Symbiotic stars as possible progenitors of SNIa

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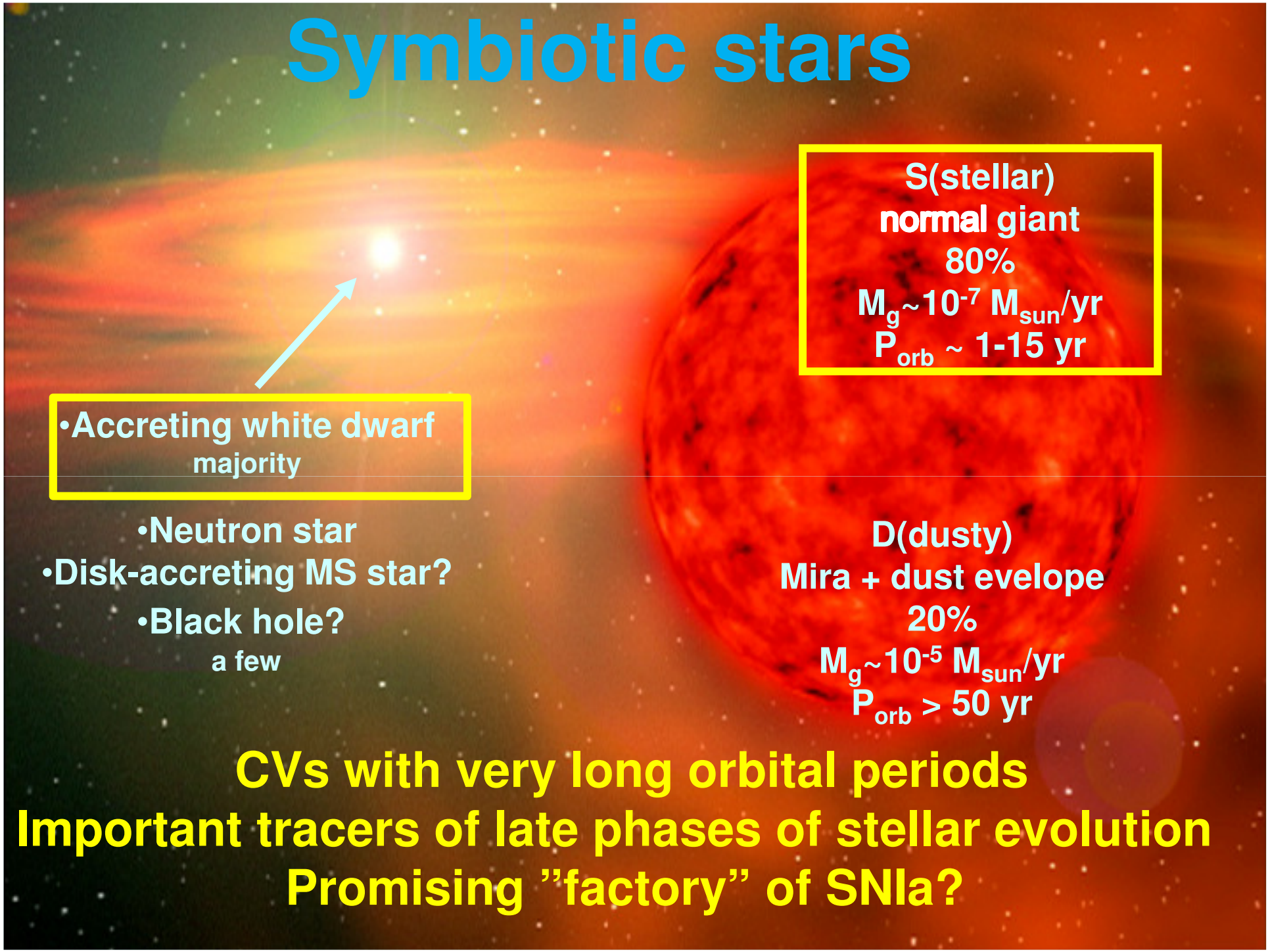
Symbiotic stars



