What we don't know about AM CVns?

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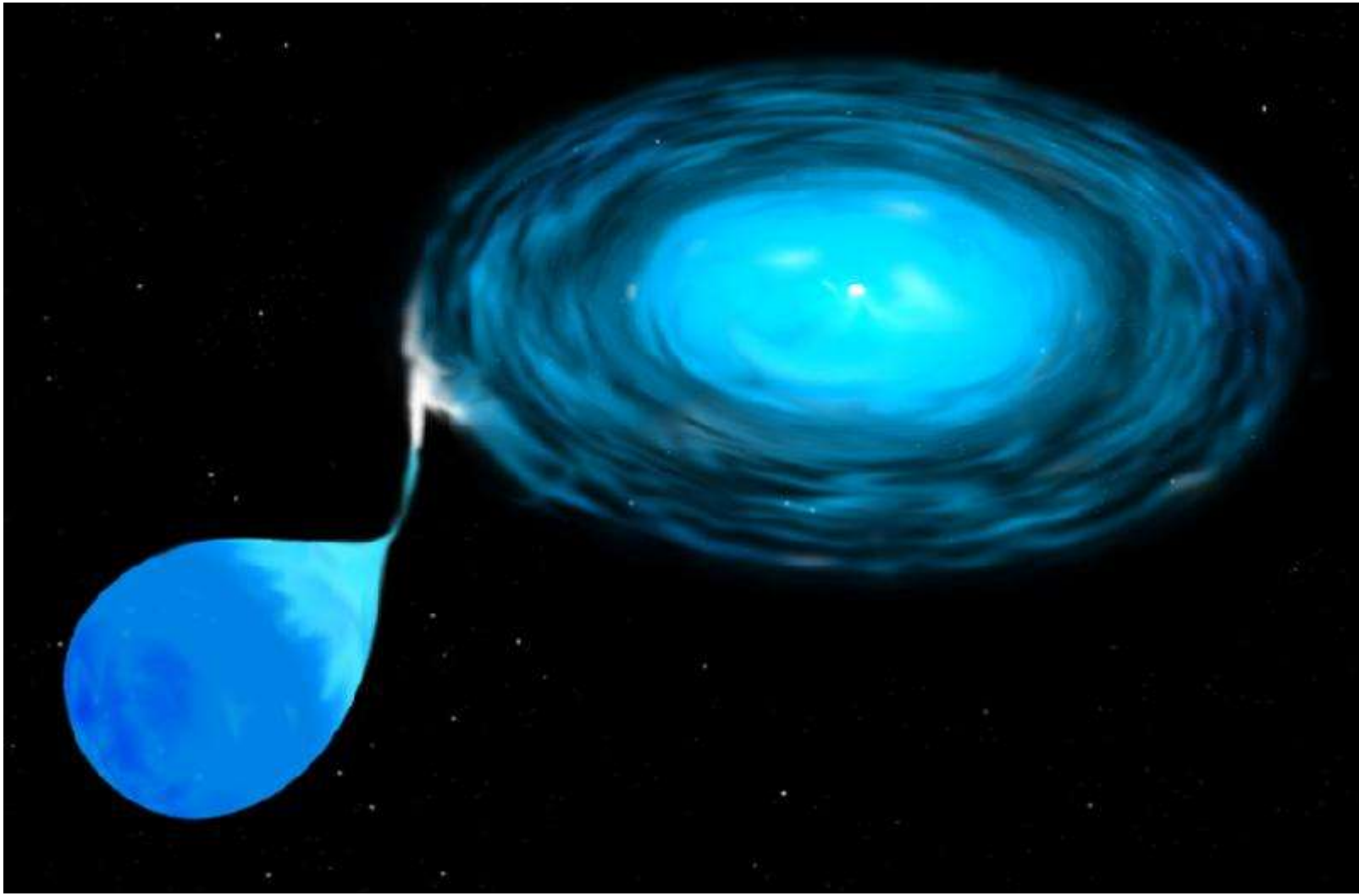
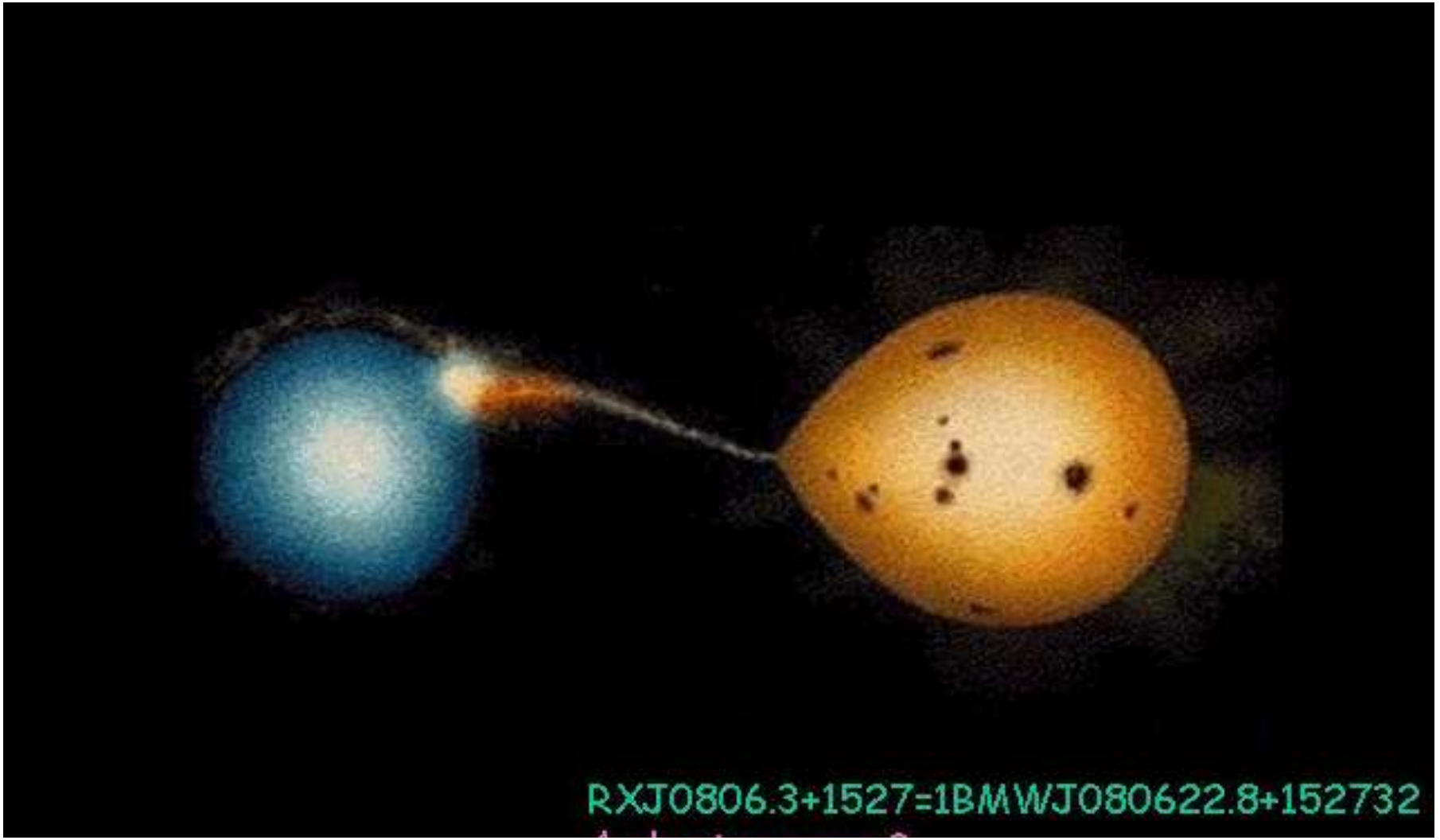
Some questions about AM CVns

Fundamental properties

- **Ultrashort (binary periods)**
  - 5-65 minutes
- **Helium rich spectra**
  - (No trace of Hydrogen) or He/H $>10^5$
- **Double Degenerate systems**
  - Sencondary: degenerate or semi-degenerate

