INFRARED EXCESS IN WOLF–RAYET STARS

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Abstract. On the basis of continuum energy distributions in the wavelength region $\lambda\lambda$3200–11 000 Å, effective temperature for 14 Wolf–Rayet stars are estimated by comparing with Kurucz (1979) model atmospheres. The continuum energy distribution curve shows strong infrared excess emissions above of λ5000 Å in every star.

1. Introduction

The determination of the temperatures of the Wolf–Rayet (WR) stars has been an intriguing problem since their discovery in 1867. The presence of a large number of emission lines in a wide range of excitation and ionisation potentials poses a serious problem in defining a unique temperature; consequently, there has been a correspondingly large range in temperature estimates.

The continuous energy distribution of WR stars in the UV and visible regions has been the subject of many studies (e.g., Kuhi, 1966, 1968; Holm and Cassineli, 1977; Willis and Wilson, 1978) for deriving their effective temperatures, since most of their energy is emitted in this spectral region. A complete understanding of Wolf–Rayet stars is not yet clear due to a wide range of phenomena exhibited by individual stars. Wolf–Rayet stars are high-luminosity stars with extended moving atmospheres or envelopes. Their variable nature has been studied by several previous workers. Some of the common features associated with Wolf–Rayet stars are irregular variations of light, optical variations on time scales of hours to months with amplitudes of less than $0\overset{m}{.}1$ attributable to changes in the continuum as well as in the emission iines (Seitter and Duerbeck, 1982), UV flux variation (Burton *et al.*, 1978), variations in emission line strengths (Singh, 1984), excess in ultraviolet and infrared (cf. Kitchin, 1982), and variations in mass loss rate due to strong stellar winds. In this paper we have estimated the effective temperatures for fourteen (WN type) Wolf–Rayet stars, single as well as binary, and discussed the presence of infrared excess emissions in all of the stars.

2. Effective Temperatures

The list of stars with their spectral types studied in this paper are given in Table I. The unreddened normalised flux values have been taken from Smith and Kuhi (1981). We have plotted the normalized value of $\log F_\lambda$ against $1/\lambda(\mu^{-1})$ shown in Figures 1 to 3. The normalizations have been done at λ5000 Å. Kurucz's (1979) model atmospheres with normal chemical composition have been used by superposing them on the observed points to estimate the effective temperatures. Their estimated effective temperatures and

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TABLE I

The list of Wolf–Rayet stars studied in this paper

S.N.	HD	Sp. type	T_{eff} (K)	log g
1	4004	WN5	35000	4.5
2	9974	WN3 + 04	30000	4.5
3	50896	WN5	40000	4.5
4	186943	WN4 + B	30000	4.5
5	187282	WN4	35000	4.5
6	190918	WN4 + O91	30000	4.5
7	191765	WN6	40000	4.5
8	192163	WN6	35000	4.5
9	193077	WN5 + OB	30000	4.5
10	193576	WN5 + O6	35000	4.5
11	193928	WN6 + OB	30000	4.5
12	211853	WN6 + O61	30000	4.5
13	214419	WN7 + O7	35000	4.5
14	219460	WN4 + B0	30000	4.5

