Simultaneous spectroscopic and photometric coverage of 2007 outburst of V455 And = HS2331+3905

AN OBJECT THAT HAS IT ALL

- Orbital Period: 81.08 min
- Permanent superhumps: 83.38 min (2.8% +P_{orb})
- Spin period of WD: 1.12 min
- Non-radial WD pulsations: ~ 5-6 min.
- A large-amplitude quasi-sinusoidal radial velocity modulation of the Balmer and Helium lines with a period ~3.5 h.
- Super-outburst.
Observations.

- **4.2m William Herschel Telescope.** ISIS is a high-efficiency, double-armed, medium-resolution spectrograph (1.4 Å).

- **2.12m San Pedro Martir.** B&Ch, medium-resolution spectrograph (FWHM 1.95 - 3.2 Å resolution).

- **2.12m San Pedro Martir.** Echelle, high-resolution spectrograph (0.4 Å).
The system is in quiescence, displaying its spectacular double period in trailed spectra.
Six nights before the outburst, similar picture

$H_\beta$
**V455 And, the Outburst**

This is probably the best spectroscopic coverage of the WZ Sge type superoutburst, or even any DN outburst. Particularly, the onset of the outburst is the most difficult to catch.
This is probably the best spectroscopic coverage of the WZ Sge type superoutburst, or even any DN outburst. Particularly, the onset of the outburst is the most difficult to catch.
- spectral observations started when the system has brightened only 1.5 mag (out of 8 mag super outburst)

- it is widely believed that DNe outbursts are both due to a thermal/viscous instability of the accretion disc triggered when hydrogen becomes partially ionized (Osaki 1996; Lasota 2001). In this picture, the accretion disc performs a limit cycle between a cold, quiescent state of low accretion rate and a hot, viscous state of high accretion rate corresponding to the outburst.

- it is also believed that there are two types of outbursts (Smak 1984). The systems with high $\frac{dm}{dt}$ undergo outside-in kind of outburst, while in low MTR accretion disks the thermal instability first sets in at the inner-most region and propagates to the out.

- In order to explain super outbursts, Osaki (1989) combined thermal instability and tidal instability models (Paczinski 1977, Whitehurst 1988) to allow the disk growth beyond critical radius throughout normal outbursts.

- However WZ Sge objects does not have series of normal outbursts in between super-outburst and the later recurrence time is extremely long.
Such long occurrence times were obtained by lowering the viscosity of the accretion disk from usual $\alpha_{\text{cold}} \sim 0.03$ to $\alpha_{\text{cold}} \sim 0.001$ (Smak 1993, Osaki 1994, Howell et al 1995). The low viscosity also helped to simulate light curve of WZ Sge type super-outburst closely resembling to the one we observed in V455 And.
Pre-outburst: JD 2454342
THE START: JD 2454348

$H\beta$ emission component
Hβ emission component
THE START: JD 2454348

Hβ emission component

$\beta$
THE START: JD 2454348

H\(\beta\) emission component
THE START: JD 2454348

H\beta emission component

\[ i=75.0 \quad M1=0.80 \quad q=0.075 \quad P_{\text{orb}}= 0.05631 \text{d} \]
Hβ emission component
THE START: JD 2454348

**Hβ emission component**

\[ \text{i}=75.0 \quad M1=0.80 \quad q=0.075 \quad P_{orb}=0.05631d \]
THE START: JD 2454348

Hβ emission component

$\lambda = 75.0$ $M_1 = 0.8$ $q = 0.075$ $P_{orb} = 0.05631d$
H$_{\beta}$ emission component
THE START: JD 2454348

Hβ emission component

$i=75.0 \ M1=0.80 \ q=0.075 \ P_{orb}=0.05631d$
H\textsubscript{\beta} emission component
THE START: JD 2454348

Hβ emission component
Hβ emission component
Hβ emission component
Hβ emission component
THE START: JD 2454348

H$_\beta$ emission component
THE START: JD 2454348

Hβ emission component

i=75.0  M1=0.80  q=0.075  P_{orb} = 0.05631d
**Hβ emission component**

![Graphs and plots related to Hβ emission component.](image)
Hβ emission component

THE START: JD 2454348
THE START: JD 2454348

Hβ emission component

i=75.0  M1=0.80  q=0.075  P_{orb} = 0.05631d

+ 69.3 min

Counts (normalized)
H$\beta$ emission component

THE START: JD 2454348

348.348337
348.405434
THE START: JD 2454348

H\textsubscript{\(\beta\)} emission component

\( i = 75.0 \quad M1 = 0.80 \quad q = 0.075 \quad P_{\text{orb}} = 0.05631\text{d} \)
H\textsubscript{\beta} emission component
Hβ emission component

1.4 mag

THE START: JD 2454348

348.348337
348.405434

i=75.0  M1=0.80  q=0.075  P_orb = 0.05631d
THE START: JD 2454348

Hβ absorption component

1.4 mag
He I absorption component

1.4 mag

THE START: JD 2454348

348.348337
348.405434

i=75.0  M1=0.80  q=0.075  P_{orb} = 0.05631d

Counts (normalized)

