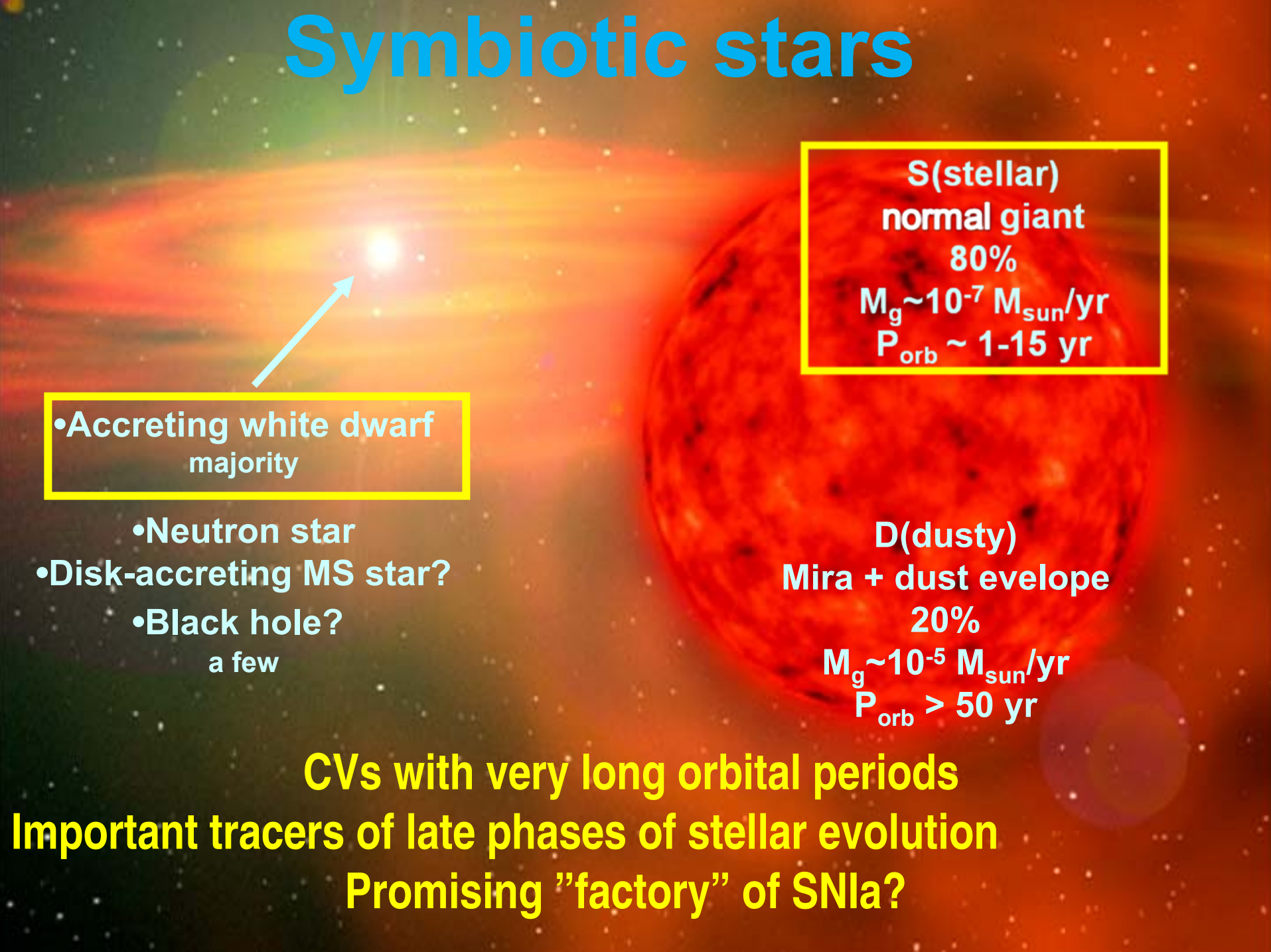




Mass transfer and accretion in symbiotic binaries

**Joanna Mikołajewska
Copernicus Astronomical Center
Warsaw, Poland**

Symbiotic stars



The background image shows a large, textured red giant star on the right and a smaller, bright white dwarf on the left. A white arrow points from the white dwarf towards the red giant, indicating the direction of accretion. The space between them is filled with a glowing, orange-red nebula.

•Accreting white dwarf
majority

- Neutron star
- Disk-accreting MS star?
- Black hole?
a few

S(stellar)
normal giant

80%

$M_g \sim 10^{-7} M_{\text{sun}}/\text{yr}$

$P_{\text{orb}} \sim 1-15 \text{ yr}$

D(dusty)
Mira + dust envelope

20%

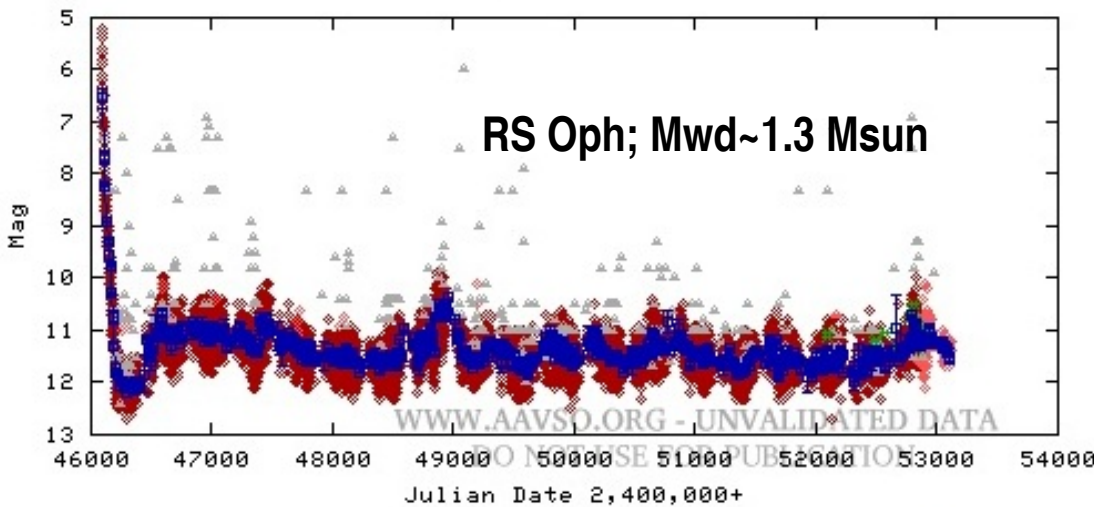
$M_g \sim 10^{-5} M_{\text{sun}}/\text{yr}$

