NOVA AQL 1918: A NUDE OLD NOVA.*

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ABSTRACT

IUE observations at high and low resolution of Nova Aql 1918 show neither evidence of outflow nor the presence of nebular lines. This indicates that the shell ejected at the time of the outburst and surrounding the system for many years (Mustel and Boyarchuck, 1970) has by now disappeared.

The high excitation spectrum presents rapid variations in the far UV and eclipse effects in the near UV that seem well correlated with the orbital phase.

The observations can be interpreted in terms of phenomena occurring in or near the accretion disk surrounding the white dwarf. However, the small inclination of the orbital axis raises serious problems in trying to model the system.

1. INTRODUCTION

V 603 Aql=Nova Aql 1918 is a typical member of the classical old novae family. During the 1918 outburst it reached at maximum a visual magnitude of about -1 (Weaver, 1974), followed by a very fast decline. An exhaustive analysis of its spectral evolution during the first 20 years was reported by Wyse (1939). The structure and evolution of the nebular shell that surrounded the nova after the 1918 outburst was extensively described by Mustel and Boyarchuk (1970) and by Weaver (1974).

Its binary nature was discovered by Kraft (1964), who found the value of 0.13854 days for the orbital period. The others Kinematics elements are: 2K=75 km s^{-1} (orbital) and v sin i =240 km s^{-1} (rotational), (Kraft, 1964, Warner, 1973).

* Based on observations with the IUE collected at the Villafranca Satellite Tracking Station of the European Space Agency.

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The two components of the close binary system are a hot white dwarf (or subdwarf) and a red dwarf filling its Roche lobe and transferring matter via an accretion disk on to the hot component. The masses of the components are 1.1 and 0.5 solar masses respectively (Warner , 1973).

The visual spectrum is characterized by the broad emissions of the Balmer lines and the HeII λ 4686 line. There is no evidence of absorptions.

The first UV observation of V 603 Aql was made with the OAO-2 Wisconsin Experiment Package by Gallagher and Holm (1974), who estimated a colour temperature of 25,000°K. They did not find evidence of light variations.

More recently, the UV spectrum has been studied on low resolution IUE data in two separate analysies by Dultzin-Hacyan et al. (1980) and by Duerbeck et al. (1980). Their conclusions are somewhat different: the energy distribution curve can be fitted by two black bodies with T=50,000°K and 8,000°K according to Dultzin -Hacyan et al., while only one B.B. with T=30,000°K is required according to Duerbeck et al.. Duerbeck et al. also reported that the strongest emission (CIV, λ 1550) is accompanied by a blue -shifted absorption indicating the presence of mass-loss.

2. THE OBSERVATIONS

Among classical novae at minimum, V Aql is the brightest one in the UV region covered by the SWP IUE camera (λ 1200-2000). This is why we have chosen it, rather than other candidates, as the most suitable object for an SWP high resolution spectrum. It was taken at VILSPA on 29 Aug. 1979 during an 427 minutes exposure. For the present analysis we have also utilized all the low resolution spectra available at the data-bank of VILSPA. They were taken by Seitter and Duerbeck (SWP 5758 and LWR 4994) and by Andrillat (SWP 5919, SWP 5921 and LWR 5162).

- THE HIGH RESOLUTION SPECTRUM.

The Hi Res spectrum is slightly underexposed and affected by numerous spurious features caused by particle events during the long exposure time. After the recognition and "cleaning" of these spurious features only 3 stellar lines are definitely present i.e. SiIV λ 1400, CIV λ 1550 and HeII λ 1640. They all present the same kind of profile, which appears to be a wide and shallow emission centered at the nominal wavelength. The half-half widths indicate velocities of around 900 km s^{-1} that cannot be ascribed to the orbital and rotational motions which, as reported before, have lower velocities. The shape of the lines does not resemble the typical nebular one, but rather looks like that of a line formed in

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a fast-rotating accretion disk. The characteristic double peak is not present, but this is probably due to the low inclination of the system (Payne-Gaposchkin, 1957, Robinson, 1976). It is remarkable that the Hi Res spectrum has not revaled any additional lines, either in emission or in absorption, besides the 3 emissions that are clearly evident in the low resolution spectra. Some possible reasons for this are:

- The S/N ratio is quite low and weak features are masked by the noise.
- The (possible) absorptions of the primary are strongly broadened by high rotation and pressure.
- The exposure time of the Hi Res spectrum corresponds to 2.14 orbital periods, and therefore weak lines are not detected because broadened by the orbital motion.

The emission intensities of CIV λ1550 and HeII λ1640 are 8.63×10^{-12} erg cm^{-2} s^{-1} and 1.83×10^{-12} erg cm^{-2} s^{-1} respectively.

