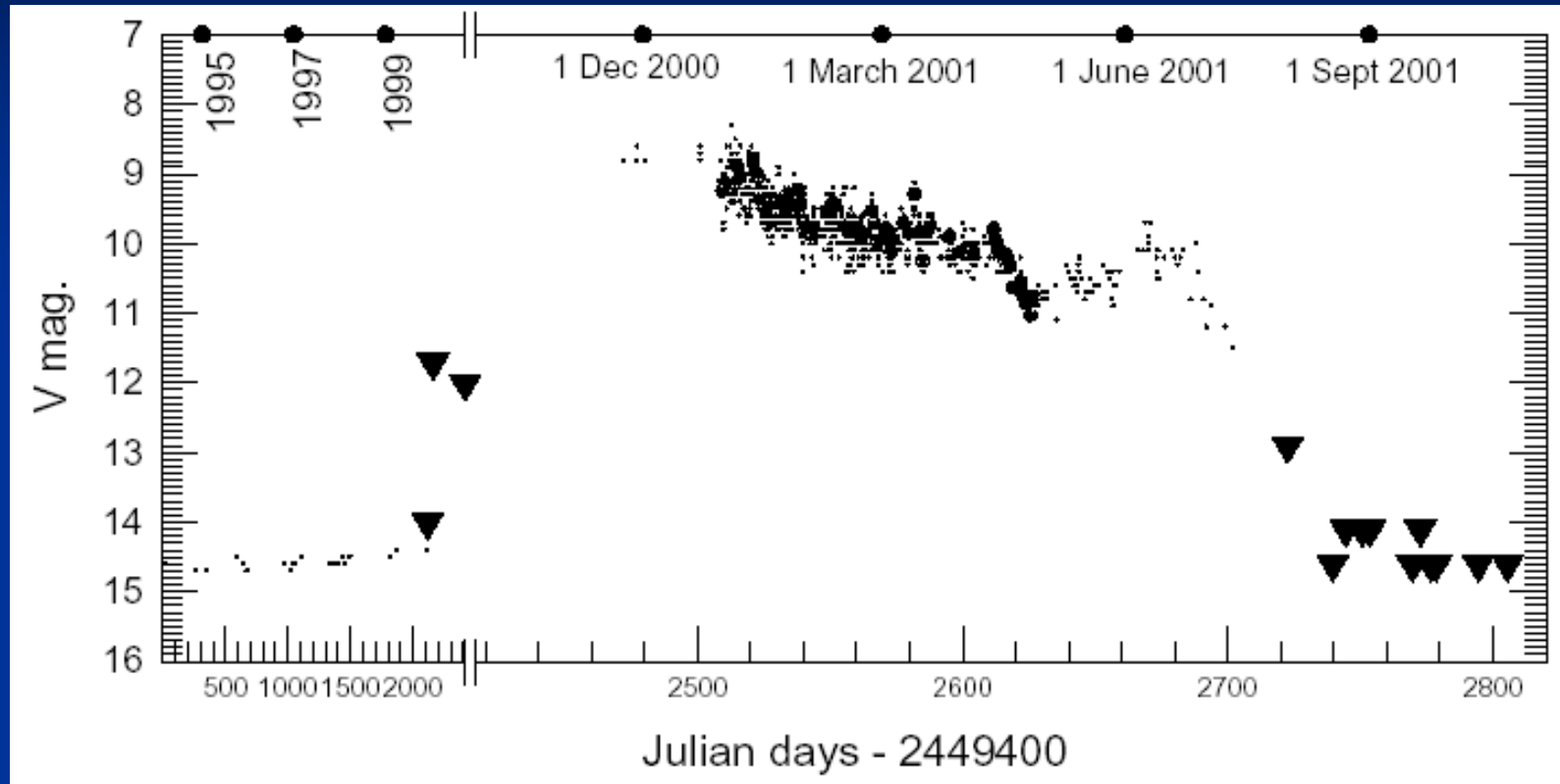


# V445 Pupppis – He Nova ?

Thanks - Patrick Woudt, Danny Steeghs for their recent updates

# Light Curve of V445 Pup