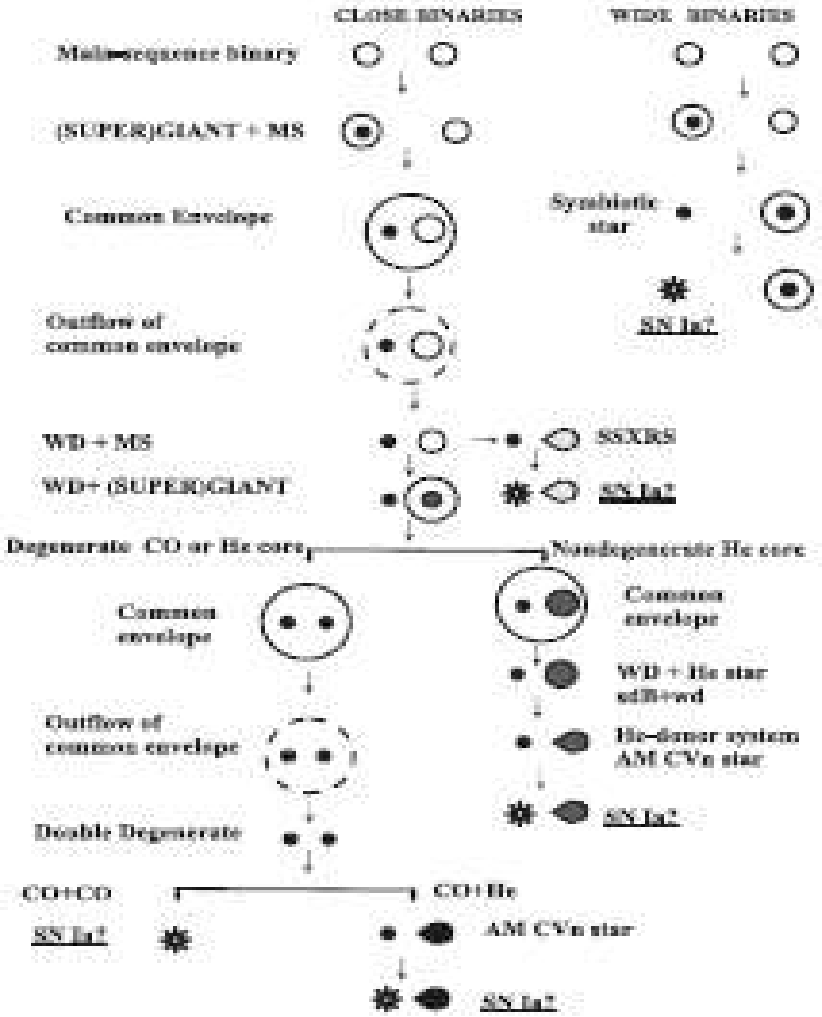



RXJ0806.3+1527=1BMWJ080622.8+152732

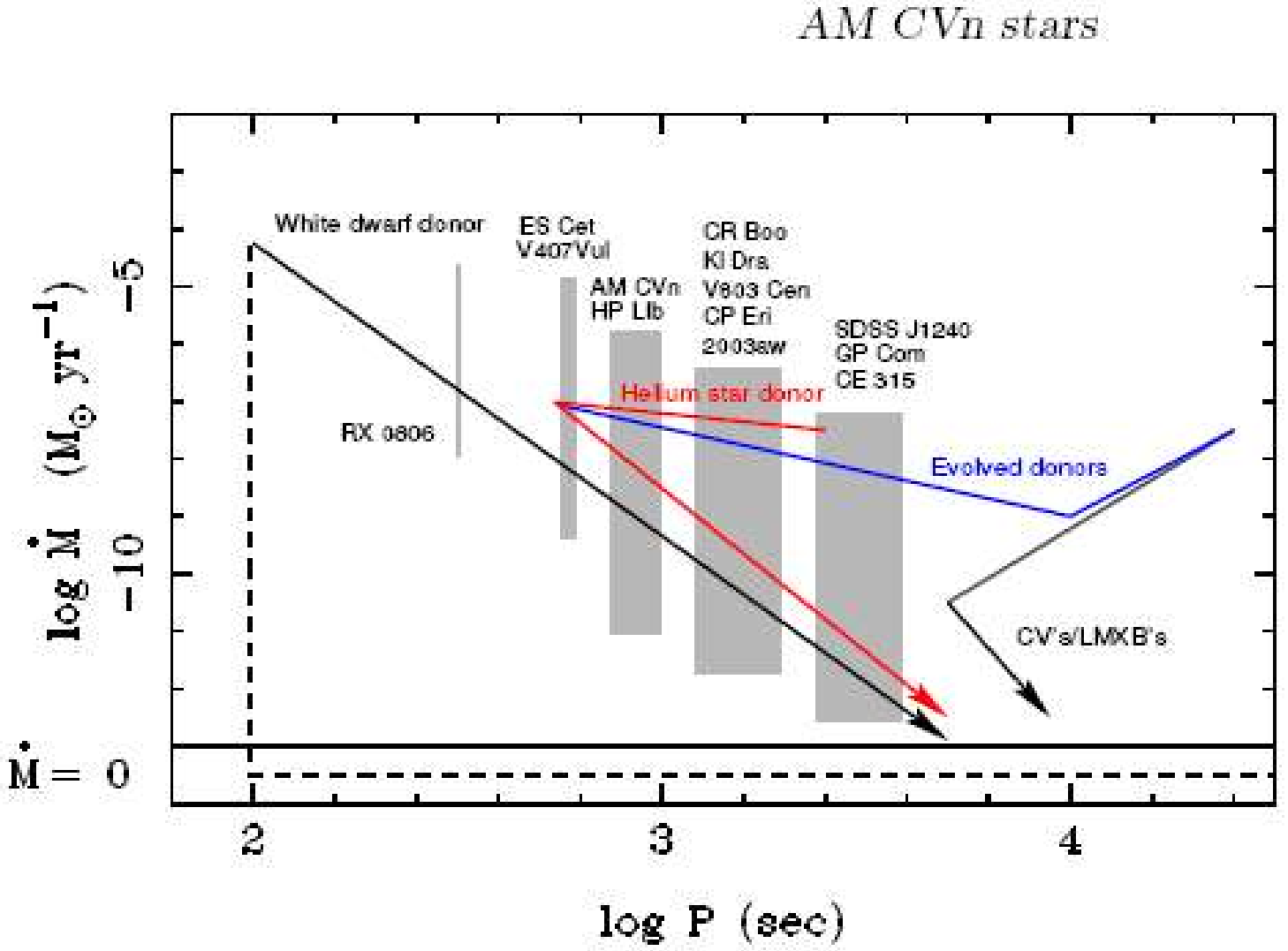
Some basic questions

- What are AM Cvn's?
  - What defines an AM CVn object?
  - Where do they come from?
  - Where do they go?
- What do they look like?
  - Can we produce a direct image?
  - Or rely on models ?
  - Or just guess?

Complicated past – exiting future:

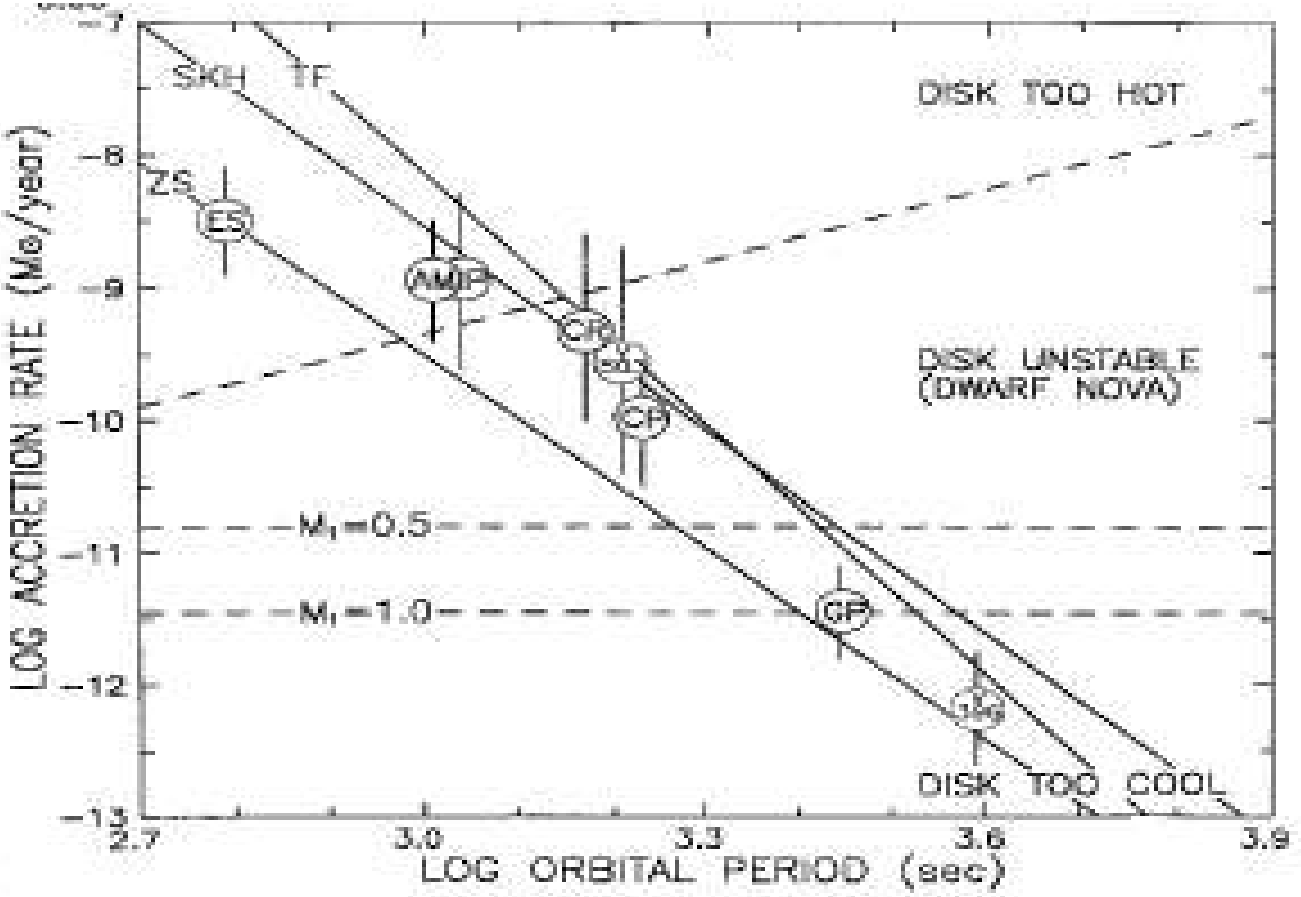


Mass transfer versus Period



Nelemans, 2005

Accretion rates, disc instabilities, Mass-Radius relation for donor



Secondary mass-radius relations:

ZS: cold Zapolsky-Salpeter WD;

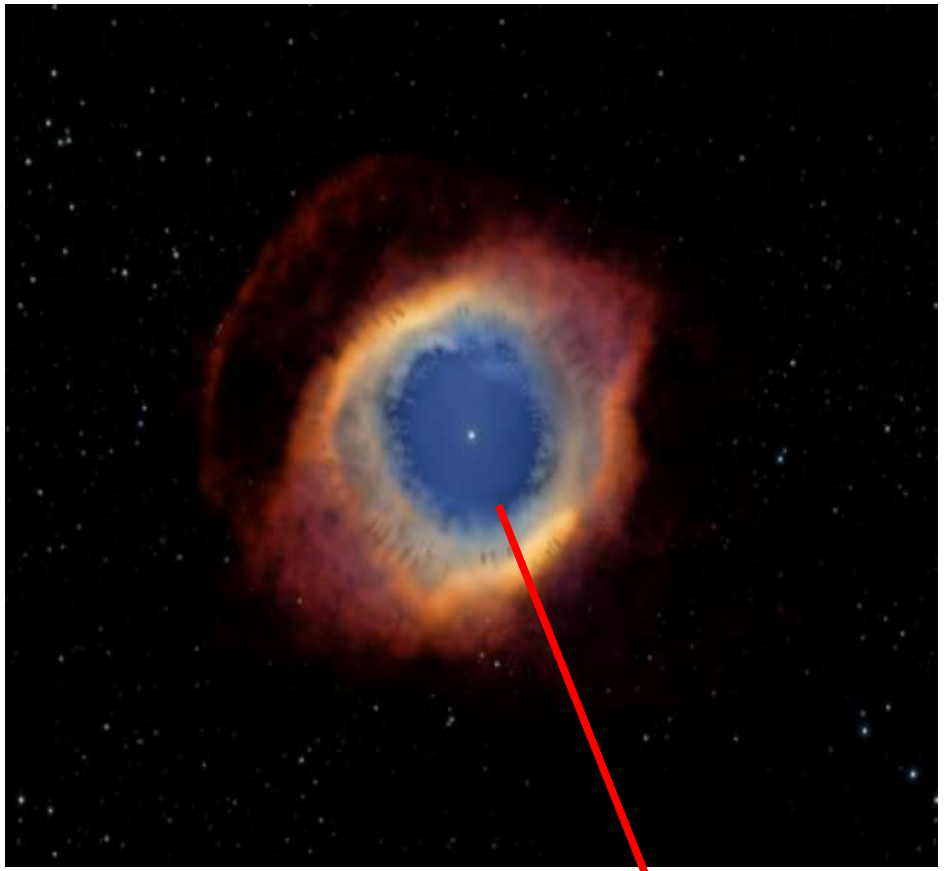
SKH: semi-degenerate Savonije, de Kool &Van den Heuvel;

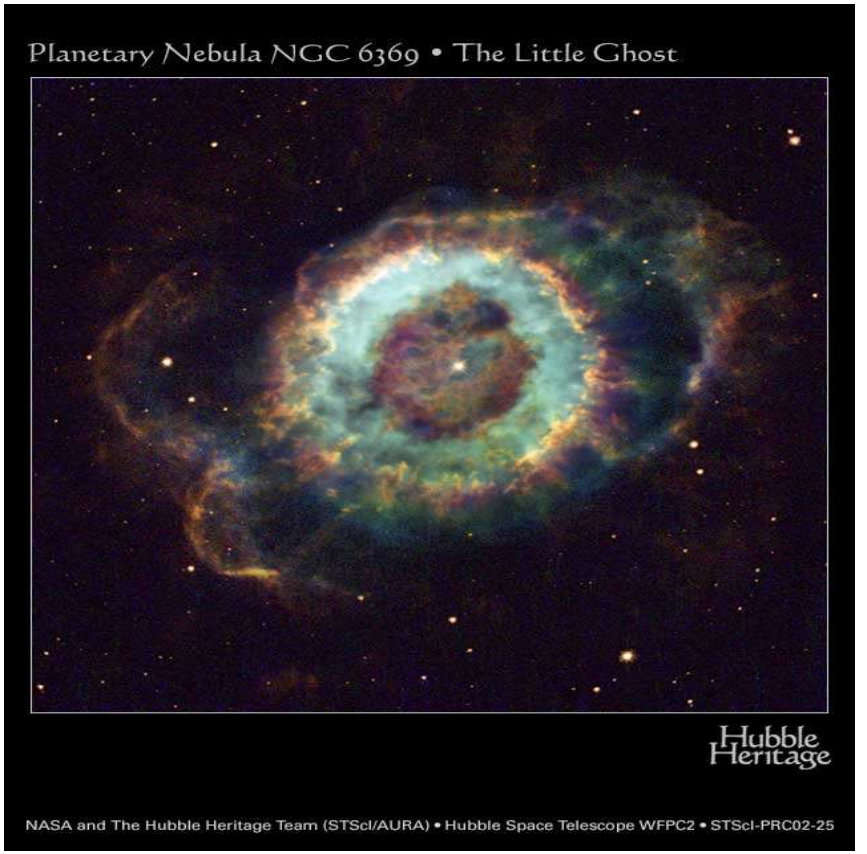
TF: semi-degenerate Tutukov & Fedorova

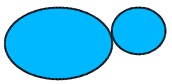
Espaillat et al., 2005

What does an AM CVn star look like?

