ISSN 2229-5518

OPTICAL SPECTROSCOPY OF V838 MONOCEROTIS

E. Viswanathan[a*] U. S. Kamath [b]

Abstract--The star known as V838 Mon underwent an eruption in 2002. Its spectrum has been evolving to later types since then. There are some theoretical models which try to explain the nature of this object, but none has satisfactorily explained all the observed features. Optical spectra of this star have been obtained from the 2m HCT. To understand the post outburst spectral evolution of V838 Mon (A spectrum obtained on 24 mar 2006 has been analyzed).

Index Terms--Variable star (V838 Monocerotis), Optical Spectroscopy, Light Echo, L-Type Supergiant.

1 INTRODUCTION

The peculiar variable star V838 Monocerotis was discovered early in 2002 by Brown et al (2002). The outer layer of this star rapidly expanded while outbursting. Light from this sudden eruption has illuminated interstellar dust surrounding the star, producing the most spectacular light echo in the history of astronomy. So for several rather different explanations for the eruption of V838Mon have been published. In this discussion we are going to study spectral evolution of V838 Mon; for which we mainly use spectra obtained with the 2m telescope HCT, which is operated in India by Indian Institute of Astrophysics.

2 COORDINATES - BASIC DATA

ICRS Coordinates

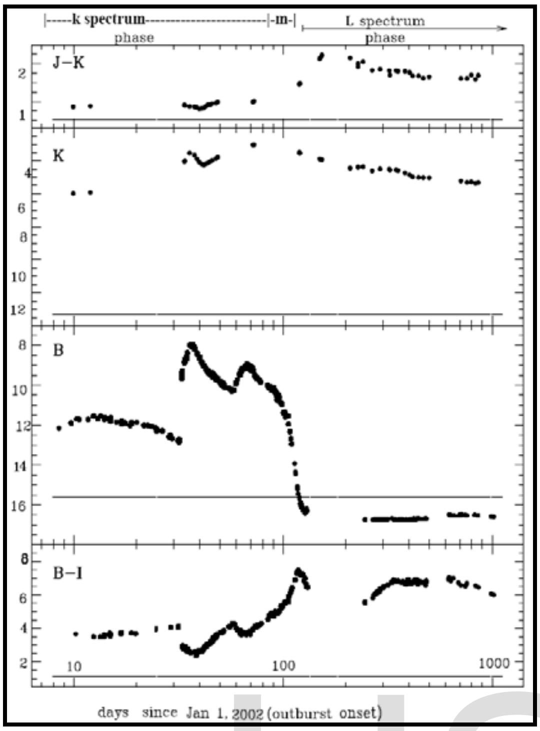
RA	: 07h 04m 04.85s
DEC	: -03° 50´ 561´´
Ep	: J2000
Apparent Magnitude	: ~15.4
(when our spectra were obtained)	
Radius	: 1570 ± 400 $R_\odot$
Galactic coordinates (ep=J2000)	: 217.7975 +01.0522

[b]Scientist, Indian Institute of Astrophysics, Bangalore, India.
[a*]Research Scholar, Department of Physics, Sathyabama University, Chennai, India.
Corresponding author E-mail: viswa_gently000@yahoo.co.in

