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HD 42927 and HD 126341: two pulsating B stars surrounded by circumstellar dust*

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Abstract. We have performed an infrared study of pulsating B stars. The main conclusion is that none of the 163 (non-)radial pulsators shows an IR excess flux due to free-free emission, despite the fact that the sample contains several rapid rotators. Two β Cep stars and two slowly pulsating B stars do exhibit an unexpected infrared colour excess at 12 μm.

The small IR excess of the B 2 IV β Cep star HD 126341 (τ^1 Lup) is not accompanied by H α emission nor by a near-IR excess. It follows an energy distribution described by a power-law that points to dust emission. An optically thin dust model is fitted to the IR data and leads to the presence of circumstellar dust which is situated very far from the star.

The infrared data of the star HD 42927 also point towards the presence of (hotter) dust which is situated close to the star. We have gathered follow-up photometry and high-resolution spectroscopy that confirm the Hipparcos classification of the star as a new slowly pulsating B star.

We briefly discuss the connection between these two pulsating stars and the occurrence of circumstellar dust around main-sequence stars.

Key words: stars: circumstellar matter – stars: individual: HD 42927 – stars: individual: HD 126341 – stars: variables: general – stars: oscillations – infrared: stars

1. Introduction

It is often claimed that stellar pulsations are one of the main causes of the onset and the variability of mass-loss in OB-stars. The most detailed effort to show that this is the case has recently been presented by Rivinius et al. (1998a, 1998b) for the Be star μ Cen. They suggest that the beat-periods of the short-term line-profile variability govern the occurrence of the line emission outbursts in this star. Detailed modelling of the observed line profiles in terms of non-radial-pulsation theory (or any other physical model) is undertaken at present (Rivinius et al., in preparation; see also Rivinius 1998 for the preliminary results). Our work originates from the lack of a general firm connection between photospheric pulsations and mass-loss in early-type stars.

A division between the hot O and very-early B stars on the one hand, and later B stars on the other hand, is necessary. The effect of radiatively driven winds to infer mass-loss decreases rapidly for stars later than B 0. The status of ongoing theoretical efforts to understand the wind structure of O stars is summarised by Owocki (1998). At present, he did not yet succeed in taking into account the two most commonly suggested perturbation mechanisms, namely magnetic fields and non-radial pulsations, in the calculations that simulate the wind structure. The models are currently restricted to a driving modulation induced by the occurrence of bright and dark spots in the stellar photosphere. Improvements towards the full inclusion of the two perturbation mechanisms mentioned will probably be achieved in the near future. From an observational point of view, the mass-loss of stars earlier than B 0 can best be studied from UV resonance lines. An extended observational study of O-star winds is presented by e.g. Fullerton et al. (1996) and Kaper et al. (1997). They give an overview of the observed line-profile variability among O-type stars. Photometric studies of O stars reveal the occurrence of microvariations with a large range of periods (see e.g. Van Genderen 1985). For a recent study of the photometric variability in O-star runaways and in Wolf-Rayet stars based on Hipparcos data, we refer to Marchenko et al. (1998). They find that about half of the selected stars are variable while many of them were considered to be constant before the Hipparcos mission. The question if the observed photometric and spectroscopic periods are caused by the same mechanism is still open.

Regarding the Be stars, it is not clear what mechanism causes the presence of the circumstellar disk. Non-radial pulsations have been suggested as a prime cause of the onset of the disk formation. The question whether or not Be stars exhibit pulsations remains, however, unanswered (see e.g. Baade & Balona 1994). As far as the maintenance of the circumstellar disk around rapidly rotating B stars is concerned, promising physical mechanisms, such as the Wind-Compressed Disk model (Bjorkman & Cassinelli 1993), have been challenged seriously as a theoretical explanation (Owocki et al. 1996).

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As recently shown by Cohen et al. (1997), wind attenuation of X-rays decreases abruptly beyond B 0 and becomes negligable around spectral type B 2. These authors also tried to investigate if pulsating B stars have a different X-ray behaviour compared to normal B stars, but failed to make any conclusion about this. The same remark is true for the Be stars in their sample.

Optical spectroscopy, polarisation measurements, and IR excesses are often used to study the mass-loss in stars cooler than B 0. In this paper, we consider IR excesses and Hα observations of mainly B-type stars. In order to study the role of non-radial pulsations in the creation of a circumstellar environment, we have undertaken an infrared study of OB-type stars that are confirmed pulsators. Our intention is to see if these stars have a larger probability of having circumstellar material compared to non-pulsators. If so, then one would expect to find a high percentage of pulsating (rapidly rotating) stars with excess fluxes at infrared wavelengths.

