Mass Transfer in Symbiotic Binaries

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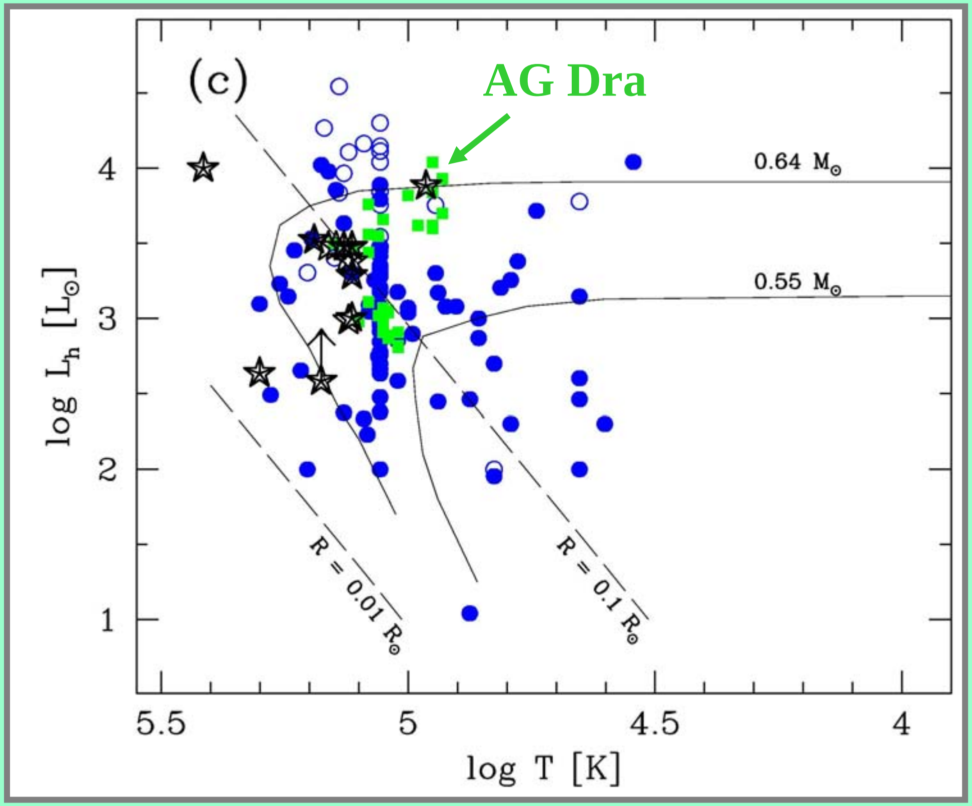
Symbiotic stars

- Accreting white dwarf
  majority
- Neutron star
- Disk-accreting MS star?
- Black hole?
  a few

S(stellar)
normal giant
80%
$M_g \sim 10^{-7}\ M_{sun}/yr$
$P_{orb} \sim 1\text{-}15\ yr$

D(dusty)
Mira + dust evelope
20%
$M_g \sim 10^{-5}\ M_{sun}/yr$
$P_{orb} > 50\ yr$

The hot component



Quiescence:

•Overlap with central stars of PNe

•TNR-powered white dwarfs

•Stable /quasi-stable H-shell burning of the accreted matter or very slow TNR on low mass wd's

•Galactic and MC SyS overlap in HR diagram; MC systems are among the hottest and brighest systems

However:

Far UV SEDs for RW Hya, SY Mus and EG And indicate much lower T than emission lines (Sion et al. 2002, 2004)

The hot component activity:

•Symbiotic novae (AG Peg, RX Pup + 6);
both S- and D-type

•Symbiotic RNe (RS Oph,T CrB +2):
repeated TNR nova outbursts ; high & low states at quiescence

•Stable (RW Hya, SY Mus) – must accrete ~10^{-8} M_{sun}/yr
or extremely slow symbiotic novae:
both S- and D-type; majority?

•Multiple outbursts Z And-type: large changes inTeff at nearly constant L

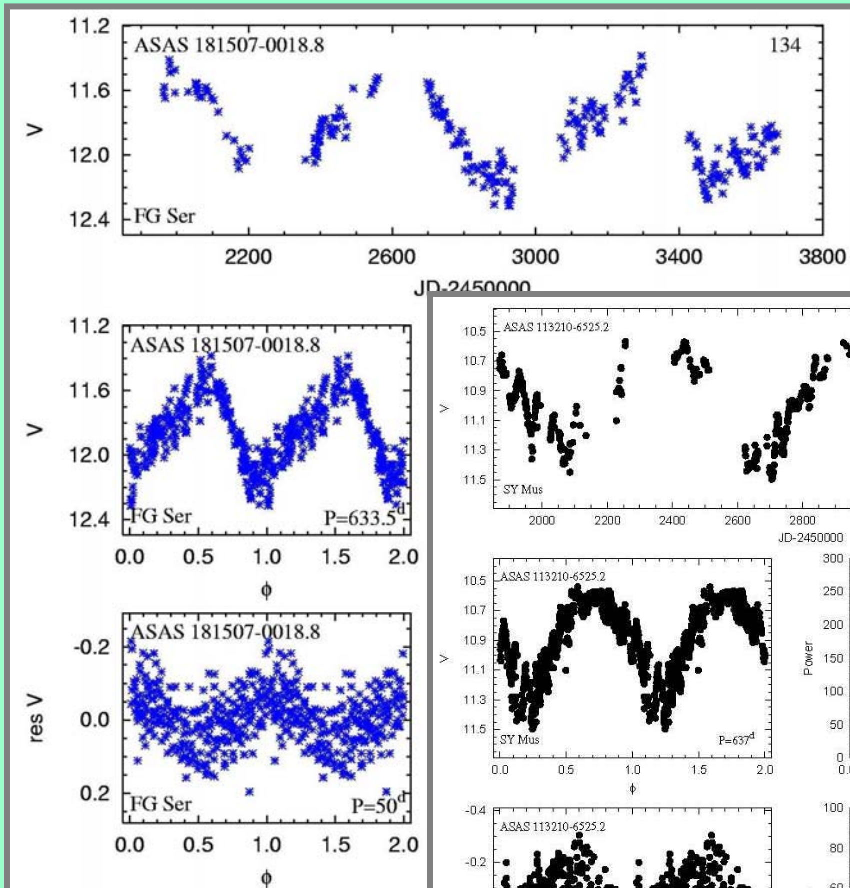
only S-type?

