

OPTICAL AND ULTRAVIOLET OBSERVATIONS OF NOVA VUL 1987

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ABSTRACT

We present a brief summary of the outburst for a nova that was discovered in November 1987 and has been followed since that time. Although we were able to observe it with the IUE at maximum, its ultraviolet energy faded rapidly and after the first two weeks we were no longer able to observe it at IUE wavelengths. It was observed to form a thick dust shell and currently is in the nebular stage.

1. Introduction

This currently bright novae was first detected in outburst on November 15, 1987 (UT: IAU Announcement Card #4488). The position of the nova was found to be at $\alpha = 19^h 02^m 32.^s$ and $\delta = +21^\circ 41' 39."$ (1950.0). These co-ordinates were determined by Gehrz (IAU Announcement Card #4501). By coincidence, one of us (S. S.) was at the IUE Observatory to obtain ultraviolet data on bright novae. We obtained a very underexposed LWP spectrum at this time and about one week later we obtained two sets of slightly underexposed SWP and LWP spectra two nights apart. After analysis, we found that the ultraviolet energy had decreased by nearly a factor of 2 between these two nights. This rate of decline is unprecedented when compared to the other novae that have been observed in the earliest stages of their outburst. In fact, the rapid rate of decline in the ultraviolet was more like that of SN1987A than that of a typical "fast" nova. Over the same time period, we also obtained optical and infrared data. Ginga did not detect the nova but this was probably caused by the low energy cutoff of the satellite of 2 keV (Dupree 1988, private communication).

2. Ultraviolet and Optical Observations

In this paper we report on our observations of this nova over the first four months of its outburst. The optical data showed major changes in line intensities and line ratios over the first two weeks. As already mentioned, the first attempt to obtain a spectrum of this nova was during the second half of the US 2 shift on November 16, 1987. The exposure times were chosen based on our previous experience with novae at maximum. However, because we were able to observe this nova so soon after discovery, we did try to be conservative and not overexpose the image. To our amazement, there was no detection in the SWP camera and only a faint image was present in the LWP camera. Unfortunately, there was not enough time left in the shift to obtain additional exposures.

We were granted additional time on Monday, November 23, 1987 and Sonneborn obtained the SWP and LWP spectra shown in Figure 1a and 1b. The SWP image is still underexposed after an exposure time of 10 minutes. The LWP image is better but required 2 minutes. Both of these times are long for a nova observed at a visual magnitude, determined from the FES, of about 8.2m. The appearance of the spectra is not unusual, as compared to other early spectra of novae, although the continuum appears somewhat flatter than those shown in the paper by Stryker *et al.* (1988; these proceedings).

On November 25, 1987 there was a false report of a supernova in M31. The IUE satellite mobilized to observe it but found no sign of any supernova at the reported location. By that time, it was too late to return the shift to the scheduled astronomer and it was decided to obtain two more exposures of Nova Vul 87. Sonneborn increased the exposure times by a large

factor (SWP: 50min; LWP: 2min 30s) but again found that the spectra were underexposed. These spectra are shown in Figure 2a and 2b and a glance at both scales shows why we were being continuously fooled in determining an optimum exposure time. The nova had faded by a factor of 2 in the two nights separating these two series of images. No previous nova has faded so fast in the ultraviolet and this rapid decline is analogous to the behavior of SN 1987A in the first observations (the supernova declined much more rapidly, of course).

Almost immediately after the report of the discovery, Garcia and co-workers at the Whipple Observatory began obtaining spectra. They found strong P-Cygni profiles in H α but all of the other hydrogen lines were in absorption (IAU Announcement Card #4489). We (Wade and Starrfield) obtained our first spectrum at the 2.1-m telescope of the Steward Observatory on the evening of the 30th of November 1987 and found that P-Cygni profiles were apparent for some of the strong lines. This spectrum is shown in Figure 3. In addition, a continuing series of optical spectra were obtained by Wagner at the 1.8-m Perkins Reflector of the Ohio Wesleyan and Ohio State Universities at the Lowell Observatory (IAU Announcement Card #4501).

One interesting feature of the spectral evolution of this nova is that the initial Whipple Observatory spectra showed deep P-Cygni profiles which gradually disappeared for a short time (Garcia 1987, private communication). However, they were again obvious by the time that we obtained the spectrum shown in Figure 3. Figure 4 shows a spectrum obtained (at the 1.8-m Perkins Reflector by Wagner and Starrfield) in late December when the P Cygni profiles were again weak. The appearance, disappearance, and reappearance of the P-Cygni profiles suggests that more than one ejection event probably took place. These spectra also showed lines of Fe II, Mg I, and O I in addition to the Balmer lines. Andrillat also reported lines of Cr I, Cr II, He I, and Mg II (IAU Announcement Card #4511).

