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Dust around Herbig Ae/Be stars : IRAS low resolution spectra

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Abstract. IRAS low resolution spectra are presented for 17 Herbig Ae/Be stars. The observed spectral characteristics are correlated with reddening $E(B - V)$ and the spectral type of the star. The silicate emission feature at 9.7 μm is found only in the spectra of Herbig Ae/Be stars with $E(B - V) \leq 1.0$ and spectral type later than ~ A0 while this feature is in absorption in stars with $E(B - V) \geq 1.0$ and spectral type earlier than ~ A0. The unidentified emission feature at 11.3 μm is found in the spectra of stars with spectral type earlier than ~A0. These observations are interpreted in terms of the composition of dust in the circumstellar environments of Herbig Ae/Be stars.

Key words : Herbig Ae/Be stars—dust—IRAS observations

1. Introduction

Herbig Ae/Be stars are young intermediate mass pre-main-sequence stars often surrounded by reflection nebulosities. These stars have envelopes of circumstellar matter distributed in the form of massive disks and/or as extended shells. An important constituent of this circumstellar matter is dust, the presence of which is clearly evident from spectroscopic studies of the infrared region, polarization measurements and from the infrared excesses of the stars commonly attributed to thermal emission by dust.

In order to study the nature of the dust around these young stars, the low resolution spectra in the 9-21 μm wavelength range obtained by the Infrared Astronomical Satellite (IRAS) are examined. The spectra show characteristic dust features, such as the 9.7 μm silicate band in absorption or emission and the 11.3 μm emission feature, for many of these stars.

2. IRAS low resolution spectra

Low resolution spectra are available for 17 Herbig Ae/Be stars in the IRAS LRS catalogue and are presented here. Of these 6 stars show 10 μm emission, 4 stars 10 μm absorption, 4 stars the 11.3 μm unidentified infrared feature and 3 show featureless spectra. The features seem to be correlated with the spectral type of the star and the $E(B - V)$ colour excess towards the star. The spectral types of the stars have been adapted from Finkenzeller & Mundt (1984) and from Finkenzeller (1985). The colour excesses have been computed using intrinsic or unreddened colours of main sequence stars from Johnson (1966). The colour excesses, spectral types and IRAS LRS spectral classes of the stars are listed in table 1.

Table 1

Star	Spectral type	IRAS LRS classes	$E(B-V)$
V376 Cas	F0	63	0.94
Elias 1	A0	50	1.50
AB Aur	A0	69	0.14
LkHα 198	B7-B8	80	0.62
HD 259431	B2	80	0.50
R Mon	B0	50	1.38
Z CMa	B/A	31	1.20
HD 97048	B9	80	0.41
HR 5999	A7	23	0.12
HD 150193	A4	69	0.42
HD 163296	A7	69	0.01
MWC 300	B:	13	1.17
BD + 40 4124	B3	31	0.94
V645 Cyg	A0	32	1.10
MWC 1080	B0	72	1.70
HD 100546	B9	82	0.09
HD 104237	A0	25	0.27

A plot of the colour excess, $E(B-V)$ and spectral type of the stars places them into well separated categories, as can be seen in figure 1.

1. The 10 μm silicate band is seen in absorption only for stars with a spectral type earlier than ~ B9-A0 and an $E(B-V)$ colour excess ≥ 1.0.

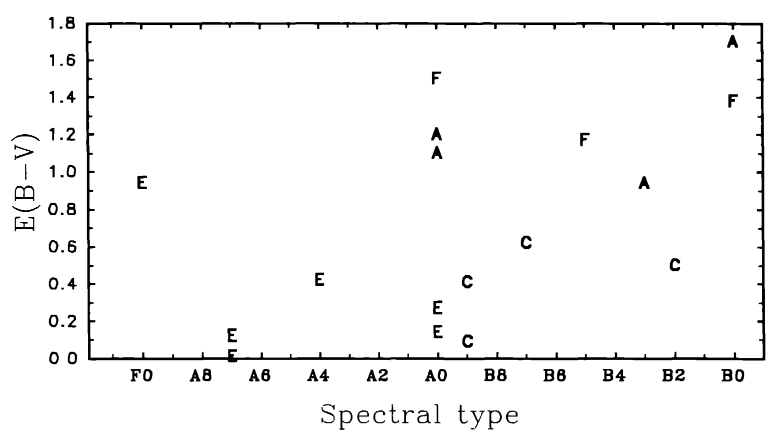

Figure 1. The $E(B-V)$ of each star has been plotted against its corresponding spectral type. The legends appearing on the plot indicate the following — F denotes stars that have a featureless IRAS spectrum, A and E, that the star has an absorption or an emission feature at 9.7 μm, and C denotes those stars with the unidentified emission feature at 11.3 μm.