3 OUTBURST EVOLUTION

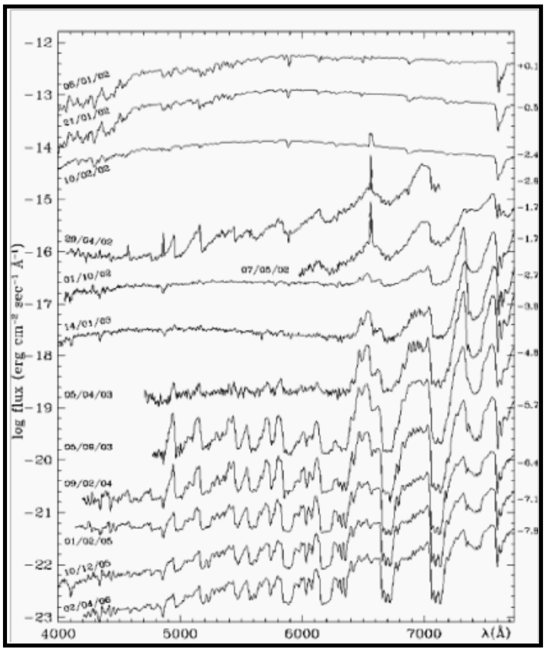
V838 Mon has undergone one of the most mysterious stellar outbursts. The unusually cool spectrum (completely unlike a classical nova) and the multi-maxima light curve helped to keep attention focused on the object of a light-echo rapidly developing around V838 Mon. During the first 90 days of the outburst the star went through three maxima and its spectrum moved back and forth within the K-supergiant types (Munari et al, 2002). V838 Mon reached maximum visual magnitude of 6.75 on Feb 6 2002 after which it started to dim rapidly, as expected. However, in early march the star started to brighter again, the time mostly in IR wavelengths range. Yet another brightening in IR occurred in early April after which the star returned to near its original brightness before the eruption, magnitude -15.6. (Wagner et al 9 Jan 2002). Its spectrum started to crossing the F0 spectral classification by ~Feb 11 2002, G0 by ~Feb 17 2002 and K0 by ~Feb 22 2002. It exhibited 3 peaks in its outburst and rapidly evolved to become an L-supergiant. The earlier spectra (in 2002) showed s-process elements and later (in 2003) IR showed VO, AlO and other molecular implying that the ejected material was oxygen rich (Munari et al, 2007). The light curve of V838 Mon is shown in the figure below. Three peak were exhibited while outburst. The decline in V is caused by the rapid cooling and the out bursting star evolved from M star to an L star. The light curve of this star can be easily divided into three distinctive phases: K, M and L supergiant spectrum phase. (S.Starrfield et al, Jan 2005, ESA SP-560, U.Munari et al, 25 Jan 2005, arXiv: astro- ph/0501546v1).

Optical and infrared light curves of V838 Mon from 2002-2004. Observations with the USNO1.0 and 1.55m telescopes.



Reference [2] (Fig1. Observations with the USNO1.0 and 1.55m telescopes)

Spectroscopic evolution of V838 Mon at optical wavelengths from Asiago 1.82 m telescope observations. (Munari and Corradi et al -Asp conference series)



Reference [1] (Fig2. Observations with the USNO1.0 and 1.55m telescopes)

4 CAUSE OF THE OUTBURST

So for several different explanations for the eruption of V838 Mon have been published (en.wikipedia.org/wiki/V838_Monocerotis).

4.1 ATYPICAL NOVA OUTBURST

The outburst of V838 Monocerotis may be a nova eruption after all, albeit a very unusual one. However, this is very unlikely considering that the system includes a B-type star, and stars of this type are young and massive. There has not been enough time for a possible white dwarf to cool and accrete enough material to cause the eruption.

4.2 THERMAL PULSE OF A DYING STAR

V838 Monocerotis may be a post-asymptotic giant branch star, on the verge of its death. The nebulosity illuminated by the light echo may actually be shells of dust surrounding the star, created by the star during previous similar outbursts. The brightening may have been a so-called helium flash, where the core of a dying low-mass star suddenly ignites carbon fusion disrupting, but not destroying, the star. Such an event is known to have occurred in Sakurai's Object. However, several pieces of evidence support the argument that the dust is inter stellar rather than centered on V838 Monocerotis. A dying star that has lost its outer envelopes would be appropriately hot, but the evidence points to a young star instead.