At about this time, the nova became too close to the sun for further observations in the optical. When the nova reappeared late in January, it was reported to be fainter than 14th. Our only explanation for this rapid decrease was that it had formed dust. This hypothesis was confirmed by the observations of Gehrz with the 2.34-m Wyoming Infrared Telescope on February 24 (IAU Announcement Card #4557) which showed that it had formed an optically thick dust shell with a temperature of about 600K.

Wagner obtained another optical spectrum with the Perkins 1.8-m telescope, on March 13.5 (IAU Announcement Card #4573), and found that it was definitely nebular. This spectrum is shown in Figure 5. In Figure 6, we show an early optical spectrum on the same scale as this last spectrum. The differences are obvious. The strong lines are due to [O III], [O I], and [N II]. He reported that the magnitude had continued to drop and was currently about 17. In addition and very important, the emission line wavelengths appeared slightly blueshifted which was consistent with a thick shell of dust obscuring the redshifted material in the ejecta.

3. Discussion

Although we continue to claim in our nova Target of Opportunity proposals that every recent nova outburst has been unique, we ourselves are still surprised when a new nova justifies this claim. The rapid decline of the ultraviolet energy suggests both that it was somewhat reddened and that a relatively thick shell was ejected during the outburst. The rapid decline in the optical, once dust had formed, is analogous to the behavior of DQ Her during its outburst. In fact, when the shell was first detected by Gehrz, it was radiating more energy in the infrared than had been observed at maximum light in the optical. The dust is probably carbon dust and this nova most likely ejected material enhanced in the CNO nuclei. Further analysis of this outburst is in progress.

Acknowledgements

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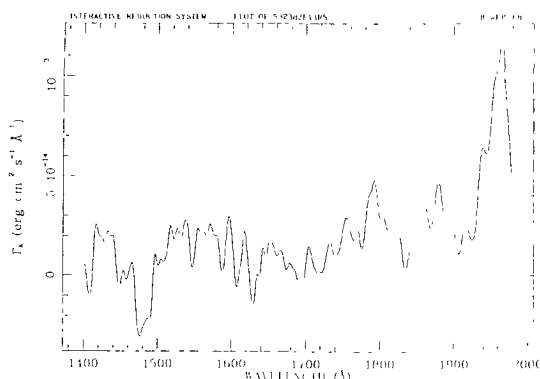


Figure 1a. This SWP spectrum was obtained on November 23, 1987 and is a 10 minute exposure.

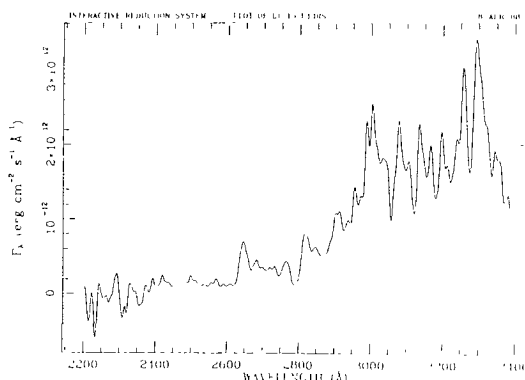


Figure 1b. This LWP spectrum was also obtained on November 23, 1987. It is a 2 minute exposure. Note that all of the spectra have different vertical scales.

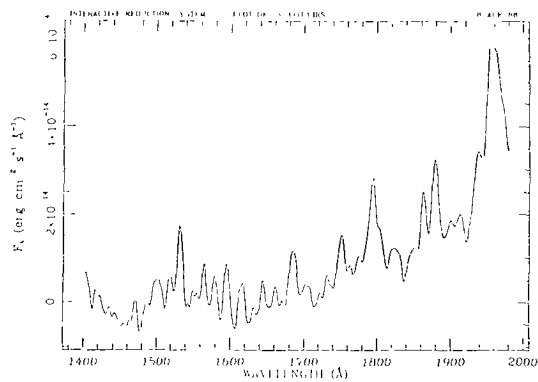


Figure 2a. This SWP spectrum was obtained on November 25, 1987 and the FES magnitude of the nova was still about 8. This is an exposure of 50 minutes and note that the fluxes have decreased by about a factor of two since the image in Figure 1a.