$P_{\text{orb}} > 50 \text{ yr}$

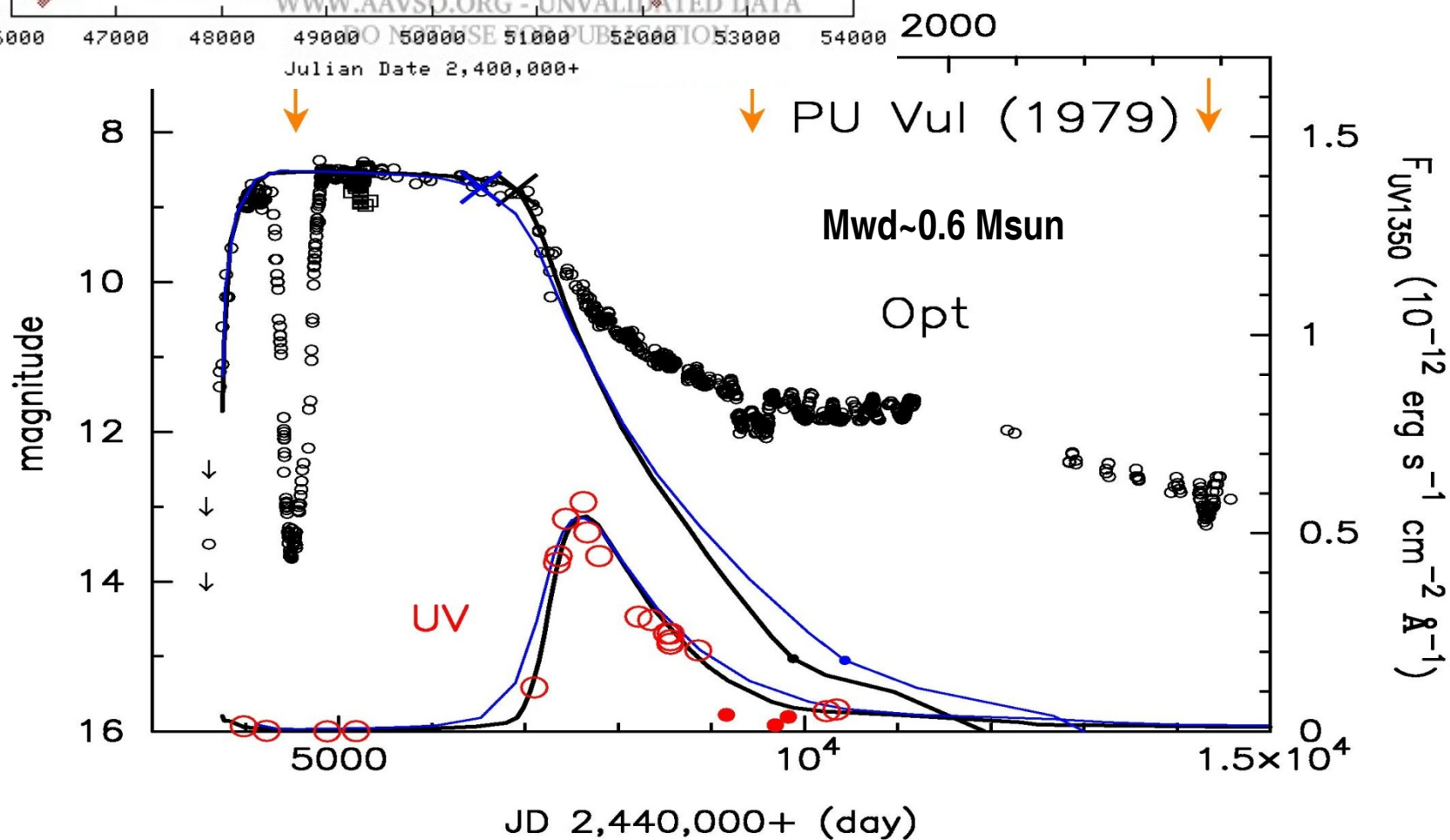
CVs with very long orbital periods

Important tracers of late