Can we observe something like this?

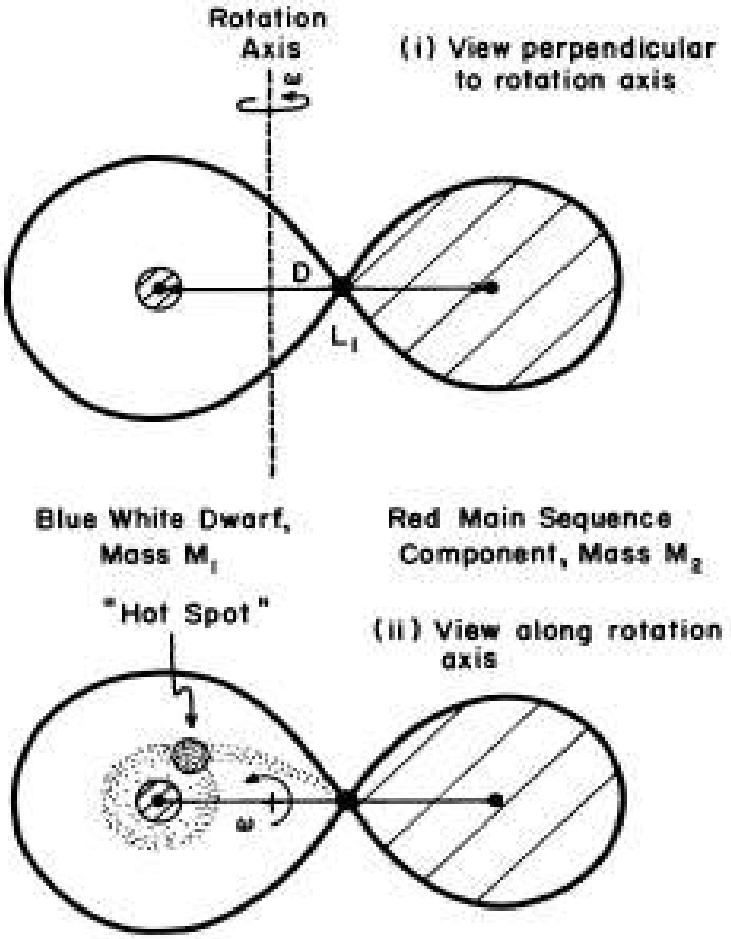






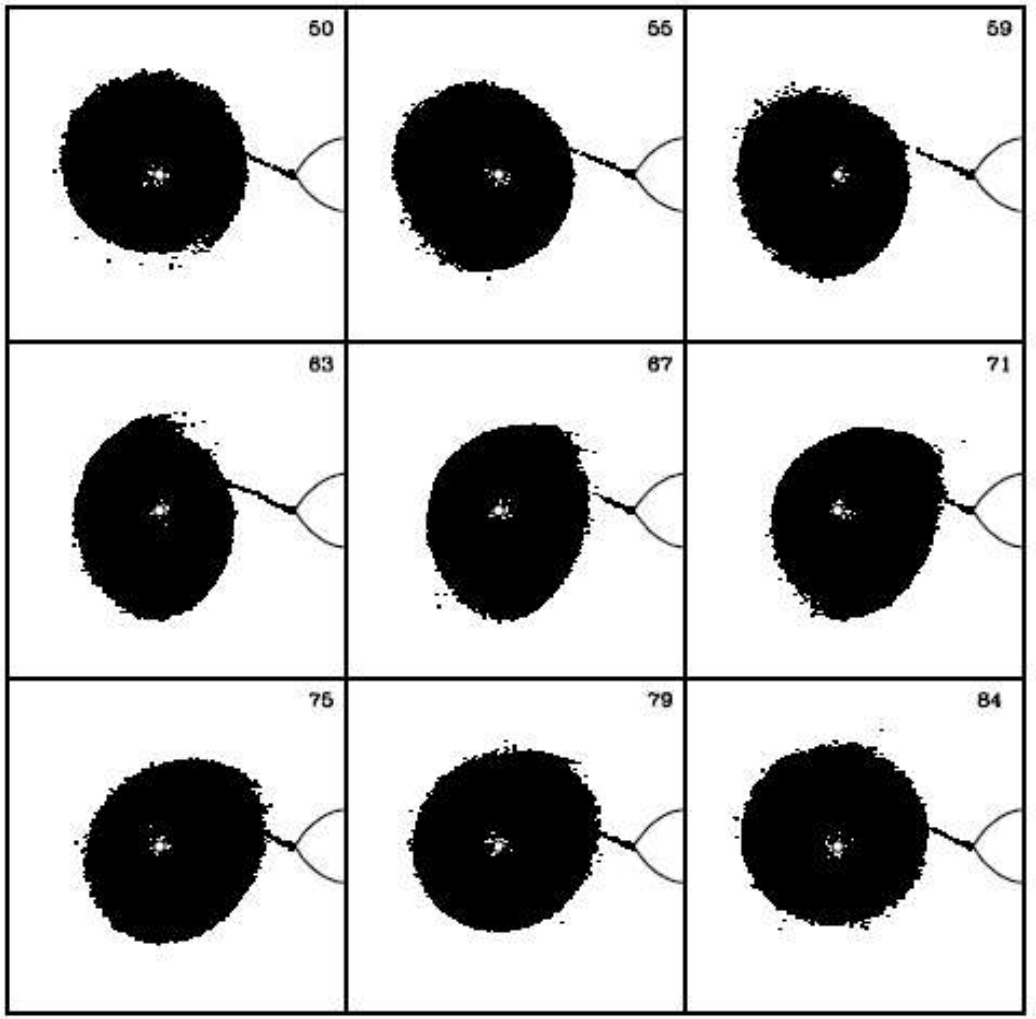
The first “picture”

$$R_L/D = 0.459\mu^{1/3} \qquad (1)$$



Faulkner, Flannery, Warner 1972

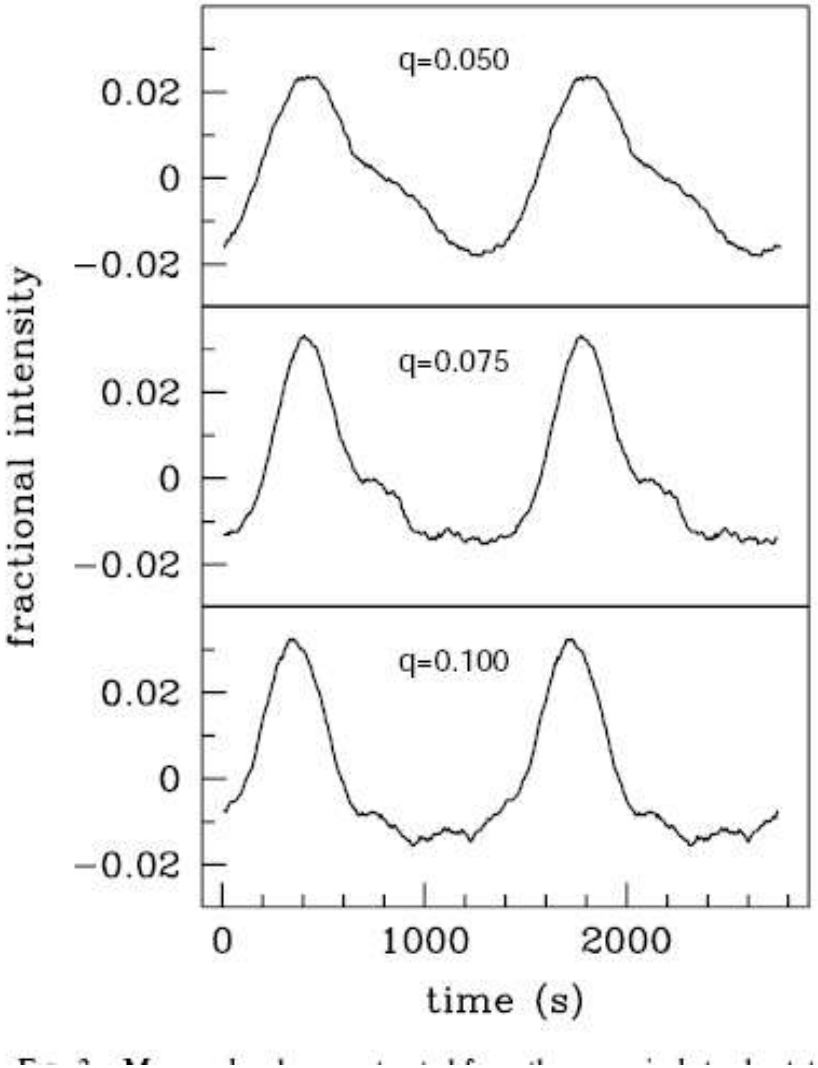
SPH simulations showed precessing non circular disc

