

How peculiar is DZ Crucis?

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INTRODUCTION

DZ Cru was discovered in outburst on 2003 August 20¹. Figure 1 shows the visual light curve of the “possible nova” from VSNET and IAU Circulars^{1,2,3,4}. At the time of discovery the visual magnitude of DZ Cru was $V=10$. The brightness fluctuated around this value for ~10 days before the visual light dropped off at a rate of 0.3 mag per day. A final observation was made on 2003 September 22, when the object was fainter than $V=11.9$.

Optical spectroscopy of DZ Cru was obtained within a few days of the discovery^{2,3}. The spectrum displayed weak hydrogen emission and other atomic lines with P Cygni profiles - the signature of mass loss. Unusually, the outflow velocities determined from the P Cygni lines were relatively low for a nova (~500kms), and many nova signatures were lacking. Photometry⁴ also showed that the “Peculiar variable in Crux” was surprisingly red at this time ($B-V = 1.25 \pm 0.05$). These oddities led to speculation² that DZ Cru is a final helium shell flash object – a born again AGB star - or even a V838 Mon type of eruptive variable (see below).

Here we present New Technology Telescope (NTT) near infrared spectra of DZ Cru obtained on three occasions in a five month period starting in 2005 February (~1.5 years after outburst). These observations shed new light on the nature of DZ Cru.