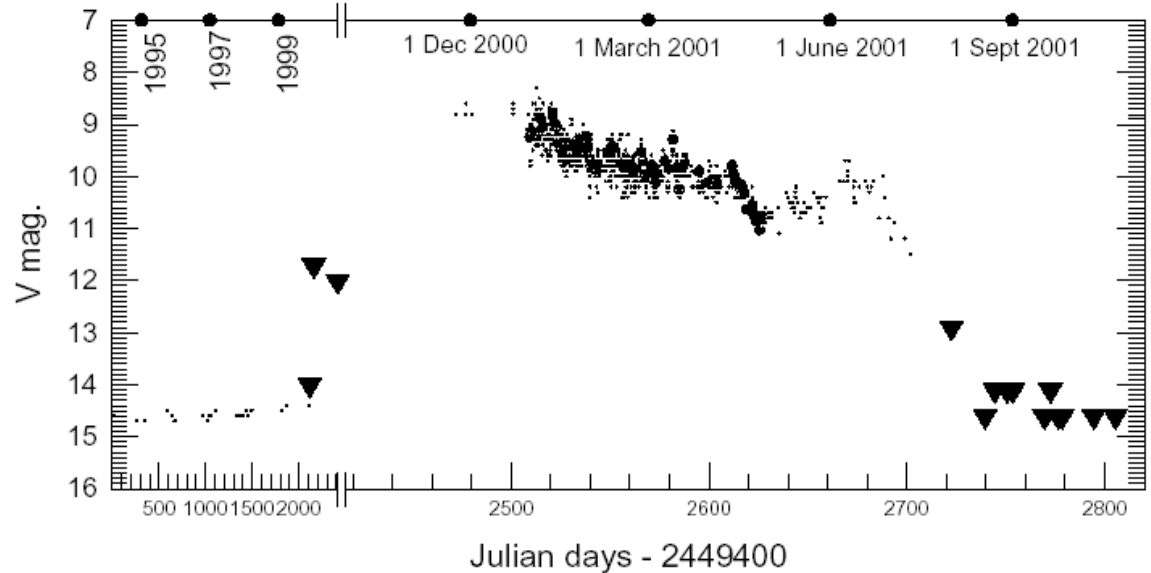
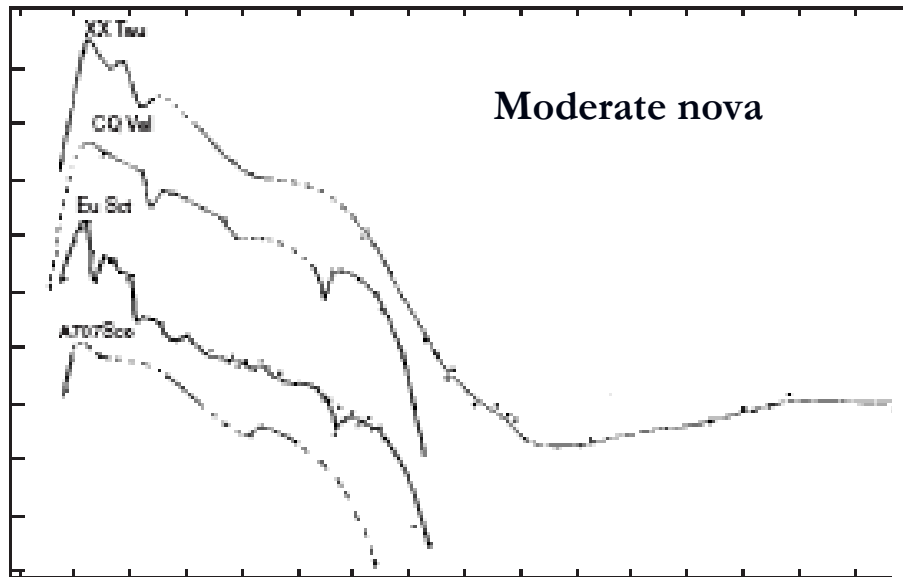
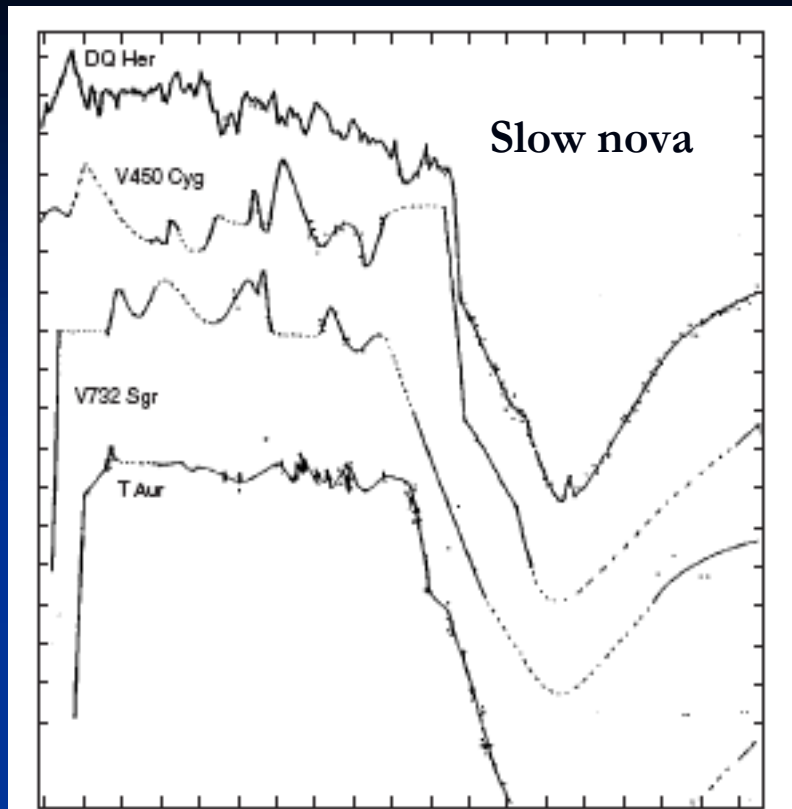
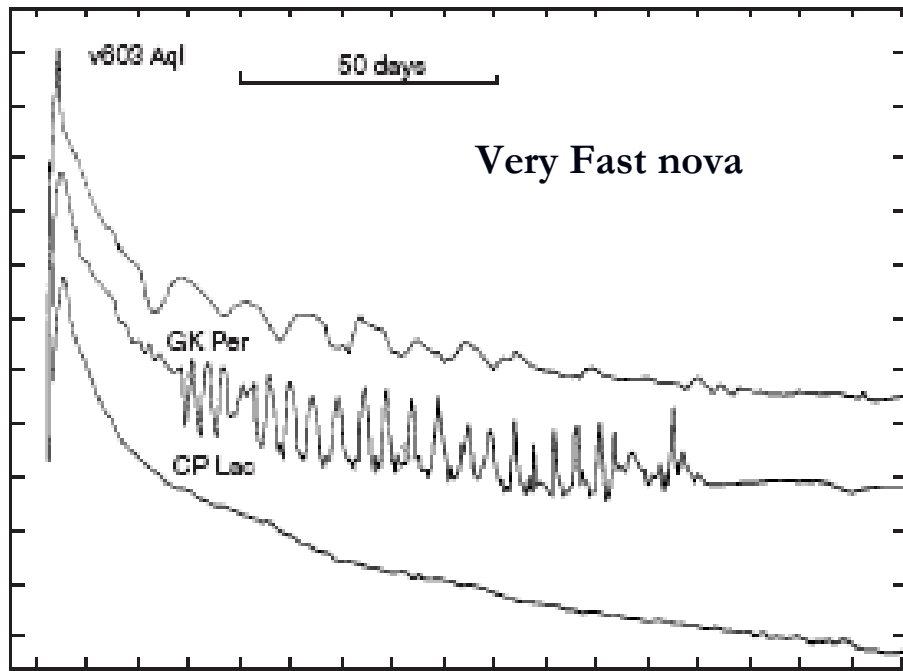
Ashok & Banerjee 2003