4.3 THERMONUCLEAR EVENT WITHIN A MASSIVE SUPERGIANT

According to some evidence, V838 Monocerotis may be a very massive supergiant. If that is the case, the outburst may have been a so-called helium flash, a thermonuclear event where a shell in the star containing helium suddenly ignites and starts to fuse carbon. Very massive stars survive multiple such events, however they experience heavy mass loss (about half of the original mass is lost while in the main sequence) before settling as extremely hot Wolf-Rayed stars. This theory may also explain the apparent dust shells around the star. V838 Monocerotis is located in the approximate direction of the Galactic anticenter and off from the disk of the Milky Way. Stellar birth is less active in outer galactic regions, and it is not clear how such a massive star can form there. However, there are very young clusters like Ruprecht 44 and the 4 million years old NGC 1893 at a distance of ca. 7 kpc and 6 kpc, respectively.

ISSN 2229-5518

4.4 MERGE BURST

The outburst may have been the result of a so-called *merge burst*, the merger of two main sequence stars (or an 8 M main sequence star and a 0.3 M pre-main sequence star). This model is strengthened by the apparent youth of the system and the fact that multiple stellar systems may be unstable. The less massive component may have been in a very eccentric orbit or deflected towards the massive one. Computer simulations have shown the merger model to be plausible. The simulations also show that the inflated envelope would have come almost entirely from the smaller component. In addition, the merger model explains the multiple peaks in the light curve observed during the outburst.

4.5 PLANETARY CAPTURE EVENT

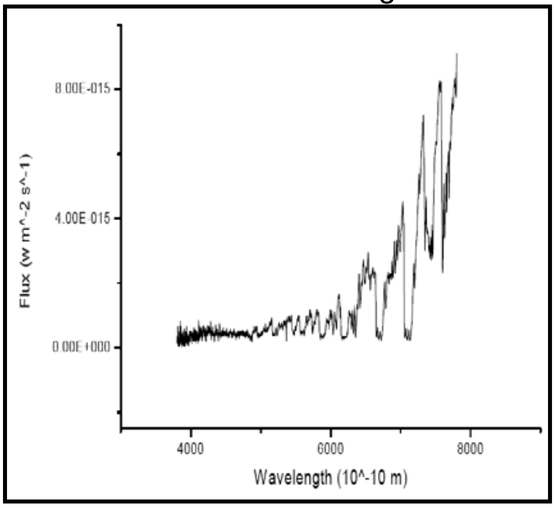
Another possibility is that V838 Monocerotis may have swallowed its giant planets. If one of the planets entered into the atmosphere of the star, the stellar atmosphere would have begun slowing down the planet. As the planet penetrated deeper into the atmosphere, friction would become stronger and kinetic energy would be released into the star more rapidly. The star's envelope would then warm up enough to trigger deuterium fusion, which would lead to rapid expansion. The later peaks may then have occurred when two other planets entered into the expanded envelope. The authors of this model calculate that every year about 0.4 planetary capture events occur in Sun-like stars in the Milky Way galaxy, whereas for massive stars like V838 Monocerotis the rate is approximately 0.5–2.5 events per year.

5 OBSERVATIONS

Spectra of V838 Mon were obtained using the HFOSC instrument on the 2m HCT on 24 March 2006. Grism 7 (resolution~1.54Å/pix) & grism (resolution~1.54Å/pix) were used. A standard star, Feige 34 was observed flux caliberation.All reductions were done in the standard manner using the IRAF software.

HFOSC grism 7 spectrum obtained on 24 Mar 2006.