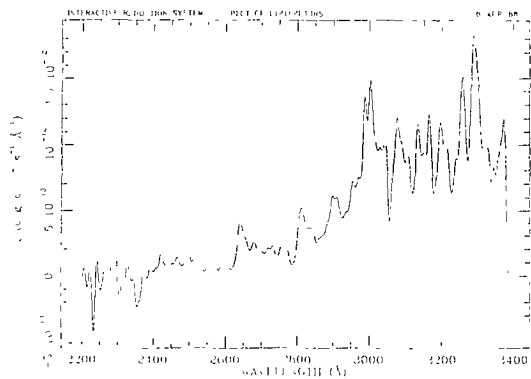


Figure 2b. This LWP spectrum is a 2.5 minute exposure on the same day as the SWP spectrum in Figure 2a. Note that the fluxes have also decreased between this figure and Figure 1b.

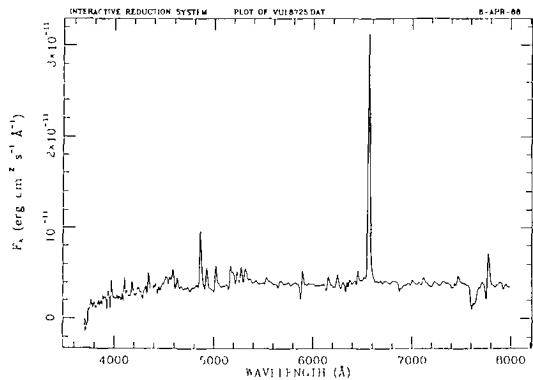


Figure 3. This optical spectrum was obtained on the 2.1-m telescope of Steward Observatory on November 30, 1987.

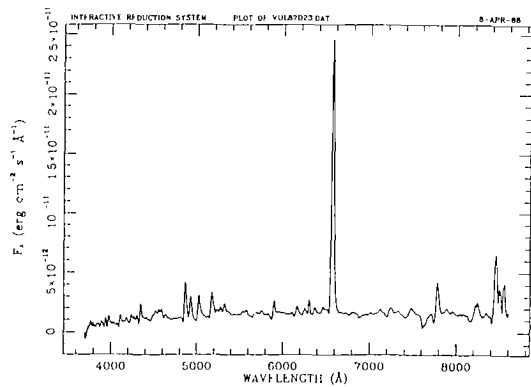


Figure 4. This spectrum was obtained on December 23, 1987 at the 1.8-m Perkins telescope. The P-Cygni profiles for many of the lines had decreased in strength since the spectrum shown in Figure 3.

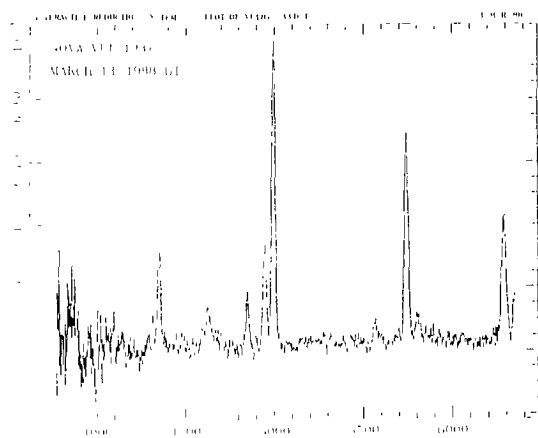


Figure 5. This optical spectrum was obtained at the 1.8-m Perkins telescope. The nova had definitely entered the nebular stage and the strongest lines are due to [O III].

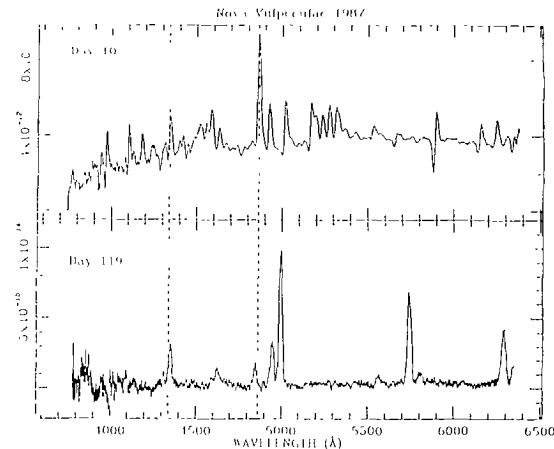


Figure 6. This montage shows a comparison of two optical spectra of Nova Vul 87. One was obtained early in the outburst and the other is also shown as Figure 5. Once dust formed in the expanding shell (see text), this nova experienced an extremely rapid decline in its optical magnitude.