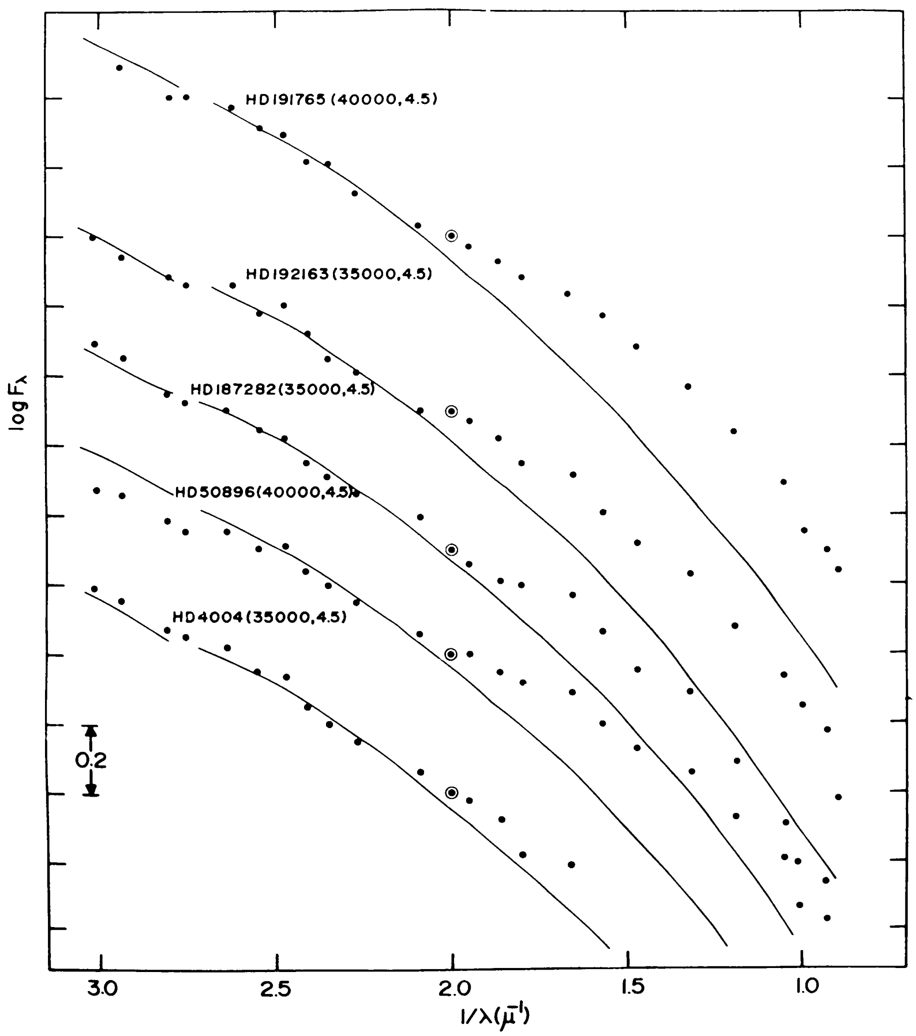

Fig. 1. Normalized dereddened energy distribution curves of Wolf–Rayet stars (filled circle) superimposed by best fitting models (solid continuous curves). The normalization has been done at λ5000 Å which is denoted by a filled circle surrounded by an open circle. The matching has been done by eye.

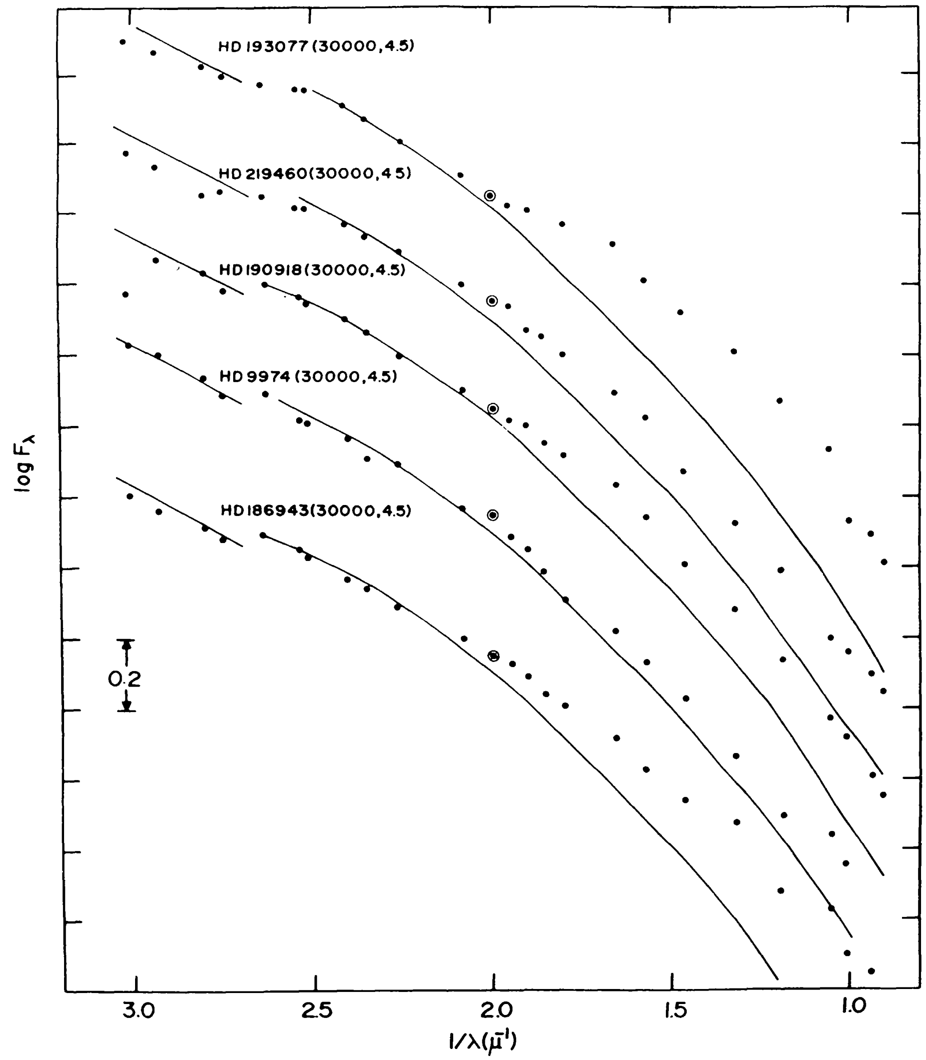

Fig. 2. See Figure 1.

log *g* values are given in the same figures. Continuum fits to stellar models are considered only in the wavelength region $\lambda\lambda$4000–5000 Å (Seitter and Duerbeck, 1982). From the figures it is clear that the model fits very well for all the stars below the λ5000 Å wavelength region. A strong near-infrared excess emission above of λ5000 Å is seen in all the stars.