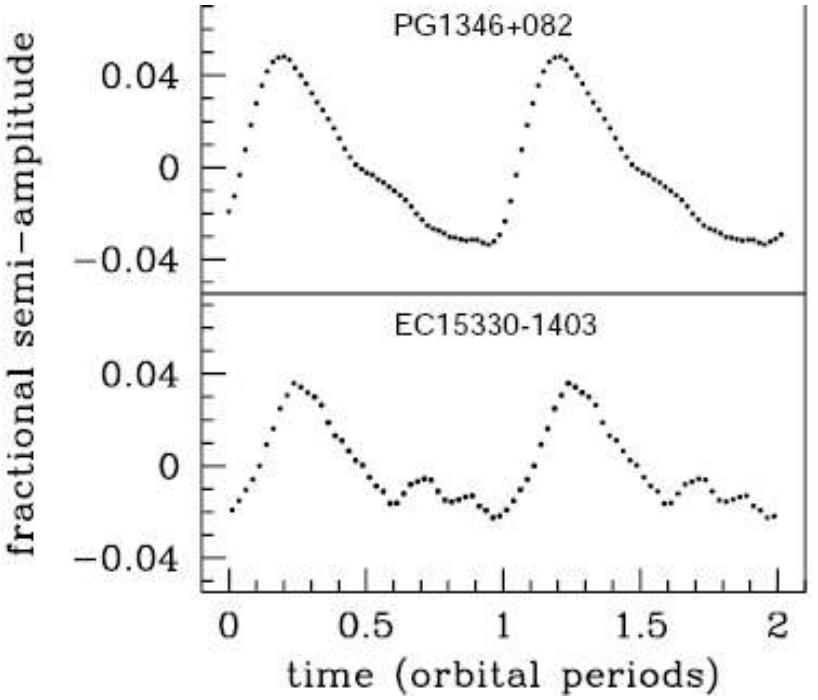


q=0.1

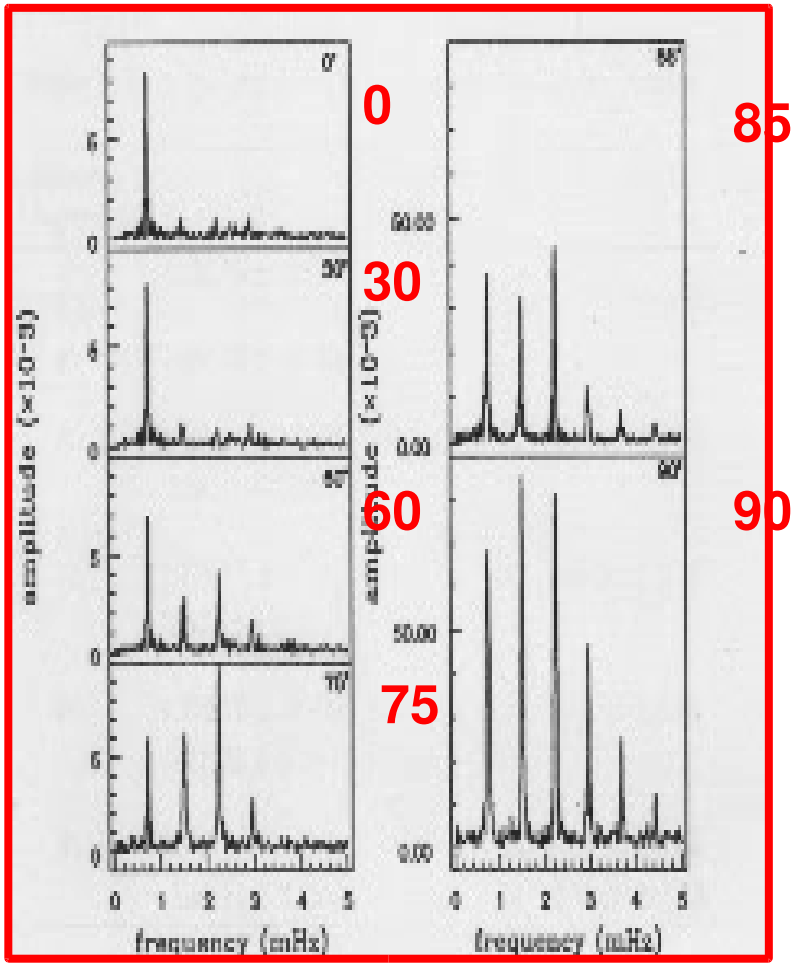
Simpson & Wood 1998

SPH simulations gave shape of light curve pulse





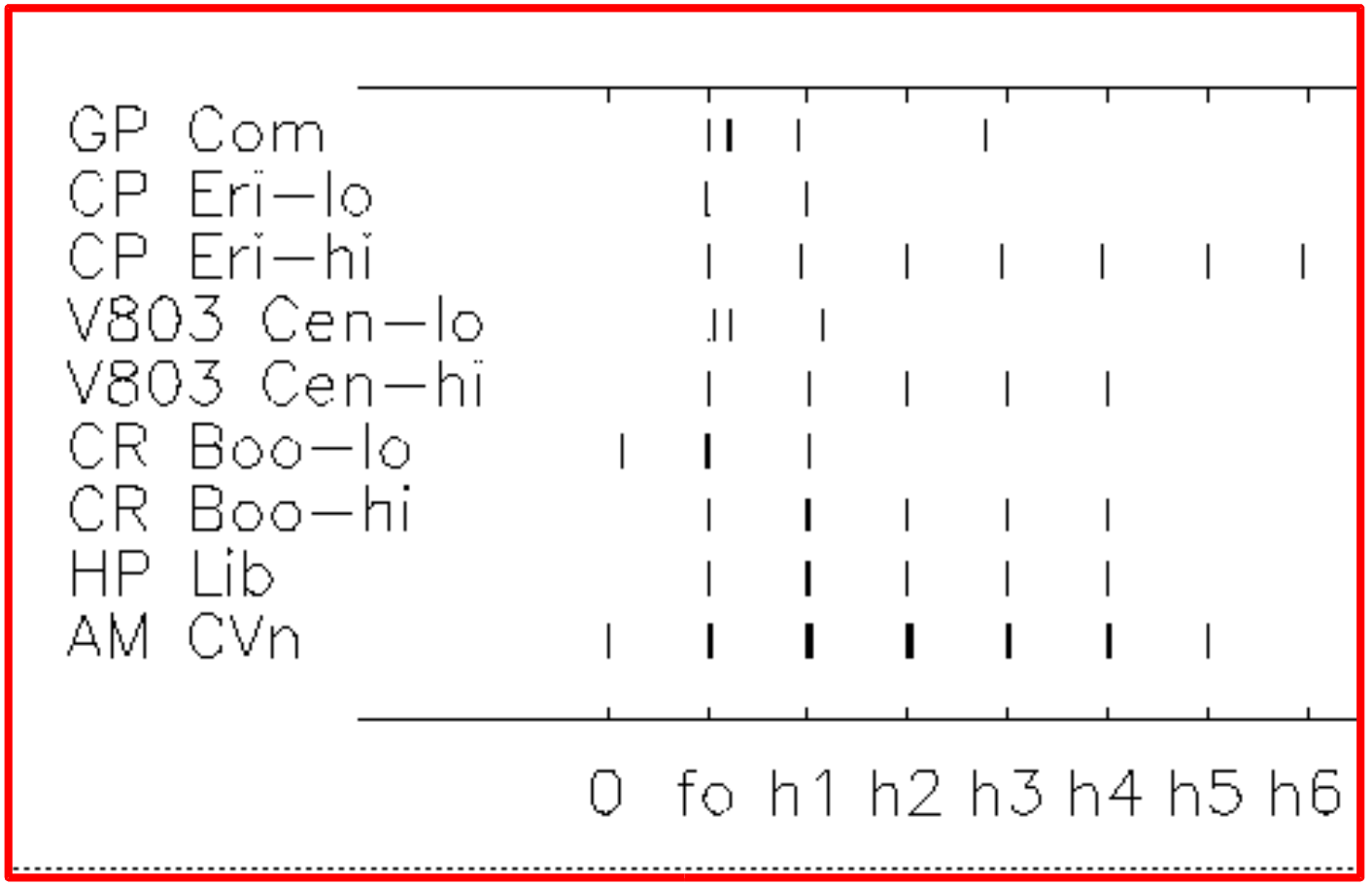
Shape of disc + inclination = harmonics of superhump frequency



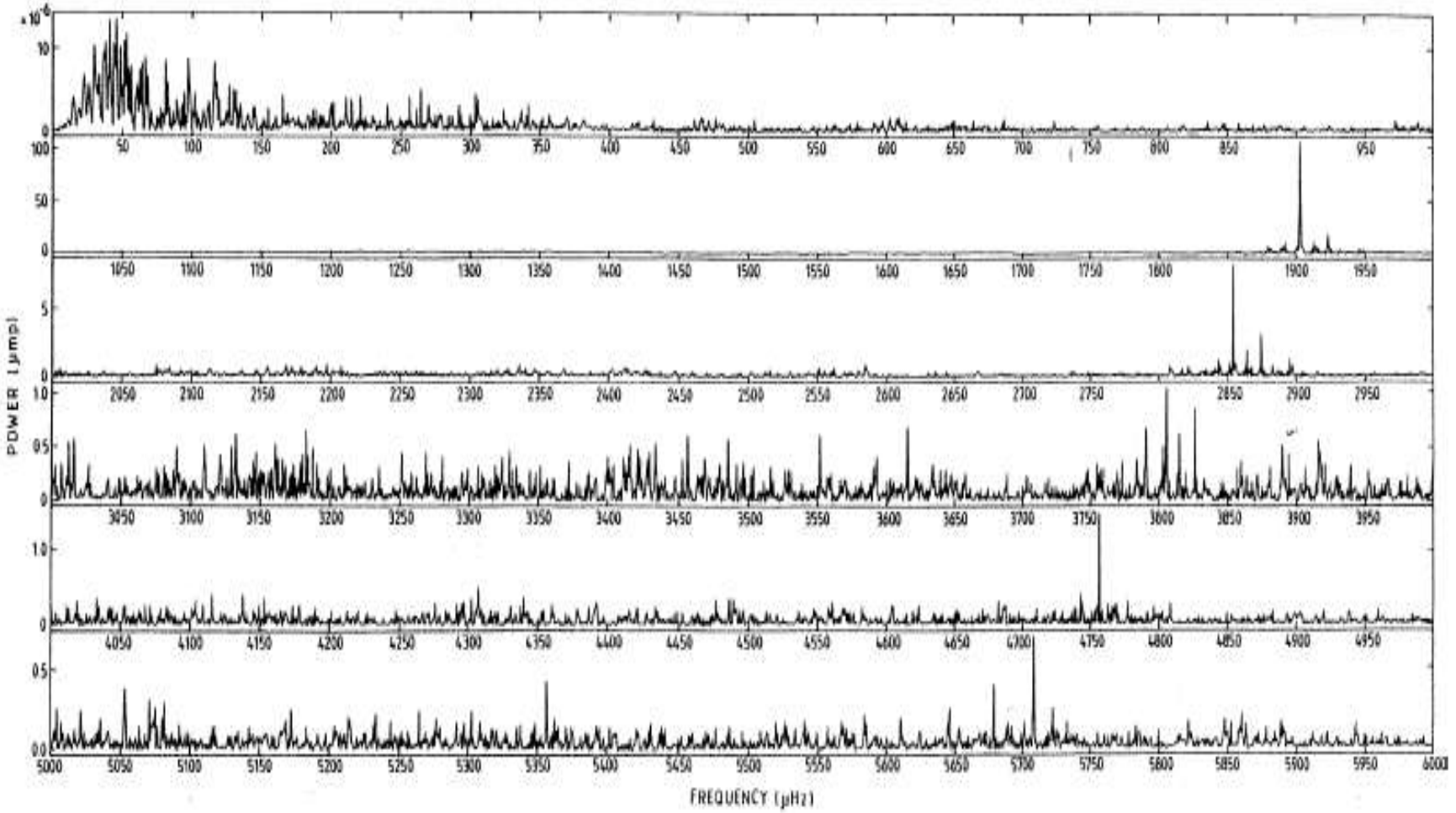
- **NON-Cicular shape of disc with spiral arms**
- **Harmonics of superhump frequency**
  - **Higher amplitudes at higher angles**
  - **Mixed with harmonics of orbital period at exteme angels**