phases of stellar evolution

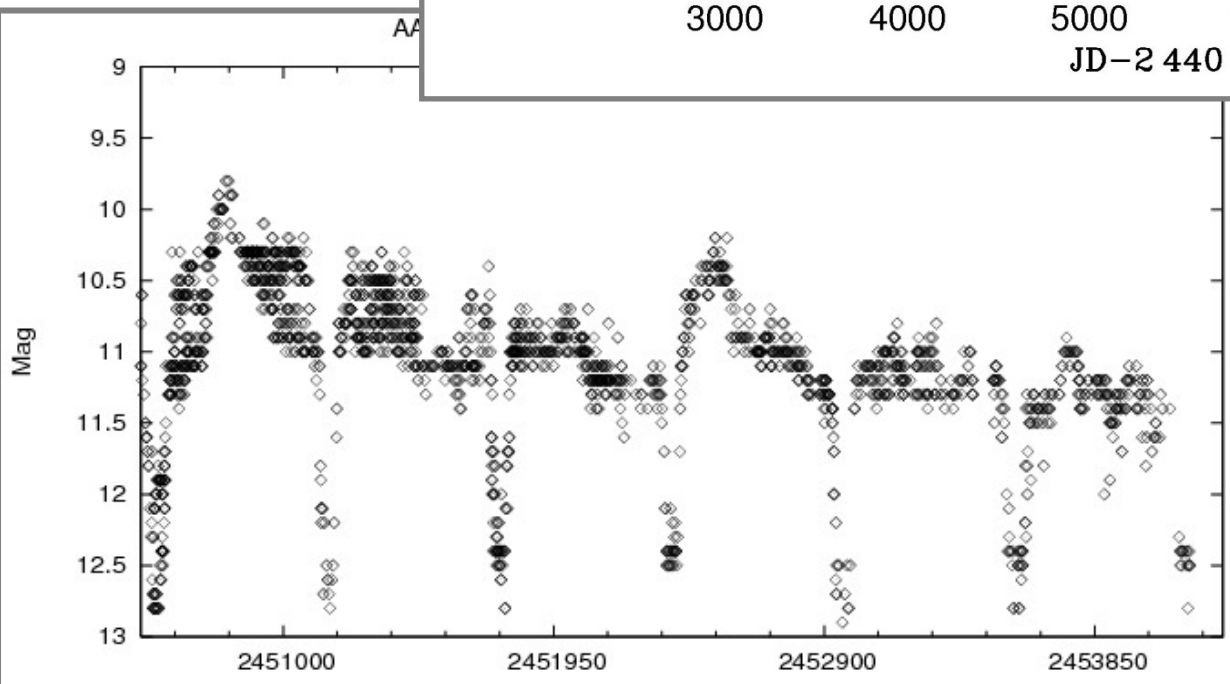
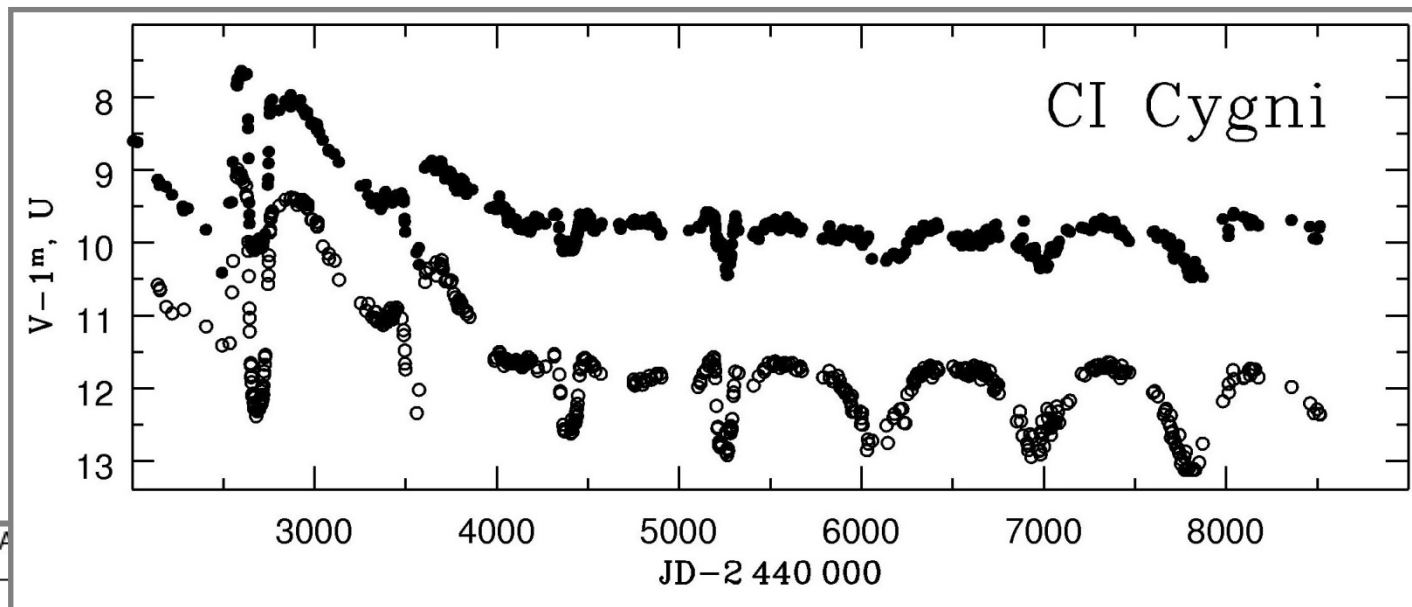
Promising "factory" of SNIa?



