THE LUMINOSITY AND KINEMATICS OF A SAMPLE OF HOT SUBDWARFS

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ABSTRACT

With Hipparcos we have derived the astrometric distance of three hot subdwarf stars (sdO): BD +37°442, BD +75°325, BD +48°1777, and given a lower limit to the distance of BD –3°2179 and BD +37°1977. We have found that these stars, which have similar effective temperatures, span a very large range of visual luminosity, from $M_V < +2.2$ to +4.6. In particular the stars with high velocity wind are systematically brighter. The large space motion of the order of 100 km s^{-1} is in agreement for their belonging to Population II. We also confirm the much larger brightness ($M_V \sim -1.5$) of the Carbon–poor, X–ray binary sdO6 star HD 49798, which in addition has a lower space motion and should therefore not belong to the same stellar group.

Key words: hot subdwarf stars; stars: kinematics; stars: distance; X-ray sources.

1. INTRODUCTION

Hot subdwarfs (sdO) are stars with high surface temperature (around $5\times10^4 K$) placed below the Main Sequence, and belong to a region in the H–R diagram crossed by the evolutionary paths to the white dwarf stage of stars evolving off the Horizontal Branch and the Asymptotic Giant Branch. The study of their optical and ultraviolet spectra seems to indicate that the class of sdO stars is not homogeneous with a large range of effective temperature and surface gravity. The precise knowledge of their distance might provide the opportunity to derive a better determination of their luminosity and radius, hence of their mass. Pre–Hipparcos astrometry and optical and UV spectrometry has shown that most of the stars classified as sdOs are high velocity objects which, together with their high galactic latitude, supports the idea that they are low mass Population II stars. Within a program of ultraviolet spectroscopy with the International Ultraviolet Explorer (*IUE*), Rossi et al. (1984) have analysed the high resolution ultraviolet spectrum of four stars (BD +37°442, BD +75°325, BD +48°1777, and BD +37°1977), which appeared to be high velocity objects, and are very rich of high ionization species, especially of Fe IV and Fe V. Two stars of the sample (BD +37°442 and BD +37°1977) possess a high velocity wind, as indicated by the P Cygni profile of the N V and C IV resonance lines and the blue wing of the radiation dilution sensitive N IV 172 nm line (Viotti et al. 1981). The presence of a weak wind in BD +75°325 was recently found from Hubble Space Telescope observations. Another mass losing object is the spectroscopic binary HD 49798, a nitrogen–rich hot subdwarf which has an X–ray pulsating companion which is accreting matter from the sdO wind (see Israel et al. 1997). A target of interest is also BD –3°2179, a very hot sdO which is known to have a high velocity wind (Darius et al. 1979). In an attempt to shed light on non thermal phenomena in mass losing sdO stars, D'Antona et al. (1983) observed this star with the Einstein Observatory, but derived only an upper limit of $\sim10^{31}$ erg s^{-1} for its X–ray luminosity.

2. HIPPARCOS OBSERVATIONS

Six target stars were included in the Hipparcos Input Catalogue within the approved programme #174. The basic data are summarized in Tables 1 and 2. Parallaxes and proper motions are given in mas and mas per year, respectively. The standard errors are also reported. Table 1 also gives the Tycho visual magnitude V_T and colour index $B_T - V_T$. Good parallax estimates were obtained for three targets, while for another two the standard error σ_π is larger than the measured value of π. In these cases we took the sum $\pi + \sigma_\pi$ as the upper limit to the target's parallax. This upper limit however should be only considered as a rough estimate of the minimum distance, rather than a physical limit. Hipparcos observations also remark that the mass losing star BD –3°2179 is a probable astrometric binary.

3. DISCUSSION

We have computed the dereddened absolute visual magnitudes (or their upper limits) of the target stars using the colour excess derived from the $B_T - V_T$ colour index. The most evident result is that our sample is far from being homogeneous, since the absolute visual luminosities are spanning a wide range of values, from +4.6 for the non mass-losing star BD +48°1777, up to about –1.4 for the peculiar binary HD 49798. The limited number of stars prevented us to look for any correlation of M_V with $T_{\rm eff}$.

