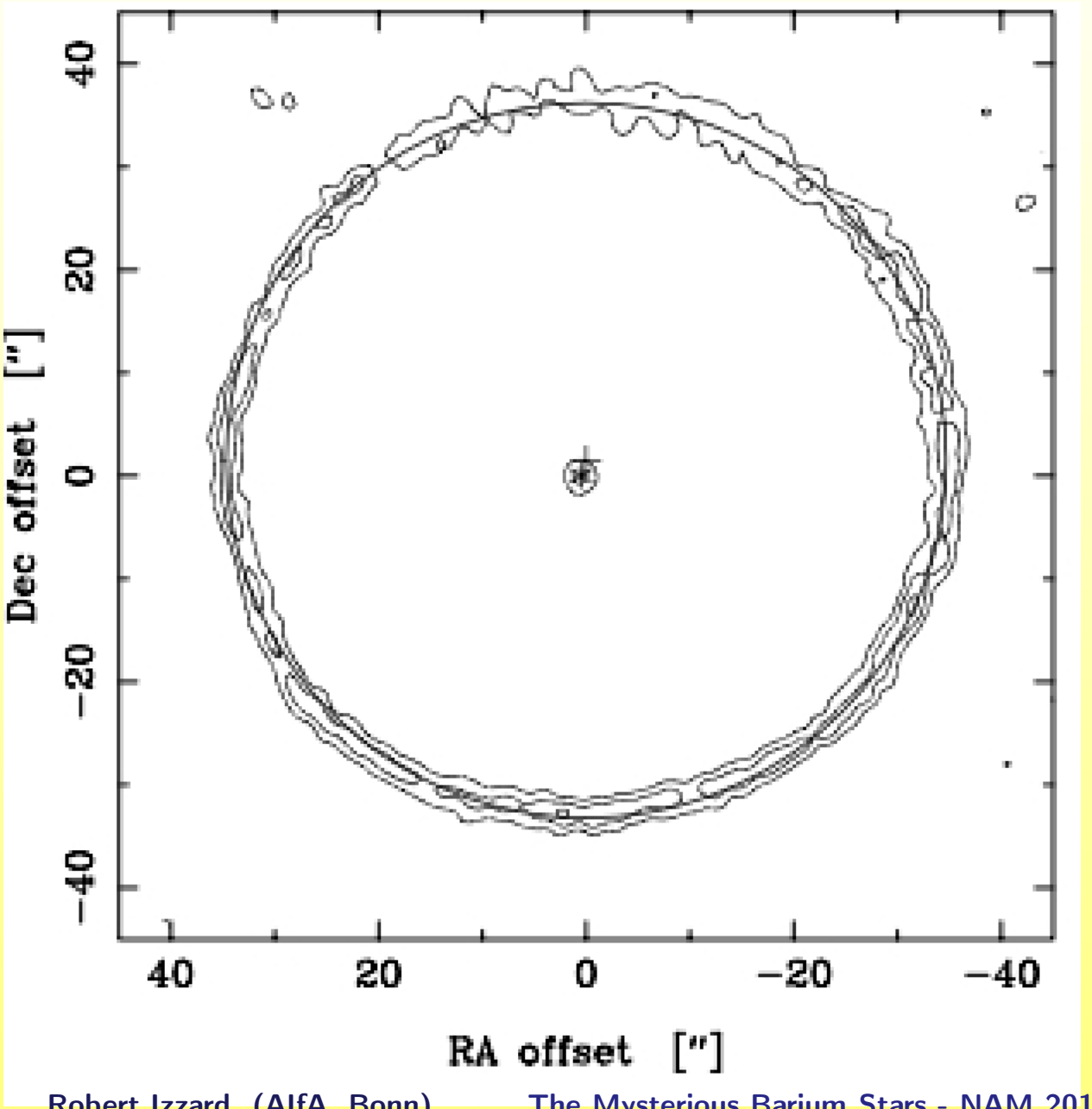
Globular Cluster models



Kick Implications: PNe (TT Cygni in CO)



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



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 γ prescription $\rightarrow$similar!
- Only for $\mathrm{P} \lesssim 2000\,\mathrm{days}$

Angular momentum?

- Huang 1956:
  - *when the lost mass is collected by the secondary component, the major axis will decrease*
- $$\dot{J}_{orb} \propto \left(-|\dot{M}_1| - \frac{M_2}{M_1}|\dot{M}_2| \right)$$
- Second term **large** for efficient accretion!
- $$\dot{J}_{orbit} = l\frac{J_{orbit}}{M_1+M_2}(\dot{M}_1 + \dot{M}_2) \quad (l \gtrsim 2)$$
- Alternatively:
  - magnetic braking
  - disc mass loss?

Efficient accretion: Mira