

HdBe STARS: HYDROGEN-DEFICIENT SUPERGIANTS WITH EMISSION LINES

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1. The hydrogen-deficient Be stars

The hydrogen-deficient B stars (often known as extreme-helium stars: EHes) show weak or absent Balmer lines and the following properties (Heber 1986a): $T_{\text{eff}} \sim 12 - 25\text{kK}$, $\log g \sim 2 - 3$, $\log n_{\text{H}} \sim -3 - -4$, $n_{\text{He}} \approx 0.99$, $n_{\text{C}} \sim 0.01$. Their galactic positions and apparent magnitudes indicate that they are low-mass supergiants belonging to the Galactic bulge (Jeffery et al. 1987).

All EHes have been observed using high-resolution échelle spectrographs (at ESO and the AAT). A small number show an emission-line spectrum, usually consisting of He I, C II and Si II lines; other lines including Balmer lines are occasionally seen. Whilst the spectra vary from object to object, the general characteristics (see table) and specific behaviour (Jeffery & Heber 1992) resemble that observed in normal Be stars (Balmer lines excepted). The term 'Hydrogen-deficient Be stars' refers to these objects.

2. Origin of the emission lines

From the type of ions detected, the stellar T_{eff} and the relative strengths in the He I lines, the emission lines are deemed to arise in an extended atmosphere (shell) with a temperature similar to or slightly below that of the photosphere.

One object, BD-9°4395, has a low surface gravity close to the Eddington limit, a relatively high rotational velocity ($v_{\text{eq}}/v_{\text{crit}} > 0.36$), pulsations (Jeffery et al. 1985, Jeffery & Heber 1992) and a radiatively driven wind (Hamman et al. 1981). Although less well studied, LSE 78 and DY Cen show similar properties. It is reasonable to suppose that the combination of high luminosity, rapid rotation and pulsations supports an extended atmosphere.

3. Related objects

Although extremely rare, the EHes may be related to other hydrogen-deficient stars, including RCrB stars, late-type Wolf-Rayets (WC10,11), H-deficient subdwarf O stars (HdsdO) and planetary nebula central stars

(HdCPN), and PG1159 stars. Some of these (see table) have similar T_{eff} to the EHes. They differ in having stronger emission spectra with P Cygni profiles (e.g. V348 Sgr: Leuenhagen & Hamman 1993). It will be proposed elsewhere (Jeffery, in preparation) that although qualitatively different, HdBes, WC11s, RCrBs, HdOs, HdCPNs and PG1159s share a common evolutionary origin, probably as a white dwarf (possibly binary) which experiences helium-shell reignition. Diversification depends critically on the structure of the progenitor(s) and the process leading to helium-shell ignition.

Star	T_{eff}/K	$n_{\text{H}}/n_{\text{He}}$	Type	Reference
MV Sgr	15 400	low	EHe / hot RCrB	Jeffery et al. 1988
	Emitting ions H α He I O I Mg II Ca II Si I Ti II Fe II			
BD -9°4395	22 700	0.0015	EHe	Jeffery & Heber 1992
LSE 78	18 000	< 0.0001	EHe	Jeffery 1993
DY Cen	19 500	0.1	EHe / hot R CrB	Jeffery & Heber 1993
	H $\alpha\beta$ He I C II Si II			
V348 Sgr	19 000	0.05	hot RCrB / WC11	Leuenhagen et al. 1993
	H $\alpha\beta\gamma\delta$ He I C I,II N I,II O I Mg II Ne I Al II,III Si II,III,IV P II,III S I,II Fe III			
CPD -56°8032	~ 25 000	low	WC10 / HdCPN	in preparation
He 2-113	~ 25 000	low	WC10 / HdCPN	in preparation
	H $\beta\gamma\delta$ He I C II,III N II O II ...			
HD 160641	32 000	low	EHe	Heber 1986b
LSS 5121	28 000	low	EHe	Heber 1986b
	448.6, 450.4 nm id ?			

References

- Hamann W.-R., Heber U., Schönberner D.: 1981, *AA* **116**, 273
 Heber U.: 1986a, ‘‘ in Hunger, Schönberner & Rao, ed(s)., *Hydrogen-deficient Stars and Related Objects, IAU Coll. 87*, Reidel:Dordrecht, 33
 Heber U.: 1986b, ‘‘ in Hunger, Schönberner & Rao, ed(s)., *Hydrogen-deficient Stars and Related Objects, IAU Coll. 87*, Reidel:Dordrecht, 73
 Jeffery C.S.: 1993, *AA*, in press
 Jeffery C.S., Heber,U.: 1992, *AA* **260**, 133
 Jeffery C.S., Heber U.: 1993, *AA* **270**, 167
 Jeffery C.S., Heber U., Hill P.W., Pollacco D.: 1988, *MNRAS* **231**, 175
 Jeffery C.S., Skillen I., Hill P.W., Kilkenny D., Malaney R.A., Morrison K.: 1985, *MNRAS* **217**, 701
 Leuenhagen U., Hamann W.-R.: 1993, *AA*, submitted
 Leuenhagen U., Heber U., Jeffery C.S.: 1993, *AAS*, in press