RESIDUAL EXTINCTION EFFECTS IN SPECTRA OF NEWLY FORMED STARS

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ABSTRACT. Extinction laws observed in spectra of B_e stars are shown to be evidently different from the mean extinction curve. They do not contain in many cases the prominent extinction feature - the 2200A bump. The results are derived both from multicolour (ranging from the far-IR until the ultraviolet ANS) photometry and from TD-1 UV spectra. It is strongly suggested that the observed extinction phenomena are originated in circumstellar, disk-shaped shells as the shape of resultant extinction curve suggests both the presence of big, core-mantle grains and continuous infrared emission of circumstellar origin.

1. INTRODUCTION

The variability of extinction law (Massa and Savage 1989) is certainly caused by differences in physical properties of interstellar grains. Dust particles may grow in the dark, cold clouds and thus their sizes, shapes and chemical composition may vary as well as their crystalline structure from one cloud to another. Evolutionary tracks of interstellar grains have been recently discussed by Greenberg (1984).

The growth of grains may be especially fast in dense and cold clouds - the expected birth-places of new stars. Thus big, core-mantle grains are to be expected in globules or elephant trunks observed in vicinities of newly formed objects as well as in circumstellar shells, possibly disk-shaped. The remnants of the parent clouds are strongly irradiated with the stellar radiation in close vicinities of young stars. It seems thus to be of basic importance to check whether such grains produce the extinction obeying or not the mean law observed in the truly interstellar medium. Similar extinction effects are to be expected in vicinities of all young stars.

2. DESCRIPTION OF THE METHOD

B_e stars are well known objects closely related to some circumstellar matter - possibly remnants of their parent clouds. Very peculiar extinction curves derived from spectra of at least some of them (Sitko

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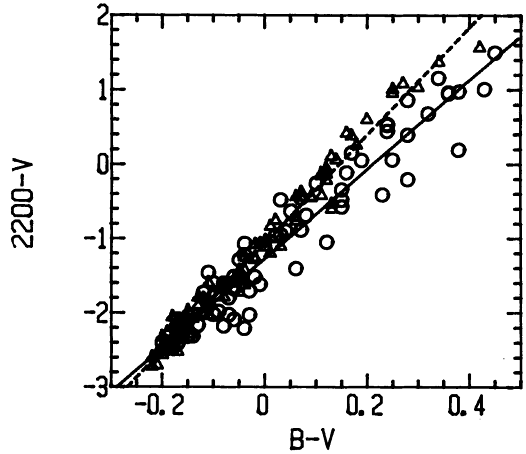
et al. 1981) make a more systematic investigation really attractive. Let's select a sample of B_e stars of nearly the same spectral type and luminosity class. A difference in the extinction law should be most easy to detect in the UV, particularly around the famous 2200**A** bump. Thus an analysis of possible peculiarities of extinction in B_e stars should start from a consideration of this prominent feature.

The spectral type and luminosity class most frequently observed from astronomical satellites is B2V. Thus we have selected the sample of these stars from the ANS Catalogue (Wesselius et al. 1982). The colour index between the ANS 2200**A** band and the V band was correlated with the B-V in the selected set of normal B and B_e stars. The result is shown in Fig.1.

Fig.1 *Two-colour diagram relating the colour index between the 2200A ANS band and V band to B-V. Normal B2V stars - triangles; B2Ve - open circles. Note the different slopes of the mean relations - they intersect close to the assumed $(B-V)_0$ indicating that stars of both samples are intrinsically identical.*



The observed variety of colour indices among the sample of the same Sp/L should result only from different reddenings. The observed different slopes of the two-colour relations for normal B2V and B2Ve stars, as shown by Krełowski and Strobel (1987), indicate for different extinction laws towards the stars of both samples. The 2200**A** extinction bump is apparently stronger in relation to E_{B-V} when observed in spectra of normal B2V stars. Let's emphasize that the scatter observed in Fig.1 is also greater in the case of B_e stars. Thus the latter sample is probably much less homogeneous - reflecting different stages of the evolution of circumstellar grains or different geometry of intervening clouds (disks?).

The most interesting cases are, however, these of very low reddenings. In such cases we may expect that extinction effects are caused by single clouds or solely by circumstellar shells in the case of B_e stars. Thus a comparison of extinction curves derived from spectra of slightly reddened B_e stars with the mean extinction curve may be very interesting. In spectra of heavily reddened B_e stars the truly interstellar effects become more and more important and thus their extinction curves get more and more similar to "normal" ones.

The stars selected for this purpose are: HD 20336, 32343, 44458, 57150, 60606, 65875, 88661, 202904, 59878, and 63462. They are mostly

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B2V stars; the criterion of selecting the above sample was the availability of stellar photometric data from far infrared (Gezari et al. 1984) through the UBV up to the ANS UV bands as well as of the TD-1 spectra (Jamar et al. 1976, Macau-Hercot et al. 1978). All these data allow to construct extinction curves in a very broad wavelength range.

The individual extinction curves of the chosen stars have been calculated using the standards recommended in our recent paper (Papaj, Wegner and Krełowski 1989). After deriving all these curves with the aid of the standard pair method the results have been averaged over the whole sample. The comparison of the B_e extinction curve with the mean galactic one (Savage and Mathis 1979) is shown in Fig.2 together with that for the B_e stars (HD10516, 68980, 41335, 45910, 59878, 63462, 200775, and 153261) for which only photometric data are available. The error bars show possible uncertainties.

