# THE INTERACTION OF A NOVA WITH ITS CIRCUMSTELLAR ENVELOPE

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The existence of dusty envelopes around novae is shown by various authors using different methods:

We have used the Balmer decrement of novae. In the case of all novae a sudden variation of this decrement is observed a certain time after the beginning of the outburst, the $H\alpha/H\beta$ ratio rising from its normal value to a maximum and then decreasing again to its normal value.

We have shown in detailed calculations (Malakpour, 1973a), that the for the conditions existing in the envelope ejected by a nova, radiative and collisional excitation and ionization from level 2, have only negligible effect on the observed decrement. We finally found out that the observed decrement variation is produced by a dusty envelope with a radius of the order of $10^{15}$ cm; it exists before the beginning of the outburst of the nova, and the radius of a grain belonging to this envelope is of the order of 0.10 micron; the visual absorption produced by the envelope is variable and was 1.12, 3.29 and 2.24 magnitudes for nova Delphini 1967 in 1968, 1969 and 1970, respectively (Malakpour, 1977). The mass of the circumstellar envelope of nova Delphini 1967 is of the order of $10^{-9}$ $M_{\odot}$ (Zellner, 1971).

Other authors have studied the infrared emission of 4 novae and found that they are surrounded by dusty envelopes. For example, Geisel et al. (1970), as well as Hyland and Neugebauer (1970) found that the infrared excess observed for nova Serpentis 1970 was produced by dust particles in a circumstellar envelope which had an extension of $5 \times 10^{14}$cm. Studies of the spectrum of nova Serpentis 1970 by Code (1972) and Gallagher and Code (1974) indicated for this envelope a visual absorption of about 3 magnitudes. The total mass of the dust particles of nova Serpentis 1970 is the order of $10^{-6}M_{\odot}$ (Geisel et al., 1970 ; Kawara et al., 1976). According to Vrba et al. (1977), also nova Aquilae 1975 had a dusty envelope with a mass increasing from $3 \times 10^{-9}$ $M_{\odot}$ to $3 \times 10^{-8}$ $M_{\odot}$ for the period from June 16 (i.e., 10 days after the explosion) to July 1, 1975, and that particle growth was not yet completed. In general, the total mass of the dust particles of novae is several times $10^{-6}$ $M_{\odot}$ (Clayton and Hoyle, 1976).

However, Kawara et al., (1976) did not find any excess infra red emission using multiband photometry for nova Cygni 1975 for the period from 2 to 69 days after light maximum. They concluded that nova Cygni 1975 did not have a dusty circumstellar envelope.

These studies show that novae are surrounded before their explosion by a dusty circumstellar envelope with a radius of $5 \times 10^{14}$ to $5 \times 10^{15}$cm. The corresponding dust particles have a radius of 0.10 micron and their physical properties are similar to those of interstellar dust. The reddening produced by the envelope is variable and the average visual absorption ($A_V$) is of the order of 3 magnitudes.

The presence of circumstellar absorption systems in the spectra of novae (Abt 1963, Malakpour 1973b), also confirms the presence of such an envelope.

According to the present author, the dusty circumstellar envelope of novae is formed from matter ejected by the preceding explosion in the following manner:

The ejected gas reaches a distance from the nova, where conditions are suitable for the condensation of particles with radii not larger than 0.10 micron. When the nova finally reaches again its pre-outburst stage, the radiation pressure is small and the dust particles already formed approach the nova and remain at a distance of $5 \times 10^{14}$ to $5 \times 10^{15}$ cm; at this distance the gravitational attraction of the particles is of the same size as the radiation pressure.

Support of the proposed mechanism comes from the fact that novae are recurrent. The recurrence period is of the order of $10^3$ to $10^7$ years, which (in the latter case) is quite close to the time necessary for the formation of a particle with a radius of 0.10 micron. A nova like nova Cygni 1975 which according to Jacchia (quoted in Hoffman et al., 1976) exploded for the first time, should therefore be without a dusty circumstellar envelope. An infrared excess was in fact not observed for nova Cygni 1975 (Kawara et al., 1976), and also no thermal X-rays emission (Brecher et al. 1977) which according to Brecher et al. (1977), is produced by the collision of the ejected gas with the circumstellar envelope. In addition, the spectral type before the explosion, i.e., of the prenova, is O-B (Payne-Gaposchkin, 1957), and Spitzer (1941) has shown that dust particles with a radius of 0.10 micron, can approach a B5 star up to a distance of $3 \times 10^{15}$ cm.

Finally, the interaction of the ejected matter with the circumstellar dusty envelopes gives:

1. - an increase of the dimensions of dusty particles which then produce the excess infrared emission;
2. - the production of x-rays; and
3. - the production of coronal lines.

A study of the interaction of a nova with its circumstellar envelope is being made, and its results will soon be published.

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D I S C U S S I O N of paper by MALAKPOUR:

FRIEDJUNG: What Dr. Malakpour did in the case of Nova Delphini was to calculate dust absorption by 3 methods: the Balmer decrement, comparison of Balmer and Paschen line emission, and a comparison of Balmer and thermal radio emission. Consistent results were obtained, which seems to support the explanation by dust absorption.

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KRAFT: Perhaps one should consider that the circumstellar dust is a consequence of secular mass loss that may also be going on in old novae.

MALAKPOUR: This model is consistent with the accepted models for dusty circumstellar envelopes (See Pecker 1972, Mem. Soc. Roy. Sci. Liège, 6th serie, Vol. III, p. 243). If the mass of gas leaving the binary between successive explosions during mass transfer from the red component to the white dwarf is large compared to the mass of the dusty circumstellar envelope, and if the chemical composition is suitable, this gas could condense to form dust.

SURDEJ: How did you calculate the Balmer decrements?

MALAKPOUR: For more details, see my paper in Astron. & Astrophys. 1973, Vol. 28, p. 393.

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