A&A 503, 985–990 (2009)
DOI: 10.1051/0004-6361/200912631

Astronomy & Astrophysics

A FEROS spectroscopic study of the extreme O supergiant He 3–759★ *(Research Note)*

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Received 4 June 2009 / Accepted 10 July 2009

ABSTRACT

We present a study of the extreme O-type supergiant He 3–759 using new high-resolution FEROS data, revealing that it is a near spectroscopic twin of HD 151804 (O8 Iaf). We investigate the extinction towards He 3–759 using a variety of methods, revealing $A_V \sim 4.7^m$. If we assume He 3–759 has an identical absolute K-band magnitude to HD 151804 we find that it lies in the Sagittarius-Carina spiral arm at a distance of ∼6.5 kpc. We derive the physical and wind properties for He 3–759, revealing $T_* = 30.5$ kK, $\log L/L_\odot = 5.9$ and $\dot{M} = 10^{-5.17}\ M_\odot\,\mathrm{yr}^{-1}$ for a clumped wind whose terminal velocity is estimated at 1000 km s^{-1}. The atmosphere of He 3–759 is enriched in helium ($X_{\rm He} = 49\%$) and nitrogen ($X_{\rm N} = 0.3\%$). A reanalysis of HD 151804 and HD 152408 (WN9ha) reveals similar parameters except that the WN9ha star possesses a stronger wind and reduced surface hydrogen content. HD 151804 and HD 152408 lie within the Sco OB1 association, with initial masses of ∼60 $M_\odot$ and ages ∼2.7 Myr, consistent with NGC 6231 cluster members using standard Geneva isochrones. Improved agreement with observed surface abundances are obtained for similar initial masses with more recent Geneva group predictions from which higher ages of ∼3.75 Myr are obtained. No young, massive star cluster is known to be associated with He 3–759.

Key words. stars: early-type – stars: fundamental parameters – stars: individual: He 3–759, HD 151804, HD 152408

1. Introduction

In normal star-forming galaxies, massive O-type stars dominate both the Lyman continuum ionizing budget and the feedback of mechanical energy through their intense stellar winds and, ultimately, as core-collapse supernovae. The bulk of their short (3–10 Myr) lives is spent on the main sequence as an unevolved dwarf or giant, before rapidly shedding their hydrogen envelope during either the Red Supergiant, Luminous Blue Variable or Wolf-Rayet phase. O-type supergiants represent the transition between these stages for the highest mass stars, with characteristic emission lines of He II λ4686 and Hα due to their relatively strong stellar winds. N III $\lambda\lambda$4634-41 emission is also commonly seen in such stars, with a corresponding Of nomenclature.

Surveys of emission-line O-type stars in the Small and Large Magellanic Clouds are relatively complete due to the low interstellar extinction towards their sight-lines. Comparable Milky Way surveys remain highly incomplete with the exception of known OB associations in the solar neighbourhood (e.g. Humphreys 1978), although Hα surveys such as IPHAS (Drew et al. 2005; Witham et al. 2008) and VPHAS+ (Arnaboldi et al. 2007) are in the process of remedying this deficit, at least for sources detected optically.

Still, many sources from the extensive Michigan-Mt Wilson southern Hα survey (Henize 1976) remain largely neglected. He 3–759 is one such source, and is the focus of the present study. This was first reported in the catalogue of Galactic Wolf-Rayet (WR) stars by Roberts (1962, Star #41) due to broad Hα emission. The intensity and sharpness of Hβ, He II λ4686 and N III $\lambda\lambda$4634-41 emission led Carlson & Henize (1979) to favour an Of classification. However, ultraviolet spectroscopy from Shore et al. (1990) suggested a contradictory early B-type classification, providing the motivation for the present study. Subsequently, de Winter et al. (2001) included He 3–759 in their photometric catalogue of southern emission line sources, assigning it a (classical) Be spectral type (see also Thé et al. 1994).

New observations are reported in Sect. 2, with estimates of the distance and extinction towards He 3–759 obtained in Sect. 3. A spectroscopic analysis is performed in Sect. 4, including a comparison to HD 151804 (O8 Iaf) and HD 152408 (WN9ha), and conclusions are drawn in Sect. 5.

2. Observations

Previously unpublished spectroscopy of He 3–759 was obtained with the Double Beam Spectrograph (DBS) mounted at the Australian National University (ANU) 2.3 m telescope in April 1996. Subsequent high-resolution spectroscopy was obtained with the Fibre-fed Extended Range Optical Spectrograph (FEROS) at the 2.2-m Max Planck Gesellschaft (MPG)/European Southern Observatory (ESO) telescope in March 2009.

★ Based on observations made with ESO telescopes at the La Silla observatory under program ID 082-D.0136.