- THE LOW RESOLUTION SPECTRA

Even on a rough inspection of the tracings, it is easy to recognize the presence of substantial variations in the emission intensities, especially in the LWR region where these changes occurr on a very short time-scale. Trying to explain this rather unexpected trend, we have arranged all the spectra according to their mid-exposure phase using the radial velocity curve published by Kraft (1964). A typical low resolution exposure time is around 15 min., significantly smaller than the orbital period of 199.5 min. : Fig. 1 reports the observations phases.

a) THE SWP REGION.

Besides the 3 lines clearly apparent in the Hi Res spectrum, there is marginal evidence for NIV] λ1486. The intensity of the emissions of CIV, HeII and SiIV changes by a factor of about 4 at different phases, and is largest near the minimum of the R.V. curve i.e. maximum R.V. of the white dwarg toward the observer (φ =0.17). Table 1 reports the variations of the emission line intensities with phase. The values from the Hi Res spectrum (average of 2.14 periods) are in the midst of the low resolution values.

b) THE LWR REGION.

Many more lines are present in this range, although the high noise level makes it difficult in some cases to discriminate between real and spurious features. However, after a comparison between the various spectra, about 20 features appear to be real and have been reported in Table 2 together with their proposed identification. Almost all these identifications refer to high excitation subordinate lines of HeII (Paschen series) and OIII. It is remarkable that the OIII lines at λ2818.7, 2837.2, 3047.1 and 3132.9 are excited by the Bowen fluorescence

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mechanism involving the HeII Lyα line at λ 303.

TABLE 1

Variations with phase of the emissions intensity.

(in 10^{-12} erg cm^{-2} s^{-1})

SWP		PHASE	CIV	HeII
5758	S	0.08	3.22	0.52
5919	L	0.15	11.86	2.16
5758	L	0.20	6.88	1.11
5921	L	0.36	6.87	1.01

S: small aperture
L: large aperture

TABLE 2

The LWR spectrum

Wavelength	Identification	Wavelength	Identification
2200	"IUE line"	2800	MgII 2800
2250*	HeII 2252.7	2820	OIII 2818.7
2305*	HeII 2306.2	2840*	OIII 2837.2
2375*	HeII 2385.4	2890*	?
2400*	?	2955*	?
2445	OIV 2450.0	3050*	OIII 3047.1+3059.3
2460*	?	3135*	OIII 3132.9
2680	NeIII 2677.9	3200*	HeII 3203.1
(2730)	HeII 2733.3		

* : emission lines drastically changed in spectra taken in two consecutive exposures: LWR 4994 lg. ap. and LWR 4994 sm. ap.

Dramatic changes in the emission intensity are especially evident in this spectral range. The lines marked by an asterisk in Table 2 have almost disappeared in the second of two LWR spectra taken in two consecutive exposures using the large and the small aperture of the IUE spectrograph. This would suggest the presence of eclipse phenomena. The phase corresponding to the latter spectrum is $\simeq$ 0.9, quite close to the intersection of the R.V. curve with the γ axis i.e. zero R.V. of the white dwarf.

c) THE ENERGY DISTRIBUTION

We have analyzed only the SWP spectra, owing to the difficulty we met in tracing the continuum in the emission-rich LWR region.

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The curves corresponding to φ=0.15 and 0.20 present a steeper gradient below λ 1600. It should be pointed out that the maximum of the emission intensity occurs around this very phase.

We suggest that the discrepancies in the temperature values reported by previous observes could be attributed to these variations with phase of the energy distribution curve.

3. ARE THE VARIATIONS REAL?

The spectra used in this analysis have been taken employing both the small and the large apertures of the IUE spectrograph. Due to their different sizes (3"X3" and 10"X20" respectively), different regions around the nova enter the spectrograph in the two cases.

We have considered the possibility that this observational effect could be responsible for the differences between the various spectra. However, in our opinion this possibility is to be rejected for the following reasons:

1 - Variations in lines and continua are present also in spectra taken with the same (large) aperture.

2 - We would expect the strengtheninig or appearance of typical "nebular" lines in the spectra taken with the large aperture. This is definitely not observed in the SWP range where even the Hi Res large aperture spectrum has not revealed any additional lines with respect to the low resolution small aperture spectra. In the LWR range, more lines are observed in the large aperture spectra, but they are all high excitation subordinate lines, which are unlikely to be formed in a region far from the central star.