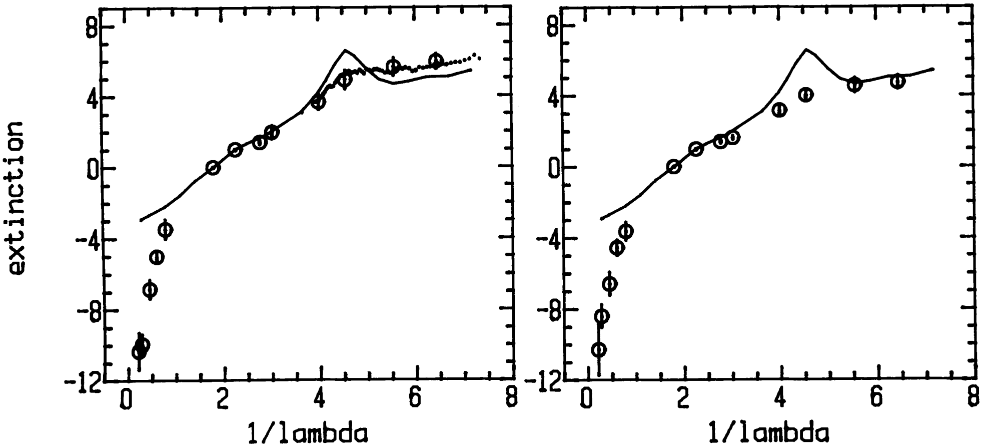

Fig.2 *The comparison of the extinction curves (normalized to E_{B-V}) averaged over the B_e samples including TD-1 spectra marked as dotted line (left) and based on photometric data only (right) with the mean extinction curve of Savage and Mathis (1979) - full line.*

Two very important phenomena are observed in the extinction curves derived from B_e stars. One of them is the lack of the 2200A bump. This astonishing fact is observed in the TD-1 as well as in the ANS data and thus it is proved beyond a doubt. It is interesting that Be and mean curve differ only shortward of 2200A in far-UV. In cases of heavily reddened B_e stars the dominating obscuration of interstellar clouds produces the bump, but it is usually weaker than in normal B stars (Fig.1) because of the circumstellar contribution. Another important phenomenon is the far-IR behaviour of the curve. The data seem to indicate for the enormously high value of the R constant (the total-to-selective extinction ratio) which should be situated at the point where the extinction curve intersects the ordinate axis. This phenomenon may be, however, at least partly due to emissions of relatively hot dust particles situated in close vicinities of the stars under considera-

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tion. But the **R** value caused by very big particles, suggested by the flat far-UV segment of the extinction curve, may be higher than the usually accepted value ≈3, due to saturation effects between B and V bands. Let's emphasize: for a great majority of B_e stars neither photometric nor spectral data exist in such a wide wavelength range. Two colour plots (like that in Fig.1) coincide in the case of very small reddenings indicating that B_e and normal B stars are characterized by the same intrinsic colours. This fact makes the results completely reliable.

3. DISCUSSION AND CONCLUSIONS

The results shown in Sec.2 show that the extinction originating in close vicinities of newly formed stars is evidently different from the "mean interstellar". This peculiarity is probably related to certain stages of evolution of the grains that remained in the remnants of the parent clouds of the observed stars. These remnants may occur in the form of disks - the latter may radiate in the IR spectral range without causing any extinction effects as suggested in our Fig.3: the energy distributions in spectra of four almost unreddened B_e stars are compared. The differences in far-IR range are quite strong whereas the UV ranges (most sensitive to extinction effects) clearly coincide as well as the visual ones. This fact together with the abnormally high **R** values may be caused by circumstellar infrared emissions in continua.

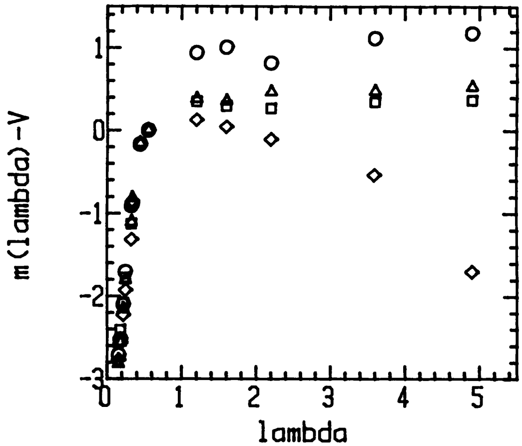

Fig.3 *The comparison of energy distributions in spectra of four unreddened B2Ve stars. HD56139 (squares), HD57219 (triangles), HD120324 (open circles) and HD158427 (diamonds). Note the great scatter in far infrared suggesting circumstellar emissions. Lambda in microns.*

We conclude that "normal" B stars and those with emission lines are intrinsically identical at least in the sense they have the same intrinsic colour indices. The extinction (together with the infrared emission) modifies however their spectra in quite different ways. The above presented "peculiar" extinction curve is probably a rather typical product of the grain evolution in vicinity of a newly formed star. This result stresses once again the fact of basic importance: every "mean interstellar extinction curve" is probably a mixture of individu-

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al contributions of clouds differing strongly in many cases. Such an "average" can hardly be used to remove small reddening effects (=single cloud effects) from high quality spectra.

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