For our purpose we have considered the infrared data gathered by IRAS of confirmed non-radial pulsators, and we have compared them to the infrared fluxes of constant stars (see Waters et al. 1987). We describe the selection of the sample of pulsating stars in Sect. 2. It turns out that none of the very few considered O-type pulsators show an appreciable excess flux in the infrared, while four pulsating B stars do exhibit an unexpected IR excess. In Sects. 3 and 4 we study the nature of the excess flux at infrared wavelengths for respectively the β Cep stars and the slowly pulsating B stars. We discuss our findings in Sect. 5.

2. Selection of the sample

We have considered the well-known pulsating B-type stars by consulting the lists given by Heynderickx (1992) and by Sterken & Jerzykiewicz (1993) for the β Cep stars, and by taking the confirmed slowly pulsating B stars (hereafter termed SPBs) listed by Waelkens (1991, 1994), North & Paltani (1994), and Chapellier et al. (1996). We extended the group of the SPBs with the OB-type line-profile variables from the list of 53 Per stars given in Smith (1977). Besides these stars, we included all new β Cep stars and SPBs found by Waelkens et al. (1998) on the basis of Hipparcos data.

For the 163 variable B stars in our sample, we selected those that have a reliable IRAS flux at 12 μm in the IRAS Faint Source Catalogue (FSC, 1990), or, when not given there, in the Point Source Catalogue (PSC, 1988). The IRAS fluxes were obtained by comparing the positions of the variables in SIMBAD with those in the IRAS Catalogues by using a $1'$ search circle. Only stars which have a point source correlation larger than 97 (see Explanatory Supplement, 1988) were selected. This results in a list of 22 β Cep stars and 22 SPBs. Four of these stars have $v \sin i$ larger than 100 km s^{-1}.

We used the intrinsic $(B-V)_0, (V-[12])_0$ relation for OBA type stars given by Waters et al. (1987) to determine the photospheric flux at 12 μm. This result was used to calculate the 12 μm colour excess ($CE(V,[12])$), for which we followed

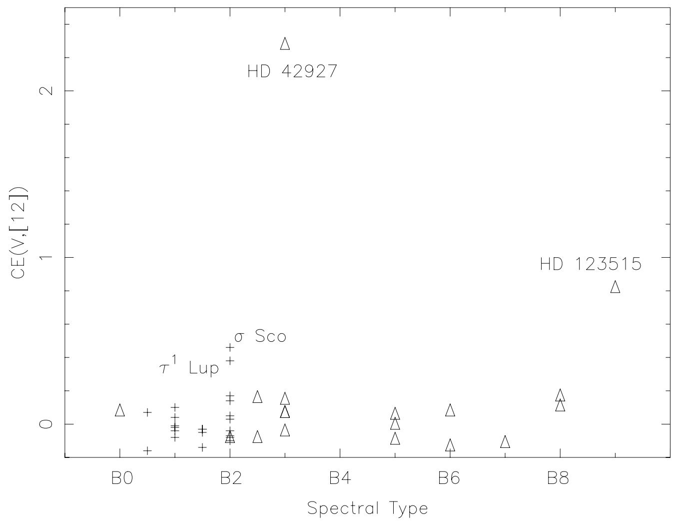

Fig. 1. 12 μm colour excess versus spectral type for the B-type pulsators measured by IRAS. The β Cep stars are denoted by $+$ while the SPBs are indicated with $\triangle$

the method outlined by Coté & Waters (1987). The result for the colour excess of the 44 stars as a function of spectral type is shown in Fig. 1. It turns out that two β Cep stars have an excess larger than 0.35 mag and that two SPBs exhibit an unexpectedly large 12 μm colour excess of respectively 0.82 and 2.28 mag. The latter excess was found for HD 42927, which is not given in the Point Source Catalogue (1988) but is listed in the Faint Source Catalogue (1990). We describe our findings for the four stars with $CE(V,[12]) > 0.35$ mag in more detail in the following section.

We remark that two stars in our sample are interesting limiting cases from a point of view of the effect of radiation-driven winds because they have spectral types between B 0 and B 1. It concerns the β Cep star β Cru (B 0.5 III, e.g. Aerts et al. 1998) and the line-profile variable ε Per (B 0.7 III, e.g. Tarasov et al. 1995). Both stars do not exhibit an infrared excess.

We performed a canonical correlation analysis (see e.g. Aerts & Molenberghs 1995) for the group of pulsating stars without the four outliers indicated in Fig. 1. The physical parameters that were considered in this study are the 12 μm colour excess, the projected rotation velocity $v \sin i$, the main period of the pulsation, and the spectral type of the star. These parameters are available for 35 stars. We find that none of the parameters shows a significant correlation with any of the others. As far as the rotation velocities are concerned, this result is consistent with the one found by Coté & Waters (1987) for the Be stars in the sense that rapid rotators are not necessarily accompanied by larger IR excesses. Waters (1986) also studied the correlation between rotation and colour excess for normal B-type dwarfs and found in general small excesses for $v \sin i < 200$ km s^{-1}. Two stars in our sample have a larger rotation velocity, but these do not show an appreciable colour excess.