Wood & Simpson 1995

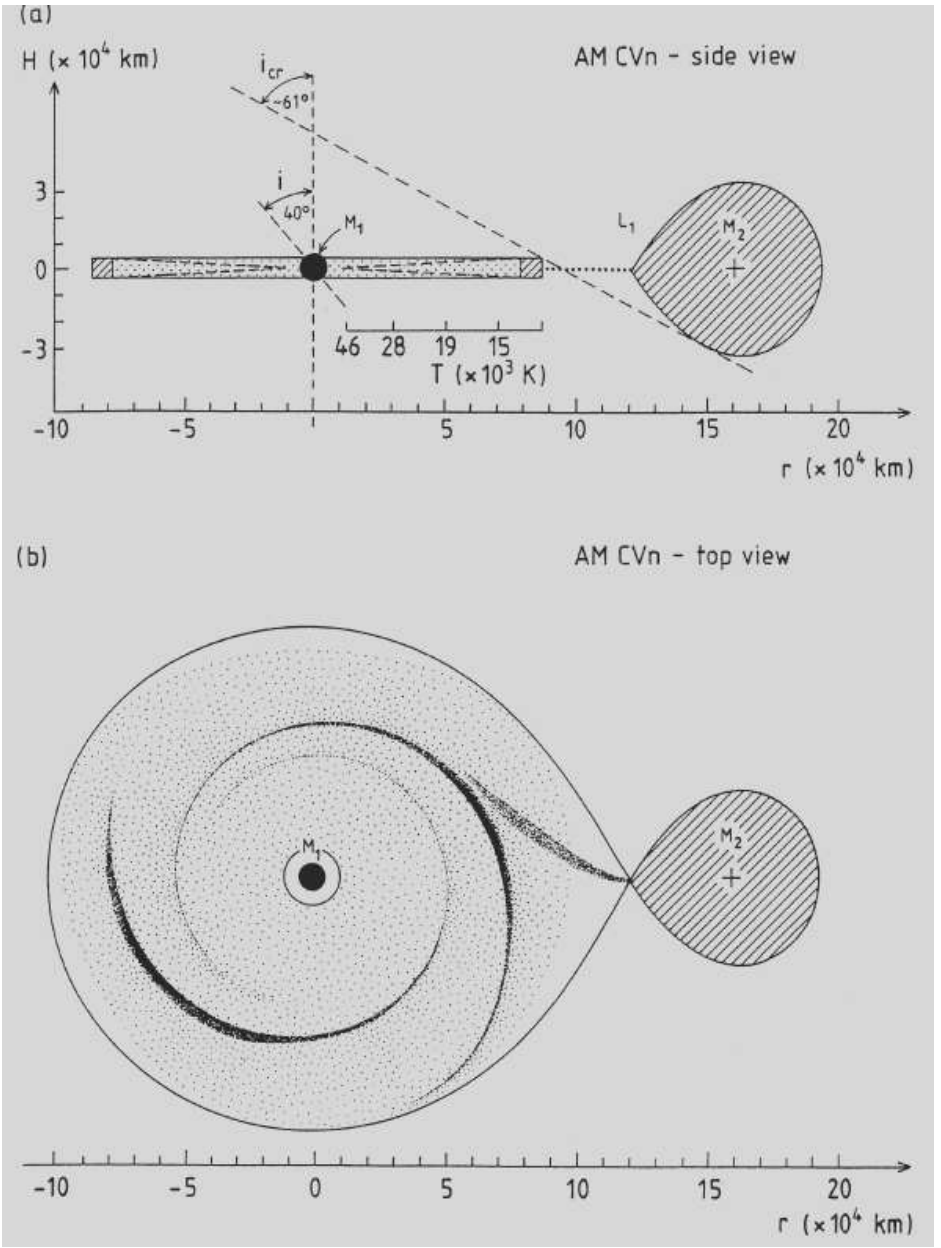
Objects with disc have harmonics in their light curves (P_{su} or P_{orb}):



AM CVn harmonic structure of superhump period



Solheim et al 1998

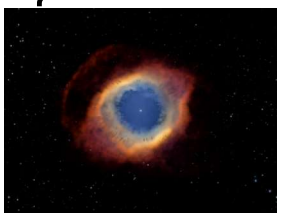

(a)
H (× 10^4 km)
AM CVn – side view
i_cr
~61°
i
40°
M1
L1
M2
3
0
-3
46 28 19 15
T (×10^3 K)
-10 -5 5 10 15 20
r (× 10^4 km)
(b)
AM CVn – top view
M1
M2
-10 -5 0 5 10 15 20
r (× 10^4 km)

How big is AM CVn?

- Linear size
  - distance between mass centers: 160 000 km
  - disc diameter: 200 000 km
  - donor diameter: 80 000 km
  - System diameter: 280 000 km
  - (The planet Jupiter diameter: 150 000 km)
- At one parsec: 3 mas (milli arc seconds)

How big are AM CVns on the sky?

Object	distance	size (\mu as)	w/shell
GP Com	75	35	?
HP Lib	200	15	?
CR Boo	340	10	?
V803 Cen	350	10	?
AM CVn	600	4,5	?
CP Eri	800	4	



Can we expect to see shells of size 10 – 100 mas?

Can the planned GRAVITY instrument on ESO VLT be used for imaging AM CVns?

spatial resolution 4 milliarc seconds

infrared wavefront sensing down to mK > 10;

internal fringe tracking down to mK > 10;

multiple baseline narrow angle astrometry with 10 microarcsec accuracy for UT operations;

interferometric imaging of faint objects with mK > 19 in 1 hour observing time.

Doppler tomography proves non circular disc – varies in shape with superhump period

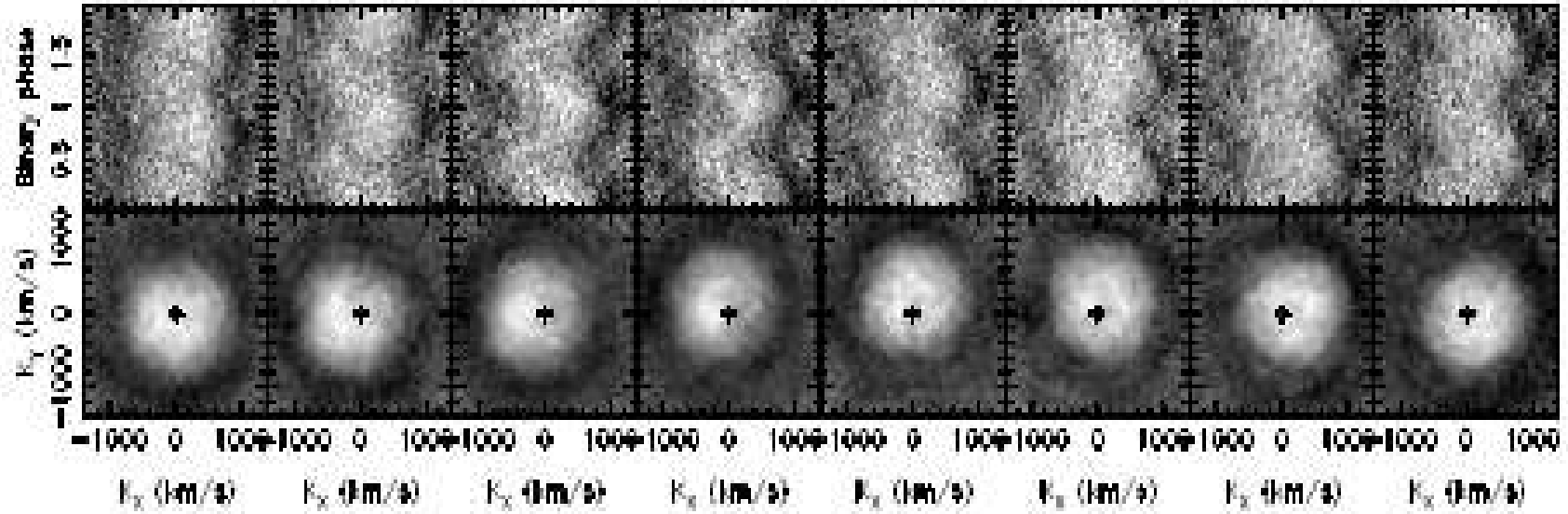
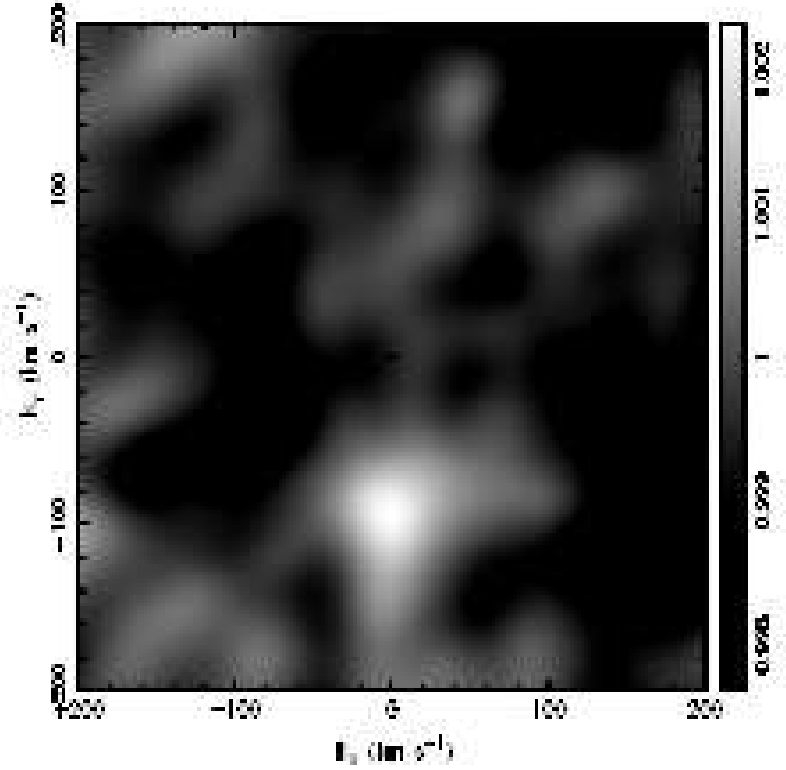
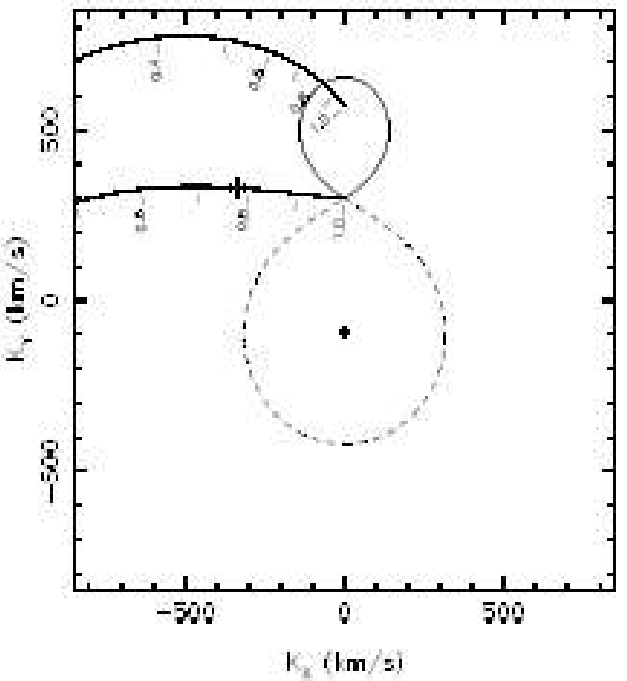


Figure 10. Trailed spectra and linear back-projection Doppler tomograms of the He II 4686 line as a function of superhump phase. One full superhump cycle is shown from left to right.

Roelofs et al. 2006

The Central object (spike) is “ seen “ in velocity space (AM CVn)





Roeloefs et al 2006

First detection of accreting star CP Eri STIS spectrum He/H ~ 10^3 ?