Article published by EDP Sciences

Table 1. Published coordinates of He 3–759, including astrometry from Tycho-2.

α (J2000)	δ (J2000)	Reference
12 11.3	–62 29	Roberts (1962); Henize (1976)
12 11.3	–62 30	Carlson & Henize (1979)
12 12 08.56	–62 29 00.6	Thé et al. (1994)
12 12 08.6	–62 29 01	de Winter et al. (2001)
12 11 18.54	–62 29 43.5	Tycho-2

2.1. Coordinates of He 3–759

The new observations highlighted discrepancies in previously published coordinates of He 3–759. These are summarised in Table 1, with coordinates precessed to J2000 equinox using the STARLINK COCO package where necessary. Note that the coordinates listed by the SIMBAD database[1] from Thé et al. (1994) are incorrect. The positions published by de Winter et al. (2001) are presumably rounded values from Thé et al.

FEROS observations of He 3–759 were initially attempted on 2009 March 18 using the SIMBAD coordinates. However the resulting spectrum was, surprisingly, of a cool M-type star, namely the long period variable IRAS 12094–6212 from Caldwell et al. (1991). We subsequently inspected the fits header information from the ANU/DBS spectroscopy, which were consistent with Carlson & Henize (1979) values, although 5$'$.45 away from the Thé et al. (1994) position. Accurate astrometry of He 3–759 from Tycho-2 is included in Table 1.

2.2. ANU/DBS spectroscopy

We used DBS at the ANU 2.3m telescope to obtain blue, yellow and red spectroscopy of He 3–759 on 1996 Apr 1–3. The detectors for both arms of DBS were 1752×532 pix SITE CCDs with blue and red 1200 l mm^{-1} gratings providing a dispersion of 0.5 Å pix^{-1}. The blue DBS arm was used on 1 Apr to obtain 1 Å (2 pix) resolution spectroscopy of λ3980–4975, with the red DBS arm used on Apr. 2 and 3 to obtain 1 Å resolution spectroscopy of the λ5695–6700 and λ4955–5955 regions, respectively. A standard CCD reduction was followed, enabling He 3–759 to be confirmed as an Of star. However, the modest S/N achieved (∼10–40) was inadequate for a quantitative analysis. A relative flux calibration was also achieved, which was absolutely calibrated using the Tycho-2 filter magnitudes, from which $V \sim 11.3^{\rm m}$ is estimated.

2.3. MPG-ESO 2.2 m/FEROS spectroscopy

Two 1800s exposures of He 3–759 were obtained with FEROS on the nights of 2009 March 19 & 20. FEROS is a cross-dispersed, fixed configuration instrument (Kaufer et al. 1999), which delivers R = 48 000 on the 2.2-m, with continuous spectral coverage of ∼3600–9200 Å. The spectra presented here are from the reduction pipeline that runs at the telescope; subsequent checks with reduction routines tailored for FEROS (as used by Sana et al. 2009) yielded indistinguishable final spectra.

[1] http://simbad.u-strasbg.fr/simbad/

2.4. Spectral classification

The blue and green-red spectral regions of He 3–759 are presented in Figs. 1 and 2, respectively. Also shown are high-resolution spectra from Crowther & Bohannan (1997) of HD 151804, HD 152408, and HDE 313846 from the Anglo-Australian Telescope (AAT) using the University College London Echelle Spectrograph (UCLES). HD 151804 is a 'normal' Of star, classified as O8 Iaf (Conti & Alschuler 1971; Walborn 1972), with the more extreme sources HD 152408 and HDE 313846 (WR108) reflected by their classification of WN9ha (Crowther & Bohannan 1997; Bohannan & Crowther 1999).

These spectra illustrate an elegant morphological sequence in terms of increasing emission-line intensities. The N III, He II and Hβ emission in He 3–759 is slightly stronger than in HD 151804, but otherwise their blue (stellar) spectra are very similar (Fig. 1), including the diagnostic He I λ4471/He II λ4542 ratio[2] and we therefore adopt an O8 Iaf classification for He 3–759. Its appearance confirms the description of Carlson & Henize (1979), with He 3–759 and HD 151804 among the rare subset of O stars in which Hβ is observed in emission, signifying extreme mass-loss properties.

The green-red region (Fig. 2) reinforces the notion that He 3–759 is a slightly more extreme Of star than HD 151804, with stronger Hα and He I 5876 emission. However, its emission features are not as pronounced as in HD 152408 and HDE 313846, and a normal Of supergiant classification is sufficient. Also, note the increasing intensities of the Si IV λλ6667, 6701 and He I λ6678 emission in the sequence.