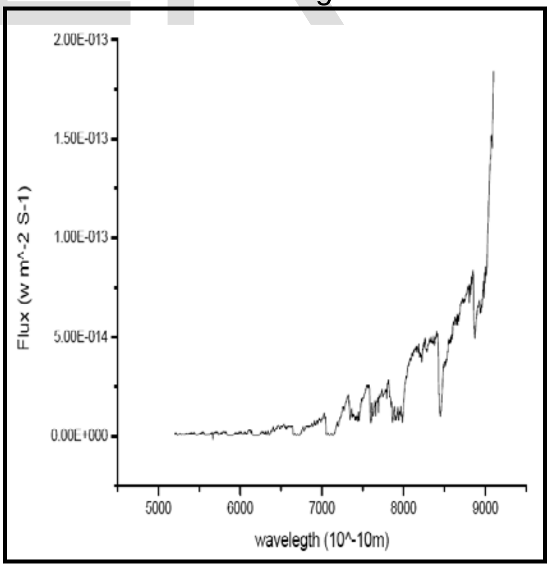
Flux Vs Wavelength



(Fig 3.)

HFOSC grism 8 spectrum obtained on 24 Mar 2006.

Flux Vs Wavelength



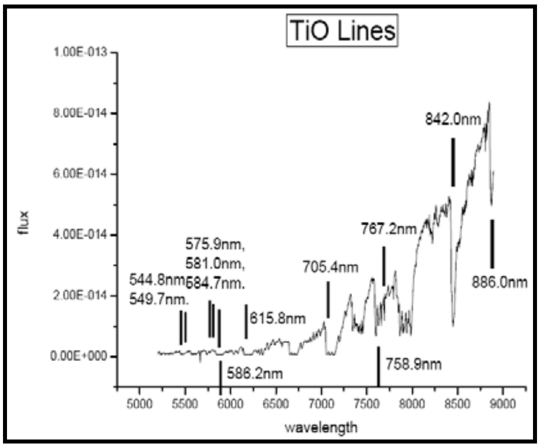
(Fig 4.)

ISSN 2229-5518

Spectra of M and L dwarfs in the range 5000-8000 Å have been used for identifying lines seen in V838 Mon.

5.1 TiO line comparison

In earlier spectra (Munari et al 19 Jan 2002 – 10 Dec 2004) TiO band at around 700 nm was weaker than in our spectrum.

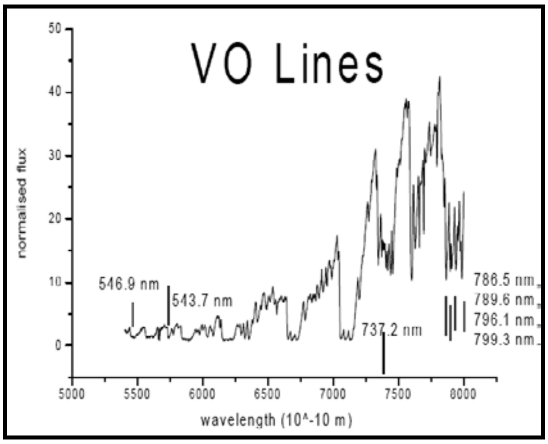


(Fig 5.)

The absorption line of TiO band at 705.4 nm had not appeared. In Apr 2002 the line was weaker. In Dec 2004 this absorption line came little stronger. Now in our spectra at 705.4 nm the TiO line is well distinguished and stronger. This spectrum resembles a L0 type dwarf [Kirkpatrick et al (1999)]. The TiO band at 705.4 nm in mid L type dwarfs slowly disappears.

5.2 VO line comparison

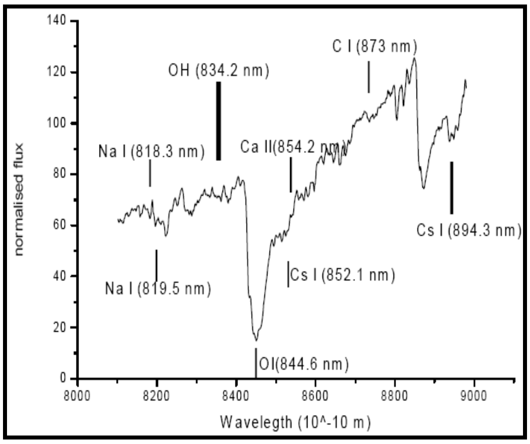
In the mid M type the VO band is weaker than mid L type. Our spectrum falls in the later M to earlier L type.