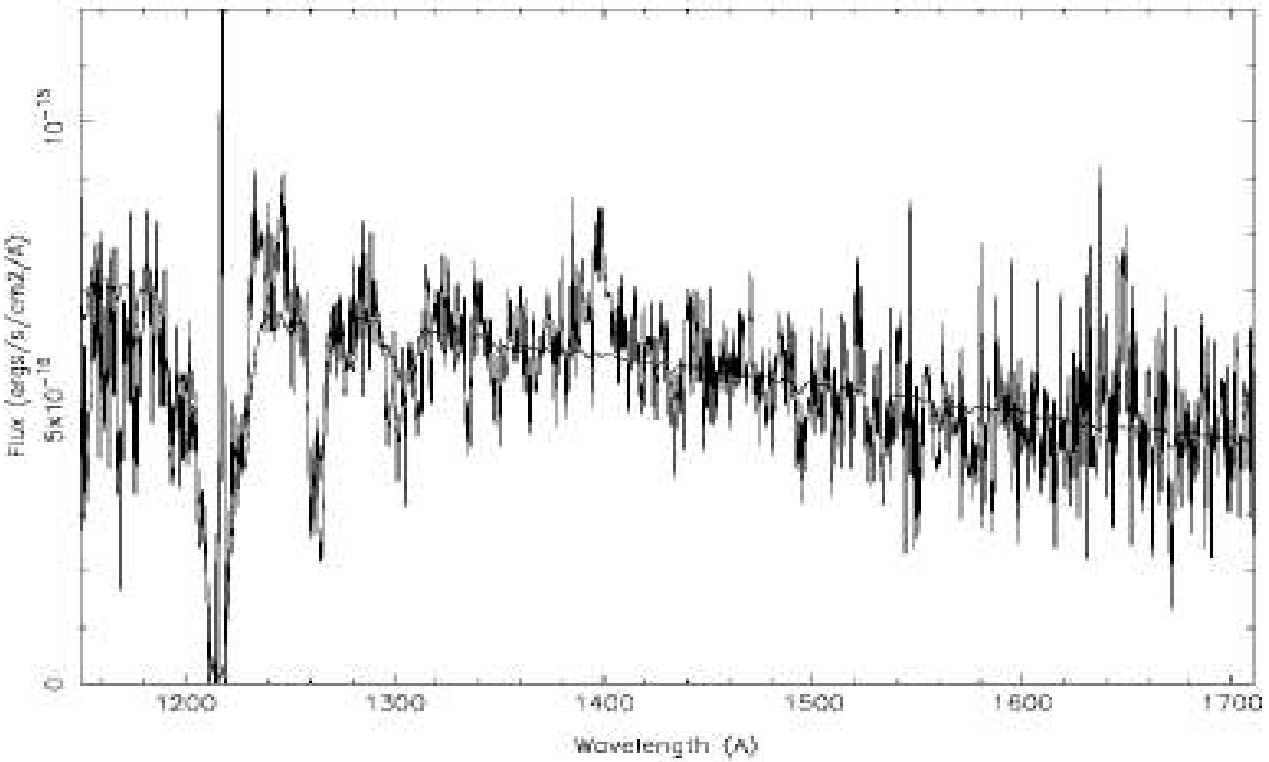
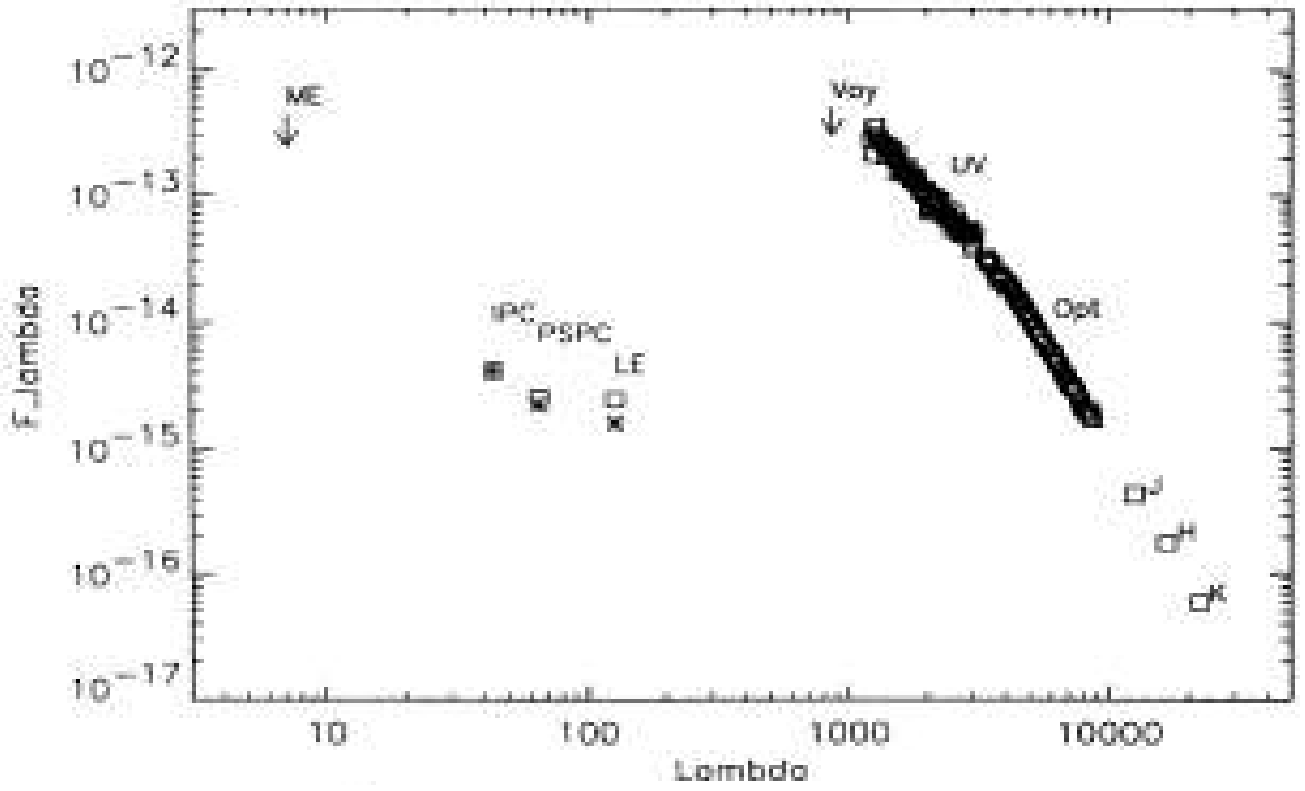


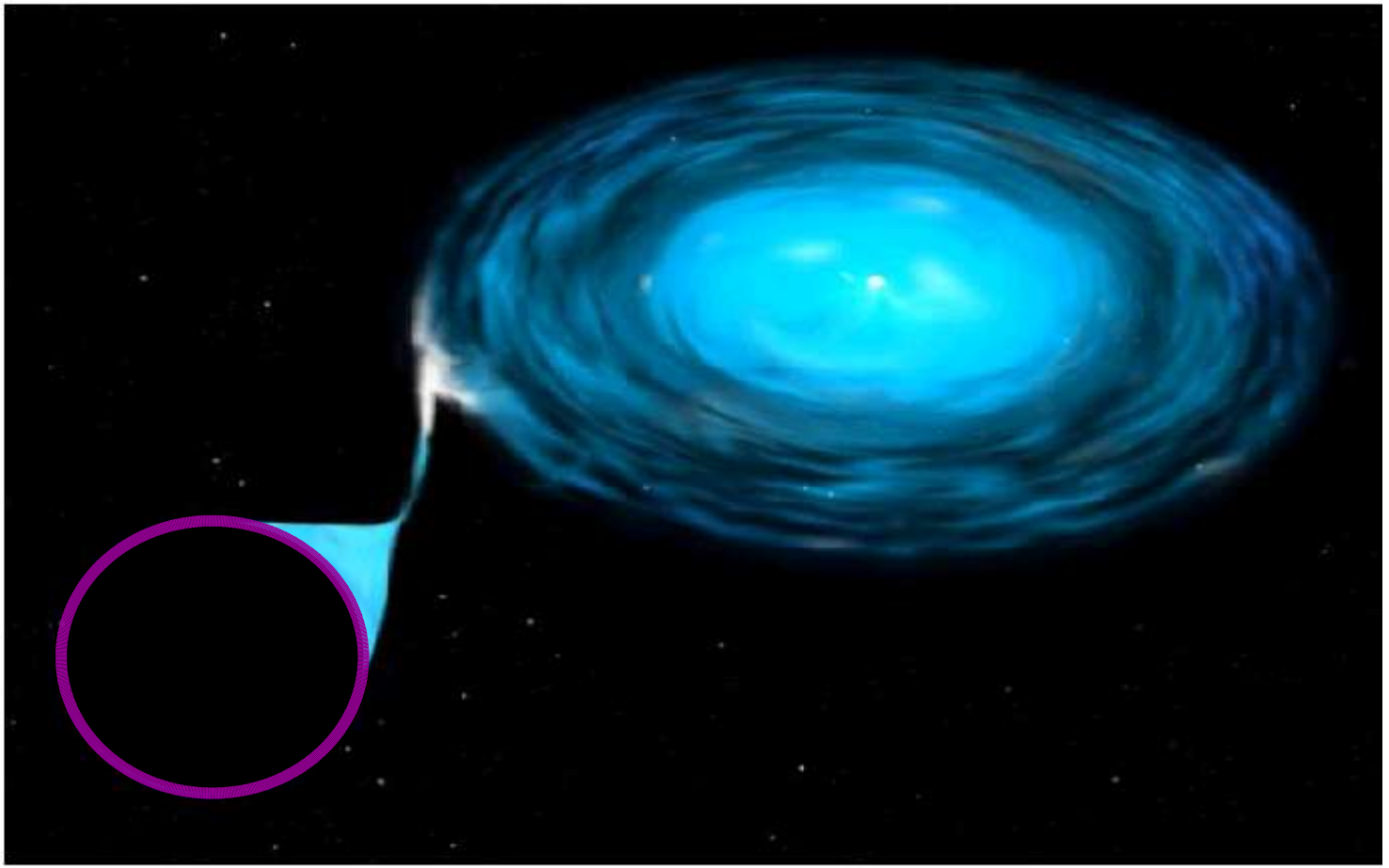
FIG. 3.—Flux distribution, flux vs. wavelength, for the best-fitting hybrid composition, DBAZ, photosphere model with $\log g = 8$, $T_{\rm eff} = 17{,}000$ K, He/H = 10^3, $Z = 0.05$, and $V \sin i = 400$ km s^{-1}, compared with the *HST* STIS spectrum of CP Eri.

Sion et al 2006

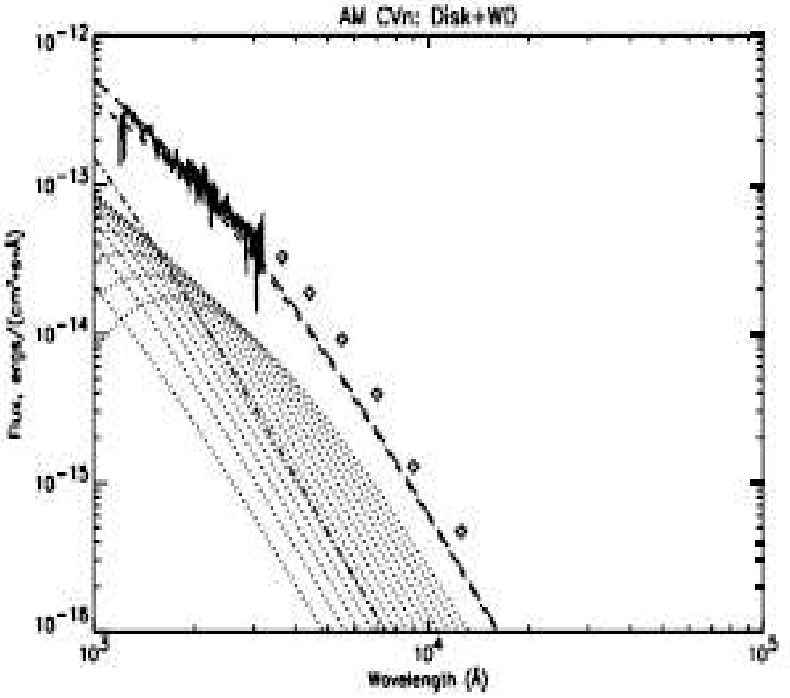
Why can't we “observe” the donor star?