3. Reddening and distance

Reliable photometry of He 3–759 is somewhat sparse in the literature so we consider three different approaches to estimate its reddening drawn from (i) infrared photometry from the Two Micron All Sky Survey (2MASS, Skrutskie et al. 2006); (ii) ultraviolet International Ultraviolet Explorer (IUE) spectroscopy from Shore et al. (1990); (iii) the strength of Diffuse Interstellar Band (DIBs) observed in the FEROS spectroscopy. An estimate of the distance to He 3–759 then follows from comparison with HD 151804 which is a member of the Sco OB1 association (distance modulus 11.4$^{\rm m}$, Humphreys 1978). thence its distance, for quantitative analysis.

3.1. Photometry

A summary of visible and near-IR photometry for He 3–759 is presented in Table 2. Optical measurements are rather heterogeneous, including the Tycho-2 ($V_{\rm T}$ = 11.45), 2nd USNO CCD (10.94) and USNO-B1.0 catalogues (B1 = 12.35, R1 = 10.85, I = 10.38). We include visual and IR photometry of HD 151804 (O8 Iaf) drawn from Leitherer & Wolf (1984), Crowther & Bohannan (1997) and references therein. Intrinsic near-IR colours are obtained from our analysis of He 3–759 (Sect. 4) from which $K_{\rm s}$-band extinctions, $A_{K_{\rm s}}$, may be obtained using the extinction relations from Indebetouw et al. (2005). Our derived extinction of $A_{K_{\rm s}} = 0.58 \pm 0.08^{\rm m}$ for He 3–759 corresponds to E_{B-V} = 1.65, assuming a standard Galactic extinction law. A similar approach for HD 151804 reveals $A_{K_{\rm s}} = 0.19^{\rm m}$,

[2] We measure log 4471/4542 = 0.19 from our FEROS dataset for He 3–759 versus 0.22 from our UCLES observations of HD 151804.