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

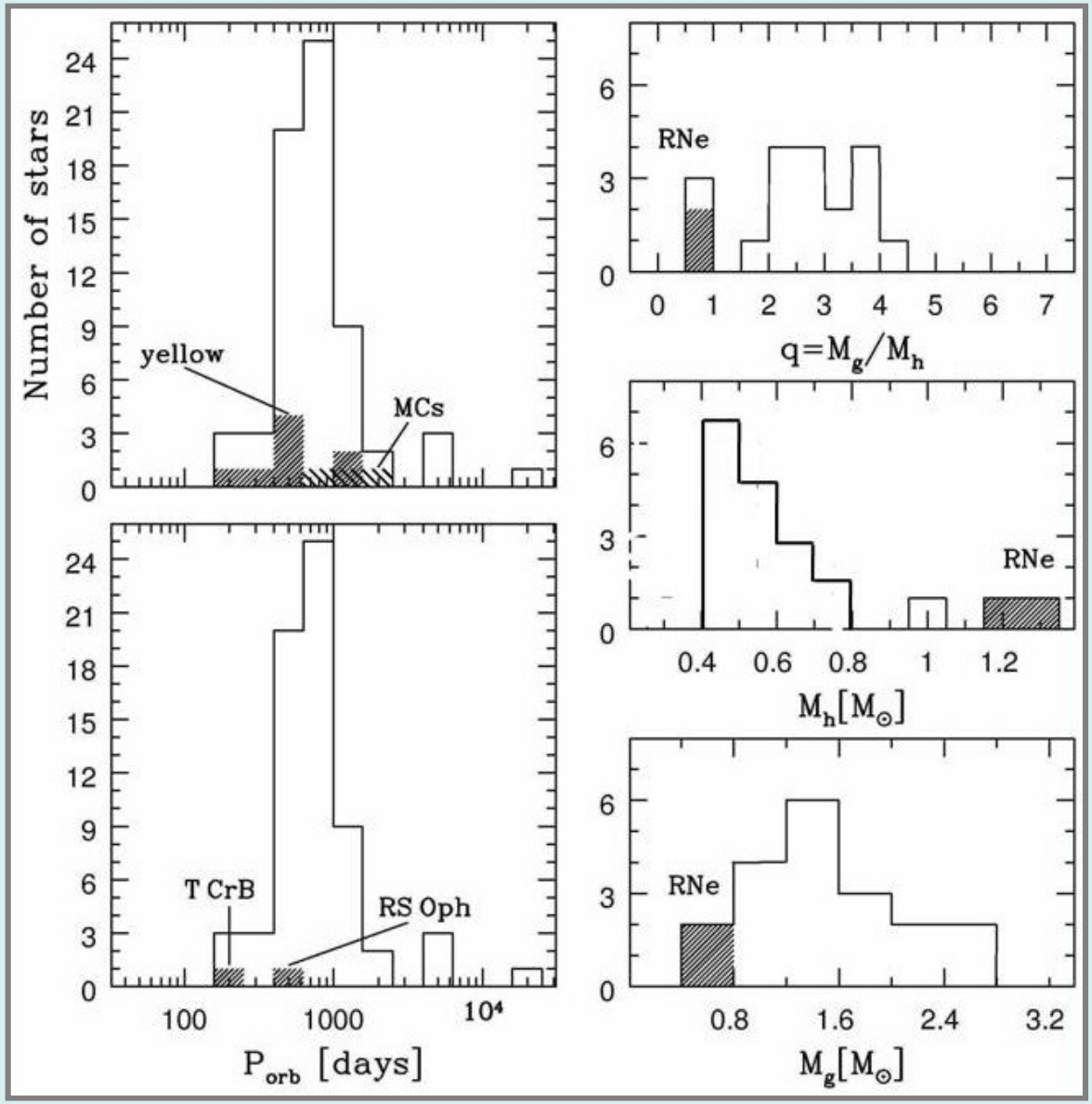
•Accreting white dwarf
majority

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

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

CVs with very long orbital periods
Important tracers of late phases of stellar evolution
Promising ”factory” of SNIa?

Orbital parameters



- **75 SyS – known orbital periods**

  (Belczyński et al. 2000, Mikołajewska 2003, 2007; Gromadzki et al. 2007, 2009; Schaffer 2009)

- **36 SyS – known spectroscopic orbits for the cool giant**

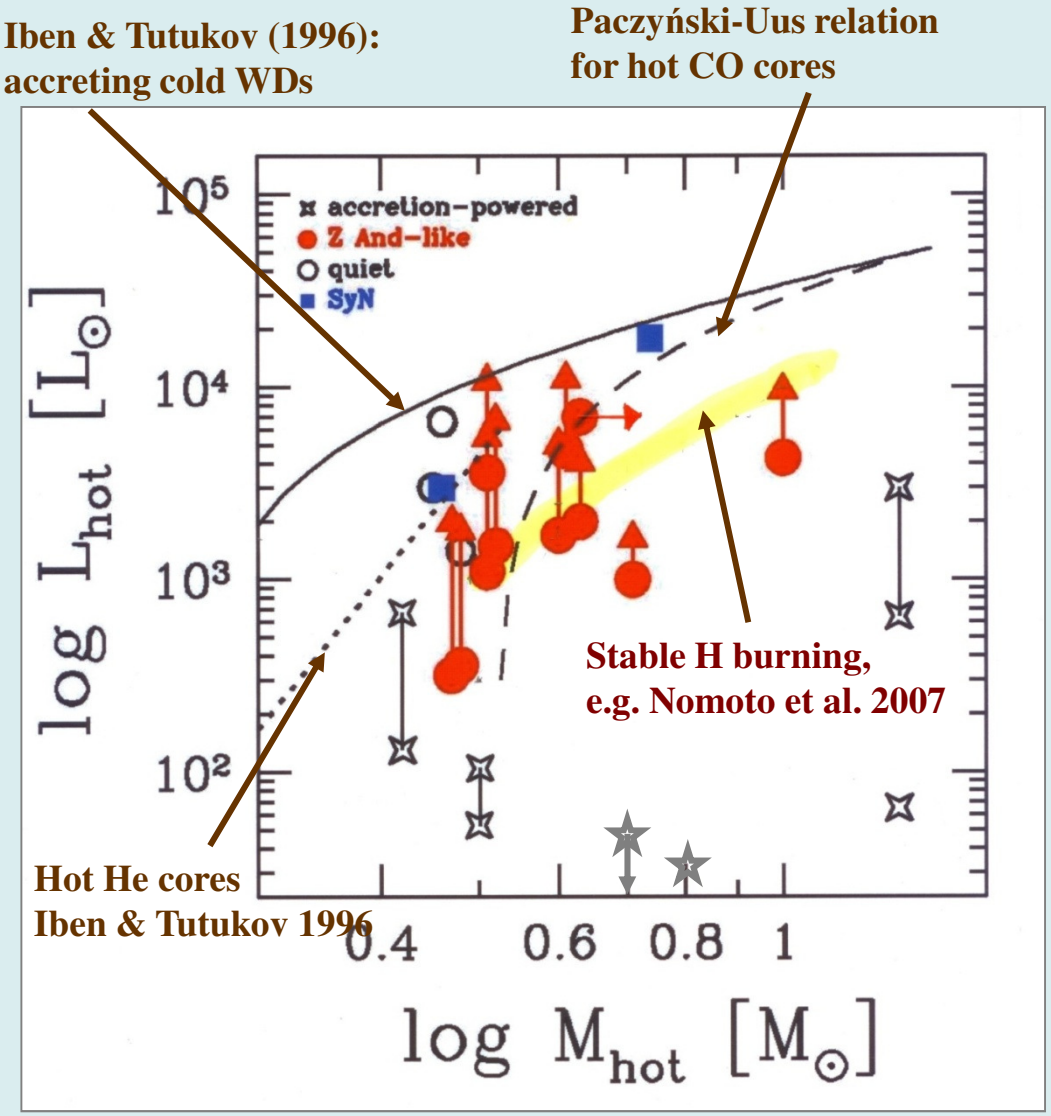
  (Mikołajewska 2003; Hinkle et al. 2006 – V2116 Oph; Brandi et al. 2006; 2009 ; Fekel et al. 2007, 2008, 2010; Gromadzki & Mikolajewska 2009)