combination-nova scenario: accretion disc instability on more or less stably burning WD
(JMik 2001; 2002; Sokolski et al. 2005)

The link between the SyRNe & Z And-type symbiotics

- Both the activity of Z And-type SyS and the high & low states of SyRNe due to unstable disc-accretion onto WD
- The WDs in Z And-type SyS burn the accreted hydrogen more or less stably wheras in SyRNe they don’t

The cool giant



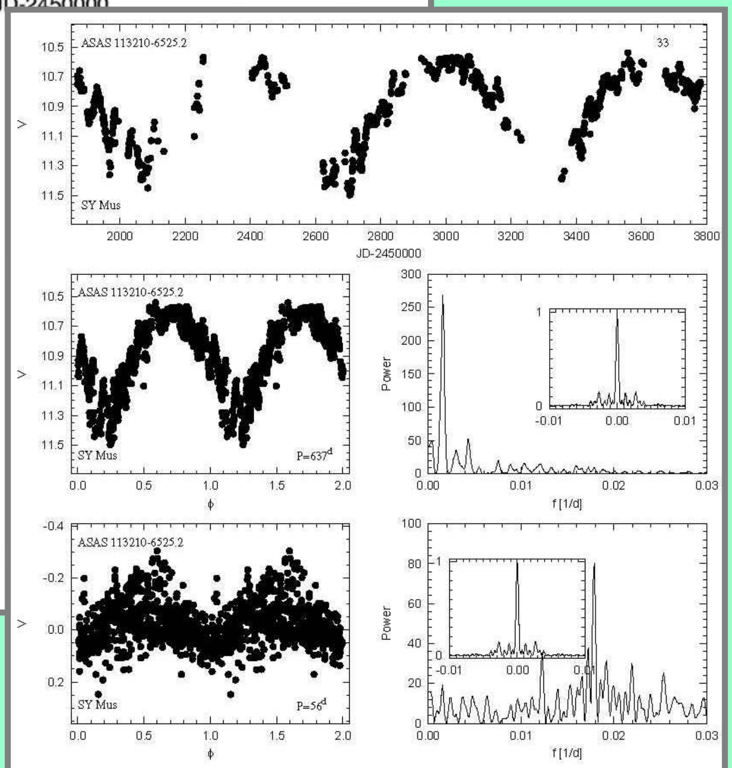


Figure 6: Light curves of .

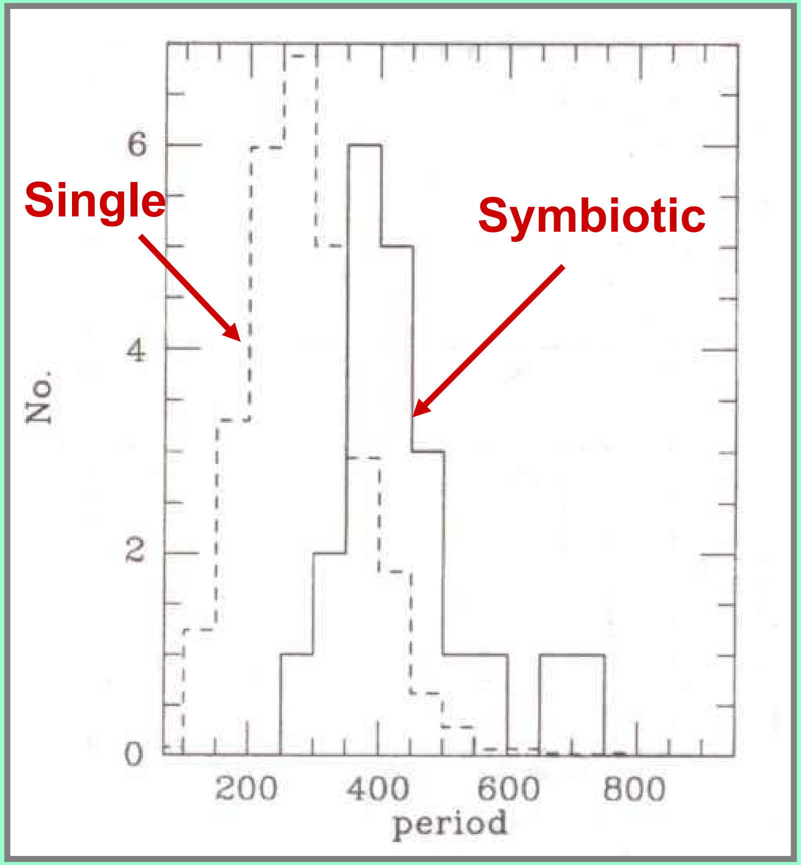
S-types:

Sp types M3-M6, with a peak at M5

Most contain SRb variables & thus may have mass loss rates ~a few 10^{-7} M_{sun}/yr

(Gromadzki et al. 2006)

Symbiotic Miras



- Longer pulsation periods
- Optically thick dust envelopes
- Higher mass loss rates, 10^{-6}-10^{-5} M_{sun}/yr, as compared to average field LPVs, 10^{-7} M_{su}n/yr
- Dust obscuration in RX Pup and other symbiotic Miras can be related to intensive and variable mass loss