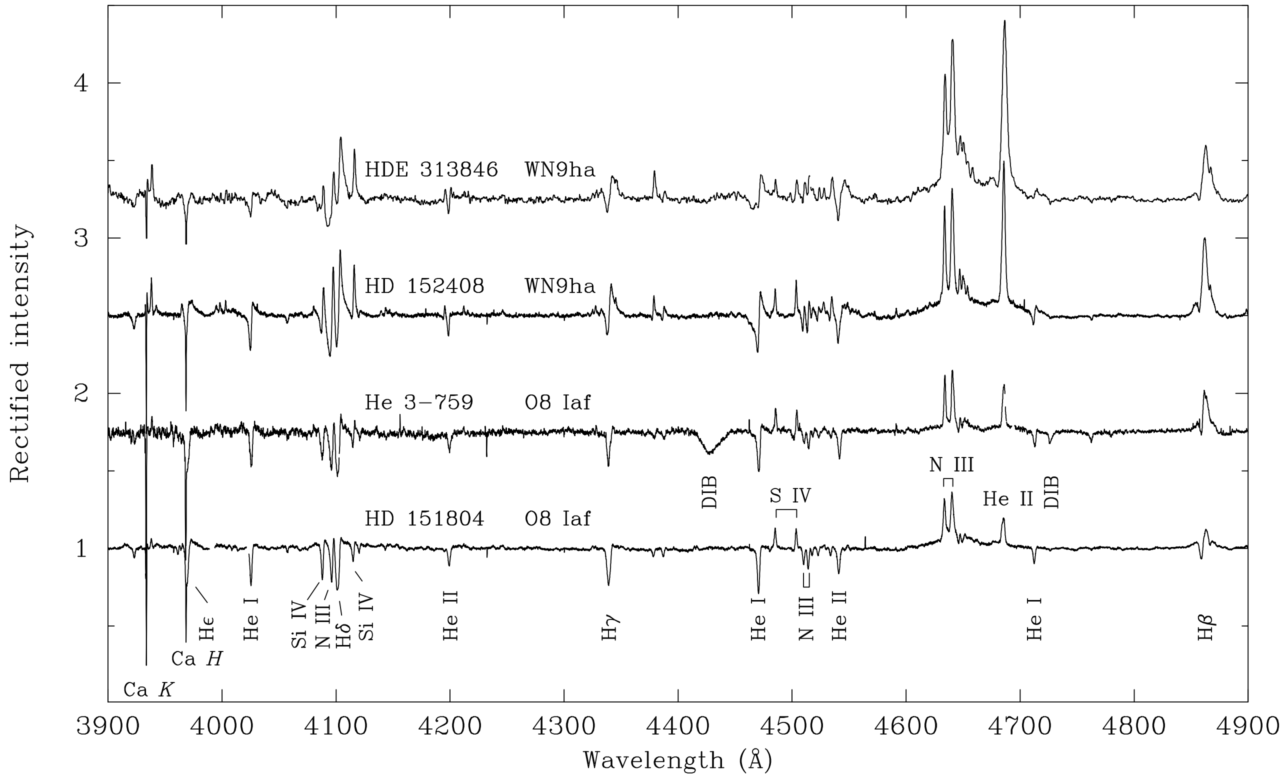

Fig. 1. Blue region FEROS spectrum of He 3–759, compared with the AAT-UCLES spectra of HD 151804, HD 152408 and HDE 313846 from Crowther & Bohannan (1997). Spectral lines identified in HD 151804 are He I λλ4026, 4713; Si IV λλ4089, 4116; N III λλ4097, 4511-15 absorption, λλ4634-40-42 emission; the Hϵ, Hδ, Hγ and Hβ Balmer lines; He II λλ4200, 4542 absorption, λ4686 emission; S IV λλ4486-4504 emission. The λλ4428, 4727 DIBs are marked in the He 3–759 spectrum which, for clarity, has been 11-pixel median filtered.

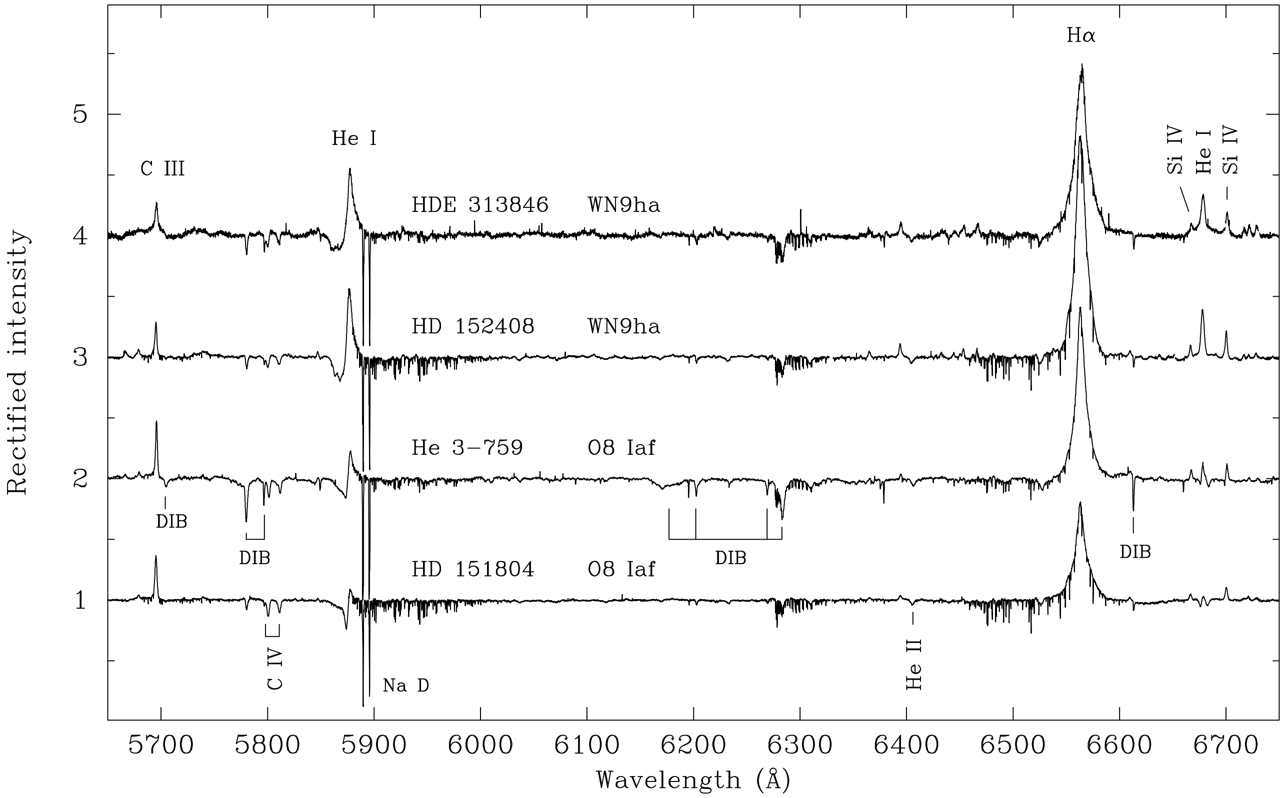

Fig. 2. Green-red region FEROS spectrum of He 3–759, compared with the AAT-UCLES spectra of HD 151804, HD 152408 and HDE 313846 from Crowther & Bohannan (1997). Emission lines identified in HDE 313846 are C III λ5696, He I λλ5876, 6678, Hα, and Si IV λλ6667, 6700. Absorption lines marked in HD 151804 are C IV λλ5801, 5812, He II λ6406, and the strong interstellar Na D lines. The strong DIBs marked in the He 3–759 spectrum are λλ5705, 5780, 5797, 6177, 6203, 6269, 6283, 6613.