- **20 SyS – mass ratios**

  (Mikołajewska 2003; 2007; Brandi et al. 2009)

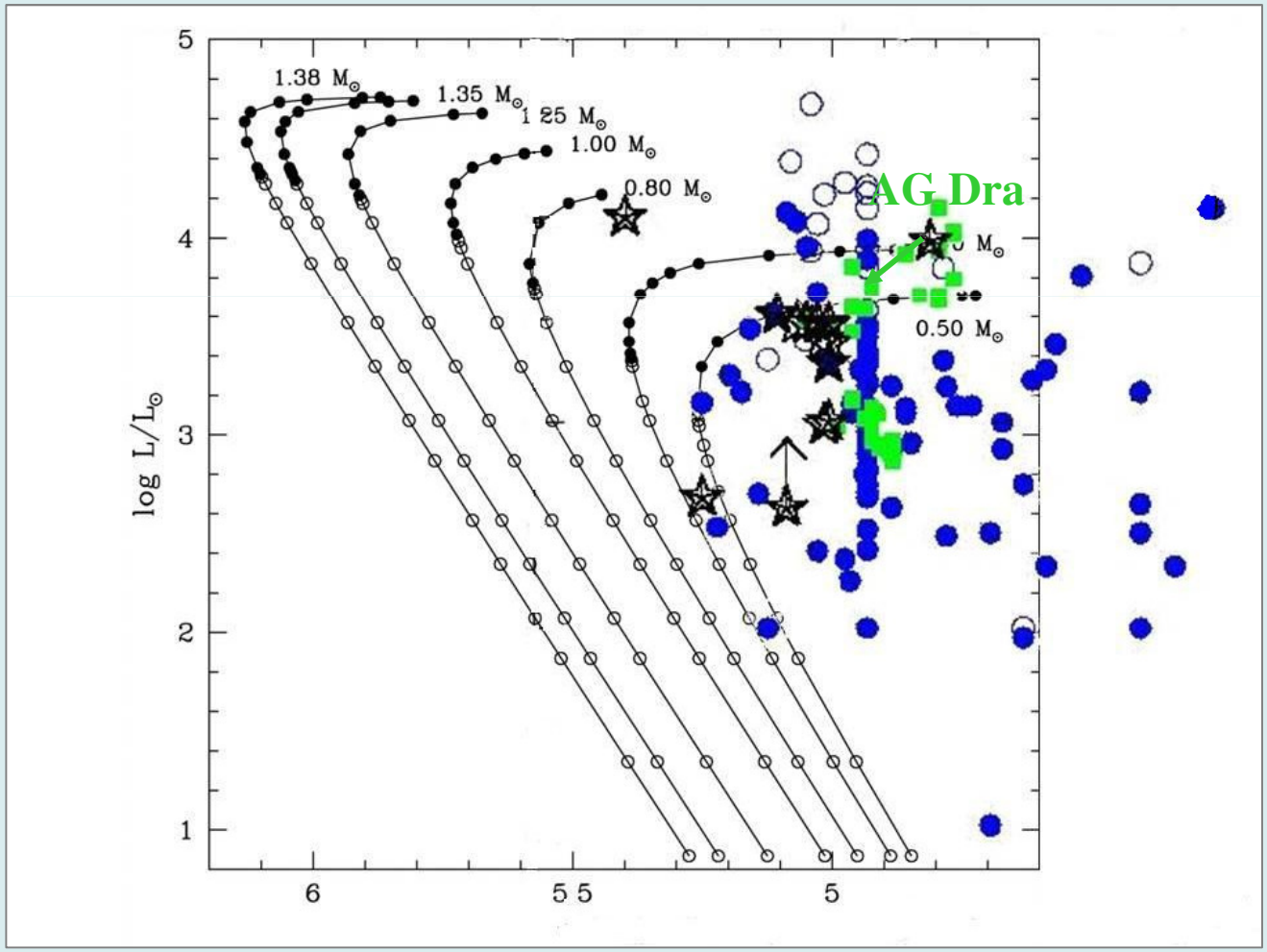
~70% have P~400-1000 d, & only ~20% above 1000 d

