# INFRARED OBSERVATIONS OF NOVA AQUILAE 1982

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Abstract

We describe infrared photometry and spectroscopy of Nova Aquilae 1982. The broadband observations suggest that the dust shell of Nova Aquilae was anomalous, while the spectroscopic observations point to the presence of molecules in the nova environment.

Nova Aquilae was discovered (Honda 1982) on 1982 January 27th. The visual light curve, based on visual estimates (IAU circulars), IUE FES counts (derived assuming (B-V) = 0) and photometry at the South African Astronomical Observatory (SAAO), suggest a fast nova with visual decay rate $\dot{m}_V = 0.3$ mag $d^{-1}$. Spectral development and outburst amplitude suggest that the nova was discovered at maximum.

An infrared excess was first detected, 37d after outburst, by Williams and Longmore (1982) and subsequent infrared photometry has been carried out at SAAO (reported here), UKIRT and by Gehrz et al (1982). The light curve at 2.2 μm, based on these data, together with the above visual light curve, is shown in Fig. 1. Assuming that Williams and Longmore's photometry caught the nova dust shell near maximum infrared luminosity, the optical depth in the dust shell

$$\tau \simeq L\ (\mathrm{IR\ max})/L\ (\mathrm{vis\ max}) = 0.15$$

consistent with the apparent absence of a break in the visual light curve.

The infrared excess of Nova Aquilae seems to be anomalous for a fast nova on two counts: (i) the amount of dust present is surprisingly large; (ii) dust formation occurred anomalously early. If the time of maximum infrared flux $t_{max}$ = 37d, the grain growth model (Clayton and Wickramasinghe 1976) implies that grain condensation occurred at $t_0$ = 16d. Even if $t_{max}$ = 60d, condensation would have had to occur at $t_0$ = 25d. For "normal" novae, obeying the usual relationships



M. Livio and G. Shaviv (eds.), Cataclysmic Variables and Related Objects, 121–125.


https://doi.org/10.1017/S0252921100090230 Published online by Cambridge University Press

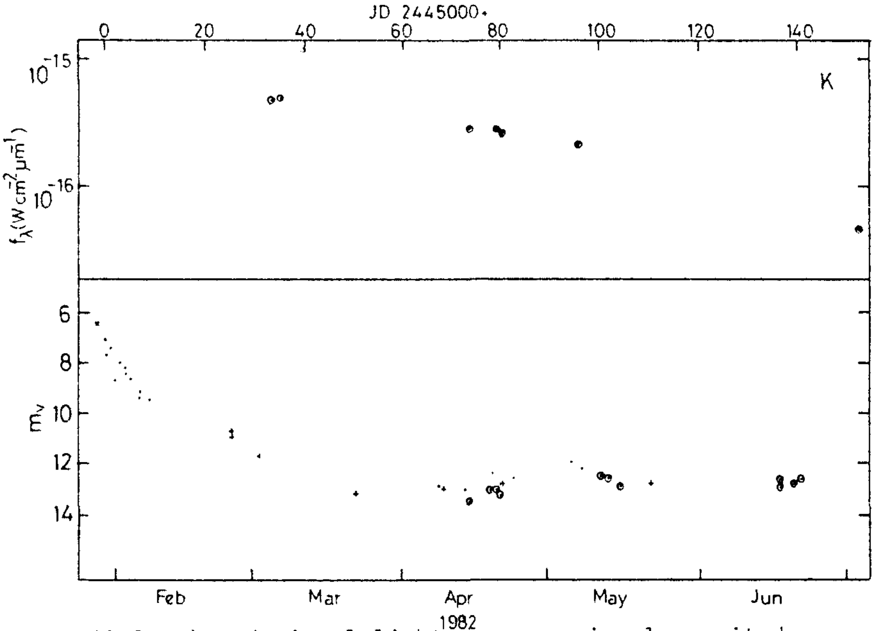


Fig. 1 K(2.2 μm) and visual light curves; visual magnitudes compiled from visual estimates (points), IUE FES (crosses) and photoelectric photometry (circles)

between speed class, bolometric luminosity and principal ejection velocity, we would expect a nova with $\dot{m}_V$ = 0.3 mag $d^{-1}$ to condense grains only after $t_0 \gtrsim 80$ d (Bode and Evans 1982). This discrepancy can be circumvented if the material from which grains formed was moving at ∿ $10^4$ km $s^{-1}$, or the nova is a factor ∿ 25 underluminous for its speed class. Although evidence for high velocity material is provided by IUE observations (Snijders et al 1982; Friedjung 1982) it is unlikely that this gave rise to grains. There is no discrepancy if the grains predate the outburst.