Table 2. Visual (Tycho-2 B_T and V_T in parenthesis) and near-IR photometry for the O8 Iaf stars He 3–759 and HD 151804, including a distance estimate to He 3–759.

Star	V	$B-V$	K_s	$J-K_s$	$H-K_s$	$(J-K_s)_0$	$(H-K_s)_0$	$A^{J-K}_{K_s}$	$A^{H-K}_{K_s}$	A_{K_s}	DM		M_{K_s}
He 3–759	(11.45)	(1.01)	7.88	0.66	0.32	–0.09	–0.04	0.50	0.65	0.58	14.0	←	–6.7
HD 151804	5.22	0.07	4.86‡	0.20‡	0.06‡	–0.09	–0.04	0.19	0.18	0.19	11.4	→	–6.7

Note 1. ‡ *JHK* magnitudes of Leitherer & Wolf (1984) are preferred to 2MASS due to a low quality index in this instance.

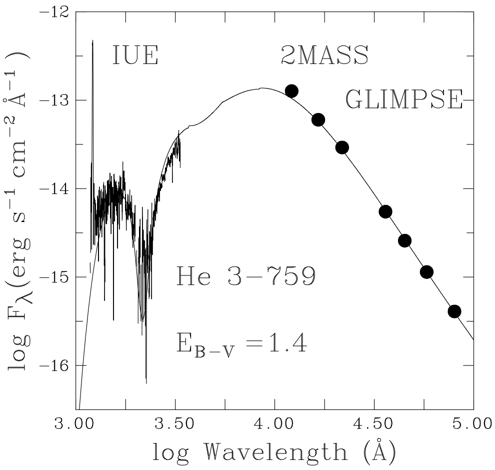

Fig. 3. Reddened model spectral energy distribution of He 3–759 (E_{B-V} = 1.4, R_V = 3.2) overlaid upon UV (IUE) spectrophotometry, plus IR photometry from 2MASS (Skrutskie et al. 2006) and GLIMPSE (Benjamin et al. 2005).

or E_{B-V} = 0.54^m, rather higher than results derived previously, such as E_{B-V} = 0.32^m from Crowther & Bohannan (1997).

3.2. Archive ultraviolet spectroscopy

Alternatively, we can exploit archival IUE ultraviolet spectroscopy of He 3–759 published by Shore et al. (1990). We have downloaded low dispersion, large aperture datasets SWP 36664 and LWP 15903 (obtained on 12 Jul 1989) from the IUE Newly Extracted Spectra archive[3]. We have reddened the spectral energy distribution of our He 3–759 model from Sect. 4 and obtain an optimum fit to the combined UV spectrophotometry and IR photometry with E_{B-V} = 1.4 using a standard R_V = A_V/E_{B-V} = 3.2 extinction law. This is presented in Fig. 3, for which overall agreement is satisfactory, including the comparison with Spitzer GLIMPSE (Benjamin et al. 2005) at mid-IR wavelengths. Intrinsic colours from our He 3–759 model include $(K_s - [8.0])_0 = 0.37^m$ and $([3.6] - [4.5])_0 = 0.1^m$.

3.3. Diffuse interstellar bands

We may also exploit the strong DIB features in the visual spectrum of He 3–759 with respect to other moderately reddened stars in Figs. 1–2, notably λλ4428, 5780 and 6613. The DIB at λ4428 is particularly strong, with an equivalent width of 2.5±0.1 Å, arguing for E_{B-V} in excess of 1.0 according to Snow et al. (2002).

Weaker DIB lines are seen to correlate reasonably well with E_{B-V}, in particular λλ5780, 5797 (Herbig 1993) and λ8620 (Munari et al. 2008). Precise measurement of these lines can be

[3] http://sdc.laeff.inta.es/ines/

Table 3. Equivalent widths (W_λ) of selected diffuse interstellar bands (DIBs) and the resulting estimates of E_{B-V}.

Line (Å)	W_λ (mÅ)	E_{B-V}	Calibration
4428	2500	>1.0	Snow et al. (2002)
5780	705	1.38	Herbig (1993)
5797	225	1.51	Herbig (1993)
8620	550	1.50	Munari et al. (2008)

Uncertainties on the widths are ±100 mÅ for λ4428, and ±10% for the other lines.

complicated, e.g., λ5780 is blended with the broad λ5778 feature (cf. Table A1, Herbig 1993). Continuum placement also introduces uncertainties. Equivalent width (W_λ) estimates for these three DIB features are given in Table 3, with uncertainties of ±10% (sufficient for the purposes of the current investigation). The average of these three estimates is E_{B-V} = 1.46^m. Finally, our FEROS spectroscopy confirms the claim from Carlson & Henize (1979) that the Ca II H line is broadened, albeit owing to stellar Hϵ, rather than being of interstellar origin.

