INFRARED SPECTRA OF NOVA DUST SHELLS

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Abstract

Results of fitting blackbody and pseudoblackbody functions to infrared photometry for three classical novae are briefly summarised.

Several classical novae have developed an infrared excess due to emission by dust some weeks after the visual outburst. Two models have been put forward to account for this behaviour, namely (i) the nucleation and growth of grains in the nova ejecta (Clayton and Wickramasinghe 1976) and (ii) the existence of a dust shell that predates the nova eruption (Bode and Evans 1980). In either case, the expected flux spectrum of the dust shell is expected to be of the form

$$f_\nu = \frac{A\, x^{\varepsilon+3}}{\exp(\eta x) - 1} \tag{1}$$

where x is a frequency parameter, ε is determined by grain emissivity and/or grain temperature gradients in the dust shell and η is characteristic of the dust shell temperature.

We have fitted Equation (1) to infrared photometry for the three novae NQ Vul, LW Ser and V 1668 Cyg, with the following conclusions:

(a) the data are consistent with blackbody fits for all times for all three novae;

(b) the dust shell temperatures of LW Ser and NQ Vul rose after an initial decline, subsequently levelled out and finally fell (cf. Fig. 1 for NQ Vul);

(c) neither pre-existing grain, nor grain growth models, in their original forms, adequately account for the time-dependence of A and η (Eq. (1))

The grain growth model is rather more versatile than the pre-existing grain model in that several options are available for

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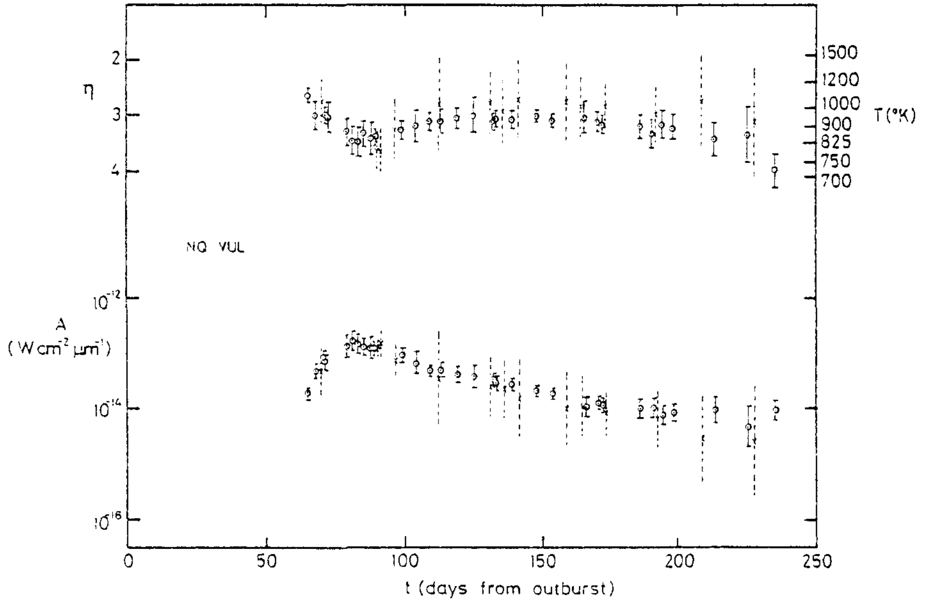

Figure 1 The variation of A and η for NQ Vul, based on a fit of Equation (1) to the photometry of Ney & Hatfield (1978) (circles) and Sato et al (1978) (crosses). Error bars are 3σ

developing the original treatment. For example,

(a) the ejecta may not be spherically symmetric and ejecta geometry may affect rate at which grains nucleate and grow;

(b) ejection in classical novae occurs on an extended timescale, ∿ days to weeks depending on speed class, whereas on grain growth models essentially instantaneous ejection is assumed;

(c) grain growth may be accompanied by concurrent destruction processes;

(d) for dust shells that are optically thick in the infrared, as is the case for NQ Vul and LW Ser, we get the establishment of what is essentially an infrared "pseudophotosphere". Details of this interpretation are given in this volume by Mitchell et al (1982).

The full text of this paper is being published in the Monthly Notices of the Royal Astronomical Society.

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DISCUSSION FOLLOWING A. EVANS' TALK

FRIEDJUNG: I think it is quite reasonable to suppose that dust is formed in the principal shell which would contain most of the mass and will be relatively cool, the continued ejection probably would not have very much effect on the dust formation. So I don't think you need to take account of the continued ejection process.

EVANS: Yes, but the instantaneous ejection is a little oversimplified.

FRIEDJUNG: Of course, but most of the mass will be in the fairly dense part which comes off near maximum and the dust will be mainly formed in it.

MITCHELL: What we are saying is that the early phase, the principal spectrum is in itself extended.

WILLIAMS: As I understand it, one of the conventional dogmas is, that you have instantaneous grain formation after the outburst, because there is usually a simultaneity between the decrease in the visual light curve and the inception of infra red radiation and I am just wondering according to your picture how would you account for the simultaneity of the two? Is it just a coincidence?

EVANS: I guess that after the recovery, to the secondary maximum if you like, the nature of the visual flux is totally different from the nature of the visual flux before the transition minimum and I guess you can ascribe the break in the light curve just to a shut-off in the mass loss rate and a comparatively sudden decrease of the pseudo-photosphere.

WILLIAMS: Are there any novae which undergo this decrease in the visual for which the infra red radiation does not occur at the same time? You don't have in your picture a natural explanation for the decrease in the visual light, associated with properties of the dust.

EVANS: They are connected in that the dust only feels the outburst when the temperature of this pseudo-photosphere goes up.

BATH: As I understand your work, there is a correlation between the optical light curve and the infra red development of the infra red light curve because one feeds the other, the optical light curve plus the UV shift is being transformed into the infra red by the absorption properties of the grains.

WILLIAMS: The absorption properties are not related to the temperature though, whereas the emission properties are, that is my point, you can have the dust there at all times and it is absorbing, but it does not emit. It seems to me that the *relative fraction of the visible radiation* that the grains are absorbing is independent of temperature, it is the same at all times. I am saying the following: suppose you have pre-existent grains which have the same size and all their properties are constant, except the temperature, (which is irrelevant to their absorptive properties) and you have this expanding shell, it seems to me that the fraction of light that they absorb at one wavelength is constant.

MITCHELL: There is a coincidence in this model, because it is the break in the light curve, which in this model is due to the underlying source, has got to be coincident with the energy distribution peaking in the region of 800 Å.

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WILLIAMS: So according to your model that is a coincidence?
MITCHELL: Yes.