Bull. Astr. Soc. India (1993) **21**, 623-625

Near infrared coronal line emission in nova Herculis 1991

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Abstract. Near infrared coronal line emission at 1.98 ± 0.02 μm due to [Si VI] detected in the spectrum of Nova Herculis 1991 as early as about 17 days after optical maximum is reported. The coronal line observations reported here are consistent with X-ray detection five days after outburst and early onset of dust formation processes in the nova. They support the model of a hot shocked circumstellar envelope at the periphery of the dust formation zone in the nova in which first X-rays and then coronal emission manifested itself.

Key words : novae—near infrared observations

1. Introduction

Nova Herculis 1991 apart from being one of the brightest and fastest novae in recent times, has also been a very unusual nova (Sugano *et al.* 1991). Following discovery the nova was observed extensively at other wavelengths as well. Near infrared photometric observations showed a brightening in the K (2.2 μm) band 14 days after burst suggesting an unusually early phase of dust formation in the nova (Chandrasekhar *et al.* 1992; henceforth called paper I). Nova Her 1991 has also been detected by ROSAT in the X-ray region just five days after optical maximum (Lloyd *et al.* 1991)—the first ever nova to be positively detected so early in its evolution. The high temperature zone needed for X-ray emission also constitutes a favourable environment for the production of highly ionized states of elements and for detectable coronal line emission from the excited states of these ions.

In this paper we discuss the strong emission feature at 1.98 ± 0.02 μm detected by us as early as day 17 following optical maximum in nova Herculis 1991. For a detailed version of the paper refer to Chandrasekhar *et al.* (1993).

2. Observations

The observations reported here were carried out with a liquid nitrogen cooled InSb detector based infrared photometer at the 1.2 m telescope at Gurushikhar (72° 47′E, 24° 39′N, 1680 m altitude), Mt. Abu, India. The IR photometer has in addition to standard J, H, K filters a circularly variable filter (CVF) operating in the spectral region 1.7-3.4 μm with a resolving power of $(\lambda/\delta\lambda) \sim 70$. Nova Herculis 1991 was observed in the region 1.9 μm-2.1 μm in the CVF mode on four days between 1991 April 9 and April 20. On some days the spectral

coverage extends up to 2.4 μm. The nova spectrum was ratioed with that of α Oph (A5 V) obtained with the same CVF resolution and then multiplied by a blackbody spectrum corresponding to the standard star's effective temperature of 8500 K in order to remove effects of atmospheric absorption.

3. Discussion

Line profiles of the 1.98 μm line obtained on the four days of observations are shown in figure 1. Instrumental spectral calibration has been carried out by observing a strong laboratory spectral line at 1.97 μm in a Mercury discharge tube. The CVF instrumental width determined from the calibration is 0.03 μm. The observed line width does not exceed the instrumental width and hence no attempt is made to derive a line profile from the observations. The line centre is established with reasonable accuracy at 1.98 ± 0.02 μm. From photometric calibration,