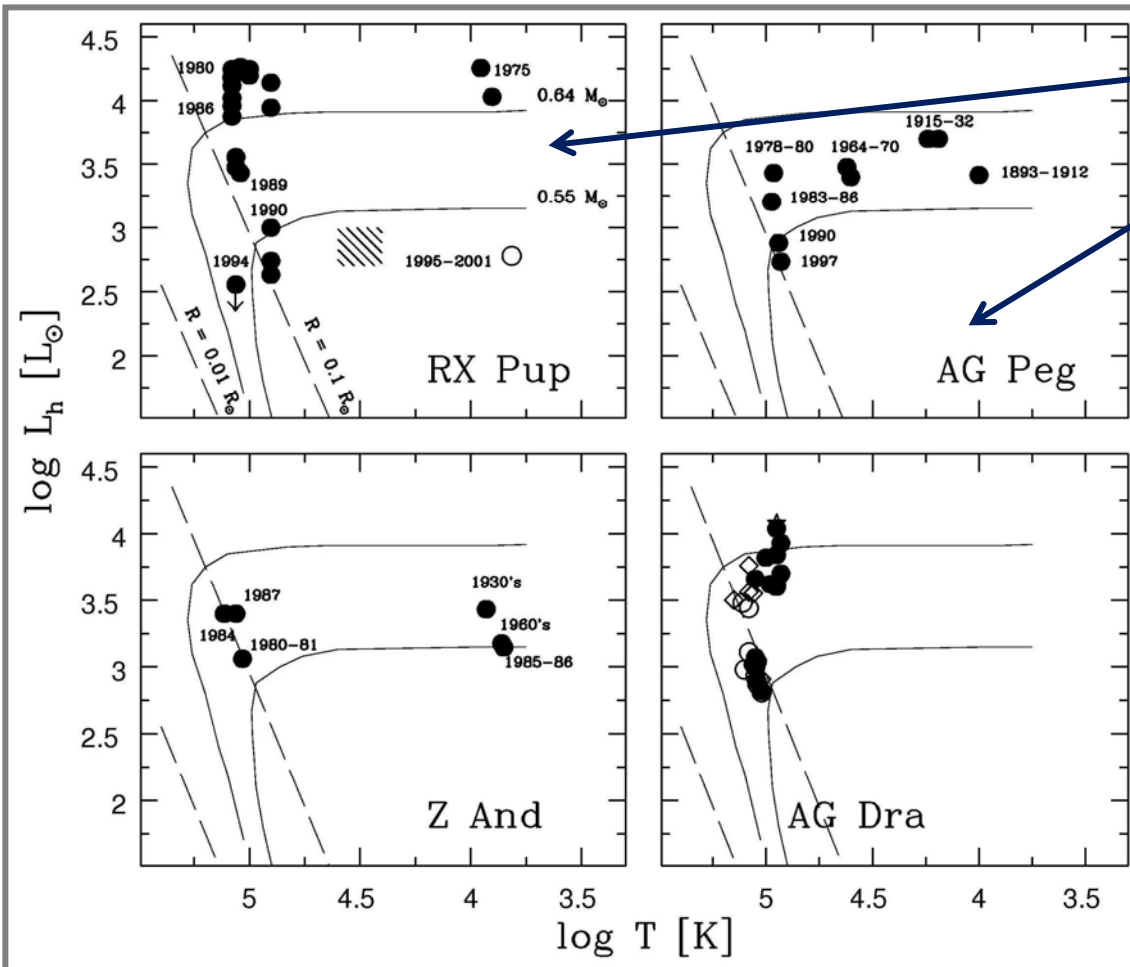
Light curves



Multiple outburst Z And-type activity



The HC outburst behaviour



• **Symbiotic novae (SyNe)**
(AG Peg, RX Pup + 8);
both S- and D-type

& Recurrent Ne
(T CrB, RS Oph, V745 Sco
& V3890 Sgr)
only S-type?

• **Stable (RW Hya, SY Mus) –**
must accrete $\sim 10^{-8} M_{\text{sun}}/\text{yr}$ or
extremely slow SyNe:

both S- and D-type
majority?

• **Multiple outbursts Z And-type:**
 $L_{\text{out}} \sim L_{\text{quiet}}$ within a factor of 2-3
only S-type
how many?

Multiple outburst Z And-type activity

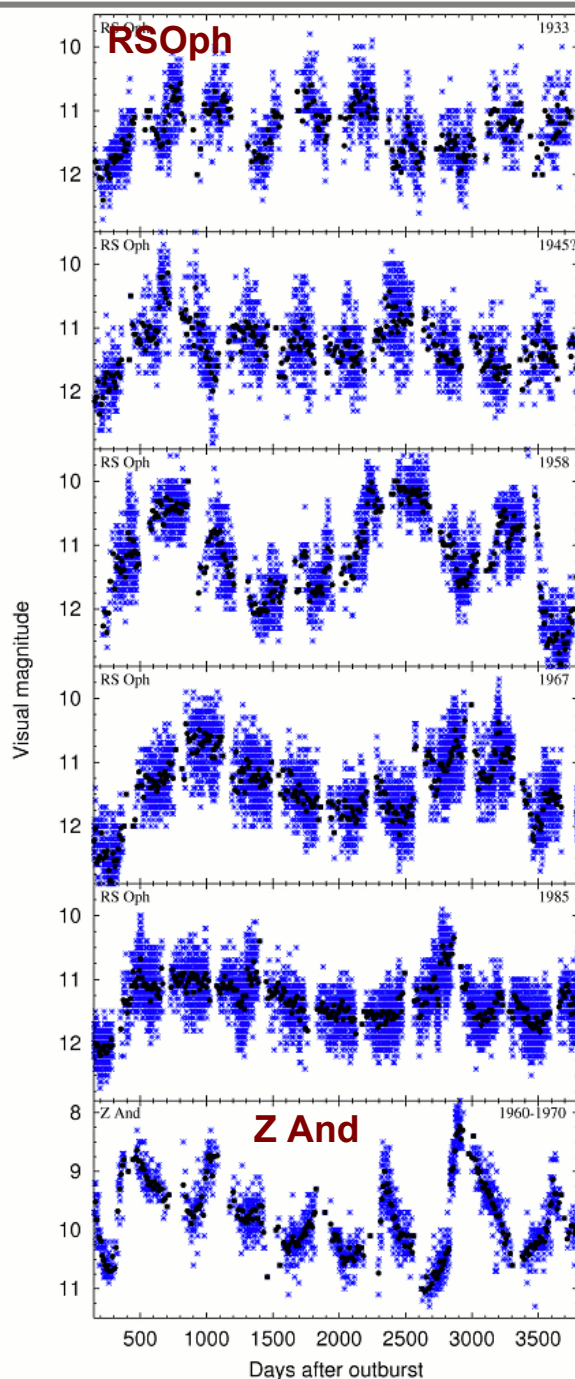
- Timescales ~ a few yr, optical amplitudes ~1-3 mag, $t_{\text{rec}} > 10$ yr;
 $L_{\text{out}} \sim L_{\text{quiet}}$ within a factor of 2-3
- Ellipsoidal, $H/R < 0.5$, B/A/F continuum source during outburst, in some permanently present (e.g. AR Pav, FN Sgr, BX Mon, etc.)
- Narrow eclipses during outburst and sinusoidal changes at quiescence
- Double-temperature structure: UV/optical emission lines require a much hotter source with L comparable to that of the B/A/F continuum
- Moving humps/secondary periodicity, ~10-15% shorter than P_{orb} visible in the optical and near-IR
- Jets/bipolar outflows associated with outbursts