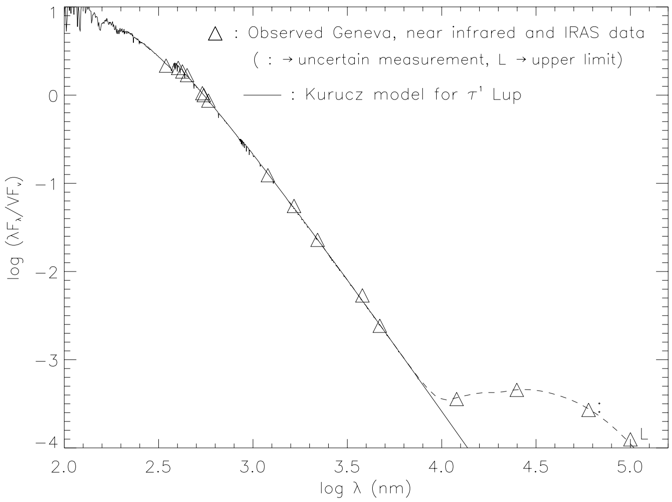

Fig. 2. Spectral energy distribution for the β Cep star τ^1 Lup

3. β Cep stars with a large infrared excess

3.1. σ Sco

The β Cep star σ Sco is a multiple system with four components of which three have spectral type between O9.5 and B9.5. We are not able to explain the large flux at 12 μm together with the flux at visual wavelengths by adding the 12 μm fluxes for the four stars, no matter what kind of atmosphere model (Kurucz 1992) we choose for the star with visual magnitude 5.5 which has an unknown spectral type. The 12 μm colour excess of 0.46 mag that we found for σ Sco is probably not connected with the star itself, but with its surroundings. This star is situated in a H II region and the fluxes measured by IRAS are flagged accordingly (small scale structure). We observed H α and found an absorption profile, confirming that σ Sco is not a Be star.

3.2. τ^1 Lup

The β Cep star τ^1 Lup is one of the coolest among this well-established group of pulsating stars. For a description of its pulsational behaviour and its stellar parameters, we refer to Heynderickx (1992) and to Heynderickx et al. (1994). The star has a $v \sin i$ of 30 km s^{-1}.

We have added the published near-IR JHKLM photometry of τ^1 Lup, which was obtained by Sterken (1991), to our Geneva photometric data and the IRAS FSC fluxes in order to construct a spectral energy distribution. The result is presented in Fig. 2.

τ^1 Lup was already noted as one of the 462 SAO stars with an infrared excess in the IRAS PSC by Oudmaijer et al. (1992). Its position in the IRAS $([12]-[25],[12]-[60])$ colour-colour diagram points towards an energy distribution of the shape $S_\nu \sim \nu^{-0.5}$ (see Fig. 3b in Oudmaijer et al. 1992). Such a power law spectrum indicates the presence of thermal dust. This is quite surprising for a B 2 IV non-emission star. Most early B-type stars with an IR excess belong to the group of Be stars. The latter have an IR excess that is caused by free-free radiation of ionised circumstellar gas, resulting in a power law for S_ν with exponent between 0.6 and 2 (Coté & Waters 1987). The position of τ^1 Lup in the IRAS colour-colour diagram is too far away from the group of the Be stars to be a member of this class of objects. To confirm this result, we have observed H α at several occasions and found that the star does indeed not exhibit H α emission.

Infrared excesses due to thermal dust are quite common for a limited group of early-B-type stars, namely those which show the B[e] phenomenon (i.e. the presence of forbidden emission lines in the optical spectrum). Lamers et al. (1998) have recently proposed new classification criteria for the B[e]-type stars. There is no observational indication that τ^1 Lup can be classified as a star with the B[e] phenomenon.

In Fig. 2, the average fluxes at different wavelengths are compared with a Kurucz model with the parameters $\log T_{\rm eff} = 4.34$ and $\log g = 4.00$ (solar abundance). The flux in the near-IR is fully compatible with an atmospheric model for the stellar parameters of the star. We fitted the IRAS data with an optically thin dust model described by Waters et al. (1988). The result is shown as the dashed line in Fig. 2. The parameters of the model are:

$$\begin{cases} T_0 = 13\,000\,\mathrm{K}, \\ x_0 = 40\,000\,R_\star, \\ x_1 = 2\,000\,000\,R_\star, \\ m = 1.3, \\ p = 1.0, \end{cases}$$

where T_0 is the temperature of the dust if it would reach the stellar atmosphere, x_0 and x_1 are respectively the inner and outer radius of the dust shell/disk, m indicates the shape of the density drop of the dust and p is the spectral index (see Waters et al. 1988). From these parameters we derive that the inner boundary of the dust shell/disk is situated at a distance of 980 AU and has a temperature of 190 K. The outer boundary stops at 50 000 AU where it has a temperature of only 40 K.