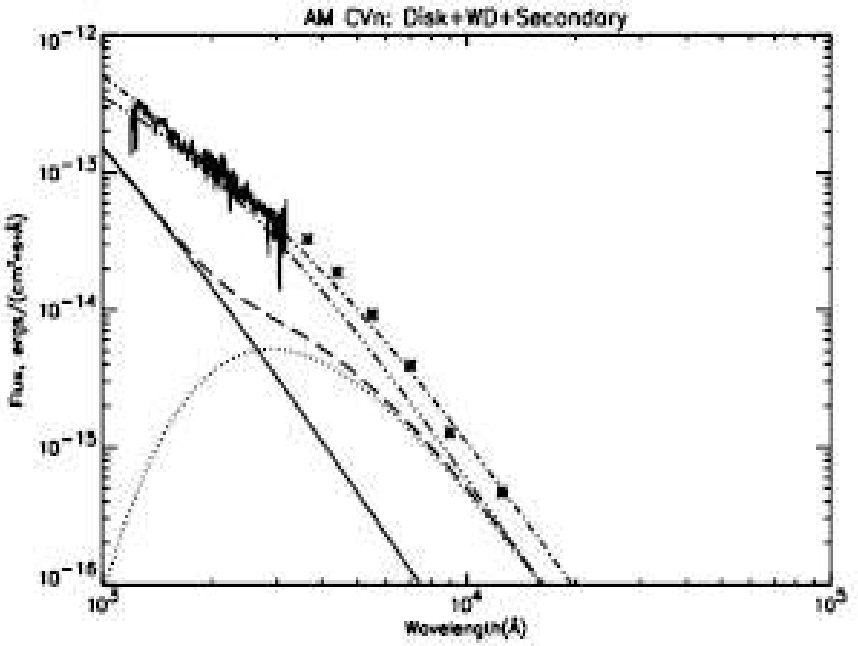
Why is the donor star not seen?



Or is the donor star irradiated to T_{disc} ?



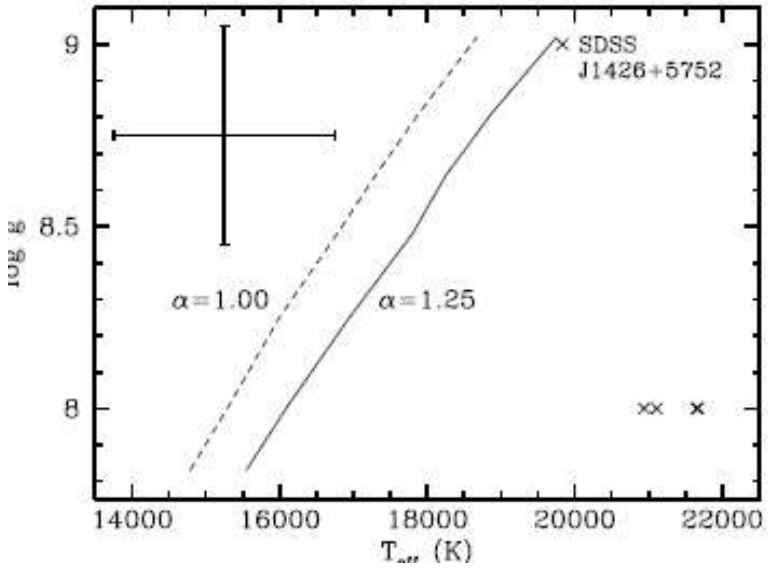
BB disc + WD

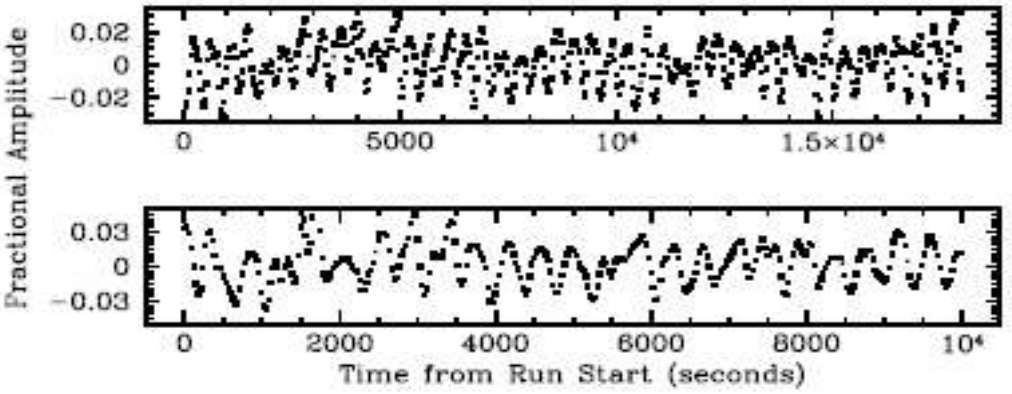


BB disc + WD + donor

The first Carbon rich AM CVn or the first pulsating DQV-star ?

SDSS J1426+5752 g = 19.2 P1 = 417,66 s + harmonics



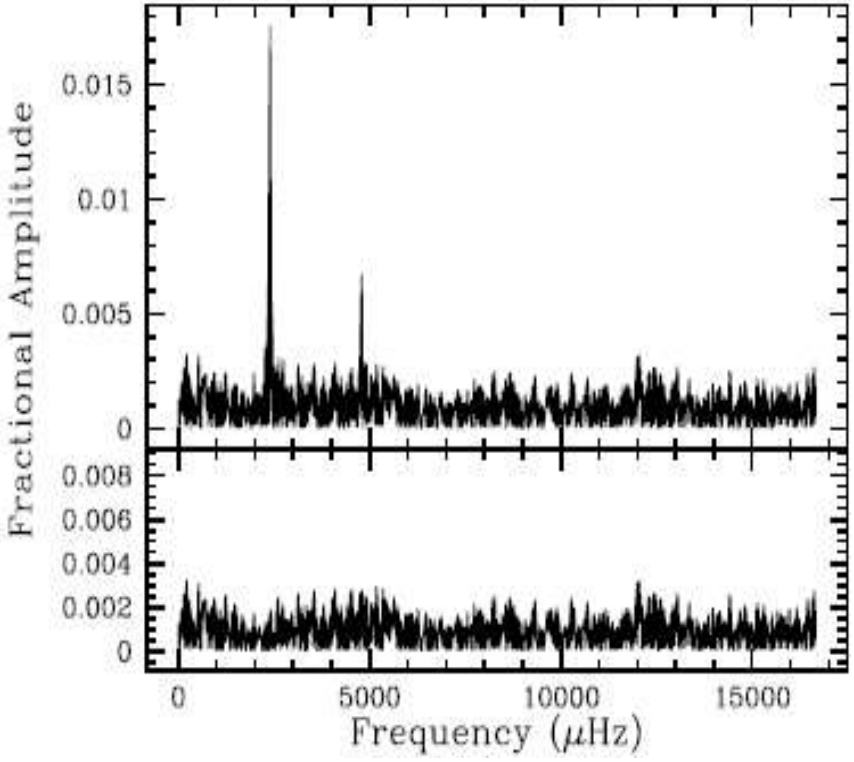


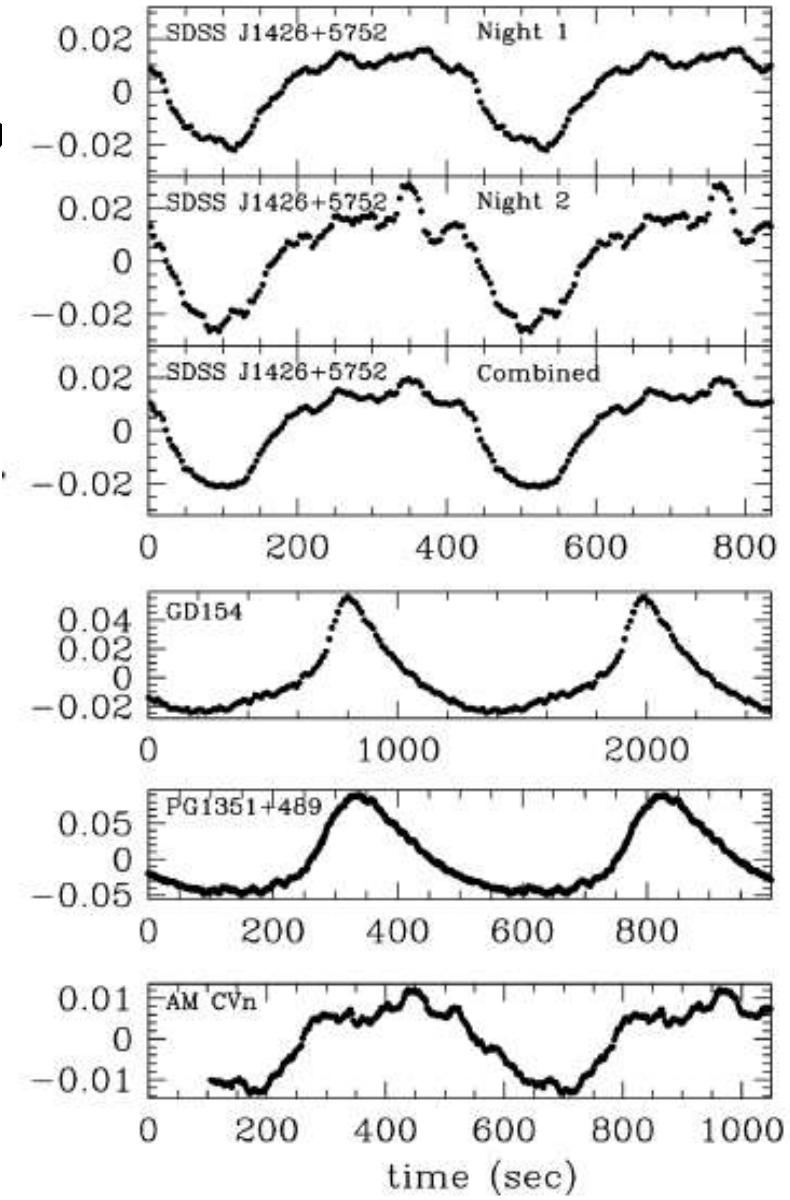
the blue edge possible DQ pulsator

Montgomery et al, 2008

The first Carbon rich AM CVn or the first pulsating DQV-star ?

