LUMINOSITY AND VELOCITIES OF OBN STARS FROM HIPPARCOS

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ABSTRACT

A hundred N enhanced or N rich O-B stars (OBN) have been observed by the European Hipparcos satellite, including five objects investigated for PSR companions (Philp et al. 1996, Sawyer et al. 1996). By implementing with radial velocity the astrometric data kindly supplied by the Hipparcos project (ESA 1997) we have inferred absolute visual magnitudes, galactocentric positions and velocities of ninety OBN stars.

By ignoring nine outliers the OBN stars show average galactocentric distances $R_g = 8.58 \pm 0.04$ (s.e.) kpc, $|Z| = 60 \pm 5$ pc and space velocities $X_g = 0 \pm 2$,$Y_g = 219 \pm 1$, $Z_g = 0 \pm 1$; velocity with respect to the LSR $V_{lsr} = 17 \pm 1$ km s^{-1}. The absolute visual magnitudes, after correcting for IS absorbtion are, on the average, larger (fainter) by 0.9±0.2, from those inferable from spectral type and luminosity class (Lang 1992) for 42 single stars.

The bulk of OBN stars behave like common O-B stars and evolves in the same space with akin kinematics. Only 3 *bona fide* runaway stars are recognized among ninety OBN's: HIP 18614, 70574 and 92198. The first object does not possess a PSR companion. HIP 70574, with galactocentric space velocity of 390 km s^{-1}, might have been ejected from a disrupted binary by an SNII event.

Subluminous, by 3 to 4 ± 1 mag, OBN stars, are recognized among OBN objects with NIII emission lines. Five subluminous ON stars are suggested to being evolving from O to the recently identified sdO stage (Dreizler 1993).

Key words: OBN stars.

1. INTRODUCTION

O-B stars with N strong absorbtion lines were first noted by Walborn (Margoni et al. 1997). Most of them are N rich stars (Leushin 1988). Their statistical properties were studied by Leushin (1988) and by Margoni et al. (1997). Both found that tides in binary system seem the most efficient cause for bringing nitrogen at the surface of OBN stars, even on MS objects.

Most OBN stars were observed by the Hipparcos astrometric satellite. We have computed with astrometric data (ESA 1997) and ground based observations, as baricentric or averaged radial velocities, spectral types, luminosity classes and projected rotational velocities, the following parameters: absolute visual magnitudes M_v with their s.e. (eM_v), galactocentric distance R_g, height Z on the galactic plane, galactocentric oriented space velocity components X_g, Y_g, Z_g and the velocity with respect to the local standard of rest V_{lsr}. They are listed in Table 1 together with multiplicity M (1 or 2).

On the average the difference between M_v and the absolute visual magnitude inferred from spectral types M_{vsp} (Lang 1992) is 0.9±0.2 mag for single stars and 0.5±0.2 mag for binaries OBN, as reported in Table 2 toghether with averaged values of other parameters from Table 1.

Table 2. Average abundances, abs. mag., gal. distances and velocities of single and binary normal OBN stars.

	Mean	s.e.	s.d.	Median	Mode	Unit	Cases	Notes
logC1	8.30	0.06	0.27	8.40	8.00		23	Single stars
logC2	8.34	0.04	0.28	8.27	8.20		20	Binaries
logN1	8.05	0.05	0.27	8.80	8.00		36	Single stars
logN2	8.50	0.06	0.33	8.60	8.60		34	Binaries
Mv1	-2.7	0.2	1.3	-2.8	-4.0	mag	42	Single stars
dMv1	0.9	0.2	1.4	0.8	1.1	mag	42	Mv-Mvsp(Lang 1992)
Mv2	-3.3	0.3	1.7	-3.7	-4.5	mag	39	Binaries;mult.modes
dMv2	0.5	0.2	1.2	0.3	-0.6	mag	39	Multiple modes
Rg	8.58	0.04	0.3	8.60	8.60	Kpc	81	Singles and binaries
|Z|	60	5	48	51	12	pc	81	Multiple modes
Xg	0	2	16	0.5	1	Km/s	79	Tow.the Sun;mult.modes
Yg	219	1	9	219	224	"	79	Gal.rotation at LSR
Zg	0	1	8	1	2	"	79	Towards N gal.pole
V(LSR)	17	1	13	14	11	"	79	Multiple modes
"	24	1	28	15	11	"	88	Including outliers

Five OBN stars, some with NIII emission lines, appear subluminous by 3 to 4 mag (see Table 3). Their absolute visual luminosity are higher than those of luminous sdO stars (Dreizler 1993) and lower than those of WN late stars. We suggest subluminous ON stars are evolving towards the sdO stage identified by Dreizler (1993).