Most stars to which the optically thin dust model is applied are much smaller and cooler than τ^1 Lup. Malfait et al. (1998), e.g., have applied this model to a group of Herbig Ae/Be stars and derive similar large values of x_0 and x_1 for some stars. Nevertheless, the presence of circumstellar dust at such a large distance from the star is not common. The derived edges of the dust shell/disk should therefore be considered as first crude estimates.

We conclude that τ^1 Lup has a circumstellar environment that consists of dust particles. In fact, the distribution and the derived temperature of the dust shell/disk of this star are very comparable to those of Vega. A more extended discussion is presented in the last section.

4. SPBs with a large infrared excess

4.1. HD 123515

The B 9-type SPB HD 123515 is a double-lined spectroscopic binary (Aerts et al. 1999) with another close visual companion (HD 123530) of spectral type K 2 III at 35″. HD 123530 is 3.1 magnitudes fainter than the SPB. The 12 μm flux measured by

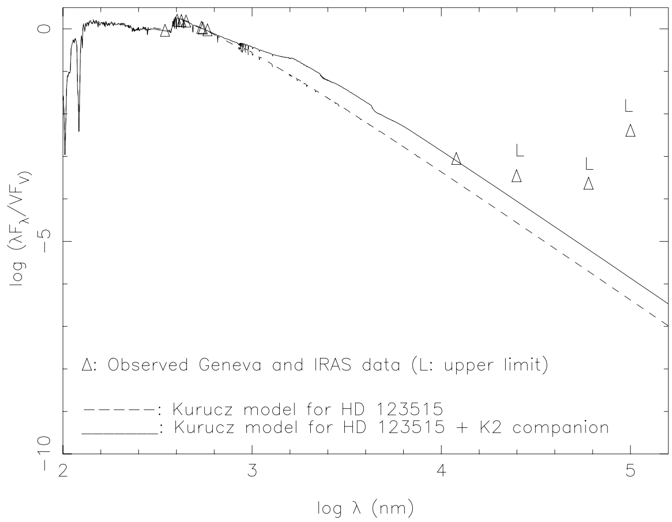

Fig. 3. Spectral energy distribution for the SPB HD 123515. The flux at 12 μm can be explained by adding the flux of the K 2 companion HD 123530 to the one of HD 123515 itself

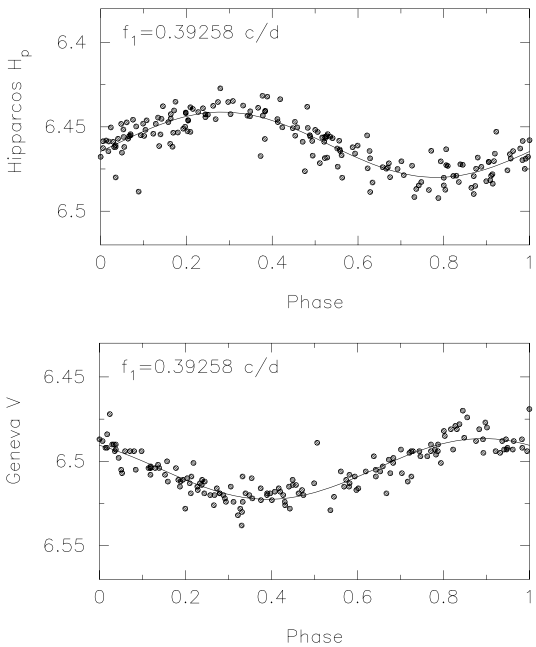

Fig. 4. *Top:* the Hipparcos data of HD 42927 folded with the frequency 0.39258 c/d. *Bottom:* the data of HD 42927 for the Geneva V filter folded with the same frequency

IRAS cannot be explained by the spectroscopic binary, but is fully compatible with adding the expected photospheric flux of HD 123515 to the one of a K 2 III star with the appropriate magnitude difference (see Fig. 3). We therefore believe that the flux measured by IRAS is caused by the companion and not by the SPB.

4.2. HD 42927

The star HD 42927 was found by Waelkens et al. (1998) as a new candidate SPB from the data of the Hipparcos mission. We show the Hipparcos data folded with a frequency of 0.39258 c/d (corresponding to a period of 2.54725 days) in the top panel of Fig. 4. This frequency immediately shows up when performing a frequency search, no matter which method is used. A fit with this frequency explains 76% of the variance present in the data. We do not find evidence for a second frequency in the Hipparcos photometry.