Last nova of the previous millenium

Discovered by K. Kanatsu (8.6 mag on 28 November 2000)

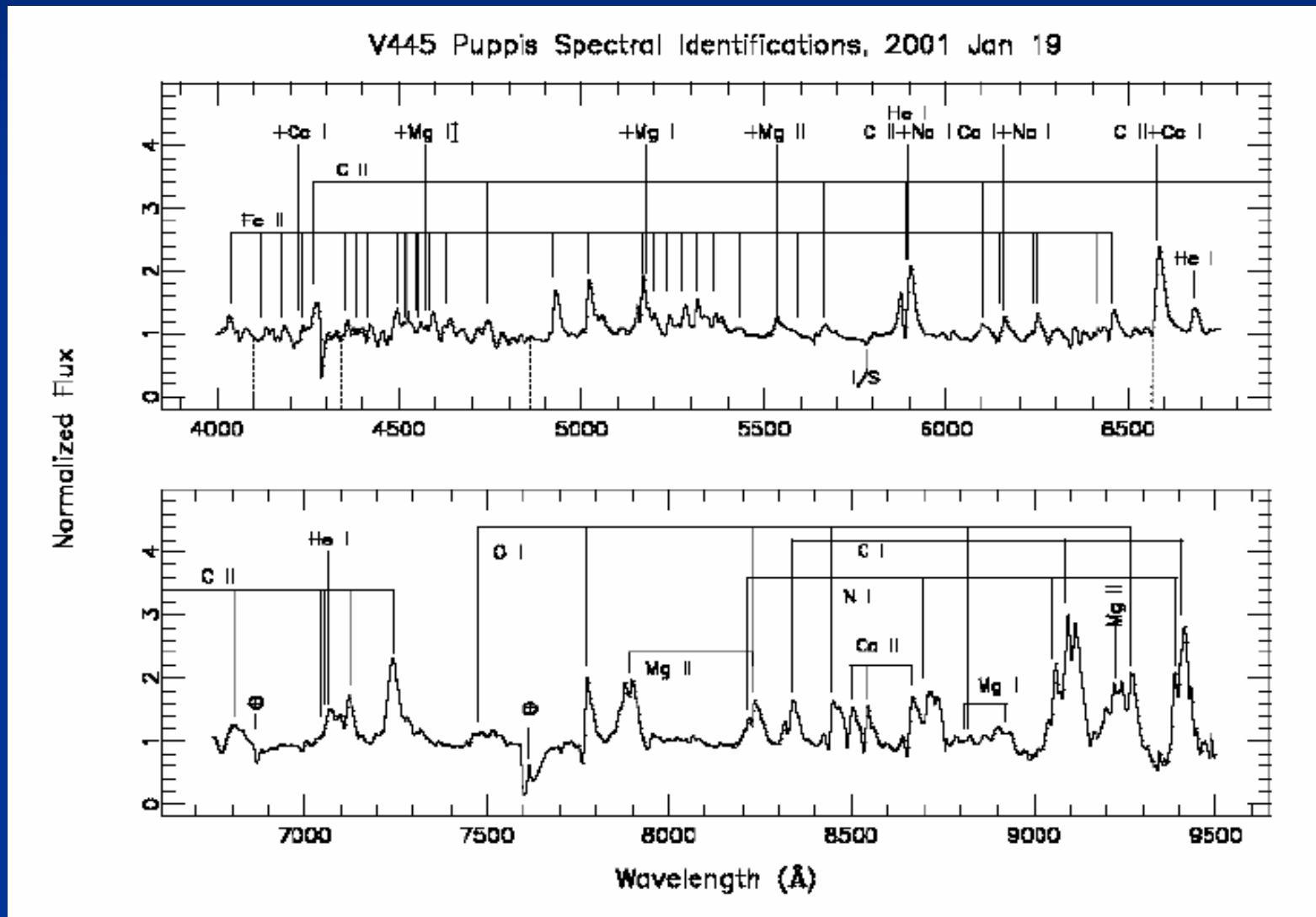
Outburst between September and 28 November 2000 (HJD 2451876)

