OBSERVATIONS OF CLASSICAL NOVAE IN OUTBURST

S. Starrfield and L. L Stryker
Department of Physics, Arizona State University
G. Sonneborn
IUE Observatory, Goddard Space Flight Center
Warren M. Sparks
Applied Theoretical Physics Division
Los Alamos National Laboratory
Gary Ferland and R. M. Wagner
Department of Astronomy, Ohio State University
R. E. Williams
Cerro Tololo Interamerican Observatory
Robert D. Gehrz and Edward P. Ney
Department of Astronomy, University of Minnesota
Scott Kenyon
Center for Astrophysics, Harvard University
R. Wade
Steward Observatory, University of Arizona
James W. Truran
Department of Astronomy, University of Illinois
C. - C. Wu
Space Telescope Science Institute

ABSTRACT

Over the past 10 years the IUE Satellite has obtained ultraviolet data on a number of novae in outburst and the characteristics of every one of the outbursts have been different. In addition, our group has also obtained optical and infrared data on many of the same novae. In this paper we present the data on three members of the carbon-oxygen class of novae.

1. Introduction

We are continuing to obtain data on novae in outburst and the novae that are still bright enough to study with the IUE Satellite are Nova Vul 1984 #2, Nova And 1986, Nova Vul 1987, and Nova LMC 1988. Nova Vul 1984 #2 is a slow oxygen-neon-magnesium nova, Nova And is a moderately fast carbon-oxygen nova, and Nova Vul 1987 had a period of about a month with nearly constant light and then started a slow decline but it exhibited a very deep transition phase when it formed dust.

The ultraviolet observations of novae done with the IUE Satellite have proved to be of extreme importance in understanding the cause and evolution of the outburst. As summarized in reviews by Starrfield and Snijders (1987), Starrfield (1987), and Starrfield (1988), the ultraviolet spectra have shown that there are two classes of novae, have shown that there are at least two classes of recurrent novae, and have allowed much more acurrate determinations of elemental abundances. The importance of the IUE data is that there are spectral lines in the 1200A to 3300A wavelength range that come from elements which do not have analyzable (or any) lines in the optical. These lines can be used to determine elemental abundances, expansion velocities, and the amount of mass ejected. Many of these lines are the commonly observed and well understood medium ionization UV resonance and intercombination lines observed in most emission line objects. However, their time-dependant behavior in novae can be used to constrain the abundances that are determined for the ejected material. A table of such lines and the time variations of their fluxes for one nova can be found in Williams, et al. (1985). Because of IUE data, we have recently been able to identify a new class of novae (Starrfield, Sparks, and Truran 1986). Finally, continuum flux distributions can be used to determine temperatures of the white dwarf and/or mass transfer rates onto the white dwarf.

In companion papers in this meeting we discuss the ultraviolet observations of Nova Vul 1984 #2, a slow oxygen-neon-magnesium nova, the ultraviolet observations of Nova V394 CrA a very fast recurrent nova; and two recent novae: Nova Vul 1987 and the 1988 nova in the LMC. In this paper we present and discuss the ultraviolet data on 3 of the other novae that we have observed in the last two years. These are Nova Vul 1984 #1, Nova And 1986; and Nova Her 1987. They are all apparently carbon-oxygen novae with differing ejection velocities and rates of decline.

2. Observations

Nova PW Vul 1984 #1. The first slow nova to be studied by IUE was PW Vul (1984 No. 1). We were able to obtain spectra for this nova from maximum light in August 1984 until late in 1986. Optical and IR data for this nova were presented by Kenyon and Wade (1986) who determined a distance of ~1.2 kpc. They also report He/H of ~0.13 (by number) and that oxygen was enhanced in the ejecta. They did not find a neon enhancement. The IUE data are currently being reduced and analyzed. Spectra taken on May 24, 1985 (SWP 26244 and LWP 6264) and October 29, 1985 (SWP 26997) are presented in Figures 1 and 2. The LWP spectrum taken in October 1985 was underexposed. Note that from May to October the peak SWP fluxes fell by almost a factor of 10. The strongest lines are from CIV, OIV, NIV, NIII, CIII, and NV. This is obviously a carbon oxygen outburst since none of the strong neon or magnesium lines, found in Nova Vul 1984 #2 (Starrfield et al. 1988; these proceedings), are present in these spectra. The nitrogen came from carbon and oxygen by means of hot hydrogen burning in carbo-oxygen enriched material.