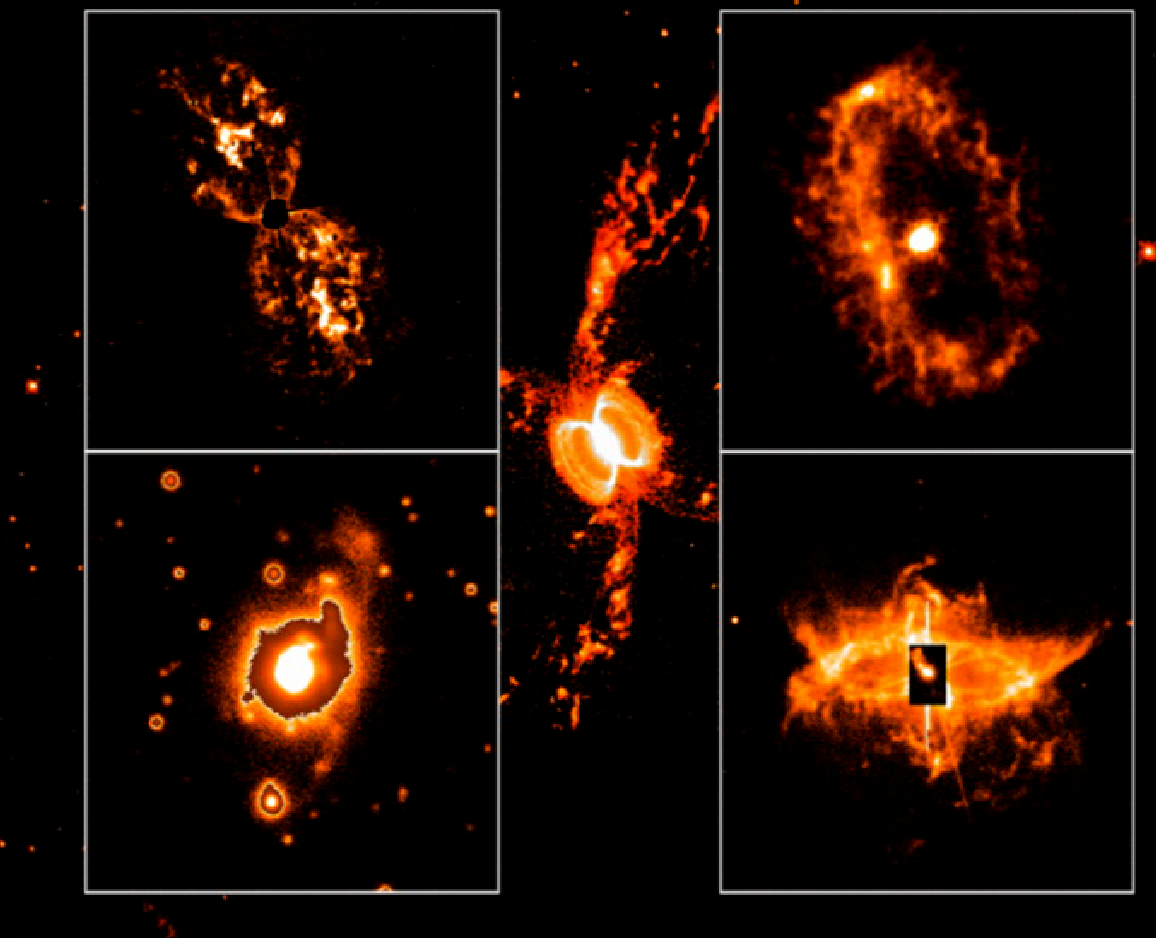
The cool giant

Large radius & high mass loss from the red giant are the key parameters for triggering the symbiotic phenomenon

Mass transfer in symbiotics

3D HD models: the cool giant wind must be focused towards the orbital plane

(Mastrodemos & Morris 1998, 1999; Gawryszczak et al. 2002, 2003):



In agreement with observations:

- **resolved nebulae in D-types** (e.g. Corradi 2003)
- **spectroscopic evidence for jets & bipolar outflows in active S-types** (e.g. Tomov 2003)

Mass transfer in S-type symbiotics:

via stellar wind?

YES (Nussbaumer & Co), because:

Sp types, *v*sin*i* indicate R_g ~0.4-0.5 R_{RL}
no evidence for ellipsoidal variability,