Can be explained by 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

Z And-type outburst activity between the nova eruptions in RS Oph (Gromadzki et al. (2007))



- 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 whereas in SyRNe they don't

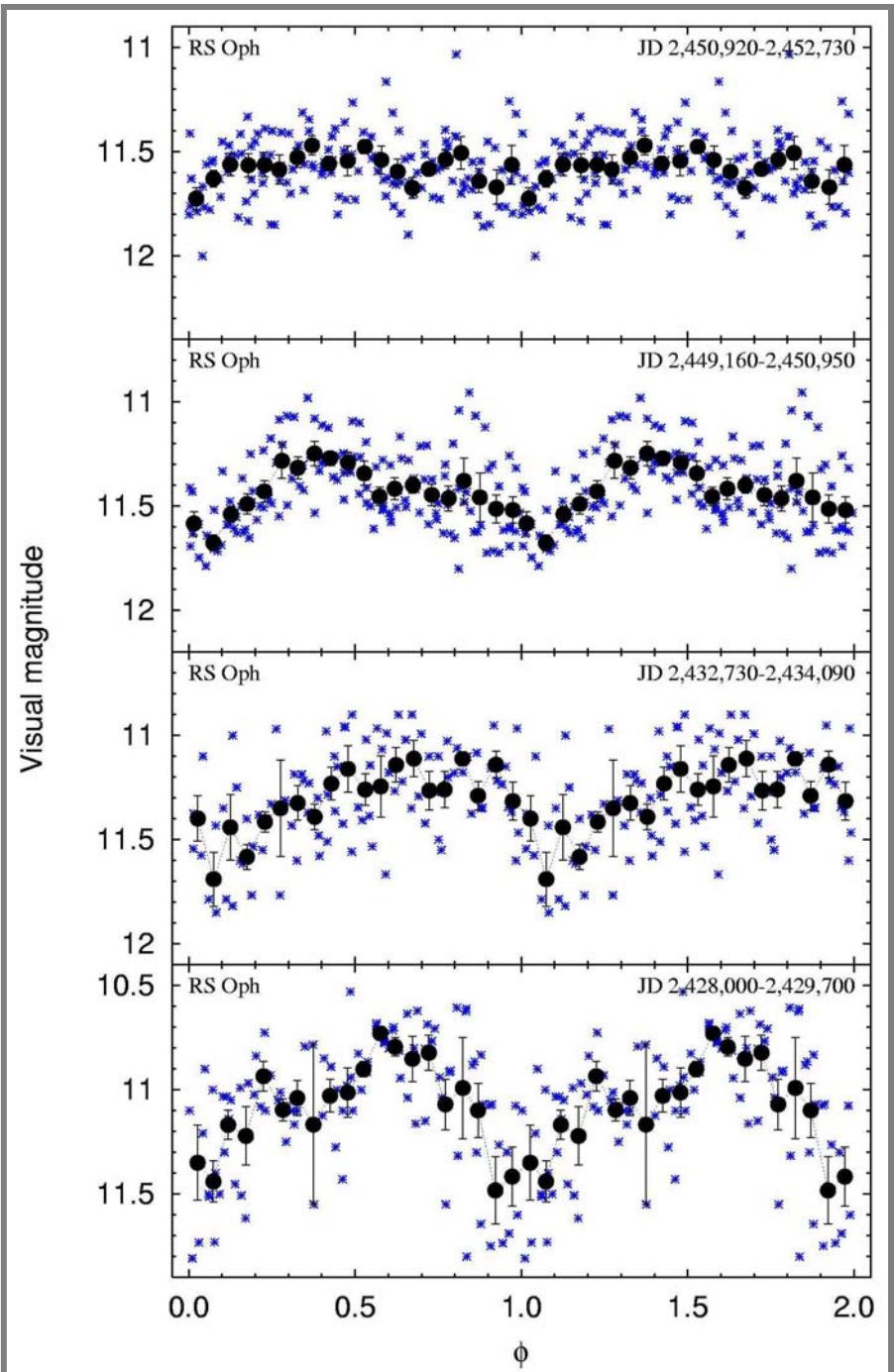
RS Oph

AAVSO data analysed by
Gromadzki et al. (2007)

- Primary minimum at the time of the spectroscopic conjunction with the red giant is in front.
- Secondary minimum veiled by a moving bump?

Moreover,

if synchronuous rotation,
vsini implies RL-filling giant



Mass transfer in S-type symbiotics:

via stellar wind?