Nova Andromeda 1986 was discovered in outburst in early December 1986 and we begain obtaining spectra almost immediately. We have been able to follow it through its outburst and are also obtaining optical data. Spectra taken at maximum are shown in a paper by Stryker et al. (1988; these proceedings). In Figures 3 and 4 we display SWP and LWP spectra obtained on July 12, 1987 and a SWP spectrum obtained on November 15, 1987. This last spectrum took 105 minutes and we were unable to obtain an LWP spectrum. This is a moderately fast nova; the peak flux of CIV 1549Å fell by less than a factor of two in the 4 month interval. The spectral features shown in these two spectra are quite similar to those of Nova Vul 1984 #1 and it must also be a carbon-oxygen nova.

Nova Hercules 1987 was discovered in outburst early in 1987 and we decided not to observe it since we were already following two other novae (Nova Vul 1984 #2 and Nova And 1986) and the European team was observing Nova Cen 1986. In April 1987 Gehrz and Jones (IAU Announcement Card #4371) found that it had formed dust with a temperature of about 1000K. In addition, they noted that there was evidence for strong [Ne II] emission at 12.8μm. Then in May 1987, Andrillat (IAU Announcement Card # 4388) reported that she had found it to be in the nebular stage with strong [O III] and NIII lines present in the spectrum.

In addition, she also reported that [Ne III] 3688Å and [NeV] 3346Å and 3426Å were present in the spectrum. These two reports suggested that this could be another oxygen-neon-magnesium nova and given this possibility, we obtained an SWP and LWP spectrum on June 11, 1987. These spectra are shown in Figure 5. As in the two other novae discussed in this paper, the spectra show mostly lines from carbon, oxygen, and nitrogen ions and it appears to be a carbon-oxygen nova. The strongest lines are from C IV, C III, N III, N V, CII, O IV, and O III. Given this result, we obtained no further spectra of this nova.

3. Summary

We have obtained ultraviolet spectra for three novae that appear to have ejected material rich in oxygen, nitrogen, and carbon. We will be unable to determine if these elements are actually enhanced in the ejecta until we have finished our nebular analysis. This work is in progress.

Acknowledgements

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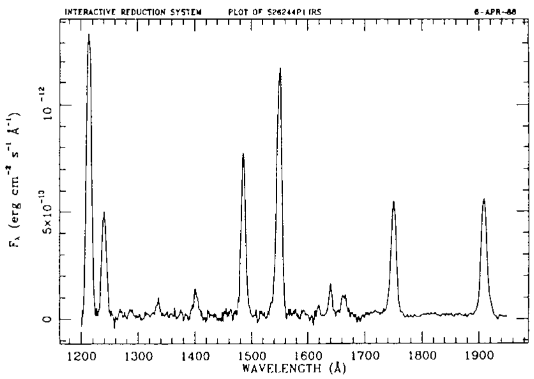

Figure 1a. This SWP spectrum was a 20 minute exposure of Nova Vul 1984 #1 obtained on May 24, 1985. The strong lines are from carbon, nitrogen, and oxygen.

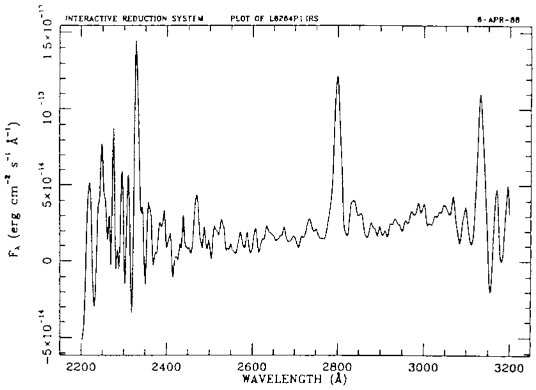

Figure 1b. This 10 minute LWP spectrum of Nova Vul 1984 #1 was obtained on May 24, 1985. Note that even after nearly a year in outburst there is still a continuum present.

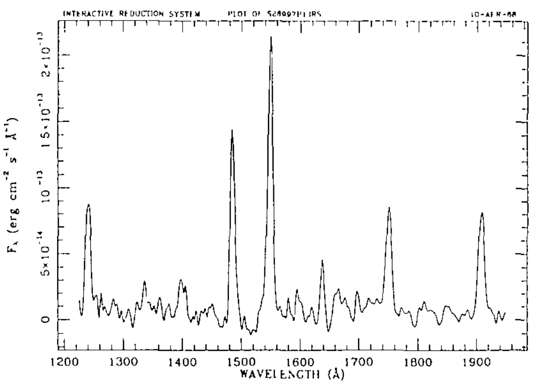

Figure 2. This 15 minute SWP spectrum of Nova Vul 1984 #1 was obtained on October 29, 1985. The peak fluxes have declined considerably.