Table 1. Results of the fit to the photometric data of the SPB HD 42927 in the seven filters of the Geneva system for the frequency 0.39258 c/d. The amplitudes are in magnitudes and f.v. stands for the fraction of the variance explained by the fit

Filter	Amplitude	f.v.
U	0.0318 ± 0.0011	85%
B_1	0.0252 ± 0.0010	82%
B	0.0232 ± 0.0009	81%
B_2	0.0213 ± 0.0009	81%
V_1	0.0189 ± 0.0008	79%
V	0.0180 ± 0.0008	78%
G	0.0193 ± 0.0008	81%

Our discovery that HD 42927 has a large infrared excess raises the question if we are dealing with a periodic Be star rather than with an SPB. We checked this by observing H α of the star and found absorption at several occasions. We therefore can exclude the Be character of the object. In the following, we first provide evidence that the star is indeed pulsating before concentrating on the IR behaviour.

We started a follow-up campaign of ground-based multicolour photometry for HD 42927 in the course of 1997 with the Swiss Telescope of the Geneva Observatory. This resulted in 132 data points spread over 400 days. We added the 26 data points that were already available for this star in the Geneva system and performed a frequency analysis on the Geneva V data. We again find the same frequency as the one present in the Hipparcos photometry. A phase plot is shown in the bottom panel of Fig. 4. This frequency explains 78% of the variance for the V filter. The amplitudes of the fit and the variance reduction for the seven filters are listed in Table 1. The frequency is clearly present in all the different filters. We could not find a significant second frequency in the multicolour photometry.

Most of the well-known SPBs (see Waelkens 1991, 1994) have multiple periods assigned to g-mode pulsations. The fact that we are not able to find a significant second frequency for HD 42927 may indicate that the other excited modes have an amplitude below the detection treshold. On the other hand, more of the new SPBs turn out to have one clear dominant mode (see Aerts et al. 1999). To make sure that we are dealing with pulsation and not with some other phenomenon, we took some high-resolution line profiles of the Si II doublet at 4128, 4130 Å with the CAT telescope in October and in November 1997. Our data are shown in Fig. 5. Although we have only 12 spectra at our disposal it is clear from Fig. 5 that the star exhibits line-profile variability. The asymmetric profiles that we have obtained are similar to those of other spectroscopically monitored SPBs (see Aerts et al. 1999). They confirm the pulsational nature of the

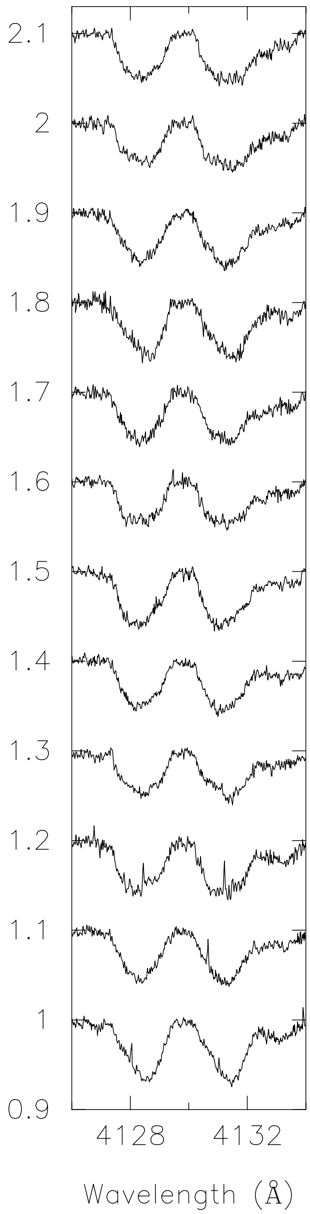

Fig. 5. Line-profile variations of the Si II doublet at 4128, 4130 Å of the SPB HD 42927. Time raises from bottom to top. The normalised spectra have been shifted arbitrarily to allow a detailed visual inspection. The five lowest spectra were obtained during one week in October 1997 and the seven upper spectra during a week in November 1997

star and justify its classification as an SPB. The peak-to-peak variation of the radial velocity and an upper limit for $v \sin i$ derived from the line profiles amount to respectively 10 km s^{-1} and 50 km s^{-1}. We do not have a sufficient number of spectra to search for a frequency in the spectroscopic data.

Since the photometric data can be accurately described by a monoperiodic model, it is meaningful to consider the multicolour photometry in order to derive the degree of the main pulsation mode that has frequency 0.39258 c/d. For a full description of the method we refer to Heynderickx et al. (1994). We here briefly mention the crucial steps in the process. To achieve mode identification, a theoretical expression for the photometric amplitude of a pulsating star is derived as a function of the wavelength λ and of the degree ℓ of the pulsation mode:

$$A_{\ell,S}(\lambda) = A\, b_{\ell\lambda} \Bigg\{ -(\ell-1)(\ell+2) + \left[\ell(\ell+1)K - 4 - K^{-1}\right] \times \Bigg[S\, \frac{\Gamma_2 - 1}{\Gamma_2} \left(\left(\frac{\partial \log F_\lambda^+}{\partial \log T_{\rm eff}} \right)_g + \left(\frac{\partial \log b_{\ell\lambda}}{\partial \log T_{\rm eff}} \right)_g \right) + \left(\frac{\partial \log g}{\partial \log p_g} \right)_{\tau=1} \left(\left(\frac{\partial \log F_\lambda^+}{\partial \log g} \right)_{T_{\rm eff}} + \left(\frac{\partial \log b_{\ell\lambda}}{\partial \log g} \right)_{T_{\rm eff}} \right) \Bigg] \Bigg\}$$