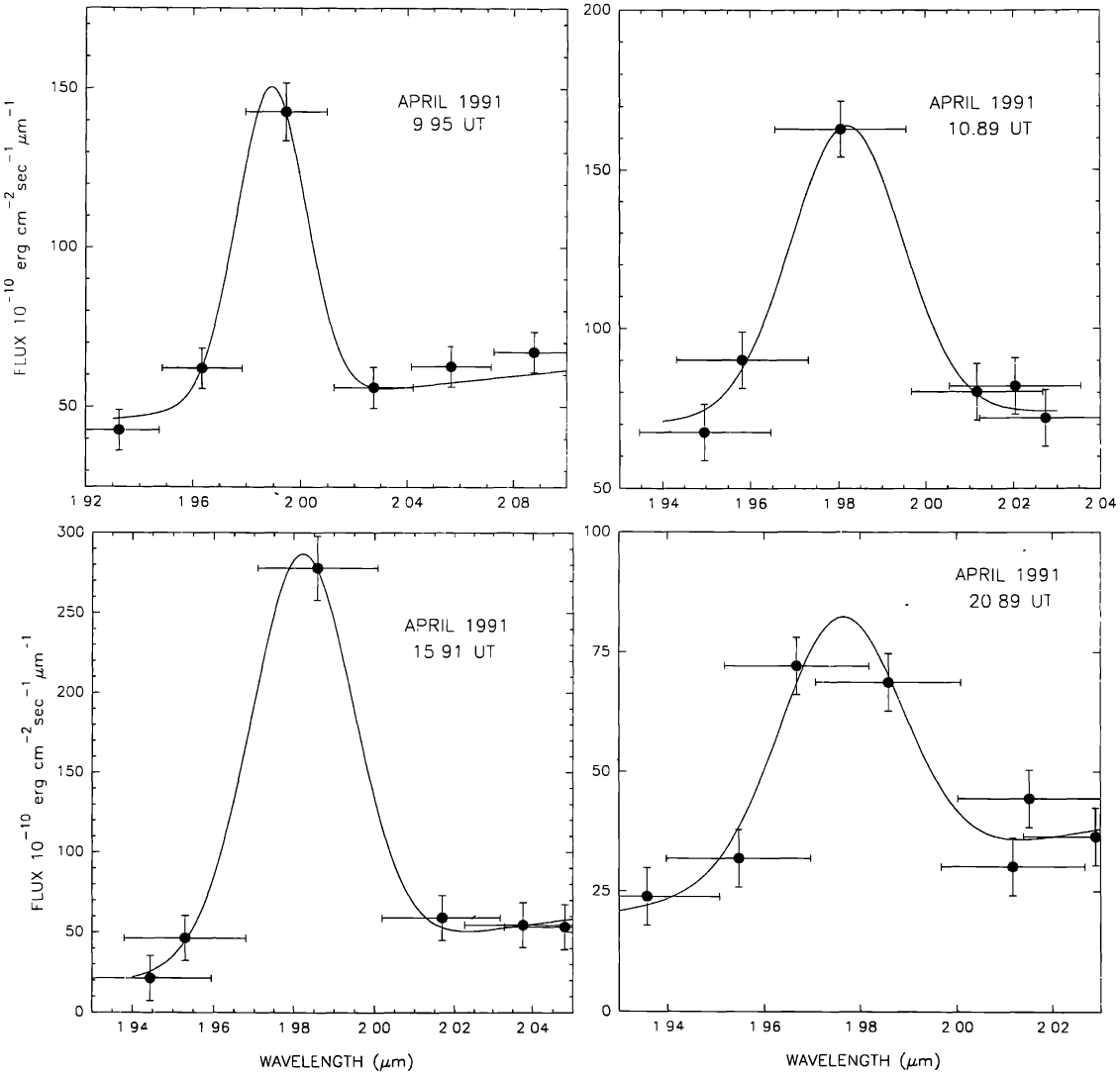

Figure 1. Observed spectral line at ~ 1.98 μm from nova Herculis 1991.

the average line strength during the period of observations is determined to be $(3.5 \pm 1) \times 10^{-10}$ erg cm^{-2} s^{-1}.

The spectral lines seen at times in novae within ±0.1 μm of 1.98 μm are HI Br δ (1.95 μm), HeI (2.058 μm), [A1 IX](2.04 μm) and [SiVI](1.96 μm). On the first and last days of our CVF observing mode, when the spectral range extended up to 2.4 μm, there is no detectable emission at 2.17 μm corresponding to HI Br γ which implies that HI Br δ if present would also be below our detection limits.

Since the laboratory spectral calibration of the CVF allows us to pinpoint line centre within ±0.02 μm, we can also rule out HeI (2.058 μm) and [AI IX] (2.04 μm) and ascribe the observed emission to the forbidden coronal emission due to [SiVI] transition ^{2}P (1/2, 3/2) at 1.96 μm. The line has an excitation temperature of 7.3×10^3 K and the ionisation potential for the ion is 205 eV.

The angular extent of dust forming region for Nova Her has been estimated from broad band IR photometry to be ~6 milli arcsec (Paper I). Further we assume the shock heated line emitting region to be located at the outer periphery of the dust forming region. Taking measured value of I_{Si}^{+5} to be ~ $(3.5 \pm 1) \times 10^{-10}$ erg cm^{-2} s^{-1} and following the method outlined by Greenhouse (1988) we obtain mass density value 3.4×10^{-15} g cm^{-3}. The mass density value derived from line strength of the coronal line is above the critical density for dust formation (Paper I) and is consistent with the argument that dust formation had begun by the time coronal emission manifested itself.

It is perhaps significant that X-ray emission was detected on day 5 about 2 days before increase in IR flux indicated onset of dust formation processes in the nova ejecta. It appears that the nova ejecta added substantially to the preexisting material of density 10^{-18}-10^{-17} g cm^{-3} present at the time of X-ray emission (day 5) and reached final value of ~ 3.4×10^{-15} g cm^{-3} by the time dust formation processes were complete (day 25).

In conclusion these observations are consistent with the X-ray emission reported earlier from the nova and could arise in the same circumstellar region at the periphery of the dust forming zone. There is no detectable cold dust in the prenova environment from IRAS data, which constrains the spatial extent of dust (at 30 K) in the pre nova environment to about 2500 AU at the distance to the nova of 10 kpc.

Acknowledgement

This work was supported by the Department of Space, Govt. of India.

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