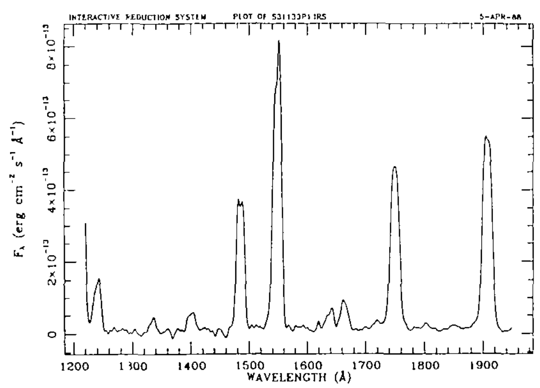

Figure 3a. This 30 minute SWP spectrum of Nova Her 1987 was obtained on June 11, 1987. There are apparently no lines of neon or magnesium present.

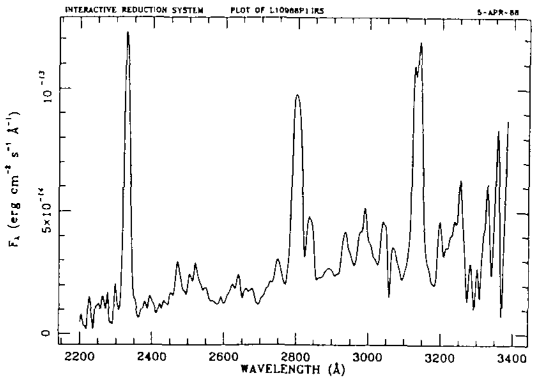

Figure 3b. This 65 minute LWP spectrum was obtained of Nova Her 1987 on June 11, 1987. Not only is there a red continuum present but the neon lines seen by Andrillat in the optical are visible at the red end of the spectrum.

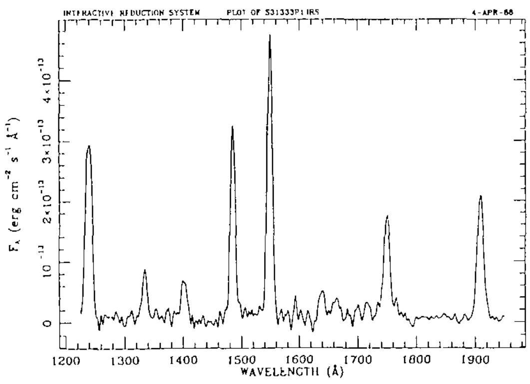

Figure 4a. This 30 minute SWP spectrum was obtained of Nova And 1986 on July 12, 1987. Note that the strong lines are from carbon, nitrogen, and oxygen ions.

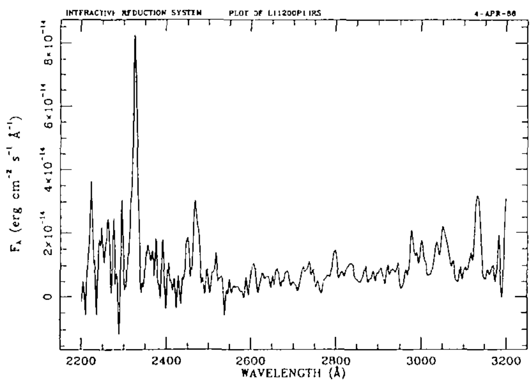

Figure 4b. This 45 minute LWP spectrum of Nova And 1986 was obtained on July 12, 1987.

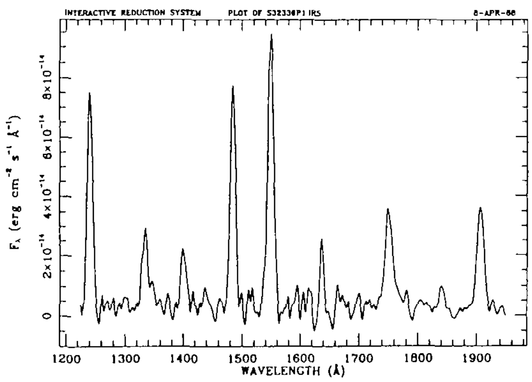

Figure 5. This 105 minute SWP spectrum of Nova And 1986 was obtained on November 15, 1987 nearly a year after maximum.