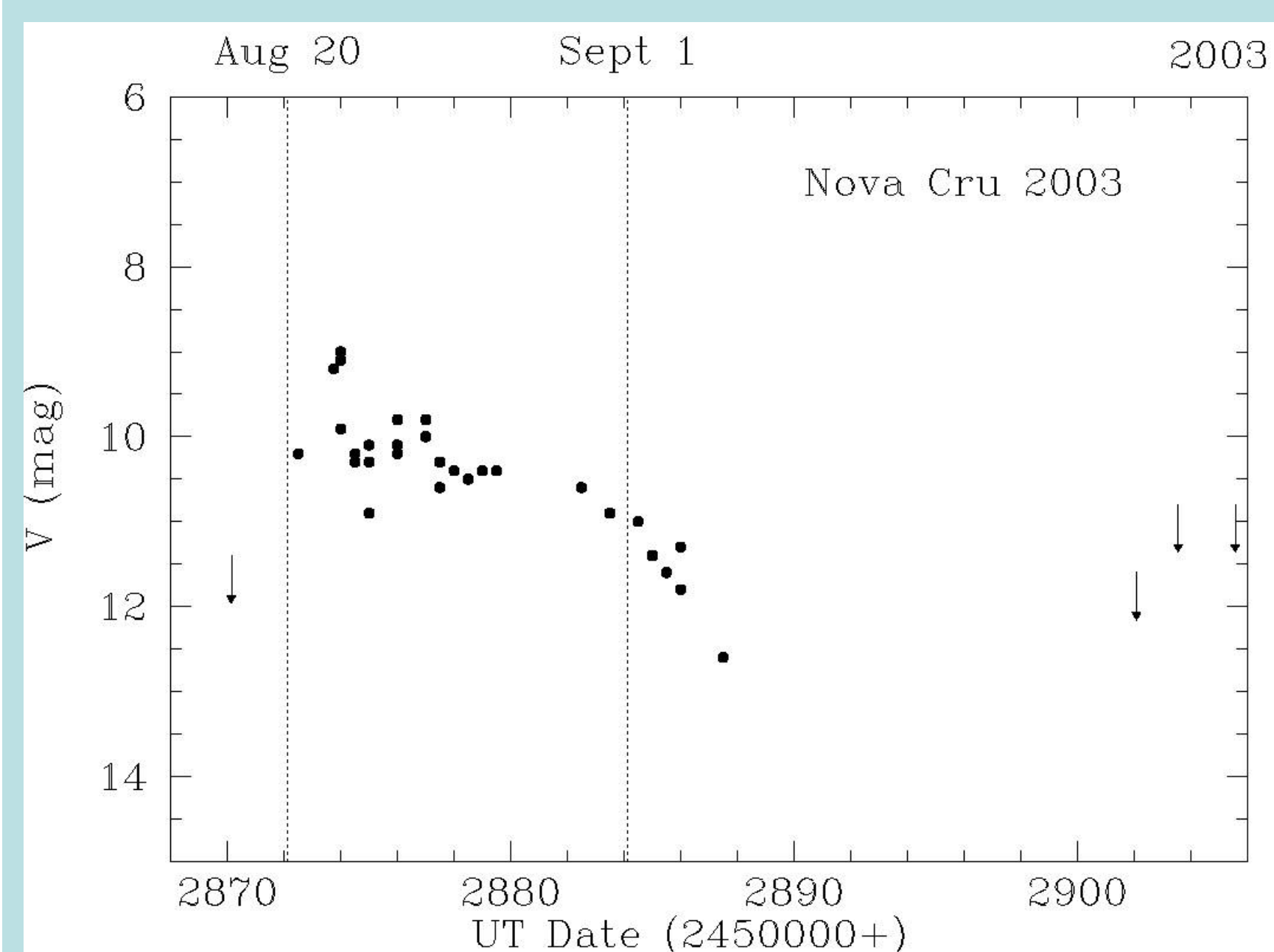


Figure 1: Visual light curve of DZ Cru. Arrows denote upper limits. Our observations were obtained ~1.5-2 years after outburst and well outside the time interval shown.

V838 Mon and the new class of variable



V838 Mon and its light echo⁵

The peculiar variable V838 Mon has been subject of immense interest since it was discovered in outburst in early 2002. The object is perhaps best known for the spectacular light echo that developed around the star shortly after discovery. The main observational property that distinguishes V838 Mon from other eruptive variables is its rapid evolution towards lower effective temperatures. V838 Mon is thought to belong to a new class of eruptive variable along with M31 RV⁶, V4332 Sgr⁷, and M85 OT2006-1⁸. Various models have been put forward to explain the outbursts of these objects^{9,10,11,12}, with the merger of two main sequence stars¹³ being favoured, although it is not clear whether or not such events could occur often enough. Thus the suggestion that DZ Cru is a ‘V838 Mon type object’ is one that warrants further investigation.

ABSTRACT

DZ Cru is a peculiar eruptive variable discovered in the early stages of what appeared to be a nova outburst in 2003 August. The nature of the object was called into question shortly after, with similarities being noted with born again AGB stars and the remarkable object V838 Mon. We present near infrared spectroscopy of DZ Cru obtained ~1.5-2 years after outburst, with the aim of establishing the nature of the object. The spectra display H I, He I, O I, and [N I] emission lines superimposed on a rapidly evolving dust continuum. Our observations suggest that DZ Cru is a nova.