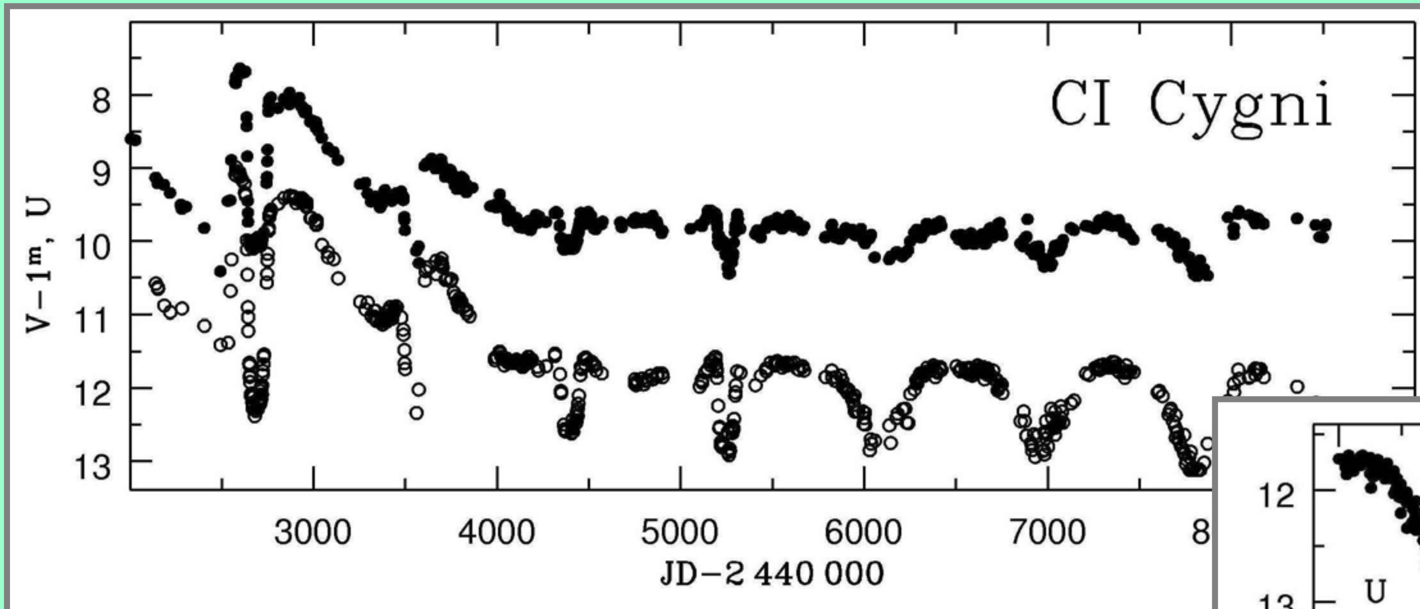
or

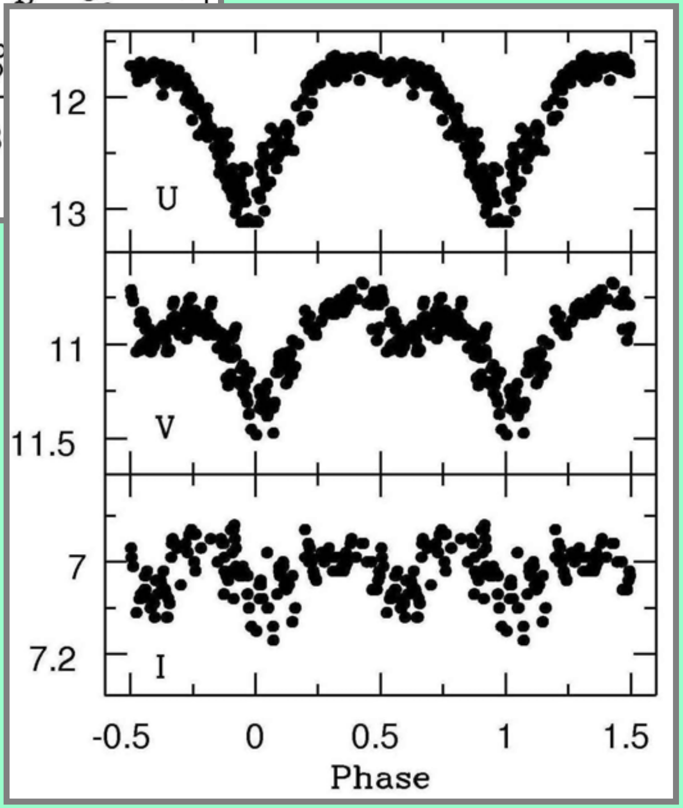
Roche lobe owerflow?

YES in multiple outburst systems (JMik et al. 2001; 2002, etc...)

need red/near-IR photometry at quiescence to see the ellipsoidal variability

Multiple outburst symbiotics



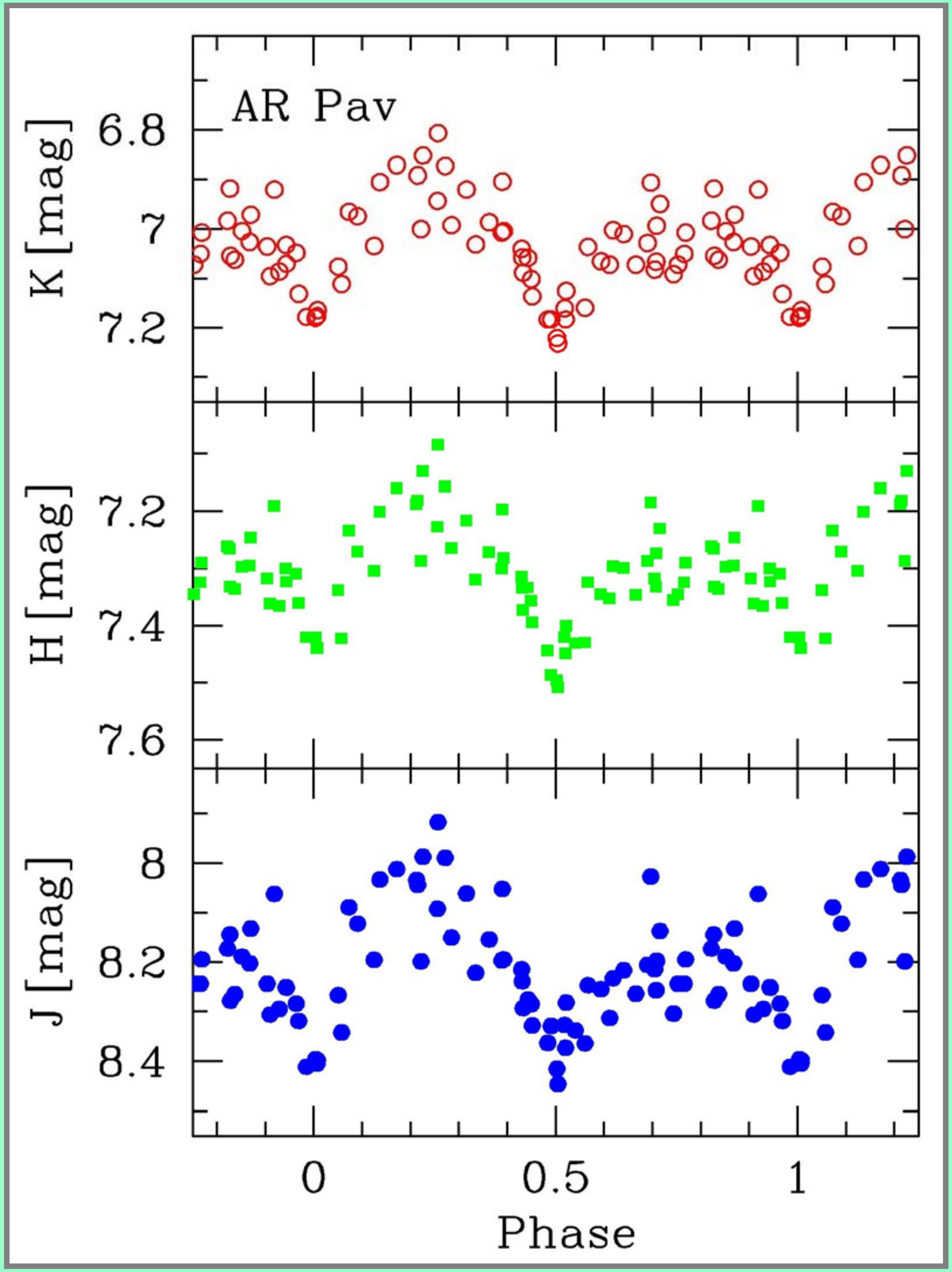


CI Cyg: quiescent LC (Mik 2001)