Slow nova (outburst lasted ~7 months)



• V445 Pup – a very slow nova

- Early outburst phase showed hydrogen deficient spectra, but contained prominent FeII, CI, Ca, O.
- There is indication (?) for the Pa $\gamma$  but without trace for Pa $\beta$



# The nature of V445 Pup Asok Banerjee 2003

## What it is not !

- **Classical Nova** Different in amplitude, Deficiency of H, large number of C lines, evolutionary different
- **Recurrent nove** — no history of earlier outburst
- **Symbiotic nova** — no high excitation emission lines, different light curve
- **RCB of Hydrogen deficient carbon star** that eject carbon shells ( but the spectra is different)
- **AM CVn** – wd-wd binary
- **Born again AGB star**
- .....

- Proposed as the first observed helium nova (Kato & Hachisu 2003; Ashok & Banerjee 2003).

### Various unique aspects:

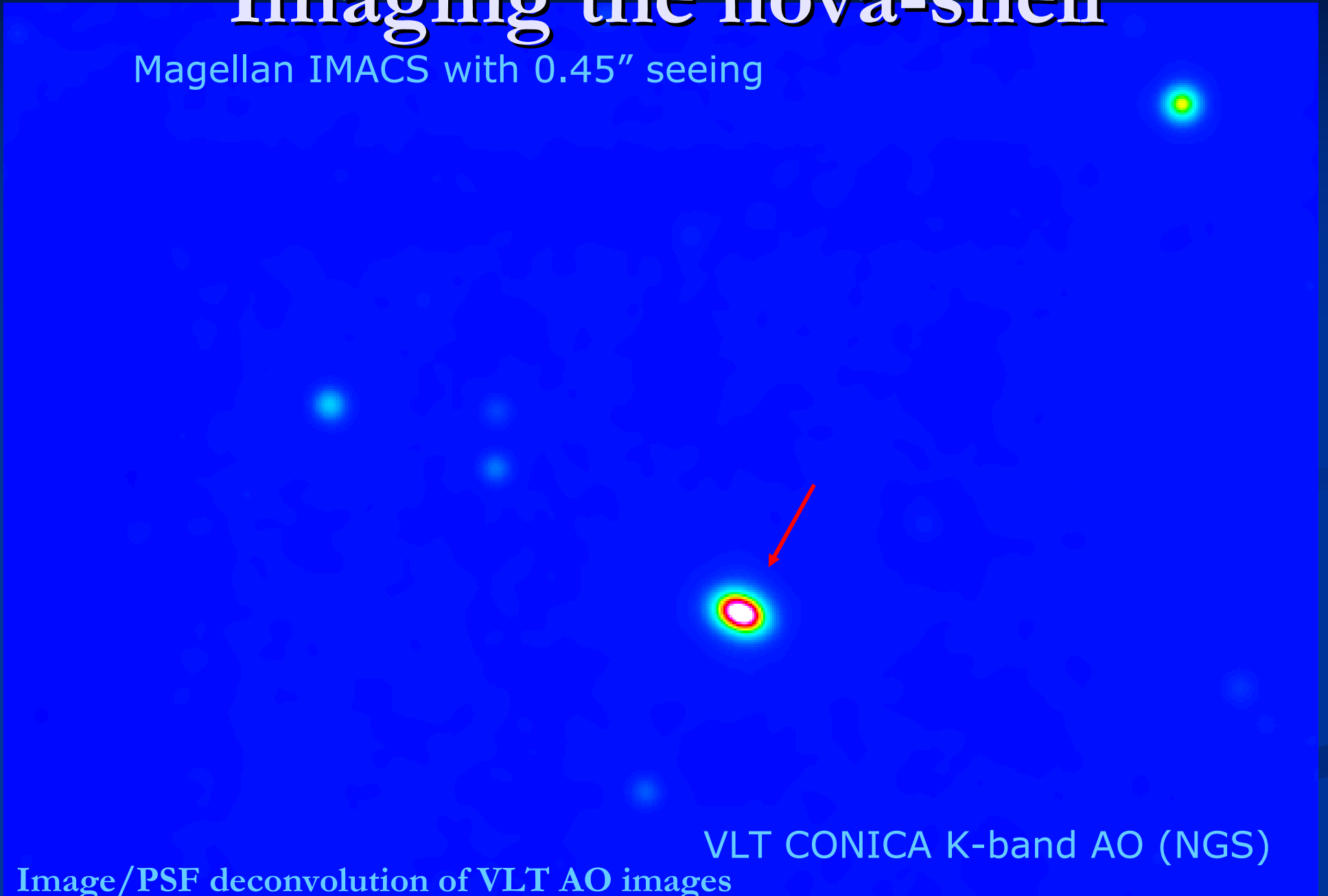
- Hydrogen-deficient (Wagner et al. 2001)
- Enriched in carbon and helium (e.g. Ashok & Banerjee 2003)
- The initially formed optically thin dust shell has developed in an optically thick shell (Henden et al. 2001)
- It still obscures the nova (4-5 years later)
- One of a kind !?