The HC mass – luminosity relation



- Most HCs cluster around the M-L relations for stars leaving the AGB with a CO core and the RG with a He core
- Relatively high, >~10^{-8} M_{sun}/yr, accretion rate required to power the hot component via stable/quasi stable H-shell burning

The HCs in HR diagram – comparison with steady models of Nomoto et al. (2007)



Symbiotic WDs significantly cooler than the steady models although some are have high L indicating massive (>~1Msun) WDs

Symbiotic stars and SD SNIa

Symbiotic Novae

- „Ordinary" symbiotic novae:
  V1016 Cyg, HM Sge, RR Tel, RX Pup, V1329 Cyg, AG Peg, PU Vul, RT Ser
  wind-accreting, Mwd<1 Msun
- Symbiotic recurrent novae:
  T CrB, RS Oph, V745 Sco, V3890 Sgr
  RLOF & massive Mwd>~1.2 Msun

  & V407 Cyg?

RS Oph:
the best studied symbiotic RN

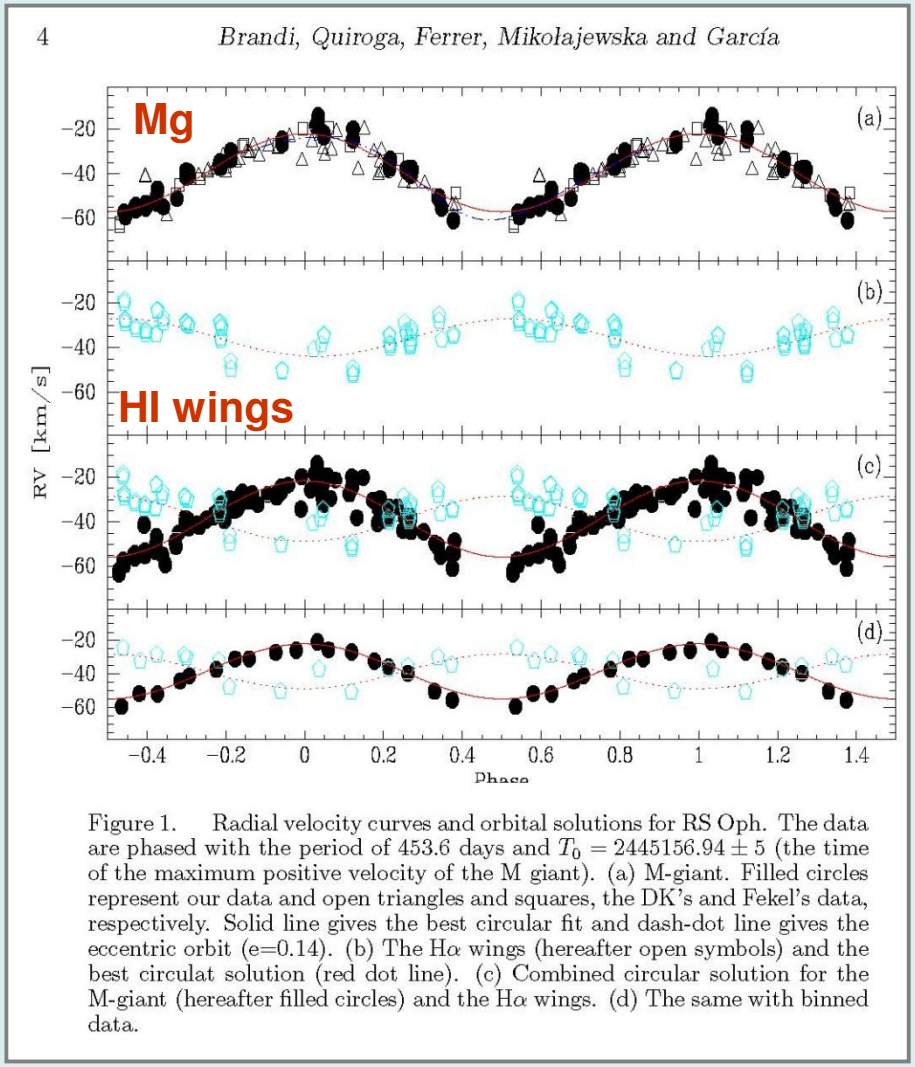


Figure 1. Radial velocity curves and orbital solutions for RS Oph. The data are phased with the period of 453.6 days and $T_0 = 2445156.94 \pm 5$ (the time of the maximum positive velocity of the M giant). (a) M-giant. Filled circles represent our data and open triangles and squares, the DK's and Fekel's data, respectively. Solid line gives the best circular fit and dash-dot line gives the eccentric orbit (e=0.14). (b) The Hα wings (hereafter open symbols) and the best circulat solution (red dot line). (c) Combined circular solution for the M-giant (hereafter filled circles) and the Hα wings. (d) The same with binned data.