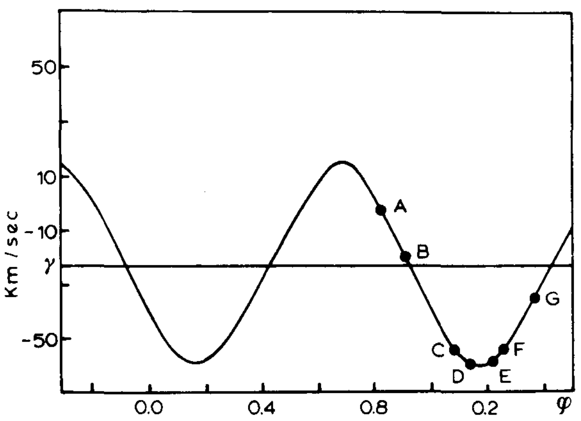

Figure 1: Radial velocity curve of V 603 Aql. The capital letters indicate the phases at which the various spectra were taken.
A=LWR 4994 lg. ap., B=LWR 4994 sm. ap., C=SWP 5798 sm. ap., D=SWP 5919 lg. ap., E=SWP 5758 lg. ap., F=LWR 5162 lg. ap., G=SWP 5921 lg. ap..

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4. DISCUSSION

First of all it is worth pointing out some observational results:

1 - The emissions are the sole features of the UV spectrum. There is no positive evidence of any absorption line.

2 - The high resolution spectrum has not revealed any additional lines (besides the I.S. ones).

3 - The shape of the lines is broad and shallow.

4 - Strong variations in the line emissions seem well correlated with the orbital phase.

5 - Variations in shape and intensity of the continuum are also evident and seem related to the phase.

6 - Besides NIV] λ 1486, for which there is marginal evidence, no other familiar "nebular" lines have been detected.

We consider that these observational data can be interpreted in terms of phenomena occurring in a disk or ring which rotates at a velocity of around 3000 km s^{-1} around the white dwarf and which is formed by accretion from the less massive red star in a semi-detached system. With a inclination i=16° of the orbital axis (Payne - Gaposchkin, 1957) this velocity approaches the observed one (900 km s^{-1}).

The different spectral behavior at the different phases can be explained in terms of orbital effects. The observer, during the orbital motion, will look at different mutual configurations of the four basic ingredients of the system: white dwarf, red companion, accretion disk, hot spot. This will produce the observed variations in the line spectra and continua.

The main problem with this picture lies in the small inclination of the orbital axis of the system relative to the direction toward the Sun, as derived from the smallness of the observed R.V. variation during the orbital motion: 2K=75 km s^{-1}. The line of sight is approximately perpendicular to the plane of the orbit (Weaver, 1974) and, therefore, it is hard to explain the occurrence of eclipse phenomena or even partial occultation effects.

We have not yet tried to define a model of the system; we reserve this task for a future analysis, although we are fully aware of the difficulties that are to be encountered if the low sin i value reported in the literature is correct.

5. CONCLUSION

From the viewpoint of the nova evolution, an important result is that there is no longer any spectroscopic evidence of the envelope ejected in 1918. There are neither shell absorption lines, nor P Cyg lines, nor typical "nebular" emissions. The ejection of the shell studied by

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Weaver (1974) and by Mustel and Boyarchuk (1970) was a transient phenomenon during the life of the nova. There is no evidence for a continuous mass-loss. The photographic observations by Weaver revealed the presence of a nebula with a composite structure and an expansion rate of $\simeq$ 2"/year. Since then, due to the expansion, the density has probably decreased so much that the nebula can now be considered to have vanished.

1st Remark.

In this article we have reported the first results of an UV analysis of V 603 Aql, and we have pointed out some conclusions that seem relevant to the subject of this IAU Colloquium. In another paper we will report all the details of this study, together with an analysis of the Bowen fluorescence for the OIII lines.

2nd Remark.

At the time of writing, we have received the copy of Astronomy and Astrophysics including a paper by Rahe et al. (1980) reporting periodic visible light variations of V 603 Aql detected with the FES aboard the IUE satellite. They tentatively interpret these variations as an eclipse of the accretion disk around the white dwarf by the late main sequence component, or by an occultation of the hot spot by the disk itself. Their suggestion, derived from photometric visual data, is in remarkable agreement with our conclusions.

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DISCUSSION

Mme Y Andrillat. - Pensez-vous qu'il est possible d'observer les raies de l'enveloppe par difference entre les spectres pris avec la petite et la grande ouverture? Existe-t-il d'autres vieilles novae observeés dans ces conditions avec IUE?

Selvelli. - 1) I guess it is possible, at least in principle. However, in the SWP spectra taken with the large aperture we have not noticed any additional lines. 2) As far as I remember there are only a few spectra of RR Pic and HR Del.

Z. Šíma. - Did you find some periodic variations in line profiles depending on the phase of the binary?

Selvelli. - We have reported the presence of intensity variations with phase in low resolution spectra. In order to detect profile variations we need high temporal and spectral resolution. IUE cannot fulfill these requirements for this faint object.

Friedjung. - The differences in continuum temperatures found depend very much on how one fits. We found a rather peculiar energy distribution. HR Del shows rapid orbital variations and also P Cyg profiles indicating a wind. However, it went off much more recently.

Selvelli. - The energy distribution varies with the phase, so the temperatures found can be different. I think that this is the main reason for the discrepancies in the temperature determination.

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