DID NOVA AQUILAE 1982 POSSESS A SUPERCRITICAL WIND ?[1]

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Abstract

The extremely high velocity absorption components observed in the ultraviolet with IUE, could have been produced by a supercritical wind. In this case most radiation would have been emitted shortwards of Lyman α, even at the time of the first IUE observations.

Nova Aquilae 1982 was discovered on January 27, but was difficult to observe at first because of closeness to the sun. A number of IUE spectra were obtained by Blades and Snijders from February 24, and the results were communicated to members of the ESA + SERC nova target of opportunity team. A preliminary report concerning these spectra has been made by Snijders, Seaton and Blades (1982).

The most surprising result obtained up to now is perhaps that concerning the high velocity absorption components seen on February 24 and March 2. The low resolution of all the well exposed spectra shows the presence of absorption components of two absorption systems at about 3000 and 7000 km s^{-1}, denoted systems a and b respectively. The violet edges of systems a and b lie at velocities at the order of 4000 and 9000 km s^{-1} respectively. The latter velocity if interpreted as a terminal velocity is enormous; velocities of this order are only known for supernovae. The largest classical nova Orion velocity given by Payne-Gaposchkin (1957) is 3820 km s^{-1} in her table 10.7. It is because of the enormous velocity, that doubts have been cast on whether Nova Aquilae 1982 is a classical nova.

The model which appears best to fit the observations of classical novae involves a rapid ejection of about 10^{-4} $M_\odot$, followed by a diminishing continued ejection (see Friedjung, 1977). The latter is most

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easily considered to be a wind pushed by the radiation pressure of an object above the Eddington limit (Friedjung, 1966 ; Bath and Shaviv, 1976). In a recent study of mine (Friedjung, 1981), conditions are given for this type of wind. When the object is significantly above the Eddington limit the trapping of photons in the acceleration region of the wind gives an order of magnitude relation between the photospheric radiation flux and the kinetic energy flux, as well as one for the wind terminal velocity :

$$\chi_{Ts} L \simeq \frac{64}{3}\pi V_s^3 r_s \frac{V_{ac}}{V_s} \tag{1}$$

Here χ_{Ts} is the total opacity at the photosphere, L the luminosity, V_s the terminal velocity, V_{ac} the velocity mean where the wind is accelerated, and r_s is the photosphere radius. Taking $V_{ac} = 0.5V_s$ one obtains numerically when electron scattering dominates the opacity.

$$\frac{L}{r_s} = 100 V_s^3 \tag{2}$$

Comparison with observed velocities for FH Serpentis suggests that this should be replaced by

$$\frac{L}{r_s} \simeq 10 V_s^3 \tag{3}$$

in the later stages.

The IUE observations of Nova Aquilae 1982 on February 24 were made when the nova had faded at least 4 magnitudes, so it is reasonable to suppose that it was then in the later stages of continued ejection. Observations of novae as well as equation (3) indicate an increase of V_s as a nova fades, because r_s decreases while L only decreases a small amount. It will therefore be supposed that system b had a velocity characteristic of the wind around February 24, and system a consisted of material ejected earlier, and being swept up by system b. Such an interpretation is supported by the fact that both systems a and b are seen for the CIV and SiIV resonance lines, while system a is only seen for the lower ionization AlIII resonance doublet, and system b only for an excited NIV line (letters of T. Snijders to the target of opportunity team). This is consistent with the envelope being photoionized and being more excited near the photosphere, while system a is formed further than system b from the latter.

Equation (3) can then be applied to the observations of February 24, so as to see whether the large velocity of system b could have been produced by the type of wind considered here. Taking the mean velocity of 7000 km s^{-1} (the justification for taking this rather than the velocity of the violet edge will be given later),

$$\frac{L}{r_s} \; 3.43 \times 10^{27} \text{ erg s}^{-1} \text{ cm}^{-1} \qquad (4)$$

If $L = 1.55 \times 10^{38}$ erg/s, twice the Eddington limit of a half solar mass object, $r_s = 4.5 \times 10^{10}$ cm. The corresponding photospheric temperature is 1.0×10^{5}° and if the nova is at a distance of D kpc, the predicted flux at 1250 Å is $1.2 \times 10^{-10}/D^2$ erg cm^{-2} s^{-1} Å^{-1}. The observed flux on February 24 near 1250 Å corrected for reddening corresponding to $E(B-V) = 0.55$ (Snijders, Seaton and Blades, 1982) is near 1.5×10^{-11} erg cm^{-2} s^{-1} Å^{-1}. Hence for the assumed luminosity too large a flux would be observed for D less than 3 kpc.

The energy distribution given by Snijders, Seaton and Blades as well as in letters of T. Snijders to the target of opportunity team is not far from a classical Lynden-Bell steady state accretion disk distribution, with a total luminosity near 1×10^{36} D^2 erg s^{-1} on February 24. This is considerably less than the super Eddington luminosity required here for the wind, most of which is in wavelength regions unobservable with IUE. It seems that within the framework of the model proposed here, it is easiest to suppose that the flux in the wavelength regions observed came from material between the components of the binary and perhaps also the secondary, all being heated by radiation from the photosphere. The fairly rapid flux variations on February 24 involving a flux decrease of up to 25% in some wavelength regions in 5 1/2 hours, lead one however to cast some doubt on the interpretation in terms of a steady state disk.

Lines formed near the photosphere would be broadened both by electron scattering and by radiation damping. It is easy to show that the latter could explain the CIV system b width, if all carbon near the photosphere was in the form of CIV, and there was an overabundance of only 5, with respect to the cosmic abundances of Allen (1973). For larger overabundances the same effect would, occur if most carbon was in other ionization stages. In any case there seems little justification in measuring the violet edges of absorption components and calling the corresponding velocity a "terminal" velocity.

Another test of the self consistency of the explanation of the system b velocity proposed here, can be made from equation (12) of my recent study (Friedjung, 1981). In the electron scattering dominant case $\alpha = 1$, and the radius of the region of acceleration r_{ac} is given by

$$\frac{r_{ac}}{r_s} = \frac{16}{3} \frac{V_s}{c} \frac{V_{ac}}{V_s} \qquad (5)$$

This gives $r_{ac} = 3 \times 10^{9}$ cm, which is larger than the radius of a white dwarf. Therefore acceleration can be considered as occurring above the surface of a perhaps somewhat bloated white dwarf; the result would have been embarassing had r_{ac} been smaller than a typical white dwarf radius.

The explanation given here appears consistent though other possible explanations could exist. It should be noted that the system b velocity is of the order of the escape velocity from a white dwarf. Hence alternative explanations should in any case involve winds from a white dwarf.

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