In this expression, A is a wavelength independent function determined by the kind of mode and by the inclination of the star, $b_{\ell\lambda} = \int_0^1 h_\lambda \mu P_\ell(\mu) d\mu$ with h_λ a normalised limb-darkening function, $K = GM/(f^2R^3)$, $S \in [0,1]$ is a free parameter taking into account non-adiabatic effects ($S = 1$: adiabatic pulsation), and Γ_2 is one of the generalised isentropic coefficients taken to be 5/3. By calculating the above expression for different values of ℓ, λ, and S, and by comparing the results with the observed photometric amplitudes at the same wavelengths, one determines the value of ℓ that best fits the observations. This is achieved by considering ratios of amplitudes, such that the constant A is eliminated.

The logarithmic derivatives can be evaluated by interpolation in atmosphere models (Kurucz, 1992). In order to do so, we need values for $\log T_{\rm eff}$ and $\log g$. Moreover, we need the pulsation constant Q to identify the mode. We derived the effective temperature and the gravity from Geneva reddening free parameters by means of the code recently published by Künzli et al. (1997). Subsequently, we used the evolutionary tracks published by Schaller et al. (1992) to estimate the mass of the star. From this we derive the radius and the pulsation constant. The results are:

$$\begin{cases} \log T_{\rm eff} = 4.25, \\ \log g = 4.06, \\ M = 6.0 M_\odot, \\ R = 3.37 R_\odot, \\ Q = 0.848. \end{cases}$$

From the average Geneva parameters X and Y, we find that the star is a B 3 V object still close to the ZAMS, rather than a B 5 II/III star as indicated in the BSC. This result is in full agreement with the one derived by Guetter (1968) from spectrograms. He also classifies the star as a B 3 V object.

We have considered the square root of the sum of squares of the differences between the observed and theoretical amplitudes divided by 7. This quantity is defined as the "amplitude difference" and was determined for $S = 0.0, \ldots, 1.0$ in steps of 0.05 and for $\ell = 0, \ldots, 7$. The most likely mode is the one with the lowest amplitude difference. The outcome of the mode identification is shown in Fig. 6. It can be seen from this figure that the observed amplitudes in the seven filters can best be fitted by a mode with degree $\ell = 1$ (full line) and that the agreement between theory and observations is good. The three best solutions are not strongly dependent on the value of S (see left panel