YES (Nussbaumer & Co), because:

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

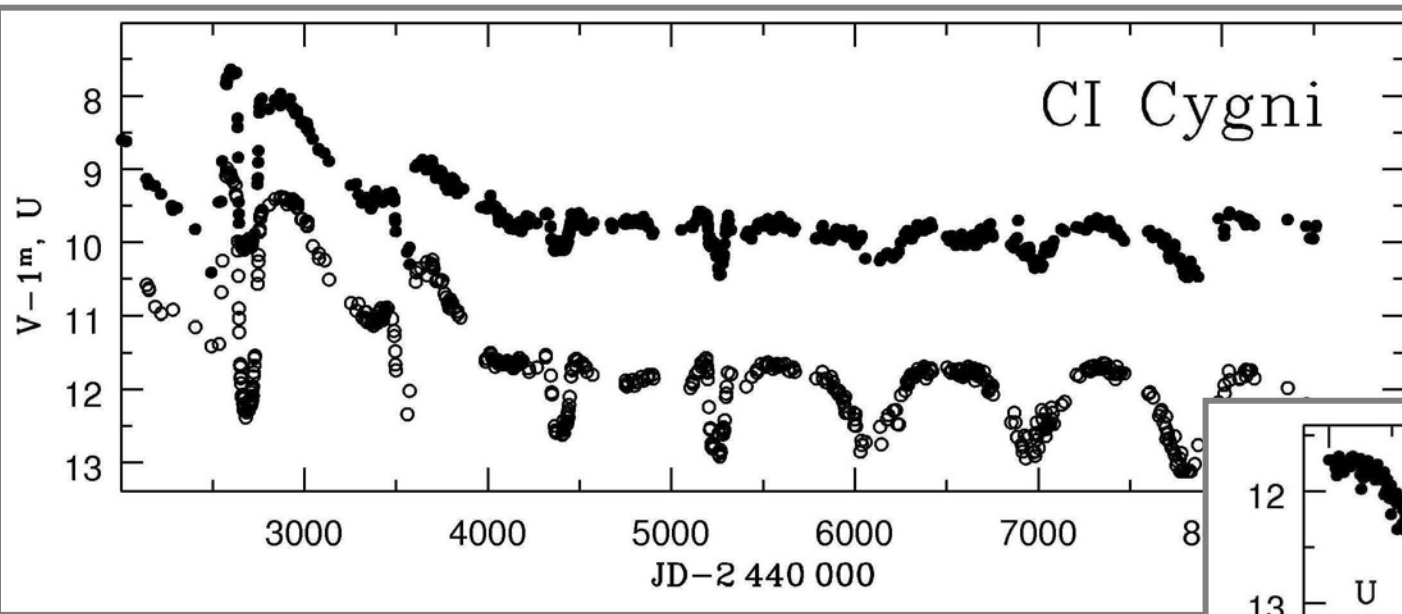
or

Roche lobe overflow?

**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

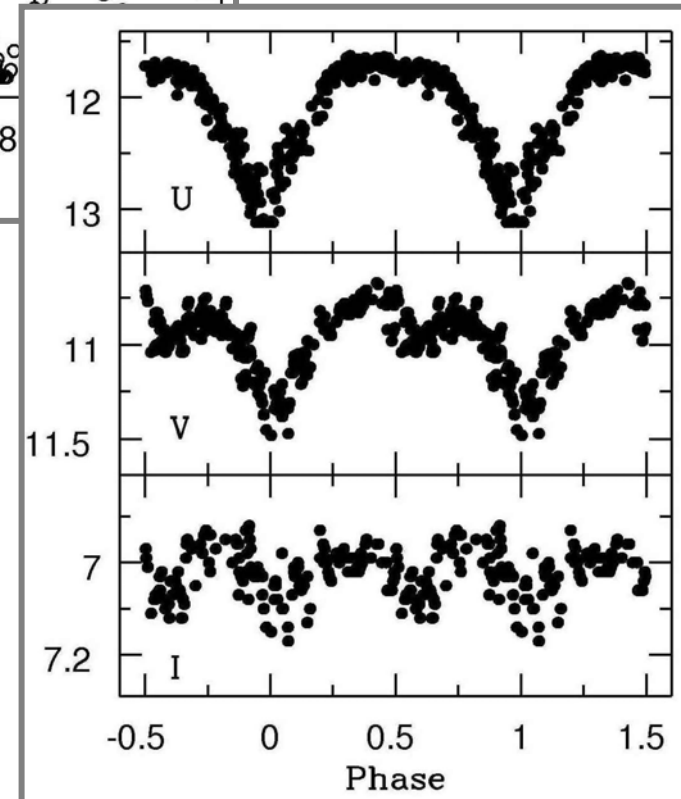


CI Cyg: quiescent LC (Mik 2001)