sinusoidal

but

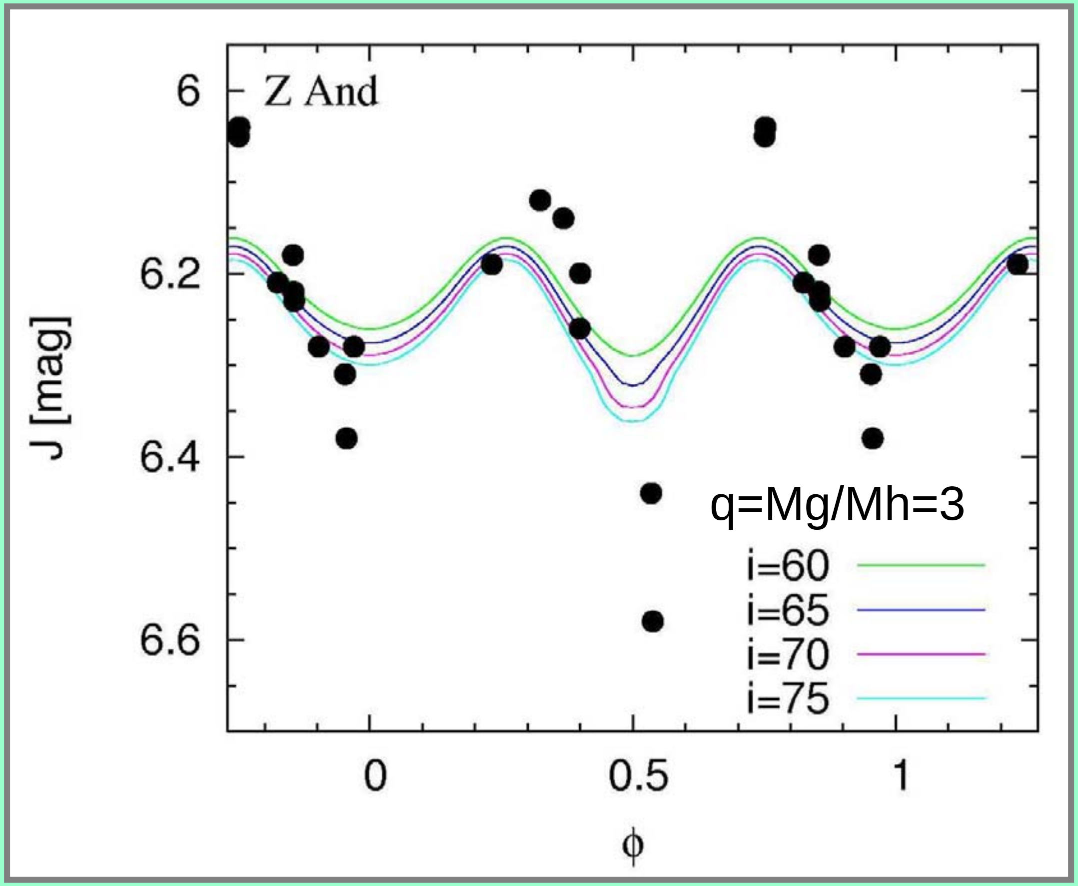
with P_{orb} in U & $P_{orb}/2$ in VRI…



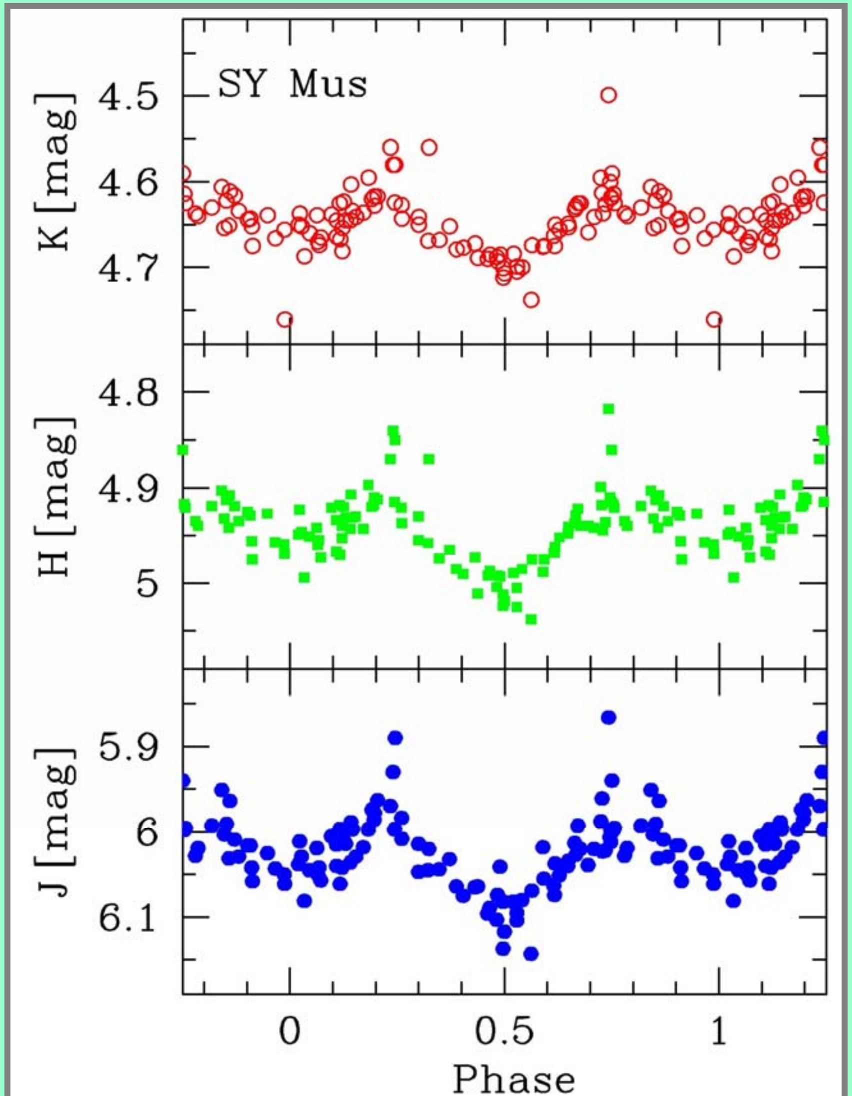
AR Pav

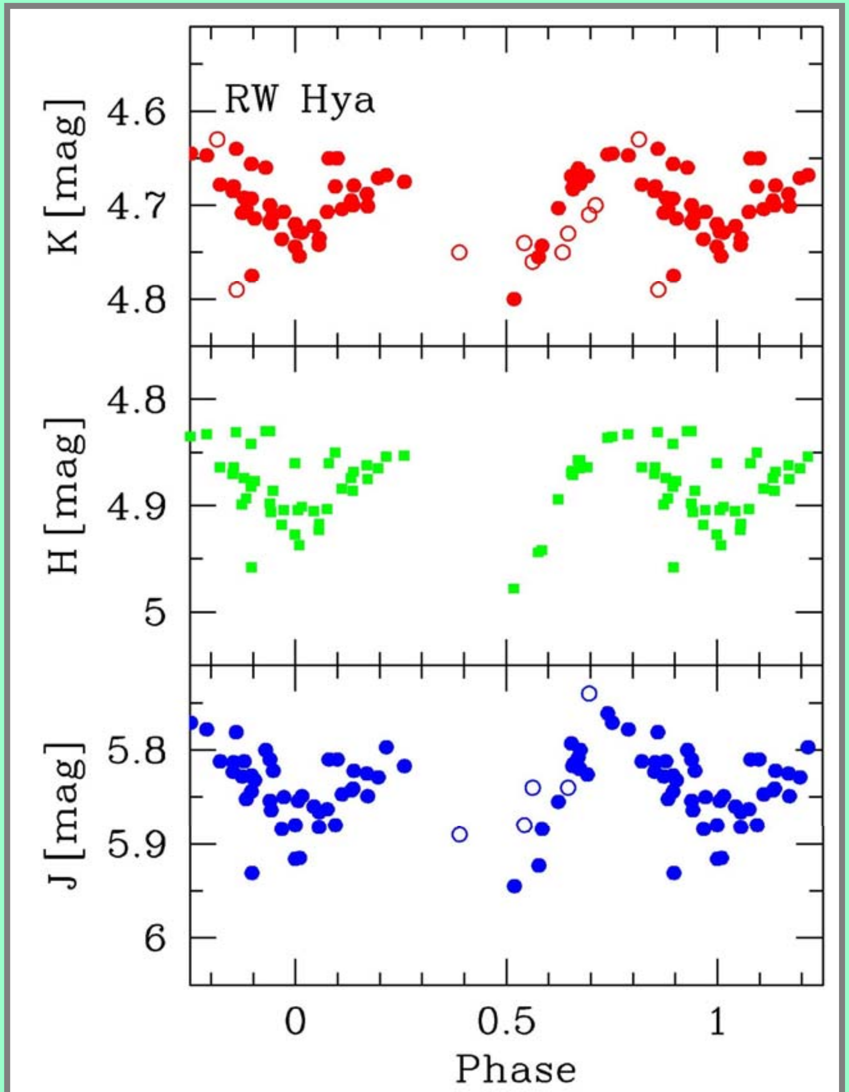
- A/F continuum most of time
- Secondary P, also visible in JHK ...

Z And