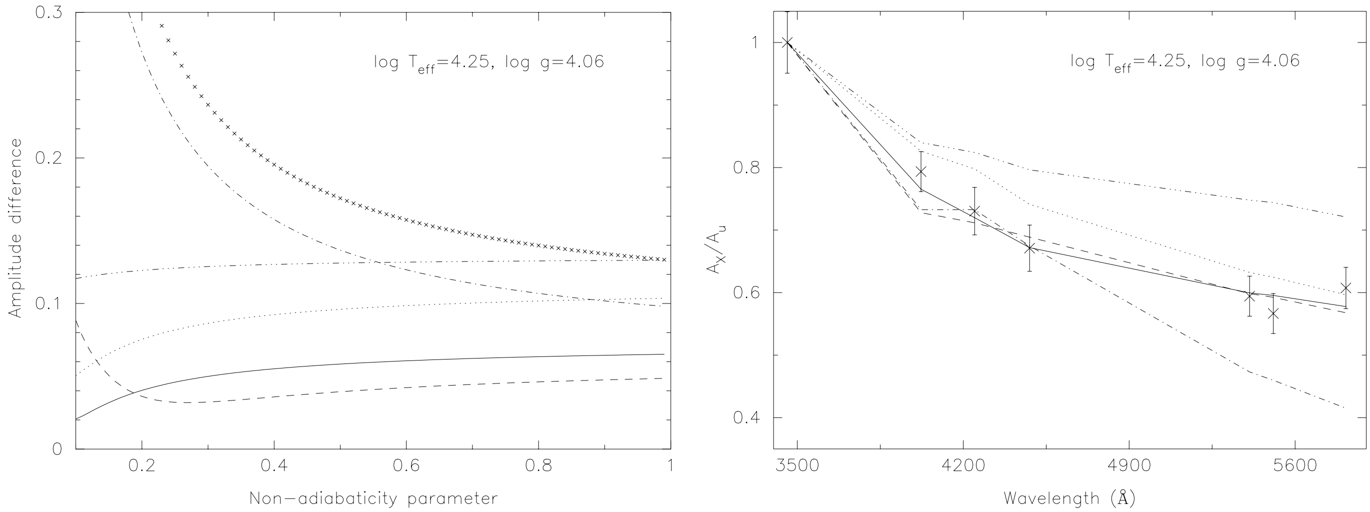

Fig. 6. *Left:* the amplitude difference (in magnitudes) as a function of the non-adiabaticity parameter S (see text for an explanation) based on the Geneva multicolour photometry for HD 42927. Different symbols denote different degrees of the pulsation: full line: $\ell = 1$, dashed line: $\ell = 2$, $\times$: $\ell = 3$, dotted line: $\ell = 4$, dot-dashed line: $\ell = 5$, dashed-dot-dot-dot line: $\ell = 6$. ***Right:*** Amplitude ratios as a function of wavelength for the five best solutions in the parameter space ℓ, S: full line: $\ell = 1, S = 0.1$, dashed line: $\ell = 2, S = 0.2$, dotted line: $\ell = 4, S = 0.1$, dot-dashed line: $\ell = 5, S = 1$, dashed-dot-dot-dot line: $\ell = 6, S = 0.1$. The error bars are derived from the standard errors listed in Table 1

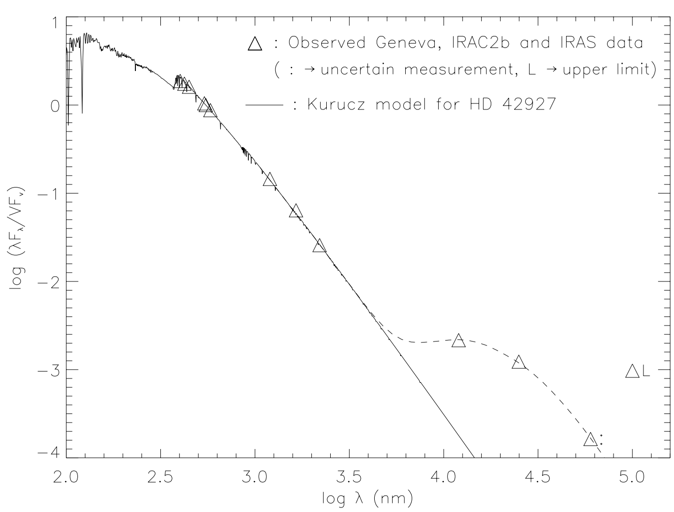

Fig. 7. Spectral energy distribution for the SPB HD 42927

of Fig. 6). We conclude from an analysis of the visual data that HD 42927 is a typical SPB as far as the period and the excited mode are concerned. We next turn to the infrared behaviour.

The IRAS source IRAS 06107–1744 is situated at less than 9 arcseconds in both α and δ from HD 42927 and all other optical sources are separated more than 5 arcminutes from the infrared source. It is thus clear that HD 42927 is the optical counterpart of IRAS 06107–1744. The fluxes given in the IRAS FSC for HD 42927 are 0.51, 0.62, 0.20:, and 1.76L Jy for respectively 12, 25, 60, and 100 μm. We disregard the measurement at 100 μm and treat the one at 60 μm with caution. The fluxes at 12 and 25 μm give rise to colour excesses of CE(V, [12])=2.28 mag and CE(V, [25])=4.08 mag, which are unexpectedly large for a normal B-type star.

In view of the large colour excess at 12 and 25 μm, we observed HD 42927 on January 15th 1998, using the IRAC2b near-infrared camera mounted on the ESO-MPI 2.2m telescope. The camera is equipped with a 256x256 pixel NICMOS-3 array (field of view of 71″x71″, using lens LB) that is sensitive over the 1 – 2.5 μm spectral region. We calibrated the data of HD 42927 using two standard stars located nearby, which we observed in the same way, i.e. by performing very short integrations – due to saturation problems – with the star located at 5 different positions on the CCD, in order to be able to perform an accurate background subtraction and flatfielding. This results in a J, H, and K magnitude of respectively 6.84, 6.94, 7.08. We considered the average magnitudes in the Geneva filters, together with the IRAC2b data and the IRAS fluxes to construct a spectral energy distribution. The data are compared with a Kurucz model for the parameters $\log T_{\rm eff} = 4.25, \log g = 4.06$ (solar abundance) in Fig. 7. It is clear from this figure that the star exhibits a large IR excess. The flux in the near-IR is fully compatible with an atmosphere model for the stellar parameters of HD 42927, i.e. we do not observe a near-IR excess.