Table 1. Observational and physical parameters of the hot subdwarfs.

star	HIC	V_T	$B_T - V_T$	π	M_V
BD +37°442	9221	9.893±.034	–0.266±.040	4.1±1.4	$+2.91^{+0.66}_{-0.91}$
HD 49798	32602	8.242±.010	–0.334±.012	1.2±0.6	$-1.36^{+0.88}_{-1.51}$
BD –3°2179	39309	10.381±.057	–0.363±.064	<3.2	<+2.9
BD +75°325	40047	9.473±.021	–0.344±.025	7.8±1.2	$+3.93^{+0.31}_{-0.36}$
BD +37°1977	46131	10.089±.046	–0.306±.053	<2.9	<+2.2
BD +48°1777	46659	10.665±.055	–0.340±.062	6.2±2.1	$+4.62^{+0.63}_{-0.90}$

Table 2. Kinematics of the hot subdwarfs.

star	l	b	HRV	$\mu_\alpha cos\delta$	μ_δ	U	V	W	V_{LSR}
BD +37°442	137.08	–22.45	–113.1	–10.8±1.3	–9.2±1.2	+87	–68	+31	117
HD 49798	253.71	–19.14	+3.0	–5.4±0.6	+6.1±0.6	–29	+10	–13	30
BD –3°2179	224.81	+13.79		+2.5±2.4	–17.0±1.6				
BD +75°325	139.51	+31.25	–68.6	+7.4±0.9	+9.6±1.0	+50	–34	–33	68
BD +37°1977	187.02	+45.58	–56.6	+13.7±1.8	–12.7±1.1				
BD +48°1777	170.36	+46.02	–34.9	+83.5±1.4	–84.7±0.9	+68	–65	+27	98

It is however evident that the stars in our sample which are known for having a high velocity wind—BD +37°442, BD –3°2179, BD +37°1977, and HD 49798—are much brighter than the other two which do not have a high velocity wind. This is not surprising as spectroscopic investigations have shown that the mass losing stars have smaller surface gravity.

As far as HD 49798, this object is a single lined spectroscopic binary which was recently discovered to be a 13 s pulsating ultrasoft X-ray source (Israel et al. 1995, 1997). The X-ray spectrum and luminosity seem to favour the hypothesis that the companion of the sdO be a weakly magnetized WD (Bisscheroux et al. 1997). The distance as derived from the Hipparcos parallax is $d \approx 830$ pc, which is in agreement with previous estimates (typically 650 pc). Assuming a bolometric correction of –4, the absolute luminosity of the O star turns out to be quite high: log $L/L_\odot = 4.04^{+0.60}_{-0.35}$ which places it among the post AGB stars.

Previous spectroscopic observations (Rossi et al. 1984) have shown a large negative radial velocity for four stars in our sample in accordance with their belonging to Population II. The new Hipparcos observations allow the determination of the space motions of the sample from the parallax and proper motion measurements. Table 2 gives for the four stars of known distance the proper motions and the galactic components of the space velocity U, V, W, relative to the Sun (in km s^{-1}). The last column gives the space velocity in the Local System of Rest, assuming for the solar motion: $U_\odot = +9$ km s^{-1}, $V_\odot = +12$ km s^{-1}, and $W_\odot = +7$ km s^{-1}. (The derived V_{LSR} values are anyhow only weakly dependent on their actual values). It is evident that the high velocity sdO stars have quite a large space velocity, from 68 to 117 km s^{-1}, and in particular they have high velocity component directed towards the galactic centre and in the direction of the galactic poles as well, while their motion on the galactic plane appears retrograde with respect to the Sun. It would be interesting to integrate those observations with the other ones available from the Hipparcos Catalogue to better trace the space motion of this Population II group of very hot stars.

We finally remark the different kinematics of HD 49798 whose velocity vector, though rather uncertain because of the large error on the parallax, appears nevertheless more in agreement with the velocity distribution of Population I stars.

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