sinusoidal

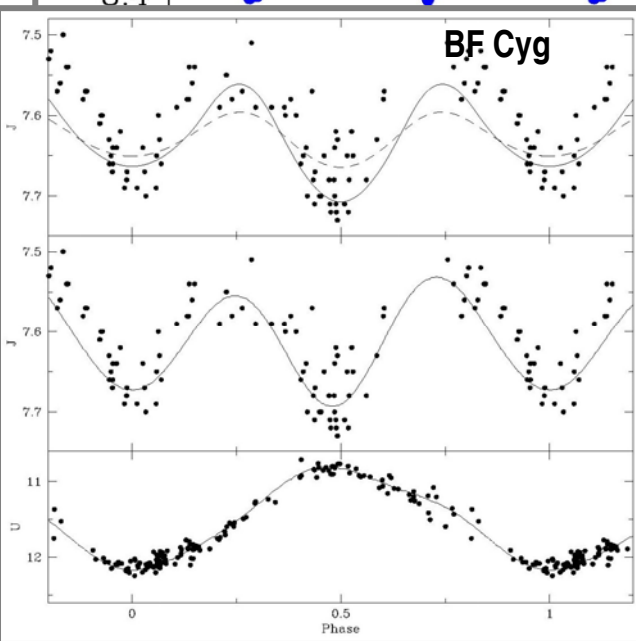
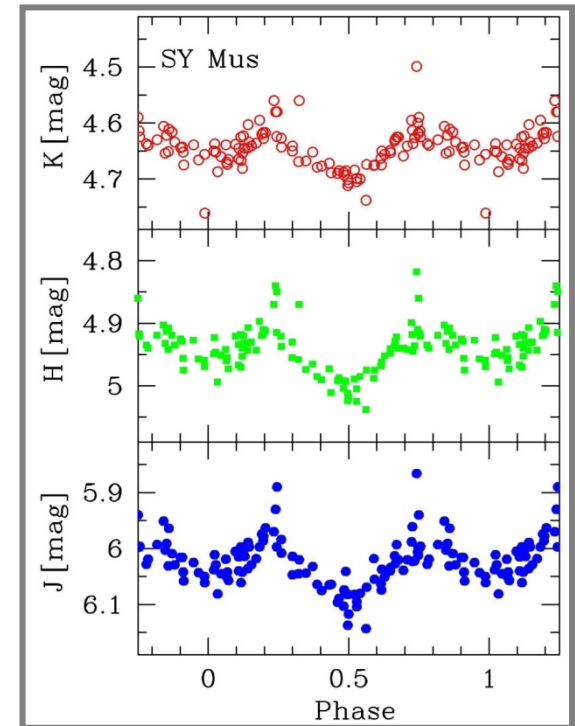
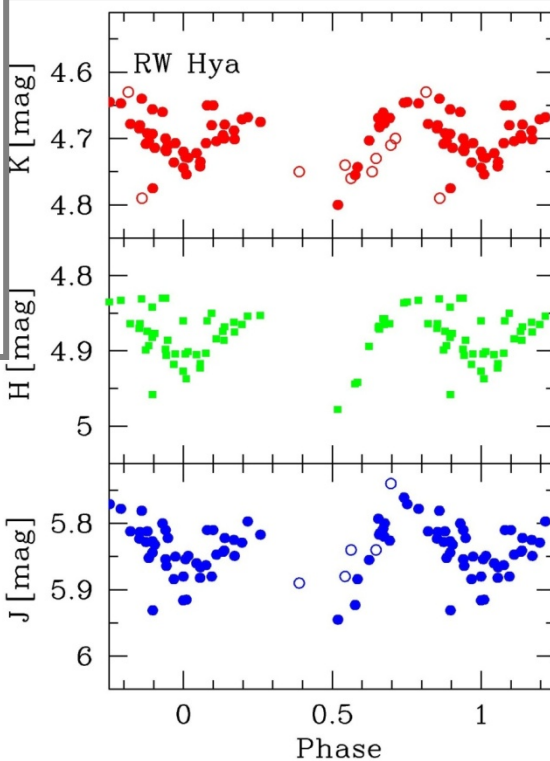
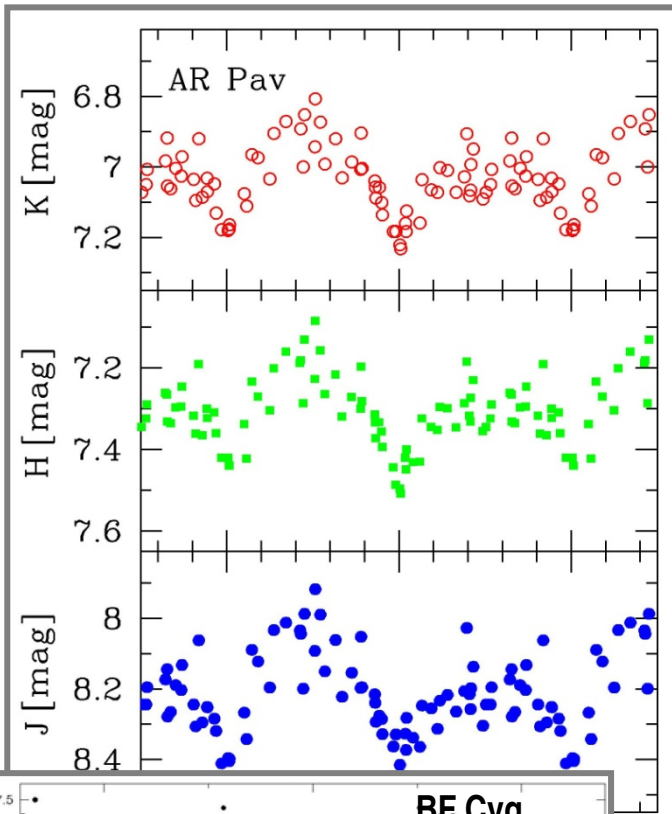
but

with P_{orb} in U & $P_{\text{orb}}/2$ in VRI...