Brandi et al.2009:

q=Mg/Mh=0.59+/-0.05

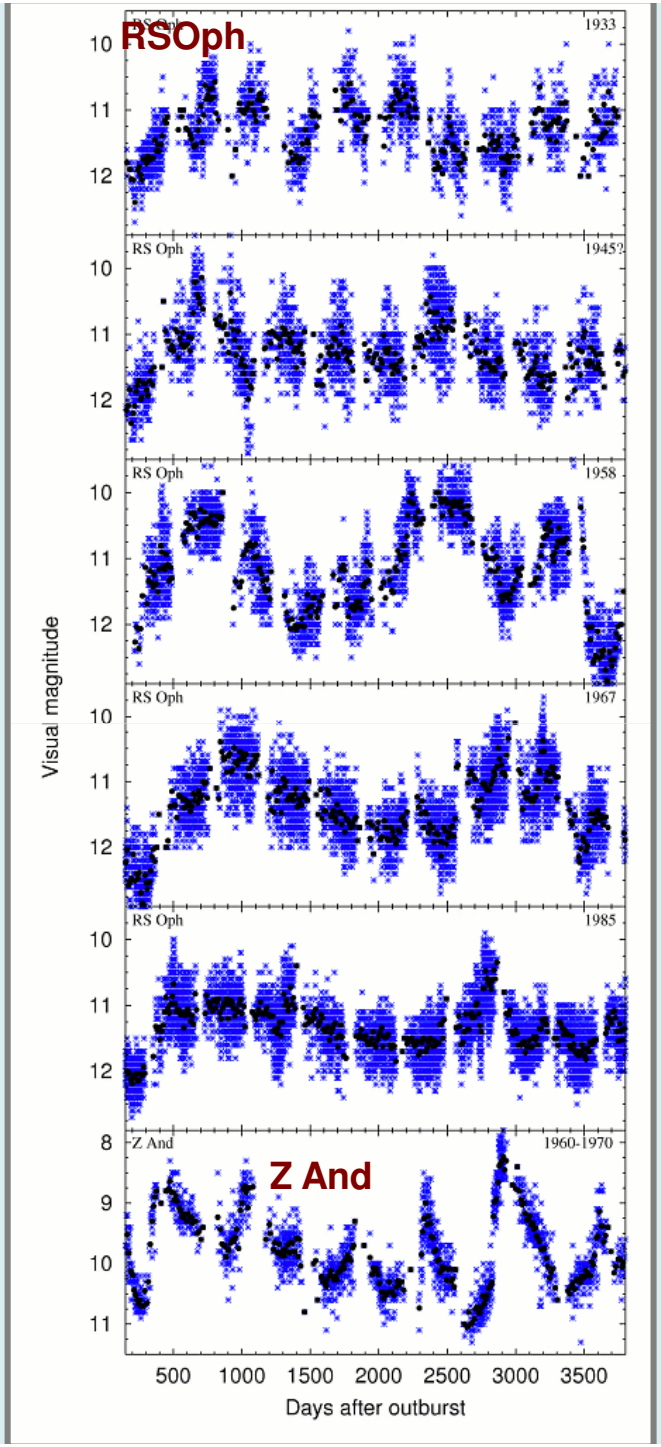
Mg $\sin^3 i$ = 0.35 Msun

Mh $\sin^3 i$ = 0.59 Msun

Mh <~1.4 Msun $\mapsto$ i >~ 49^o

$K_g/v_g \sin i \mapsto q_{min}$=0.7+/-0.1

RLOF

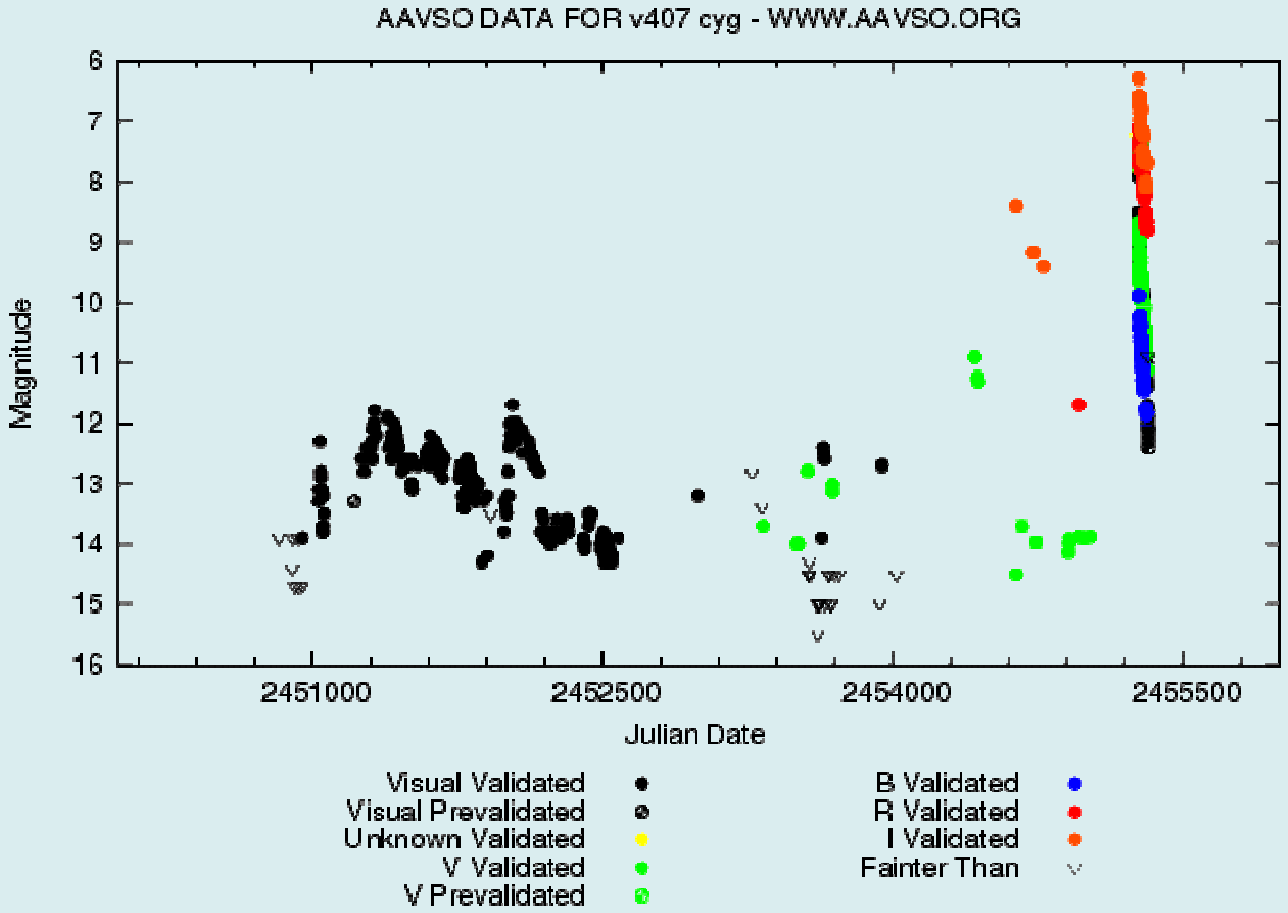


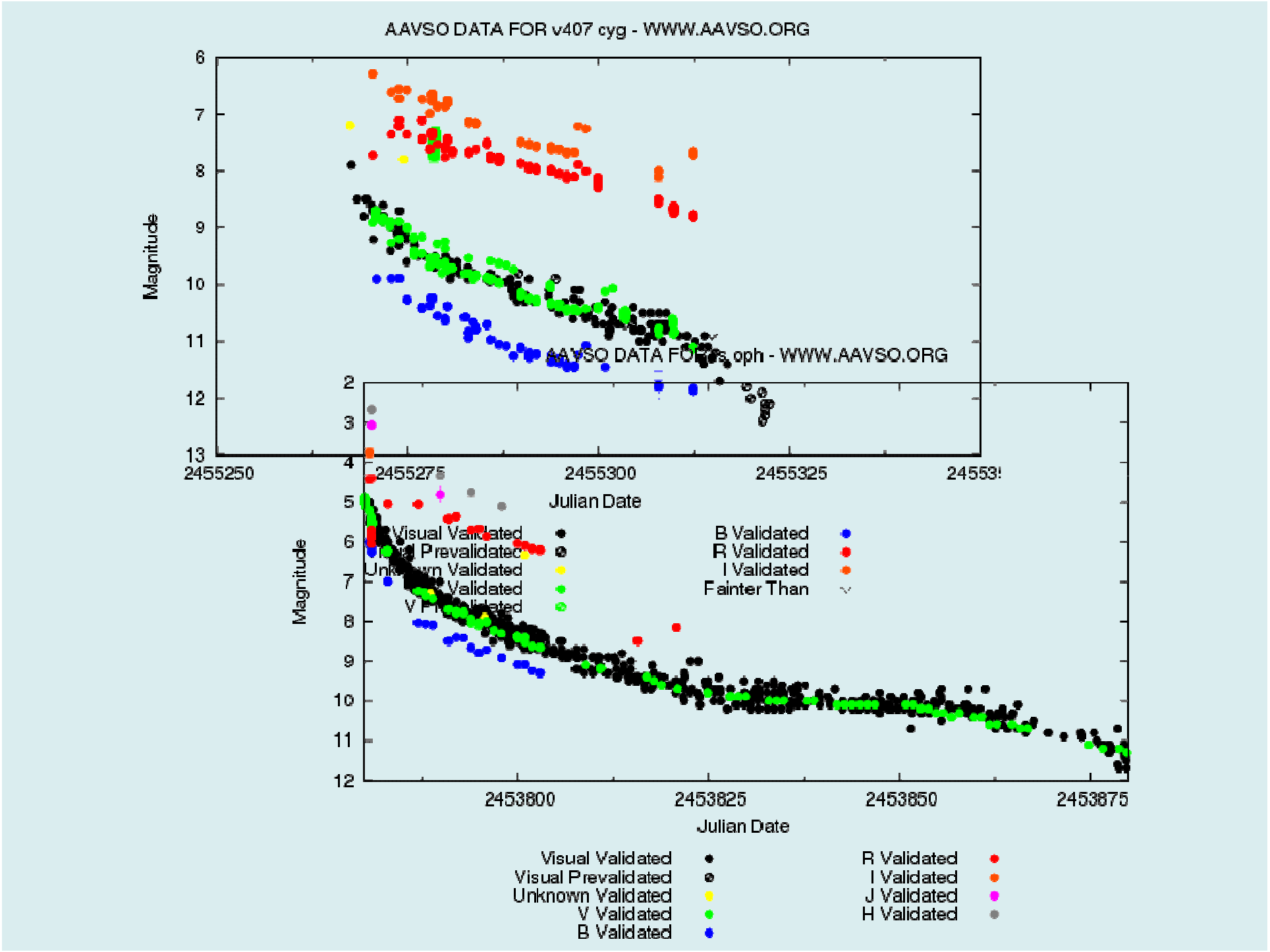
SyRNe: activity between outbursts

- Z And-type outburst activity between the nova eruptions (RS Oph, T CrB; Gromadzki et al. 2007)