… and even my best examples of the stable SyS!!!





T CrB

Roche lobe filling giant

$q = M_g / M_h \sim 0.6$

$i \sim 60$

Belczynski & Mikołajewska 1998

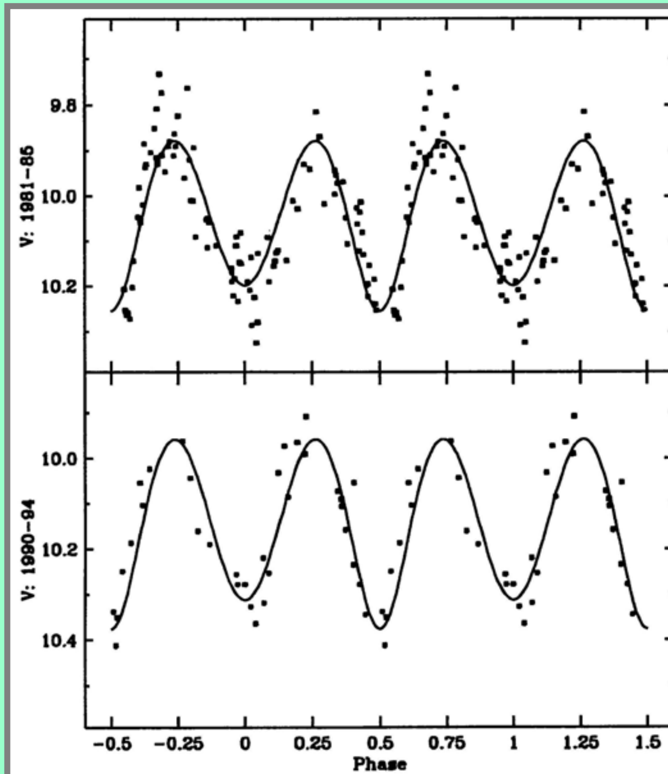


Figure 2. Synthetic *V* light curves for the model with $q=0.6$, $i=60°$, $\alpha=0.95$ and $e=0.0$.