In the near infrared ($\lesssim$ 5 μm), the dust shell spectra can be well described by blackbodies cooling from ∿ 1100 K (day 37) to ∿ 800 K (day 156). At long wavelengths ($\gtrsim$ 10 μm) however, the photometry of Gehrz et al (1982) reveals an excess relative to an extrapolation of the near infrared spectra and in particular there is a feature around ∿ 10 μm. Such a feature is unique amongst dusty novae. On the basis of 8-13 μm spectroscopy, Gehrz et al attribute this feature to SiC at 11.5 μm; Aitken et al (1982), however, interpret the feature as the 10 μm 'silicate' feature. The resolution of this issue has obvious implications for the grain condensation process; also it could tell us something about the C/O ratio before condensation, and hence about the outcome of the thermonuclear runaway that gave rise to the eruption. Also, the spectrum of the nova dust shell is much broader than blackbody, or there may be another feature at ∿ 20 μm.

The 2-4 μm CVF spectrum obtained at SAAO on 1982 April 18th is shown in Fig. 2. Several weak absorption features are apparent in the 3-4 μm band (the Brackett lines α and γ are of no great interest in the present context).

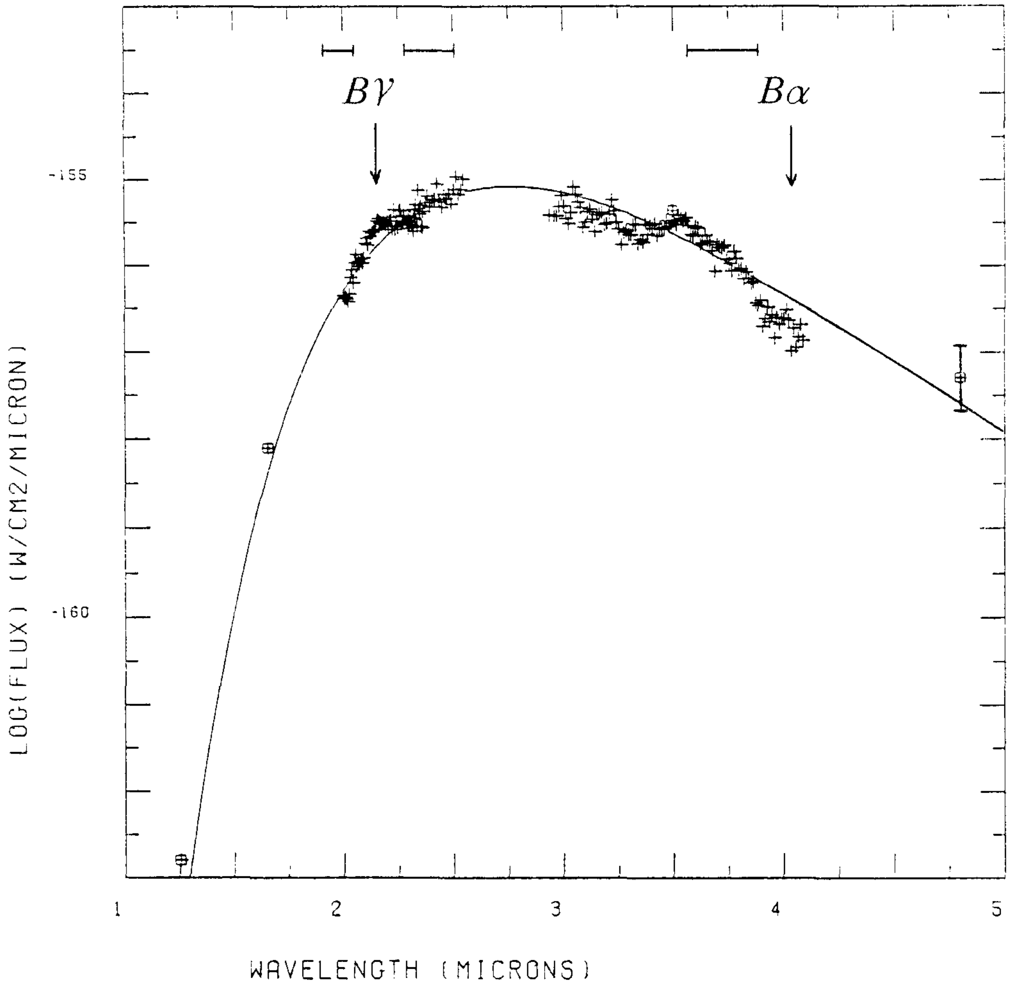


Fig. 2 2-4 μm spectrum of Nova Aquilae. JHKLM photometry included as squares. Curve is a blackbody with temperature 1050 K; horizontal lines are assumed continuum. Location of Brackett α and γ lines are indicated.

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A least squares fit of a blackbody to continuum data in the CVF spectrum gives a dust shell at 1050 K, consistent with the 5 μm photometry. This procedure leads to two absorption features, centred on ∿ 3.2 μm and 4.0 μm, a combination which, together with emission at ∿ 10 μm, is a common signature of carbon-rich stars with extensive dust shells (in which case of course the '10 μm' feature is identified with SiC). In such objects the 3.1 μm feature is identified with $C_2H_2$/HCN, while the 3.9 μm band is identified with CS/$C_2H_2$. The origin of the spectral features is uncertain, but they do point to the existence of molecules in the circumnova environment. Molecules (CN) have previously been detected - briefly - in the very slow nova DQ Her (Payne-Gaposhkin 1957). Whether these molecules are in the gas phase, or attached to grain surfaces, only more detailed observations can tell. The fact that they exist at all in the nova environment is extremely remarkable.

## Acknowledgements

We thank Dr. R. Argyle for providing a finding chart, and Drs. D. Kilkenny (optical) and P.M. Williams and I.S. Glass (infrared) for communicating data in advance of publication. MFB is supported by the SERC.

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DISCUSSION FOLLOWING A. EVANS' TALK