Table 1. Abundances, absolute magnitudes, galactic distances, galactic velocity components, and multiplicity of OBN stars.

HIP	logC	logN	Mv	eMv	Rg	eRg	Z	eZ	-Xg	eXg	Yg	eYg	Zg	eZg	Vlsr	eV	M
					(Kpc)		(pc)		(Km/s)								
1047	8.50	7.91	-2.3	0.2	8.5	1	-54	7	8	1	231	15	1	1	14	1	1
2920		8.19	-2.8	0.2	8.6	1	-8	4	-4	3	224	16	-2	7	6	4	1
12770	8.55	8.11	-1.5	0.2	8.6	1	-98	14	8	1	230	15	-9	2	16	1	1
18081		7.74	-2.6	0.6	8.8	1	-63	22	-10	3	229	14	2	10	16	5	1
20171	8.58	7.90	0.9	0.2	8.6	1	-8	3	-4	1	213	15	0	1	8	2	1
24575	8.60	8.05	-4.0	0.7	8.9	1	2	7									1
24845	8.15	8.0	-3.3	0.6	8.7	1	-136	37	-1	3	219	16	-8	6	8	6	1
25044	8.55	8.06	-3.5	0.6	8.8	1	-115	40	-17	3	224	18	0	18	17	4	1
25223		7.56	-1.4	0.4	8.7	1	-63	15	-9	3	221	21	0	26	9	4	1
25336	8.45	8.47	-2.8	0.2	8.4	1	0	3	-6	1	225	15	-3	3	8	2	1
25539		8.30	-2.0	0.4	8.7	1	-7	6	-4	6	224	51	3	85	6	52	1
25923		8.26	-3.9	0.8	8.9	1	-150	80	1	5	218	18	-4	17	5	16	1
26345	8.00	8.10	-3	1	9.0	1	-175	187	-15	3	219	19	-2	19	15	4	1
28949	8.50	8.80	-4	1	9.0	1	-114	66	-2	7	221	17	-12	10	22	10	1
29236			-2	1	8.9	1	24	3	-13	2	222	15	8	3	16	2	1
29968			-6	6	9.9	6	139	340	3	76	214	65	16	57	18	59	1
30326		7.88	-4.0	0.3	8.6	1	-16	5	-58	1	209	15	-6	1	18	1	1
33092	8.55	8.30	-3.4	0.7	8.8	1	-54	26	-18	4	220	18	4	18	19	5	1
34707	8.80	8.02	-1	1	8.8	1	-1	11	-20	6	225	16	1	5	21	6	1
38184		7.68	-5.1	0.7	8.8	1	-87	34	-24	7	214	16	6	3	25	7	1
42828		8.56	-3.4	0.3	8.6	1	46	5	-15	12	223	87	3	151	15	11	1
43937	8.00	7.78	-1.7	0.2	8.5	1	-9	4	1	2	205	15	2	1	15	2	1
45101		8.28	-2.6	0.2	8.5	1	-6	4	-15	3	213	18	-8	16	13	3	1
51681			-3	1	8.2	1	-26	58	-52	85	254	79	-10	114	61	84	1
54123	8.00	7.65	-4	1			29	14							67	119	1
54179	8.30	7.63	-6	1	8.0	2	31	16									1
61772			-5	4	7.8	2	31	18	-5	18	232	18	10	11	16	11	1
62434	8.20	7.86	-4.8	0.1	8.4	1	26	3	-3	1	205	15	1	1	15	3	1
66657		8.28	-3.1	0.2	8.4	1	37	3	4	10	223	88	2	153	6	14	1
68862	8.40	8.08	-1.5	0.2	8.4	1	66	6	4	2	218	15	3	2	11	3	1
68995			-1.8	1.5	8.2	1	-5	17	-25	15	248	22	5	23	38	16	1
70300		7.78	-1.3	0.2	8.4	1	64	5	4	1	213	15	3	1	9	2	1
70574		8.52	-1.2	0.5	8.3	1	100	18	-165	7	344	16	-59	6	114	7	1
73966	8.20	7.79	-1.5	0.5	8.2	1	50	8	-1	5	224	16	-7	7	8	7	1
76243	8.41	8.55	-3.2	0.2	8.4	1	84	7	4	3	211	14	7	4	12	4	1