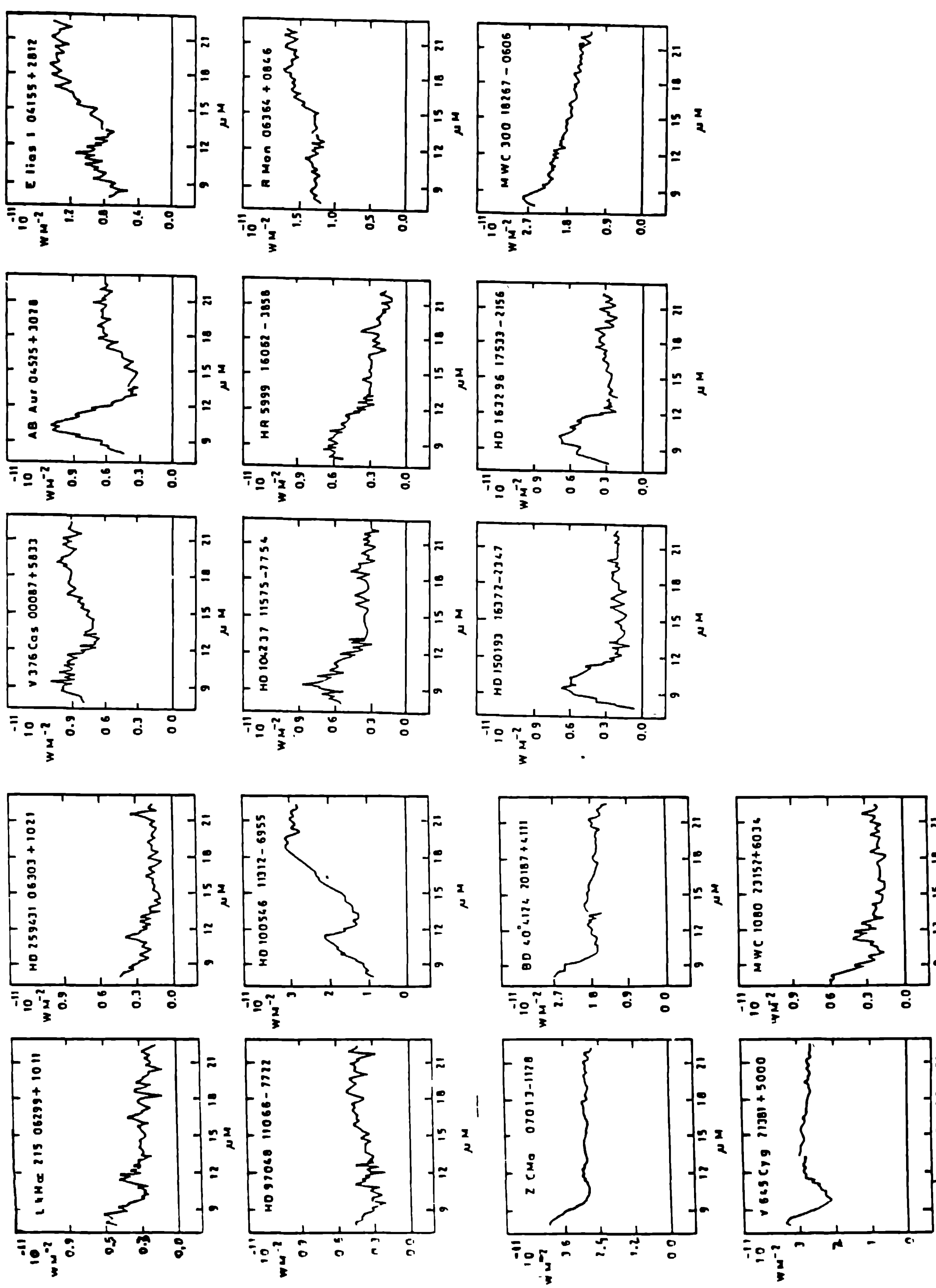

Figure 2. The figure shows IRAS low resolution spectra for the 17 Herbig Ae/Be stars in the 9-21 μm wavelength range.

2. The 10 μm silicate emission band is observed only for stars of a spectral type later than ~ A0 and with low colour excesses, i.e., $E(B - V) \leq 1.0$..
3. The 11.3 μm unidentified emission feature is present for early type stars with low colour excesses, ($E(B - V) \leq 1.0$).
4. Three early type stars show featureless spectra.

3. Discussion

There seems to be a clear demarcation between the stars with different spectral types and colour excesses. A possible explanation may be suggested on the basis of the chemical composition of the dust around the stars as well as its spatial distribution.

Spectra of earlier type stars do not show the 10 μm emission band, indicating the absence of hot dust in their close neighbourhood. The dust in their immediate vicinity is probably destroyed or blown away due to a higher radiation pressure and stronger winds. Thus along the line of sight towards these stars, only the cool outer dust is present which causes absorption at 10 μm, against the continuum background.

But however the PAH (Polycyclic Aromatic Hydrocarbon) component of interstellar dust, is extremely stable and survives even under these harsh conditions. The 11.3 μm feature, seen in 4 early type stars with low extinction, is attributed to emission from PAHs. PAH emission is not seen in late type stars, as ultraviolet radiation is required for the excitation of the PAH molecules, which later deactivate through IR vibrational fluorescence (IRF).

The 10 μm silicate band is in emission for late type stars, with a spectral type later than ~ A0, probably indicating that these stars do not effectively destroy the dust in their immediate surroundings. It should be noted here that there are no late type stars in the sample with large $E(B - V)$ which may be a selection effect.

Three early type stars with large excesses show featureless spectra. The spectra can be interpreted as continuum emission by an optically thick disk. The large $E(B - V)$ may be caused by obscuring dust clouds along the line of sight of the star, which do not obscure the disk.

4. Conclusions

The infrared spectra of Herbig Ae/Be stars show dust spectral characteristics which seem to depend on the spectral type of the central star. It is inferred that early type stars, i.e. stars with a spectral type earlier than ~ A0, destroy the dust in their immediate neighbourhood and therefore never show the 10 μm silicate band in emission. This band is seen in absorption for those stars which have large $E(B - V)$ colour excesses and hence greater extinction due to dust. The PAHs being more stable are not destroyed and cause the 11.3 μm feature in early type stars with smaller $E(B - V)$s. The late spectral type stars do not destroy dust as effectively and their spectra have the 10 μm emission band.

References

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