Ellipsoidal variability in symbiotic stars

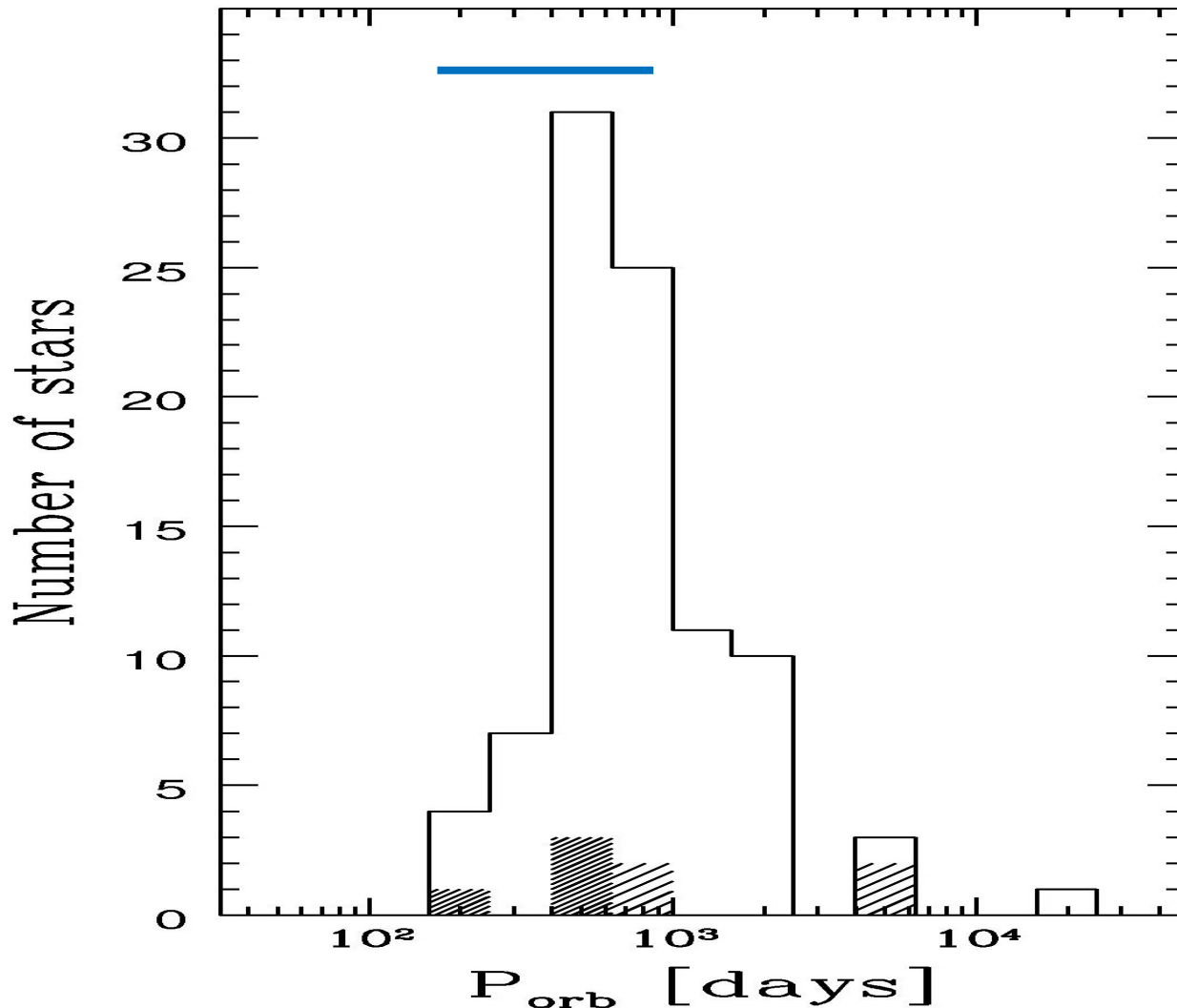
e.g. Mikolajewska et al. 2003; Yudin et al. 2003;
Rutkowski et al. 2007; Gromadzki et al. 2012



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, V745 Sgr, V3890 Sgr; need near-IR for RS Oph
- All 20 SyS with ellipsoidal variability have $P_{\text{orb}} < 1000^{\text{d}}$ and circular ($e \sim 0$) orbits

Orbital periods & mass transfer



**Systems with
 $P_{\text{orb}} < \sim 900\text{d}$:**

- Circular orbits
- $>30\%$ ellipsoidal LCs
- For all systems with $WD > 0.6 M_{\text{sun}}$ the present P_{orb} shorter than $P_{\text{orb,AGB}}$

**RLOF and tidal
interactions important**

Accretion disc models for SyS

- Kuiper 1940; AD around MS star + RL-filling giant in Z And-type
- Bath & Pringle 1982; MTI model with AD around MS for CI Cyg
- Duschl 1986; the LC of CH Cyg & other SyS can be due to time dependent evolution of an accretion disc around MS star;

second unstable branch in S-Mdot curve due to formation/disintegration of molecules (like water) in large and cold discs (expected in symbiotics)

- Plavec & Hubeny 1994; reproduced UV spectrum of CI Cyg with AD around MS but their disk unbelievable thick in the vertical direction ($z/R > 1$ at $R_D \sim 20R_{\text{star}}$!)

- Alexander et al. 2011; AD model for RS Oph

Problems with RLOF in symbiotics

- ALL SyS with ellipsoidal LCs (RLOF?) but the SyRNe have $q = M_g/M_h \sim 2-4 > q_{\text{crit}} \sim 1$ & should be dynamically unstable

Need a new mechanism stabilizing RLOF in SyS

No good solution thusfar proposed ☹️

- In most of these SyS the radii derived from LCs are systematically larger than those derived from $v_g \sin i$ assuming synchronous rotation

Need better theory including effects of wind, pulsation, etc.

Good news: ongoing interferometric observations

- can measure radii of bright SyS;
- ellipsoidal distortion in TCrB maybe detected
- optically thick AD (outburst) should be measurable in near future

Summary

- **Time dependent accretion discs in SyS: very promising explanation for many features**
- **Need extensive theoretical studies**