OVERVIEW OF THE SPECTRA

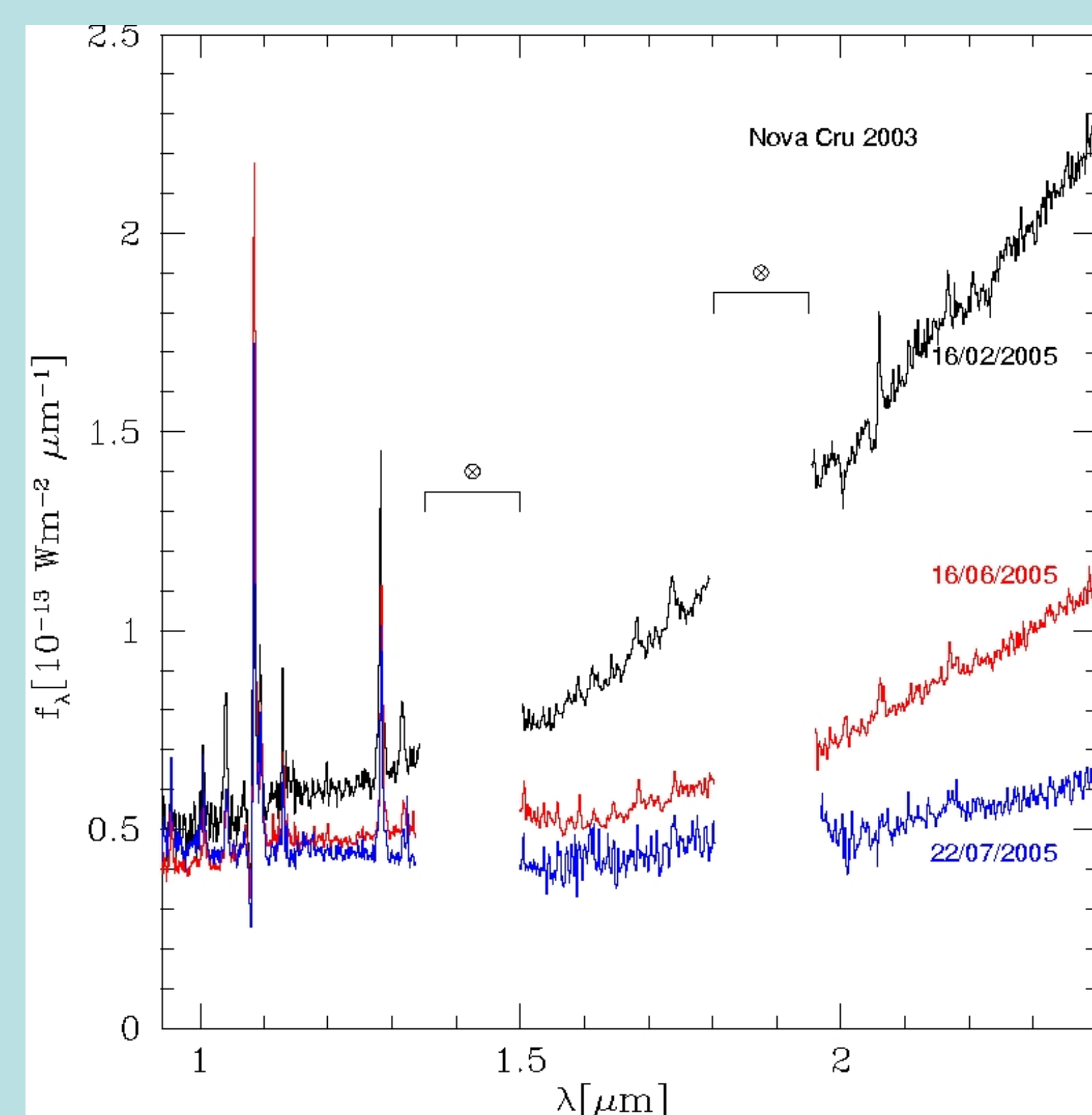


Figure 2: NTT spectra of DZ Cru. The gaps in the data are due to strong telluric H₂O absorption. The spectral lines are identified in Figure 3. Date format is DD/MM/YR.

Near infrared spectra of DZ Cru in February, June and July of 2005 are shown in Figure 2. The data are expanded to show the spectral lines more clearly in Figure 3. The spectra display hydrogen Paschen and Balmer series emission lines, together with He I P Cygni lines and O I and [N I] emission lines. Interestingly, the continuum rises to the red, indicating thermal emission from newly condensed dust. The flux in the K band decreases with time, presumably due to the cooling and dispersal of the dust over the period covered by our observations.