# Evidence for Binary System

- Evidence for accretion – the pre-outburst spectrum reminds accretion disc  $F_{\nu} \sim \nu^{1/3}$
- Radio data – synchrotron emission originating in either accretion on compact object or a shock between old and new outburst.
- The source appears too complicated at present .

# Imaging the nova-shell

Magellan IMACS with 0.45" seeing



VLT CONICA K-band AO (NGS)

Image/PSF deconvolution of VLT AO images

courtesy M.Karovska/D.Steeghs



# Imaging the nova-shell

Magellan IMACS with 0.45" seeing

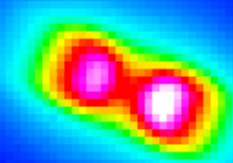


Image/PSF deconvolution of VLT AO images  
courtesy M.Karovska/D.Steeghs

VLT CONICA K-band AO (NGS)

# Imaging the nova-shell

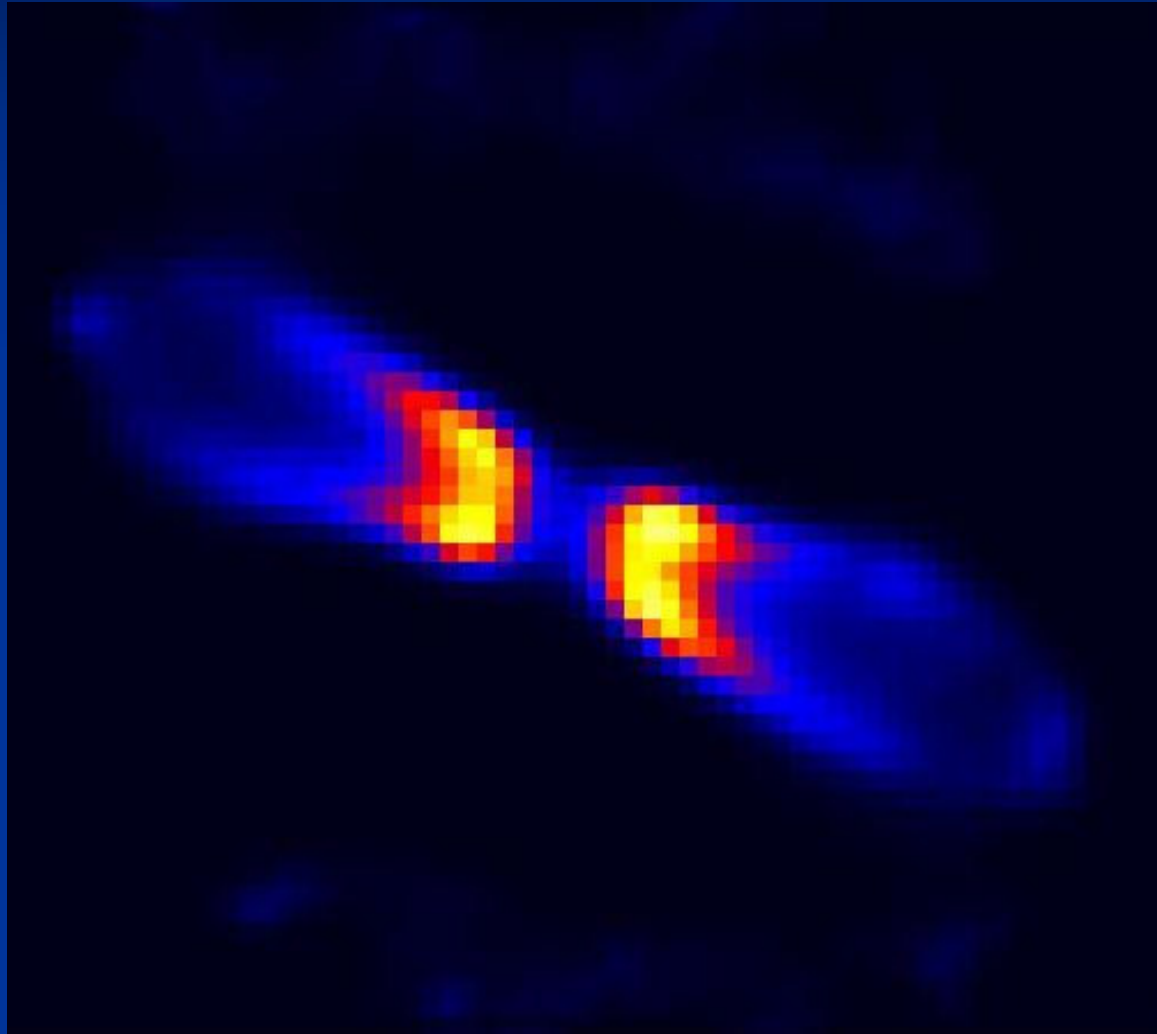
Magellan IMACS with 0.45" seeing



VLT CONICA K-band AO (NGS)