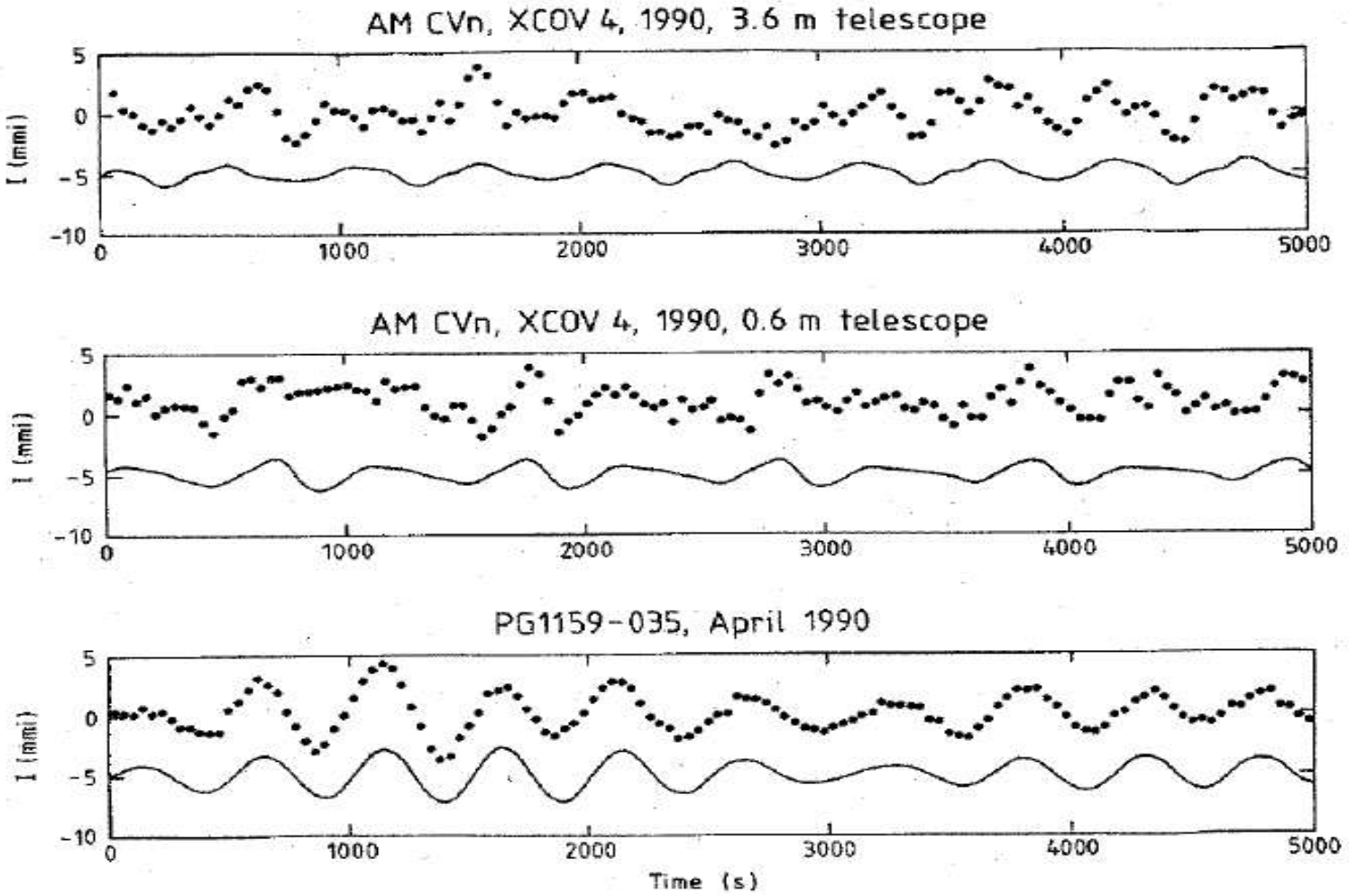
SDSS J1426+57



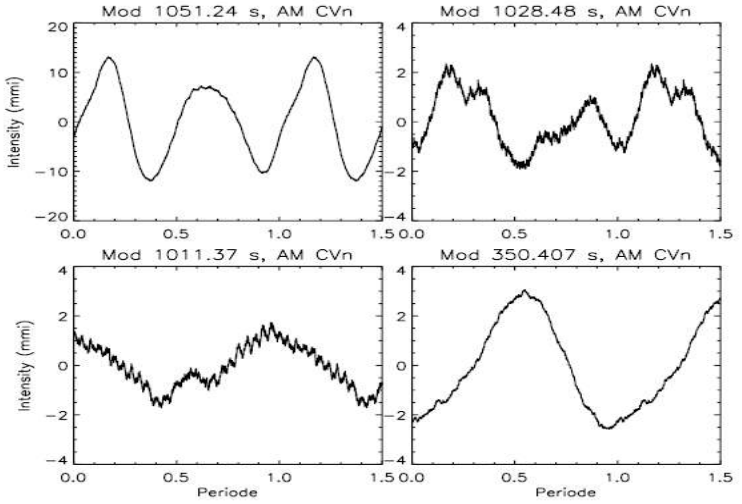


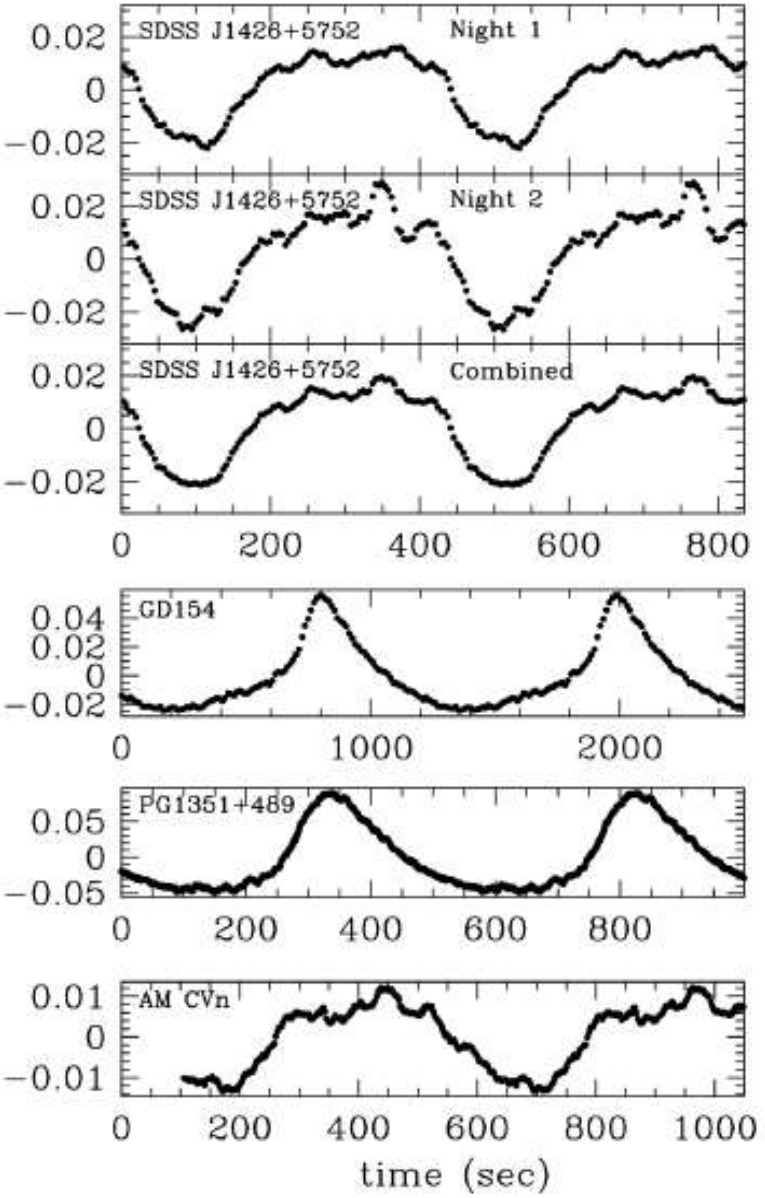
(1,4) Harmonics => pulse shape => AM CVn

Comparison between AM CVn and a multiperiodic WD pulsator



AM CVn pulse shape

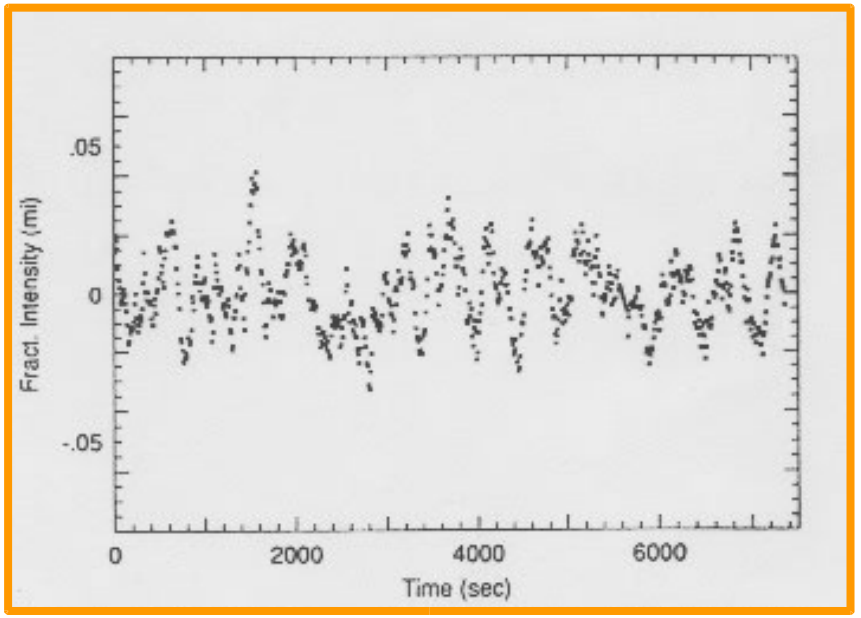




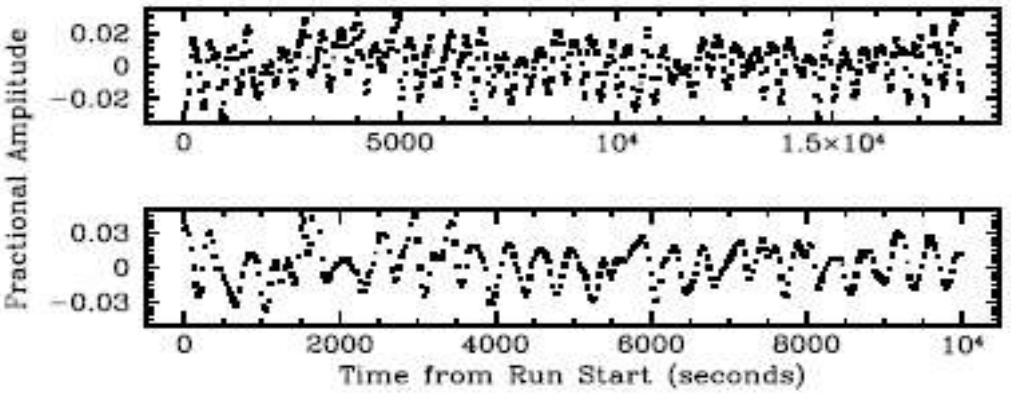
Solheim et al. 1998

Flickering = sign of mass transfer

AM CVn 1991



SDSS J1426+5752



smoothed light curve (dt~45s)

Table 1: Basic data for for AM CVn family members.

Object	V	P_{orb}	P_{sh}	spec.	ref.
Direct impact systems					
HM Cnc		321		weak em	IS02
V407 Vul	>19.7	569		no lines	St07?
ES Cet	17.0	621		em	WW02,EP05,St07
High state systems					
SDSS J1426+5752	19.2g		418	DQ-abs	MW08 (candidat)
AM CVn	13.7-14.2	1029	1051	ab	RG06b
HP Lib	13.7	1103	1119	abs	RG07a
Outburst systems					
CR Boo	13.0-18.0	1471	1488	abs-em	PK97
KL Dra	16.5-20	1500	1530	abs-em	WL03
V803 Cen	13.2-17.4	1596	1611-1618	abs-em	RG07a
SDSS J0926+36	19.3	1699	detected	ecl	AH05,MD07
CP Eri	16.5-19.7	1701	1716	abs-e	GN01,SS06
SN2003aw	15-20.5	2028	2041	abs-em	WW03,RG06
2QZ J1427-01	20.0	2194?		??	
SDSS J1240-01	18.0-19.7	2242		em	RG05,GR07
SDSS J2047+00	23.5-17.5			ab-em	AB08
SNF20060524-042			?	??	
Low state systems					
SDSS J1208+35	18.8g	2218?		em	GR07,AB08
SDSS J1411+48	19.4g	2760		em	AH05,GR07
GP Com	15.7-16.0	2794		em	Ma99
SDS J1552+32	20.2g	3376		em	AH05,RG07c
V396 Hya	17.5	3906		em	RR01
SDSS J0129+38	19.8g			em	AH05

Summary questions

- ***There is wind, circumbinary matter, outflows, .. can we make images as spectacular as for the planetary nebulae?***
- ***What does the secondary look like, why no direct observations?***
- ***The Roche lobe, and equation of balance between gravitational angular momentum loss and mass loss is all we have – can we thrust this equation?***
- ***What about pulsations - why not observed? -- the temperature of the accretor is right, theory tells what to expect, have we observed in the right way?***
- ***Why do we find only two AM CVns in continuous high state (AM CVn and HL Lib)? --They are both around 14 mag. Why don't we have any between mag 14 and 20?***
- ***SDSS J142625.71+575218.3 is it a Carbon AM CVn or pulsating DQ star?***
- ***CP Eri --> the first example of a hybrid AM CVn-other proofs needed?***