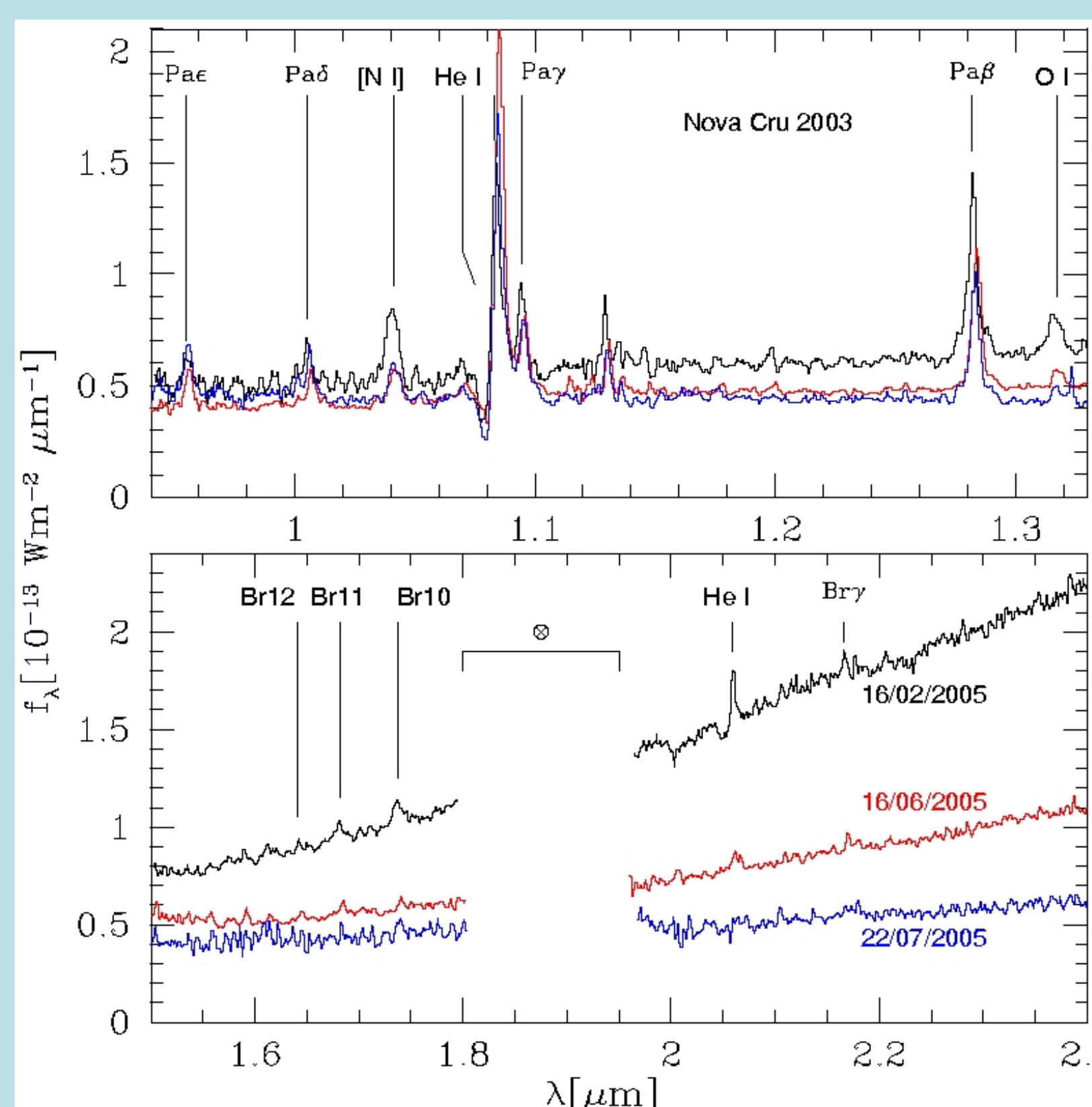


Figure 3: The spectra in Figure 2 expanded to show more detail. Br10, Br11, and Br12 are hydrogen Brackett lines labeled with their upper level quantum numbers.

KINEMATICS

The mean expansion velocity of the ejecta can be found from the FWHM of the emission lines, and the absorption minima of the He I P Cygni lines. From the hydrogen lines we find an expansion velocity of ~500kms⁻¹, consistent with those reported close to the time of the outburst². However, the He I P Cygni lines indicate mean outflow velocities of ~1500kms⁻¹, and are clearly related to a separate ejection event. Weak emission components are seen at this velocity in the hydrogen lines (see Figure 3).