- A/F-type shell spectrum accompanied by flickering (Brandi et al. 2007; 2009; Anupama & Mikołajewska 1999)
- Lacc~100-1000 Lsun requires a few 10^{-7} M_{sun}/yr whereas only ~ 10^{-7} Msun ejected from during the 2006 nova outburst of RS Oph (Sokoloski et al. 2006)

WD mass grows!

V 407 Cyg:
TNR on very massive WD?




AAVSO DATA FOR v407 cyg - WWW.AAVSO.ORG
Magnitude
Julian Date
AAVSO DATA FOR s oph - WWW.AAVSO.ORG
Visual Validated
Visual Prevalidated
Unknown Validated
V Validated
B Validated
R Validated
I Validated
Fainter Than
J Validated
H Validated

V 407 Cyg

- Mira companion (P=763d);
  Li-rich from HBB; massive ~4-8 Msun
  Mwind~10^{-5} Msun/yr
- WD must have massive progenitor >~4-8 Msun
- Active before the TNR outburst:
  filckering, high & low luminosity states
  as in RS Oph, T CrB, and accretion-powered CH Cyg with L(high)~500 Lsun/Macc~10^{-7} Msun/yr

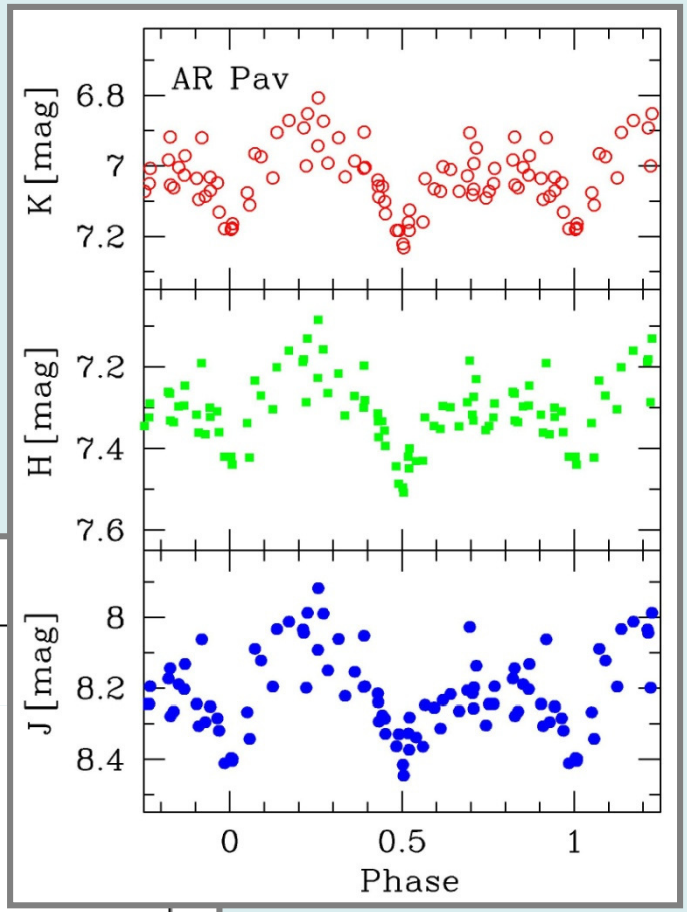
Can SyRNe produce SNe Ia?