3.4. Distance to He 3–759

The three methods outlined above provide the following estimates of $A_V = R_V\, E_{B-V}$. IR photometry results in A_V = 5.1 (for R_V = 3.1), UV spectrophotometry implies A_V = 4.5 and the line strengths of DIB features also suggest A_V = 4.5, yielding $A_V \sim 4.7^m$ or A_{K_s} = 0.53^m. If we assume that He 3–759 has a similar absolute K_s-band magnitude to HD 151804 (O8 Iaf) we may estimate its distance.

HD 151804 is a member of Sco OB1 (distance 1.9 kpc, Humphreys 1978) from which M_{K_s} = −6.7^m is obtained (Table 2), giving a distance modulus of 14.06 ± 0.5^m or distance of $6.5^{+1.6}_{-1.3}$ kpc for He 3–759. For an adopted Solar galactocentric distance of 8.0 kpc (Reid 1993), He 3–759 would lie in the Sagittarius-Carina arm, close to the Solar circle $\sim 7.5^{+0.6}_{-0.4}$ kpc from the Galactic Centre.

4. Physical and wind parameters

We have derived the physical and wind properties of He 3–759 using CMFGEN (Hillier & Miller 1998), and re-analysed optical spectroscopy of HD 151804 (O8 Iaf) and HD 152408 (WN9ha) from Crowther & Bohannan (1997) for comparison.

4.1. Method

CMFGEN solves the radiative transfer equation in the co-moving frame, under the additional constraint of statistical equilibrium. The temperature structure is determined by radiative equilibrium. Since CMFGEN does not solve the momentum equation, a density or velocity structure is required. For the

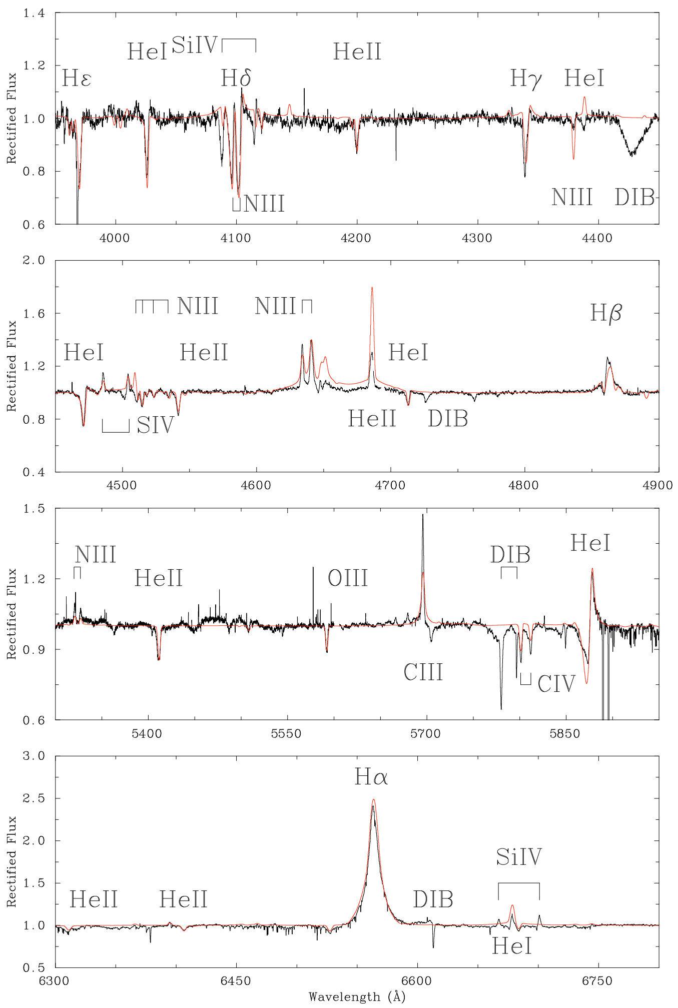

Fig. 4. Spectroscopic fits (dotted, red) to FEROS observations (solid, black) of He 3–759.

supersonic part, the velocity is parameterized with a classical β-type law, with an exponent derived from fits to Hα. This is connected to a hydrostatic density structure at depth, such that the velocity and velocity gradient match at the interface. The subsonic density structure is set by a corresponding $\log g$ = 3.0 fully line-blanketed plane-parallel TLUSTY model (v.200, see Lanz & Hubeny 2003). The atomic model is similar to that adopted by Crowther et al. (2002), including ions from H, He, C, N, O, Si, P, S and Fe.