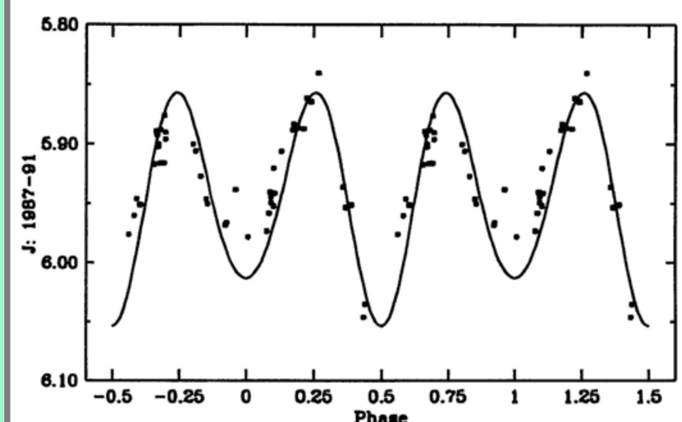
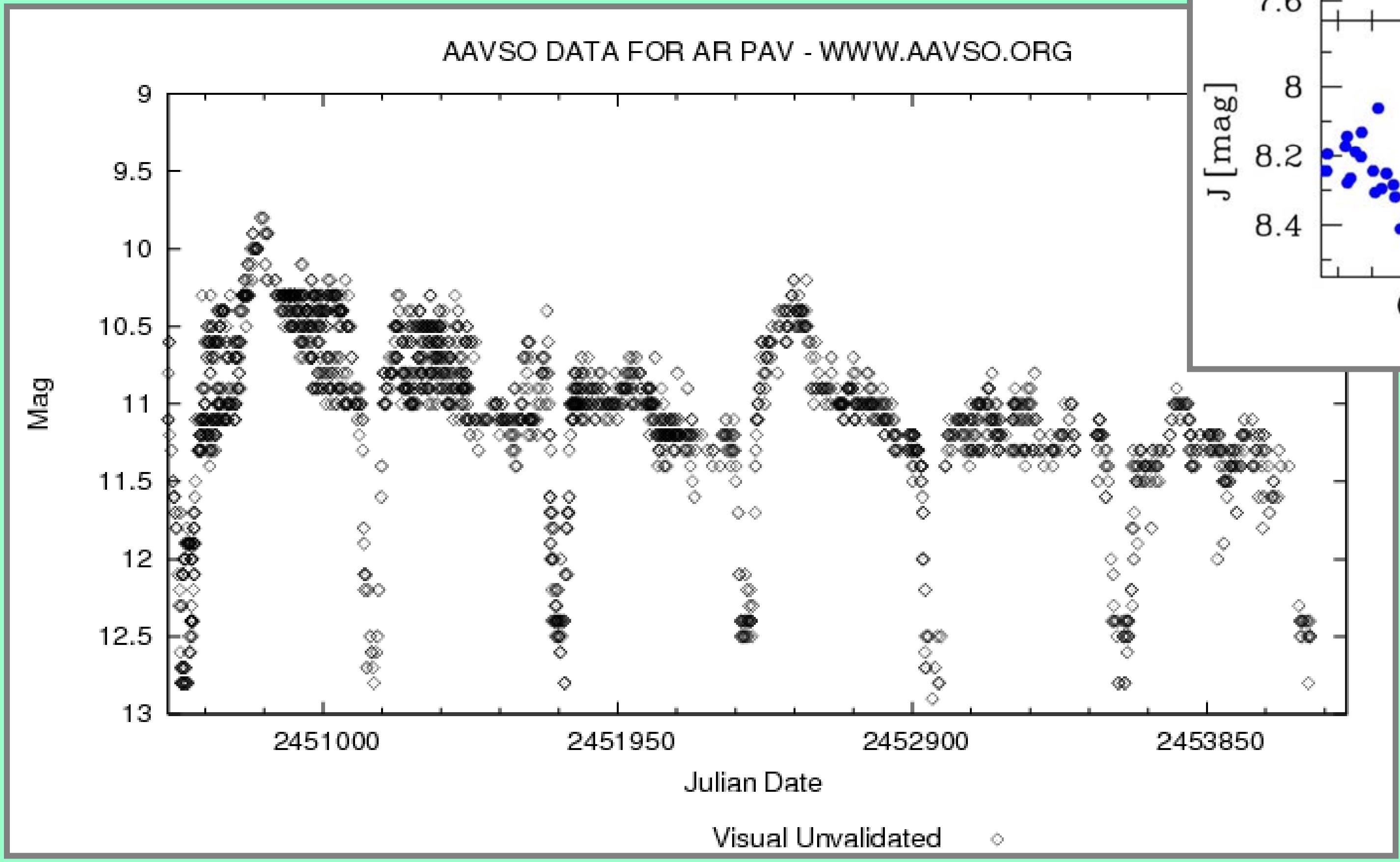
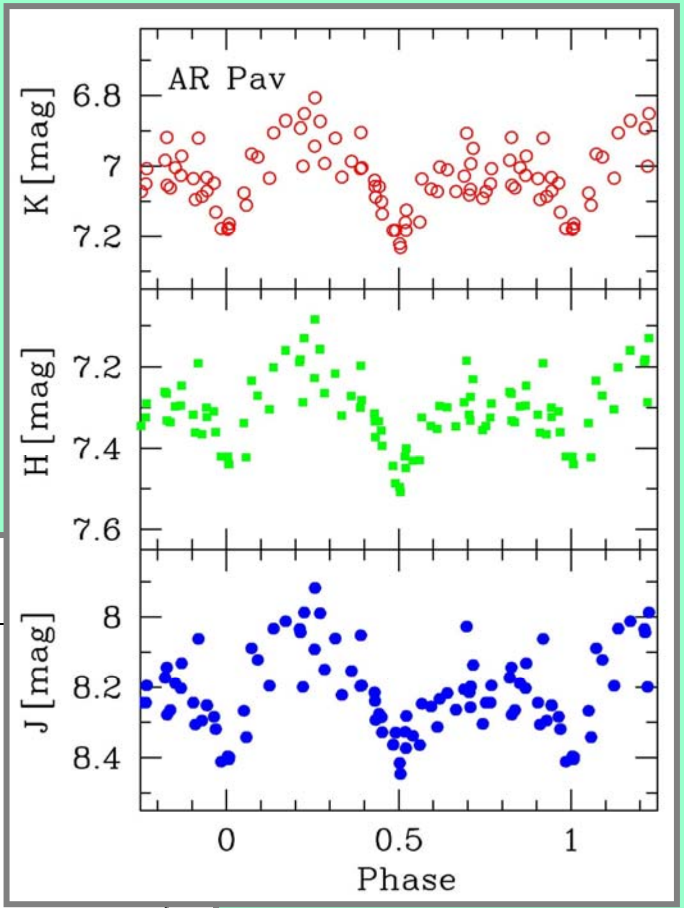


Figure 3. Synthetic *J* light curve for the model with $q=0.6$, $i=60°$, $\alpha=0.32$ and $e=0.0$.