If we place the star in an IRAS $([12] - [25], [12] - [60])$ colour-colour diagram (Waters et al. 1988), we find that it is situated on a blackbody line of some 300 K. This result has to be taken with caution because it is based on an uncertain flux at 60 μm. Nevertheless, it indicates that HD 42927 is also surrounded by a dust shell/disk. We fitted the IRAS data with the optically thin dust model. The result is shown as dashed line in Fig. 7. The parameters of the model are:

$$\begin{cases} T_0 = 11\,200\,\mathrm{K}, \\ x_0 = 5\,000\,R_\star, \\ x_1 = 145\,000\,R_\star, \\ m = 1.5, \\ p = 1.0. \end{cases}$$

From these parameters we derive that the inner boundary of the dust shell/disk is situated at a distance of 78 AU and has a temperature of 370 K. The outer boundary stops at 2270 AU and has a temperature of some 100 K.

5. Discussion

Our primary goal was to study the role of non-radial pulsations in the occurrence of circumstellar material around B stars. None of the 163 pulsators has a Be-like IR excess flux due to circumstellar gas, despite the fact that our original sample includes several stars with rotation velocities and line-profile variability comparable to those of e.g. μ Cen. Some examples are the β Cep stars α Vir (Smith 1985a,b), λ Sco (De Mey et al. 1997), κ Sco (Aerts et al. 1998), ω^1 Sco (Telting & Schrijvers 1998a), and ε Cen (Telting & Schrijvers 1998b). In the sample of 44 pulsators detected by IRAS, 8 have rotation velocities higher than μ Cen. This null result seems to indicate that non-radial pulsations cannot be the **dominant** cause of the presence of a disk around Be stars, even when the pulsation occurs in combination with rapid rotation.

On the other hand, our study did result in the detection of two pulsating B-type stars with an unexpected behaviour in the infrared. For both stars, the observed IR flux is not caused by free-free emission of ionised gas, as is the case for Be stars, but is instead caused by thermal dust emission.

HD 42927 and τ^1 Lup are the only confirmed regular pulsators that show evidence for circumstellar dust. Another interesting star in this respect is HD 41814, which is also a new slowly pulsating B star discovered from the Hipparcos mission (Waelkens et al. 1998). This star was, however, not further studied by us because it only has an accurate IRAS detection at 60 μ m (see e.g. Backman & Paresce 1993, who list the star as a possible Vega-type object).

At present, we have no further observational evidence that allows us to derive more details about the dust around HD 42927 and τ^1 Lup. As far as we know, both stars were not observed by ISO. For τ^1 Lup, we studied the 6 spectra taken by IUE to check if accreting gas, responsible for e.g. the inverse P-Cygni profiles in UV resonance lines of β Pic-like stars (see e.g. Grady et al. 1996), is present around the star. We did not find any trace of such accreting circumstellar gas. To our surprise, there are no observations available in the IUE database for HD 42927. The absence of Hα emission for both pulsators indicates that there is not much ionised material in the circumstellar environment of the stars. Zaal et al. (1995) have shown that low-density discs around B stars can give rise to HI IR recombination lines in emission, without the presence of visible emission in Hα. Such low-density discs, however, do not give rise to an IR exces at the wavelengths observed by IRAS. Therefore, the IR excess of the two stars studied here is caused by thermal dust emission.

It is interesting to find early-B main-sequence stars with an IR-excess in terms of the search for Vega-type stars. Backman & Paresce (1993) give an overview of the Vega phenomenon and list the results of surveys of such stars. Out of the 60 BSC main-sequence stars with Vega-like IR excesses in the PSC, 17 (i.e. 28%) have spectral type B. Mannings & Barlow (1998) have recently compiled a list of new Vega-like stars based on main-sequence objects given in the FSC. 29% (21 stars) of their new sample are B-type stars. The Vega-phenomenon therefore seems quite common among B stars. Yet all the Vega stars that have been analysed in detail are cooler. A dedicated study of a hot Vega-type star seems warranted.

Different working definitions of a “Vega-like” candidate are used. If we look at the condition for “accepted sources” given recently by Mannings & Barlow (1998), then HD 42927 and τ^1 Lup are new Vega-like stars. They are the first ones that are regular intrinsic variables due to stellar pulsation. HD 42927 was not found before by others, probably because it is not listed in the PSC and/or because it was classified as a star of luminosity class III. Our photometry, however, indicates that we are dealing with a main-sequence star rather than with a luminosity class III object.

So far, it is not possible to discriminate between a disk-like or a spherical dust distribution around both stars. Because of the low rotation velocity there is no a priori reason to assume that the dust is distributed in a a-spherically symmetric way. On the other hand, if the dust is really Vega-like, i.e. a reprocessed indirect remnant of the star-formation process, then a disk-like shape is plausible. The nature of the dust should be studied in more detail to evaluate this question. A way to do this is by IR-imaging at $\lambda \geq 10\,\mu$m, although the low flux levels will be a challenge to perform such observations in a successful way.

Since we found only two stars among all the B-type pulsators which show evidence for the presence of dust at a large distance from the star, we conclude that the dusty circumstellar environments of τ^1 Lup and of HD 42927 are not related to their pulsational behaviour.

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