(Fig 6.)

5.3 Other lines

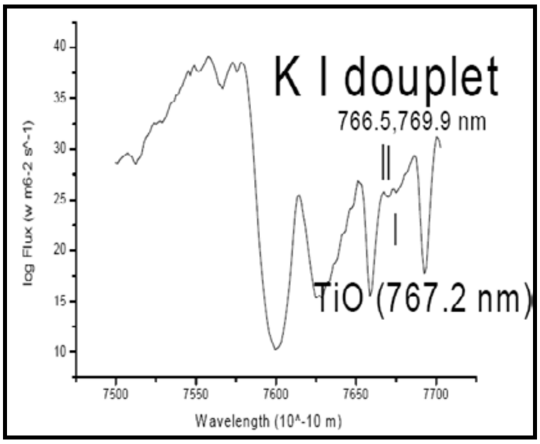
Other lines also show that our spectrum resembles that of a L0 dwarf.



(Fig 7.)

5.4 K1 lines comparison

Using the K I at 769 nm line we find that our spectrum matches that of a L0.5 dwarf (Kirkpatrick et al 1999). However, we note that the TiO absorptions at 767.2 nm are very close and may contaminate the K I absorption.



(Fig 8.)

6 Conclusion

The spectrum obtained on 24 Mar 2006 shows that V838 Mon resembles a L0 type star. It has remained at a magnitude of around 15.5 since late 2002. It has evolved significantly spectroscopically also. This indicates that the evolution has slowed down after the initial rapid change from K-M-L type. Since V838 Mon is supposed to be the first ever observed L supergiant, there are difficulties in properly assigning the observed spectral features to known atomic and molecular lines. Spectra of L dwarf have been used for comparison keep in mind that some of the features may appear quite different in V838 Mon. to that extent, the spectral features identified herein are tentative. These identifications need to be confirmed by comparison with, say, infrared spectra at a similar epoch. Some theories regarding the cause of the outburst have been proposed. All of them have predictions regarding the light curve, but no clear indications of the expected spectral signatures. It is possible that two different proposed scenarios might give rise to similar light curves, but the spectra are most likely very different. Also, no theory has been able to explain all the features of the light curve. Therefore, nothing can be said about the cause of the outburst until theoretical predictions of the special evolution are given. The best observational solution is to continue monitoring V838 Mon and note its spectral evolution in time.

Acknowledgement

I would like to express my hearty and sincere gratitude to Dr.U.S.kamath. His wide knowledge and logical way of thinking gave me a great value. His understanding, encouraging and personnel guidance from the initial to the final level have provided an understanding the basics of the subject. With his full motivation I finished well the report.

Reference

[1] R.L.M.Corradi and U.Munari eds, 2007, The nature of V838Mon and its light echo- ASP conference series, vol 363.
[2] S.Starrfield, R.M.Wagner et al, 2002, The 2002 outburst of V838 Mon: as cool as it gets.
[3] U.Munari and A.Henden et al,2004,The first three years of the outburst and light echo evolution of V838 Mon and the nature of its progenitor
[4] S.Starrfield et al, Jan 2005, ESA SP-560, U.Munari et al, 25 Jan 2005, arXiv: astro-ph/0501546v1
[5] Evans, T.R.Geballe et al, (in original form 31 Feb 2003), V838Mon: an L supergiant?
[6] Blandford, Burbidge et al, 2005, Annual review of astronomy and astrophysics, vol 43.
[7] B.A.Gould et al, 2009 Feb, ApJ, vol 137, No 1838, No-2-(pages 2949-3454).
[8] Molhy Bastian et al, 2003, ApJ, vol 594, part 1.
[9] Brown et al, 2002.
[10] Kirkpatrick et al 1999
[11] En.wikipedia.org/wiki/V838_Monocerotis