Image/PSF deconvolution of VLT AO images  
courtesy M.Karovska/D.Steeghs

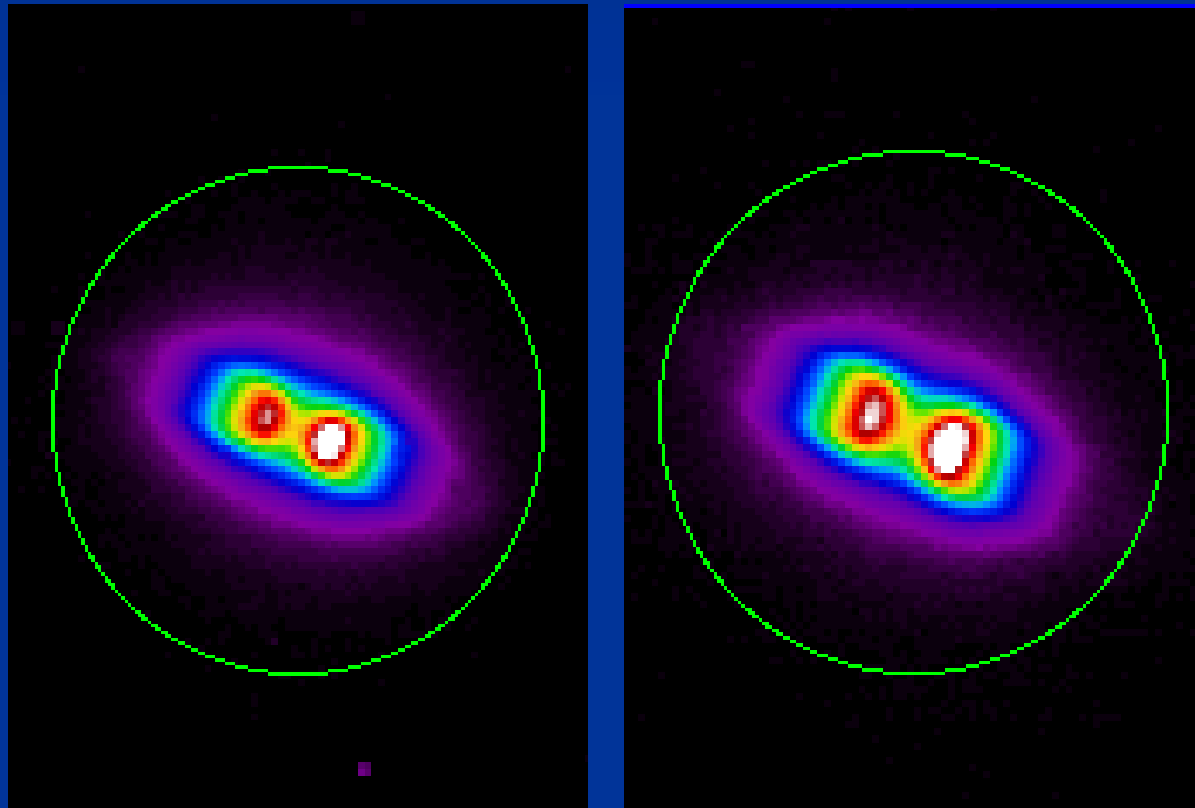
# The nova-shell deconvolved



2.5"x2" FOV

Image/PSF deconvolution of VLT AO images  
courtesy M.Karovska/D.Steeghs

# Magellan IFU observations

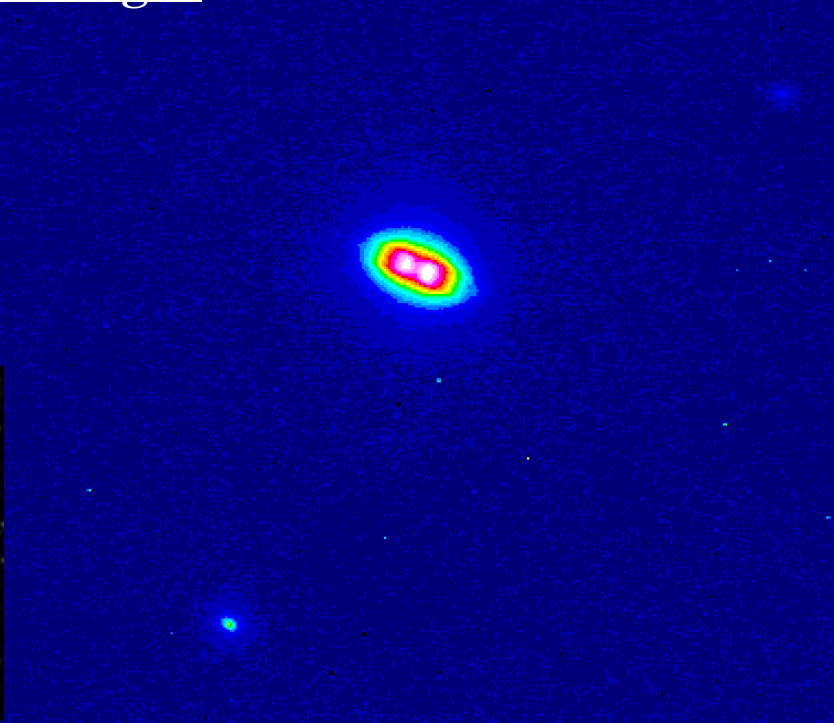


# V445 Pup: the nova shell at high resolution

courtesy Patrick Woudt, Danny Steeghs

## VLT + NAOS/CONICA

- 4 epochs of K-band imaging
  - (E1) 25 March 2005
  - (E2) 06 December 2005
  - (E3) 06 October 2006
  - (E4) 03 March 2007
- Good seeing ( $\sim 0.6''$ )
- Achieved FWHM  $\sim 0.11''$
- Expanding bipolar nova shell



Deconvolution:  
M. Karovska (CfA)

- Knots at extremes of major axis
- Viewing dust disk/torus nearly edge-on



Field of view:  $1.6'' \times 1.6''$