We have assumed a depth-independent Doppler profile for all lines when solving for the atmospheric structure in the co-moving frame, while in the final calculation of the emergent spectrum in the observer's frame, we have adopted a uniform turbulence of 50 km s^{-1}. Incoherent electron scattering and Stark broadening for hydrogen and helium lines are adopted. Finally, we convolve our synthetic spectrum with a rotational broadening profile for which $v \sin i \sim 100$ km s^{-1}. Clumping is incorporated using a volume filling factor, f, as described in Hillier et al. (2003), with a typical value of f = 0.1 resulting in a reduction in mass-loss rate by a factor of $\sqrt{(1/f)} \sim 3$.

4.2. Results for He 3–759 and other extreme supergiants

We derive the stellar temperature of He 3–759 using diagnostic He I λ4471, λ5876, He II λ4542, λ5411 lines, together with Hα and Hβ for the mass-loss rate and velocity structure. We have estimated a terminal wind velocity of 1000 ± 300 km s^{-1} based upon low-resolution IUE observations of C IV λ1548–51 using the method of Prinja (1994), while a (slow) velocity law of exponent β = 2 is used for the supersonic velocity structure since this provides an excellent fit to the Hα profile. Regarding wind clumping in Of supergiants, either He II λ4686 or Hα is suitable for determination of the volume filling factor f, if the velocity law is known. However, since Hα is used to estimate the velocity law and the peak emission of He II λ4686 is very poorly reproduced, an independent determination of f is not achievable.

Table 4. Physical and wind properties of He 3–759 with respect to HD 151804 and HD 152408, allowing for an uncertainty in absolute magnitude of ±0.5^{m}. Clumped mass-loss rates are quoted here for volume filling factors of f = 0.1.

Star	He 3–759	HD 151804	HD 152408
	O8 Iaf	O8 Iaf	WN9ha
T_* (kK)	30.5	29.0	31.8
R_* ($R_\odot$)	$32.1^{+8.3}_{-6.6}$	35.4	32.1
$T_{2/3}$ (kK)	29.3	28.1	31.3
$\log L/L_\odot$	5.90±0.20	5.90	5.98
$v \sin i$ (km s^{-1})	100	104	80
v_∞ (km s^{-1})	1000	1445	970
$\dot{M}$ ($M_\odot$ yr^{-1})	$10^{-5.17\pm0.15}$	$10^{-5.20}$	$10^{-4.94}$
$X_{\rm H}$ (%)	49	43	27
$X_{\rm He}$ (%)	49	56	72
$X_{\rm N}$ (%)	0.3	0.25	0.6
M_{K_s} (mag)	–6.7±0.5	–6.7	–6.6

Note. Formal uncertainties in T_* are ±0.5 kK, while abundances are reliable to within ±5% (H and He) or a factor of two (N).

Spectroscopic fits to FEROS observations are presented in Fig. 4, with a summary of physical and wind parameters presented in Table 4. Overall, the fits are satisfactory, with the exception of He II λ4686 that is predicted significantly too strongly in emission. In addition, P Cygni absorption for He I λ5876 is also predicted too strong, and the singlet He I λ4143, λ4387 lines are predicted to be in emission, yet they are observed in absorption. Najarro et al. (2006) discuss problems relating to the use of singlet He I lines in O stars, such that triplets (e.g. λ4471, λ5876) are favoured. We obtain a helium enriched atmosphere with He/H = 0.25 by number or $X_{\rm He}$ = 49% by mass. The prominent N III $\lambda\lambda$4097-4103 and $\lambda\lambda$4634-41 features of He 3–759 are well matched using a mass fraction of $X_{\rm N}$ = 0.3%, corresponding to an enrichment of 4 times the solar value. However, N III λ4379 is predicted to be too strong and N III λ5320-24 is too weak, such that we admit a factor of two uncertainty in the nitrogen abundance. Turning to other elements, both C III λ5696 and C IV $\lambda\lambda$5801-12 favour a high carbon abundance while $\lambda\lambda$4647-51 requires a low abundance. The model presented in Fig. 4 was obtained for an intermediate abundance of $X_{\rm C}$ = 0.2% (0.7 times the solar case), although large uncertainties are admitted. For oxygen, solely O III λ5592 is observed, from which we estimate $X_{\rm O}$ = 0.2% (0.5 times the solar value). For silicon, sulphur and iron we adopt solar values.

We have also reanalysed two of the reference stars – HD 151804 (O8 Iaf) and HD 152408 (WN9ha) – based upon our AAT UCLES datasets presented in Figs 1, 2 and the method outlined above. A TLUSTY $\log g$ = 3.25 model at depth was adopted for HD 152408 since $\log g$ = 3.0 models were not available for $T_{2/3}$ = 32.5 kK. For current stellar masses of ~40 $M_{\odot}$ (see Sect. 4.3), surface gravities are $\log g \sim 3.0$, while effective gravities, corrected for radiation pressure, are $\log g_{\rm eff} \sim 2.8$[4].