3. Conclusions

From a visual inspection of our figures it is obvious that the energy distribution fits well with the model atmospheres (Kurucz, 1979) in the best fitted region $\lambda\lambda$4000–5000 Å. However, the energy distribution becomes flat in the higher wavelength ($\lambda > 5000$ Å) region. The flatness of the energy distribution curves indicates that some excess amount of energy is emitted in this region. This is an indication of extension of their atmosphere

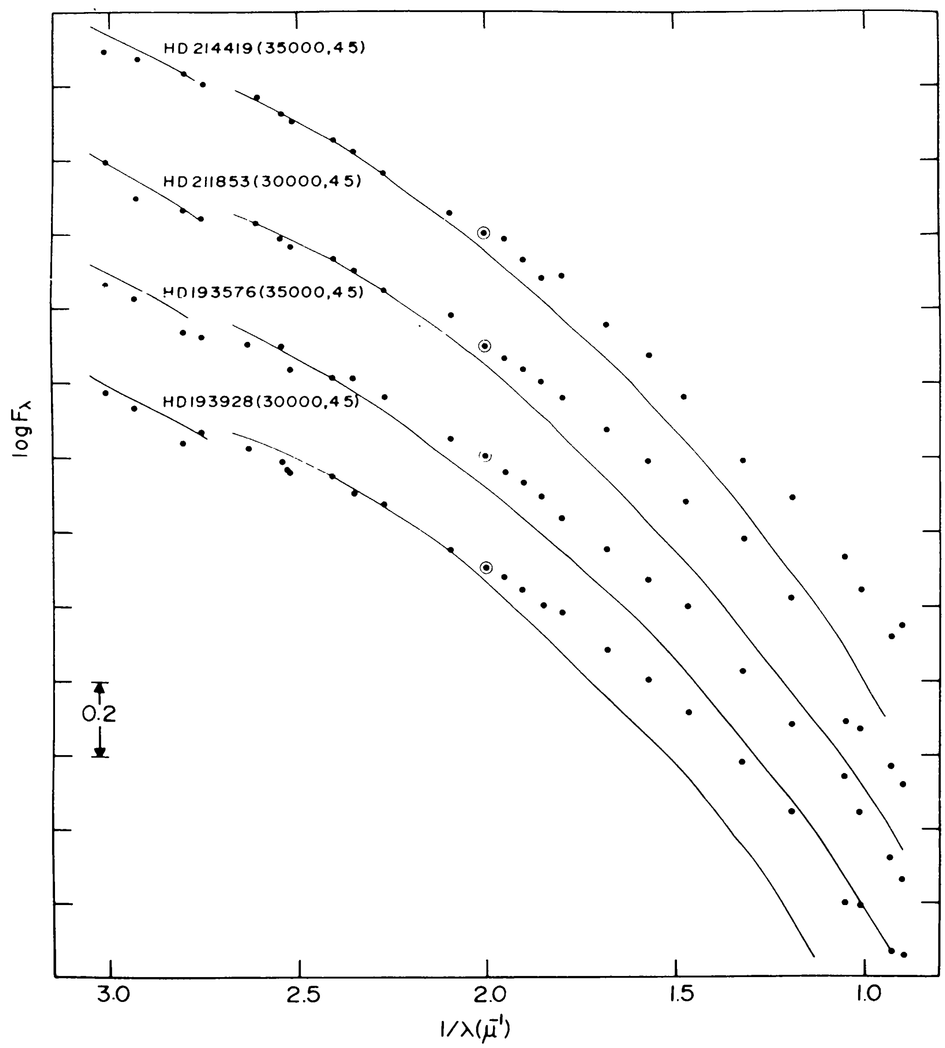

Fig. 3. See Figure 1.

and strong stellar winds. The free–free and bound–free emissions taking place in the extended atmosphere or envelope may provide a possible explanation for infrared excess emission. There is no evidence of ultraviolet excess or deficiency in any of these stars.

The effective temperatures determined by us are in the range 30000 K < < $T_{\rm eff}$ < 40000 K, which are in good agreement with the temperature star of the same spectral types. However, in the case of binary WR stars, the effective temperatures are comparatively lower ($\approx$ 5000 K). This difference may be due to the binary nature of the system, one component of which is either OB-type or O-type star.

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