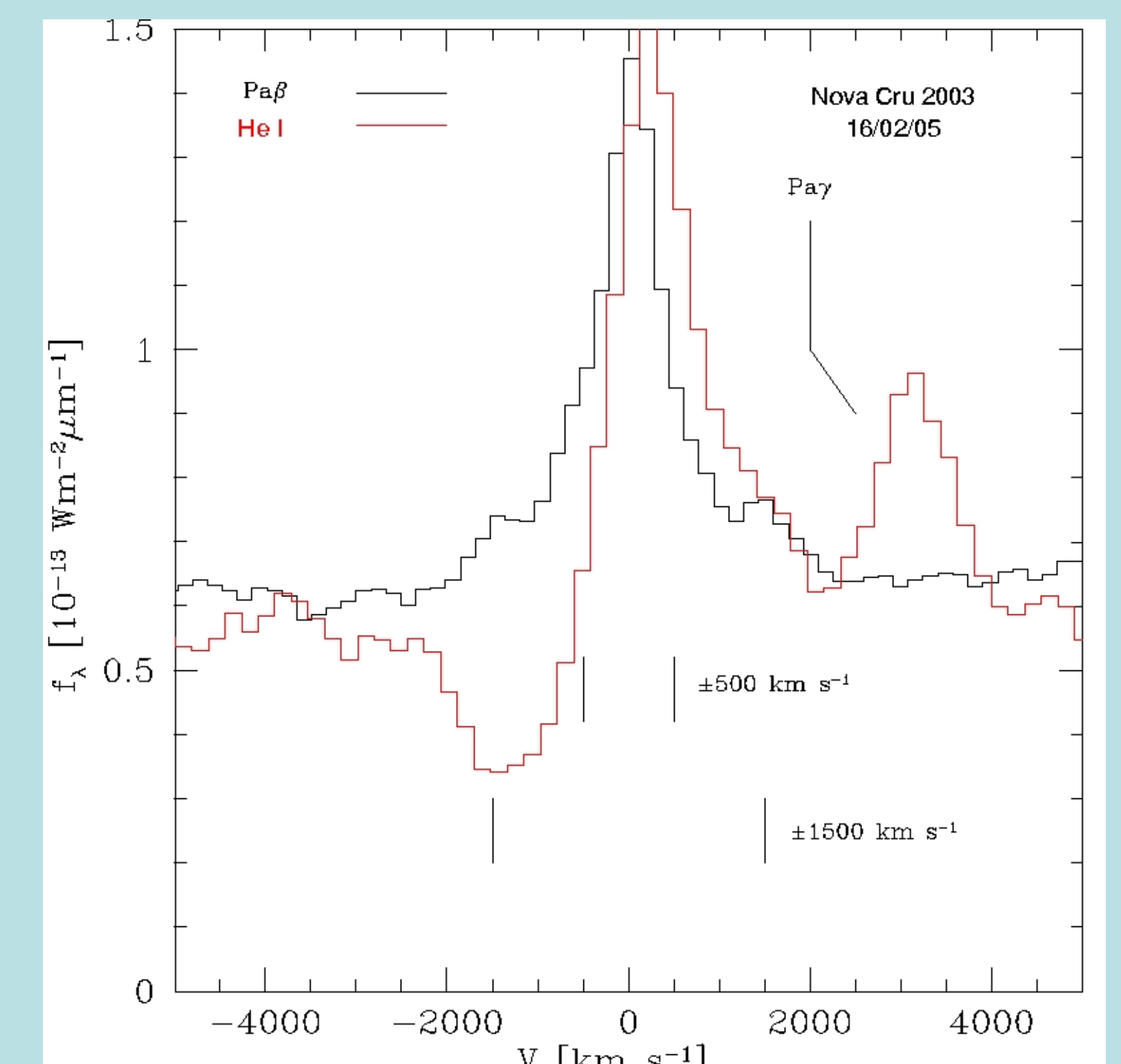


Figure 3: Close up of the Pa β line in DZ Cru. The He I 1.083 μ m line is shown for comparison. The hydrogen line contains a main component with FWHM ~1000kms⁻¹, and weaker components at ~±1500kms⁻¹.

WHAT IS DZ Cru?

A V838 Mon type object?

Our spectra bear no resemblance at all to those of V838 Mon ~1.5 years after its outburst. V838 Mon did not develop hot dust nor has it ever displayed outflow velocities above 300kms⁻¹. DZ Cru is clearly not a V838 Mon type object.

A Born again AGB star?

The main argument against this interpretation is the presence of strong hydrogen emission lines in DZ Cru. Born again stars are deficient in hydrogen and consequently display weak H I lines in their spectra. On this basis we conclude this is an unlikely explanation.

A nova type outburst?

The spectra reported here leave little doubt that DZ Cru is a nova. The line spectrum is similar to those seen in the near infrared spectra of novae, and many novae are known to have produced extensive dust shells from their ejecta. Furthermore, the outflow velocities reported close to maximum brightness (~500kms⁻¹) can be reconciled with this interpretation, but only if the object is a slow nova. By examining the galactic extinction curve along the line of sight towards the object we can also explain the peculiar redness of the object in outburst. The extinction rises steeply with distance, reaching $A_V = 3.4 \pm 0.3$ at $d = 8.02 \pm 1.33$ kpc¹⁴. It is likely that the unusual colour is due to the heavy interstellar reddening in this direction. We conclude that DZ Cru is a slow nova, and not so peculiar after all.

REFERENCES

- Tabur., V., et al. 2003, IAU 8134
- Della Valle, M., et al. 2003 IAU 8185
- Bond, H. E., et al. 2003 IAU 8185
- Liller, W., et al. 2003, IAU 8188
- Bond, H. E. et al. 2003, Nat, 422, 405
- Rich, R., et al. 1989, ApJ, 342, L51
- Martini, P., et al. 1999, AJ, 118, 1034
- Rau, A., et al. 2007, ApJ, in press
- Retter, A., Marom, A. 2003, MNRAS, 345, L25
- Lawlor, T. 2005, MNRAS, 361, 695
- Iben, I., Tutokov, A. 1992, ApJ, 389, 369
- Munari, U., et al. 2005, A&A, 434, 1107
- Soker, N., Tytenda, R. 2003, ApJ, 582, L105
- Marshall, D. J., et al. 2006, A&A, 453, 635