Fits are of comparable quality to those presented here for He 3–759, also failing to reproduce He II λ4686 emission, with their physical and wind properties also provided in Table 4. As expected, the physical parameters and chemical composition of the three stars are very similar, with the more advanced spectral type of WN9ha for HD 152408 attributable to a somewhat higher mass-loss rate – see Bohannan & Crowther (1999) for a general discussion of this subject. In addition, the hydrogen contents of HD 151804 and He 3–759 are similar, with a significantly lower hydrogen mass fraction for HD 152408. Subtle differences between the present study and Crowther & Bohannan (1997) follow from the improved metal line blanketing (primarily Fe), TLUSTY structure at depth and allowance for wind clumping.

4.3. Comparison with evolutionary model predictions

A comparison between the physical properties of He 3–759 and non-rotating, solar metallicity Geneva models from Meynet et al. (1994; see also Lejeune & Schaerer 2001) suggests an age of 2.7 Myr and initial mass of ~60 $M_{\odot}$. Similar results are obtained for HD 151804 and HD 152408, in good agreement with the age of the NGC 6231 cluster within Sco OB1, as derived by Crowther et al. (2006) using the same set of isochrones. However, these standard evolutionary models are well known not to predict the observed helium enrichment at such phases.

In contrast, comparisons with the evolutionary models of Meynet & Maeder (2000) allowing for rotation and contemporary mass-loss rate prescriptions enable reasonable matches to both the surface hydrogen abundance (~40%) and location in the H-R diagram. For a distance of 6.5 kpc to He 3–759, initial 60 $M_{\odot}$ models rotating at 300 km s^{-1} suggest a greater age of 3.9 Myr, while a slightly lower age of 3.6 Myr is obtained for a non-rotating 60 $M_{\odot}$ model. At these ages, current stellar masses lie in the range 35–45 $M_{\odot}$, from which we adopt 40 $M_{\odot}$ for surface gravity estimates. Lower mass evolutionary models from Meynet & Maeder (2000) fail to predict the combination of surface hydrogen content and its position in the H-R diagram, favouring our preferred distance to He 3–759.

In summary, He 3–759 appears to be a very high mass star at a relatively young age, but unlike HD 151804 and HD 152408 it does not reside within a known cluster or OB association. According to Larson (2003), the most massive star of a cluster (of mass $M_{\rm clu}$) scales with cluster mass according to $1.2\,M_{\rm clu}^{0.45}$ suggesting a lower limit of ~6000 $M_{\odot}$ for its birth cluster. He 3–759 does not possess a high radial velocity so it would be expected to be located close to its natal cluster. Alternatively, Parker & Goodwin (2007) have proposed that some massive stars may form in relatively low mass clusters. Such clusters would not necessarily be easily identified at large distances, as is the case for He 3–759.

5. Summary

We have presented a high quality FEROS spectrum of the poorly studied, early-type emission line supergiant He 3–759, from which an O8 Iaf classification is obtained, and clarified its coordinates. We have used three methods to estimate its high interstellar extinction, namely fitting a stellar model to its IUE ultraviolet spectrophotometry and 2MASS and GLIMPSE photometry; obtaining its near-IR extinction from comparison with intrinsic colours; deriving its visual extinction from measured strengths of DIBs. Combining these approaches implies $A_{\rm V} = 4.7^{\rm m}$ or $A_{K_{\rm s}} = 0.53^{\rm m}$. If we assume that He 3–759 has a similar absolute $K_{\rm s}$-band magnitude to HD 151804 (O8 Iaf) its distance is estimated as 6.5 kpc, within the Sagittarius-Carina arm. The presence of such a high-mass (~60 $M_{\odot}$) star in isolation is curious given the lack of a nearby cluster, which would be expected to be relatively massive (≥6000 $M_{\odot}$).

No doubt, many other emission-line OB supergiants await discovery, in view of large optical surveys such as IPHAS and VPHAS+. Alternatively, visibly obscured extreme early-type supergiants may be identified by their infrared free-free excess following the approach of Hadfield et al. (2007).

[4] The Eddington parameter – the ratio of radiation pressure to gravity – is $\Gamma_{\rm e} \sim 0.35$ for He 3–759 and HD 151804.

Acknowledgements. We thank John Hillier for his development of CMFGEN, Hugues Sana for his reprocessing of the data, and Martin Cordiner and Keith T. Smith for helpful discussion regarding the interstellar features. This publication is based in part upon INES data from the IUE satellite, 2MASS which is a joint project of the University of Massachusetts and the IPAC/CalTech, funded by the NASA and the NSF, and Spitzer datasets from NASA/IPAC Infrared Science Archive (IRSA). IRSA is operated by JPL, CalTech under contract with NASA.

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