Wavelength (Å)
THE START: JD 2454348

348.369854
348.427796

Hβ emission component
THE START: JD 2454348

Hβ absorption component

i=75.0  M1=0.80  q=0.075  Porb = 0.05631d

Counts (normalized)

Wavelength (Å)
Hβ absorption component
Hβ absorption component
Hβ absorption component
THE START: JD 2454348

Hβ absorption component

i=75.0  M1=0.80  q=0.075  P_{orb}= 0.05631d
H\textbeta\ absorption component

THE START: JD 2454348
Hβ absorption component
THE START: JD 2454348

Hβ absorption component

348.369854
348.427796
Hβ absorption component

i=75.0  M1=0.80  q=0.075  P_{orb}= 0.05631d

+ 114.4 min
THE START: JD 2454348

H\textsubscript{\textgamma} absorption component

i=75.0  M1=0.80  q=0.075  P_{orb} = 0.05631d

+ 114.4 min

Counts (normalized)

Wavelength (Å)
Boris having a break

2.9 hours is a lot of time for a coffee.
H\(\beta\) emission component

+ 5.9 hours

THE START:  JD 2454348

348.713490  348.770054
Hβ emission component

THE START: JD 2454348

348.772543
348.775078
THE START: JD 2454348

H\textsubscript{β} emission component

\begin{itemize}
  \item + 10.2 hours
\end{itemize}
Hβ emission component
Hβ emission component
Hβ emission component
Hβ emission component

i=75.0  M1=0.80  q=0.075  P_{orb} = 0.05631d

JD 2454348
THE START: JD 2454348

H β emission

H γ

He ii absorption
THE START:  JD 2454348

He I absorption

Hβ emission

Hγ

He II

348.76622
348.82311
THE START: JD 2454348

He I absorption

Hβ emission

Hγ

He II
He I absorption

Hβ emission

Hγ

He II

THE START:  JD 2454348

348.91911
348.97507
THE START: JD 2454348

He I absorption

H\beta emission

H\gamma

He II
The maximum: JD 2454349

H\(_\beta\) emission  

H\(_\gamma\) emission  

He II emission  

$P_{\text{orb}} = 0.05631$
THE MAXIMUM: JD 2454349

H$_{\beta}$ emission

H$_{\gamma}$

He II
The maximum: JD 2454349

- H\textsubscript{\beta} emission
- H\textsubscript{\gamma}
- He \textsubscript{II}

JD 349.444397
JD 349.500892
THE MAXIMUM: JD 2454349

He I absorption

$H_\beta$ emission

$H_\gamma$

He II

$349.712555$

$349.767962$
THE MAXIMUM: JD 2454349

He I absorption

$H_\beta$ emission

$H_\alpha$

He II

$He$ II absorption
THE EARLY DECLINE: JD 2454353
THE MAXIMUM: JD 2454353

H\beta emission

H\gamma

He II

353.86505
353.93774
THE LATE DECLINE: JD 2454361-62
THE LATE DECLINE: JD 2454361-62

$H_\beta$ emission

$H_\gamma$

He II
THE LATE DECLINE: JD 2454361-62

$H\beta$ emission

$H\gamma$

He II

361.78471

361.84242
THE LATE DECLINE: JD 2454361-62

H\_\beta emission

H\_\gamma

He II
THE LATE DECLINE: JD 2454361-62

Hβ emission

Hy

He II

361.90817
361.96457
THE LATE DECLINE: JD 2454361-62

Hβ emission

Hγ

He II

361.66784
361.96457
THE LATE DECLINE: JD 2454361-62

H_β emission

Hγ

He II
absorption component $H\delta$

$H\gamma$

$He\ I$
Araujo-Betancor et al (2005) deduced $K_1=32$ km/sec

$K_1 = 67.4$
Residuals: 40.5

$K_1 = 48.3$
Residuals: 54.1

$K_1 = 66.0$
Residuals: 31.2882026

$K_1 = 32$ km/sec

$F_{re} = 17.7590842$
475 km/sec
300 km/sec
THE LATE LATE DECLINE:  JD 2454378

Hβ emission

Hγ

$\text{H}_\beta$  emission

$\text{H}_\gamma$
THE END: JD 2454391-92
ONE YEAR LATER: 2454737

No sign of a long spectroscopic period in the trailed spectra
Conclusions

- The amplitude and shape of the outburst enlist V455 And to WZ Sge family of short period CVs.

- The estimate of masses places V455 And rather below the min period turnaround, than above ($M_1 \sim 0.8+/-0.08 \, M$, $M_2 \sim 0.085+/-0.02$)

- Analysis of spectroscopy should be complemented with photometry to understand better the processes going on in the accretion disk.

- We tentatively see a “pulsation” of the accretion disk, i.e. contraction and expansion of emission zone of the disk during decline.

- The 2nd long spectroscopic period in the wings of emission lines of V455 And has disappeared and did not come back yet, one year after the outburst.