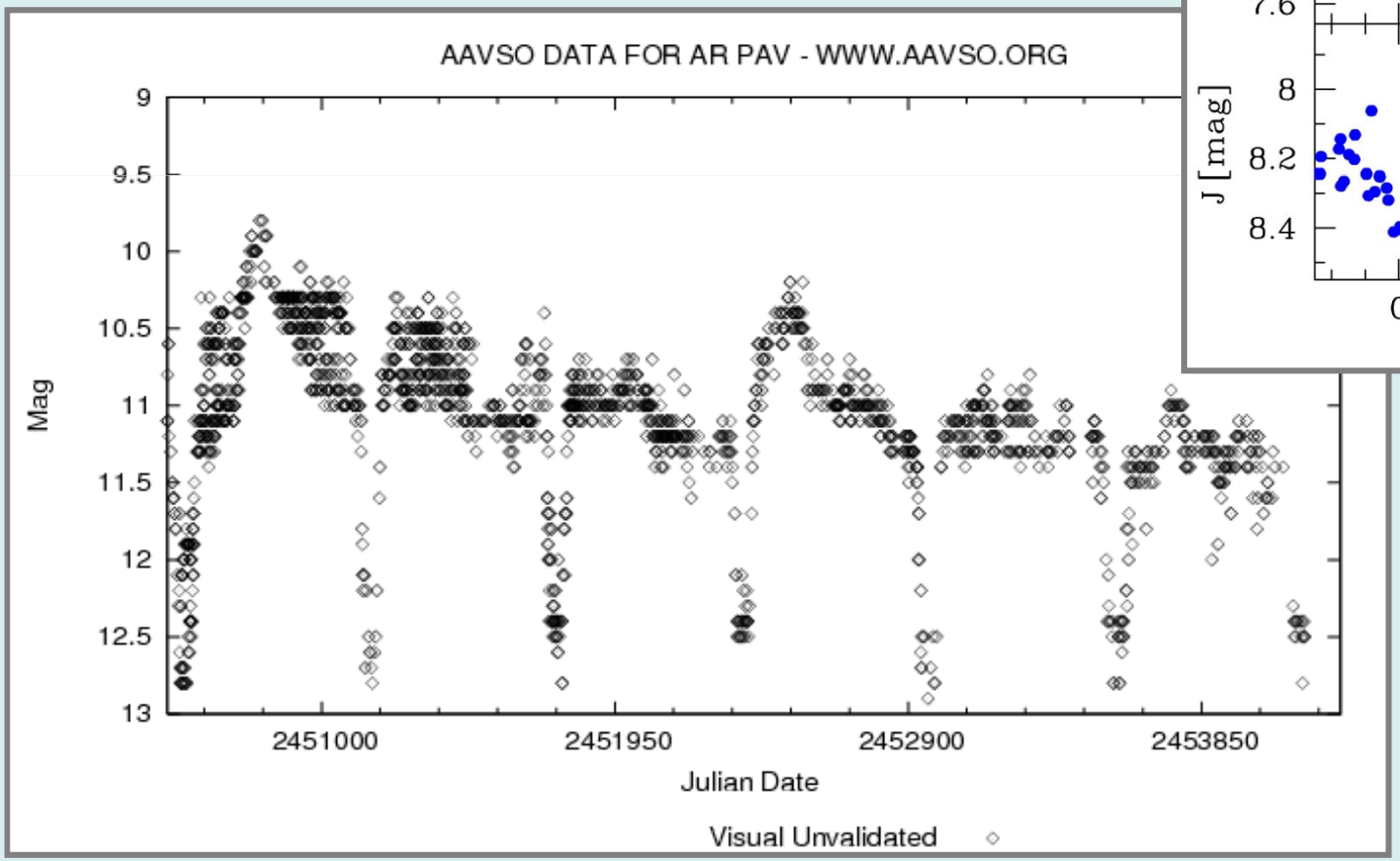
What about remnants of the giant donors in SNe Ia?

- **The red giant envelope mass in <~0.35 Msun in RS Oph, and <~0.2 (and maybe even 0.1) in T CrB. Stripping this evelope by SN ejecta would leave a low mass, <0.5 Msun), helium WD.**
  Giant donors can account for LMWDs.
- **CS material in an apparently normal SN 2006X (Patat et al. 2007) – from a RNe and/or the red giant wind (e.g. Justham & Podsiadlowski 2008).**

AR Pav:

RL-filling giant with luminous optical/FUV companion





AR Pav

- 1 Msun WD +2.5 Msun M6 III
- Lhot~5000-10000 Lsun

A/F optical (disk?) + 10^5 K FUV source
powered by steady H-shell burning?

How it will evolve?

Stable RLOF & SyRN like RS Oph?

or

CE (q=2.5) and close double 1+0.5 Msun WD binary?

Symbiotics with RLOF

- At least 20% of SyS with P<~1000 d
- Both stable (RW Hya, SY Mus) & Z And-type outbursts
- WD masses 0.5-1 Msun
- RG/AGB with 1-3 Msun & Mcore~0.45-0.55 Msun

Some may end as close pairs of DD with M~MCh?

Symbiotics and SNe Ia

- They contain WDs efficiently accreting and in most cases steadily burning H-rich matter
- Some are able to produce high mass WDs:
  - M_{wd} are already close to M_C in SyRNe
  - massive WDs accreting at high,~$10^{-7} M_{sun}$/yr, rates from Mira-type companions
- AR Pav will very likely become close pair of 2 WDs
  - ~1+0.5 Msun
- Promising candidates for both SD and DD scenarios

Symbiotic novae

- **Ordinary SyNe:**
  very slow and quiet (no optically thick wind)TNR on wind-accreting low-mass (<1 Msun) WDs but WDs can retain most of the accreted mass (e.g. Kato et al. 2010, in preparation)
- **Recurrent novae:**
  TNR on high-mass, ~>1.2 Msun, WDs accreting at very high rates, ~10^{-7} Msun/yr via RLOF.
  Low mass of the nova ejecta, ~ 10^{-7} Msun, in RS Oph (Sokoloski et al. 2006) – WD mass can grow.
- **V407 Cyg: >~1.2 Msun WD & Mira companion**