# New updates - Patrick Woudt, Danny Steeghs

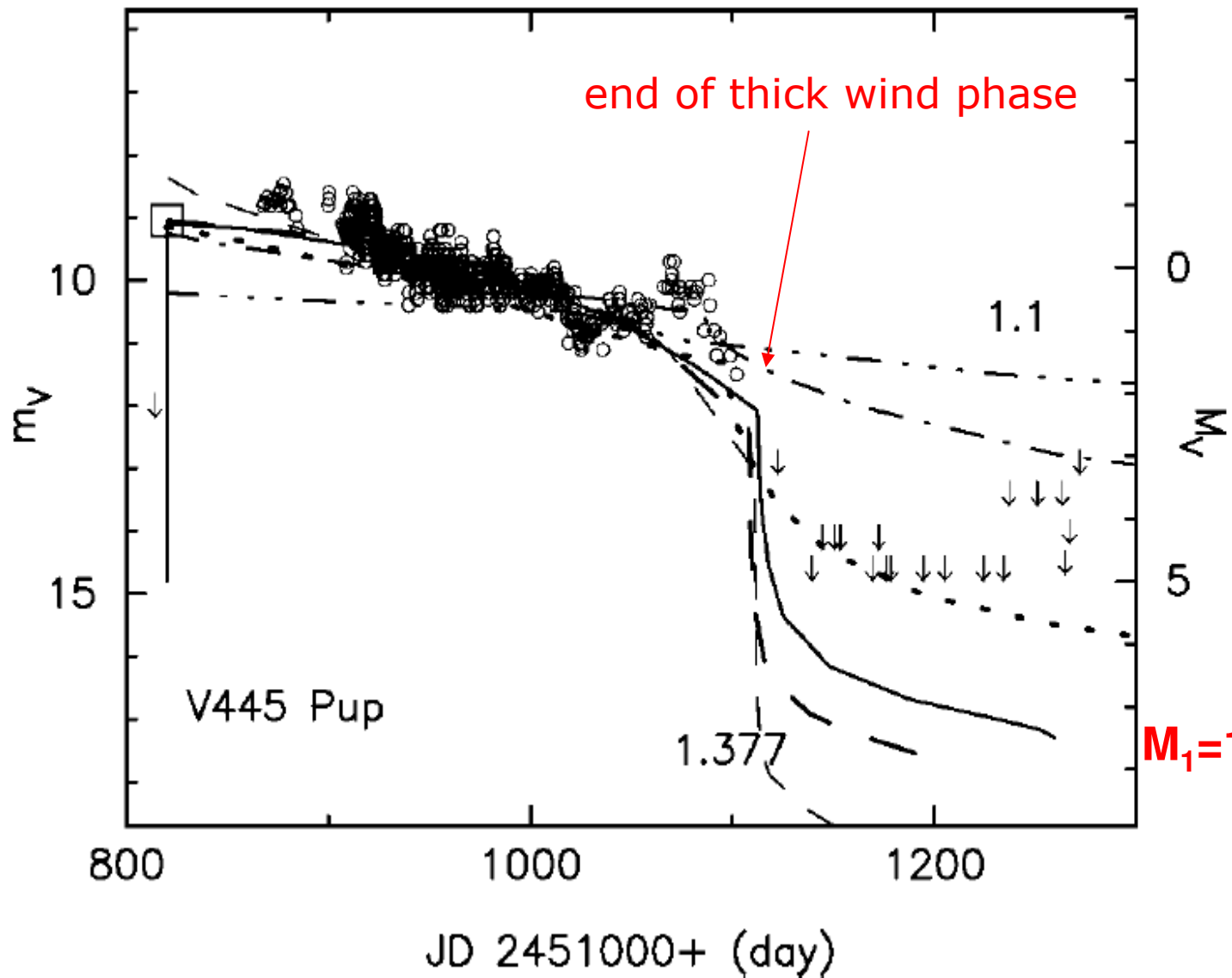
- Clearly detected an expanding, bipolar nova shell with an strongly obscuring dust disk/torus perpendicular to the ejecta.
- Distance from expansion parallax:  $> 3$  kpc
  - limits on the nature of the companion; not a WD+WD binary
  - Model must be tested rigorously (allow for changing shell structure)
- No previous outburst observed in the CfA plate archives (1890 – 1960)
  - Recurrent nova? Time scale?
- Evolution of V445 Puppis is still ongoing
  - continued near-infrared (IRSF) monitoring
- Supernova Ia progenitor?
  - New distance estimate must be compared with Kato's models to check for compatibility with the massive WD models
- White dwarf / helium star binary? When the dust clears, an orbital period must be obtained using high-speed photometry! Eclipsing?