FRIEDJUNG: Was the first dust formed later than the time when the high velocity systems were formed?

EVANS: The high velocity material was first seen on February the 24 which is day 31, the infrared excess was first picked up on day 37, but if that was at maximum then condensation should have occurred at day 16. Even if we are generous and suppose that maximum infrared luminosity was around about day 60, which is consistent with the patchy infra red light curve, we still need condensation at day 25 which again is before the high velocity material.

SHAVIV: Do you have any explanation as to how come that the grains survive the hot surroundings in the ejecta?

EVANS: The kind of model that Bode and I have been plugging for a couple of years now, involves not grain condensation in the ejecta but grains existing before the outburst.

WILLIAMS: Just an observational fact, grains exist in the hot environment of planetary nebulae.

MITCHELL: You tend to favour the idea of absorption around 3.5μ on the basis that the hotter black body curve doesn't fit the 5μ point well. Supposing that you have a shell with a significant temperature gradient then you are going to get more cool dust, therefore the long wavelength end is going to be enhanced so that it further confuses the question of whether these things are absorptions or emissions.

EVANS: That's right. The only thing we've got to go on is that so far all spectra of nova dust shells have been as near black body as makes no difference. There is another aspect to this, perhaps we shouldn't hang too much on the 5μ point because in previous dust novae there has been a 5μ emission which people have attributed to CIII molecules and these have been perhaps suggested as nucleation centers, so you are right, perhaps we shouldn't attach too much emphasis on the 5μ-photometry.

PIIROLA: I have just one comment which supports the formation of dust particles around novae, in Nova Cygni 1978 the polarization changed quite remarkably 30 days after maximum light and I don't think there is any other explanation than formation of dust particles.

SUGIMOTO: Is is possible to estimate the total amount of dust?

EVANS: Yes. It depends somewhat on the distribution of grains in the shell. Typically, for a very dusty nova like say, NQ Vul it is around about several $10^{-5}M_{\odot}$, it certainly indicates that the carbon in the ejecta has to be condensed into grains pretty efficiently.

SUGIMOTO: Is it possible to estimate the amount of gas ejected?

WILLIAMS: The shell mass for Nova Cygni 1978 was $8x10^{-5}M_{\odot}$ and the carbon to hydrogen was about $10^{-2}$ by number, so it was less than $10^{-5}M_{\odot}$.

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