AR Pav:

A moving bump veils the secondary minimum in the visual LC…

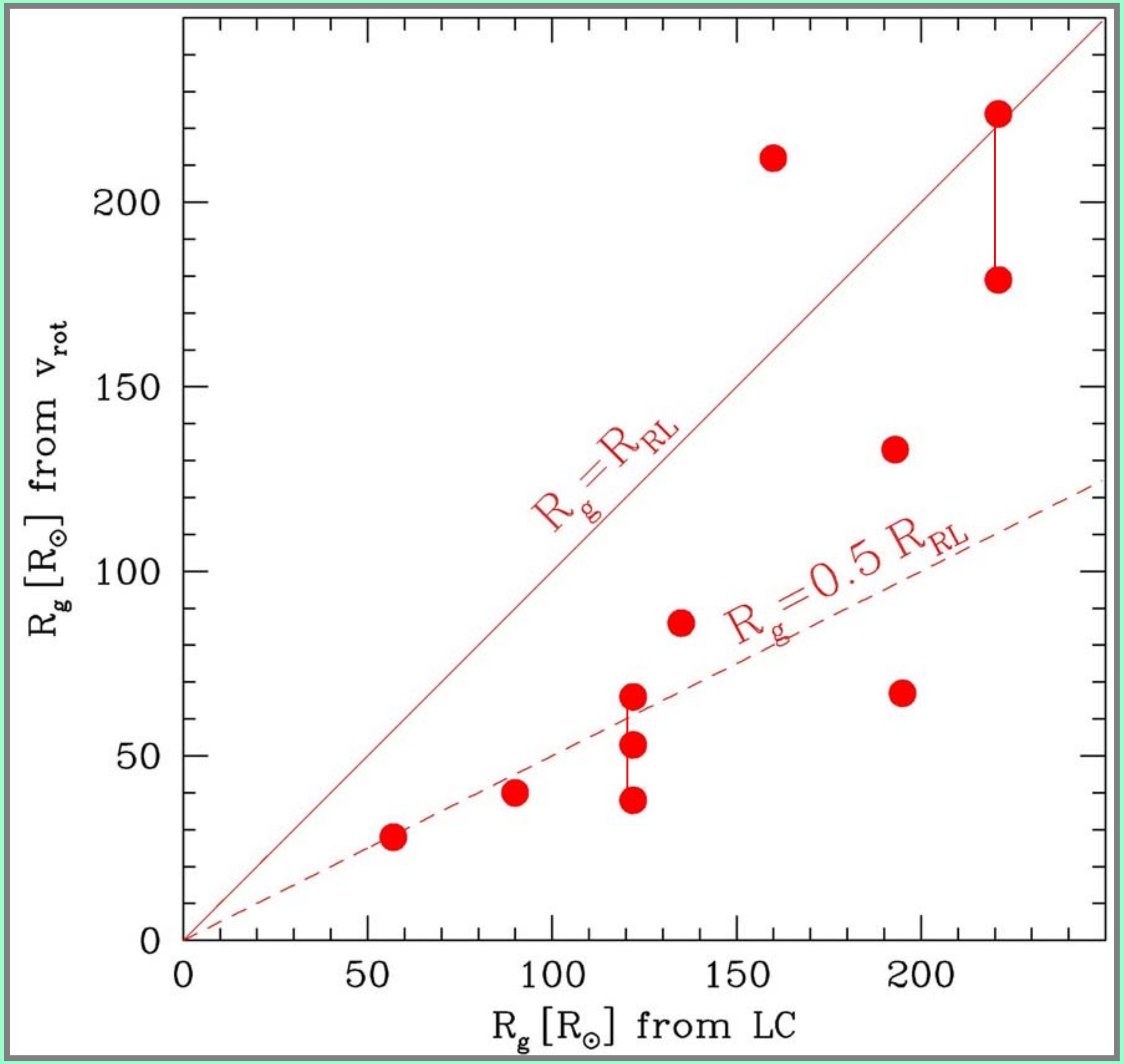




Ellipsoidal variability in SyS:

- Absent in symbiotic novae (AG Peg)
- Present in *all* (i>60; LC available) multiple outburst (Z And-type) SyS at quiescence (VRI) and activity (near-IR)
- Present at least in some steady SyS (near-IR)
- Present in SyRN T CrB; need near-IR for RS Oph
- All 12 SyS with ellipsoidal variability have P_{orb} <1000^{d} and circular (e~0) orbits except BX Mon

The RG radius – *v*sin*i* problem



What about the radius/v sin i ?

- Asynchronous rotation?

seems unlikely because of circular orbits

- RL shinkage (up to 2-3 times!) expected in luminous stars with strong winds if some force drives the mass loss & almost compensates the gravity (e.g. Schuerman 1972)

very promising in Sys with strong (10^{-7} M_{sun}/yr) and nearly constant speed winds

Main points:

- Both the symbiotic giants and Miras have higher mass loss rates than single giants or field Miras: only very evolved giants with high mass loss can support symbiotic behaviour or/and the binarity enhances the mass loss
- There is strong evidence for a flattened mass loss geometry
- RLOF can be quite common in S-type SyS. In particular, tidally distorted red giants and RF owerflow are present both in active and stable S-type systems as well as in the SyRNe.
- Both the activity of Z And-type SyS and the high & low states of SyRNe are due to unstable disc-accretion onto WD. However the WDs in Z And-type SyS burn the accreted hydrogen more or less stably wheras in SyRNe they don't
- Far UV SEDs inconsistent with em line fluxes in stable SyS may indicate the presence of accretion dics