# He nova –

Kato et al. (1989) / Iben & Tutukov (1994)

- WD accreting from He-rich donor producing a thermo-nuclear runaway on its He-rich surface
- Would expect He,C rich ejecta but no H
- Optically thick wind, He burns into C,O and accumulates on the WD, pushing it towards an AIC / Type Ia
- Some hydrogen can also be mixed in

# Kato and Hachisu 2003



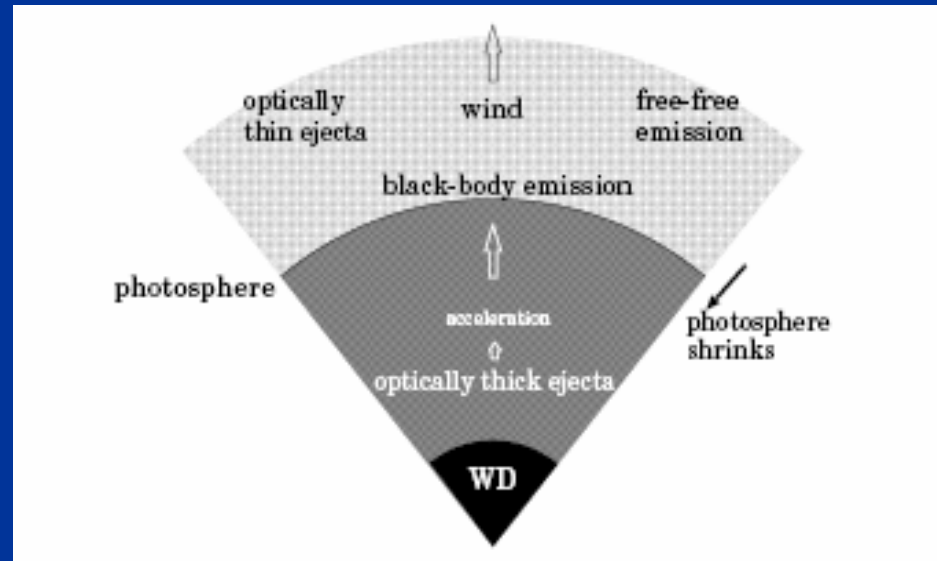


■ From modelling of the optical light curve, Kato & Hachisu (2003) deduced the following (model-dependent) parameters:

- Mass of the primary ( $M_1$ )  $> \sim 1.33 M_{\text{sun}}$
- accretion rate is several times  $10^{-7} M_{\text{sun}}/\text{yr}$
- nova recurrence time ( $t_r$ ) is  $\sim 70$  yr
- $M_1$  and  $t_r$  in their models depend sensitively on the assumed distance
- $d = 640$  pc ( $1.33 M_{\text{sun}}$  and 61 yr);  $d = 700$  pc ( $1.35 M_{\text{sun}}$  and 84 yr)

# New results from Kato

- Previous results - with BB emission
- Recent results base on free-free emission of optically thin ejecta
- $M_{wd} > 1.35 M_{sun}$
- $D \approx 6 \text{Kpc}$



- Still missing: Companion star, Orbital period Inclination.....