81266	8.40	7.95	-2.9	0.2	8.4	1	49	4	10	3	218	15	2	2	10	3	1
82545		7.96	-2.5	0.3	8.3	1	31	3	6	2	212	15	3	2	10	3	1
84970	8.00	8.08	-3.0	0.3	8.3	1	40	4	9	4	220	15	-10	4	13	4	1
89584			-2	1	8.1	1	19	3	-44	8	215	15	4	3	45	4	1
92198			-2	2	7.9	1	-18	31	60	8	239	17	7	9	62	8	1
94477	7.50	8.36	-1.4	0.4	8.3	1	7	4	4	1	229	15	3	3	10	1	1
96362	8.32	8.00	-1.5	0.8	8.3	1	71	19	-8	8	223	22	-3	26	9	11	1
96969	8.20	8.35	-2	2	7.9	1	-88	97	8	10	222	18	4	7	9	9	1
99347			-3	2	8.6	1	117	85	24	33	216	33	7	31	25	34	1
112031		7.83	-3.0	0.6	8.6	1	-99	32	18	194	217	101	8	48	19	191	1
1415	8.40	8.20	-6	3	9.3	1	-317	408	57	37	219	28	5	28	57	37	2
11099			-2.7	2	9.2	1	-264	310	35	238	195	147	-6	153	43	204	2
15063	8.30	7.90	-5.7	1	8.8	1	31	5	9	5	225	16	0	7	10	5	2
17448		8.30	-5	1	8.9	1	-118	52	-15	23	211	184	-4	320	19	117	2
18246	8.20	8.85	-5.4	0.7	8.8	1	-66	20	-12	3	225	16	-4	9	14	4	2
18614			-5.6	0.8	9.0	1	-103	47	-55	4	265	16	-1	6	65	4	2
18724	8.25	8.70	-2.1	0.1	8.6	1	-36	7	1	1	230	15	-6	1	12	1	2
21881		8.75	-1.4	0.2	8.6	1	-12	4	-1	3	224	15	-5	4	6	3	2
22549	8.30	8.75	-4.5	0.1	8.8	1	-134	48	-12	2	233	15	-7	3	19	2	2
22783			-8	3	9.9	2	336	659	41	50	278	62	37	62	91	60	2
22797	8.20	8.40	-4.5	0.6	8.9	1	-151	66	-12	2	234	15	0	6	13	2	2
25930	8.20	8.30	-5.3	0.5	8.7	1	-66	20	-3	1	226	15	5	1	9	1	2
25984			-7	2	9.7	2	7	15	8	33	218	35	-15	36	17	35	2
26241	8.25	8.60	-5.5	0.1	8.8	1	-116	43	-10	1	218	15	2	2	11	1	2
29038		8.60	-1.8	0.3	8.6	1	12	3	-8	2	211	15	1	1	13	2	2
30351	8.00	8.60	-1.1	0.6	8.6	1	-26	12	-1	5	231	46	7	77	13	55	2
35412	8.1	8.9	-4.7	1.3	9.0	1	-66	51	-11	10	238	22	0	26	15	13	2
35415	8.7	8.20	-6	1.5	9.0	1	-75	66	-29	8	207	18	3	6	32	8	2
41882			-3	1	8.6	1	-50	25	-8	7	213	17	3	6	11	7	2
58867		8.30	-2.6	0.3	8.4	1	17	3	0	1	209	15	1	1	11	2	2
58998			-2	1	8.2	1	-51	37	-8	6	236	14	2	8	20	6	2
61281		8.9	-2.1	0.2	8.6	1	132	10	-25	6	210	25	-10	34	39	14	2
64004	8.20	8.00	-1.4	0.2	8.4	1	48	4	5	1	210	15	4	1	10	2	2
65474	8.20	8.60	-3.7	0.1	8.5	1	82	5	1	1	214	15	2	1	6	1	2
73473	8.50	8.70	0.0	0.3	8.4	1	83	6	-36	3	217	18	-7	17	37	4	2
78820		8.30	-4.2	0.4	8.4	1	85	12	9	7	214	18	-2	1	11	6	2
93847		8.80	-1.0	0.3	8.4	1	24	3	10	6	204	18	-4	4	19	3	2
94822	8.38	8.40	-1.0	0.7	8.3	1	43	6	7	3	209	18	-2	3	13	3	2
95143	8.68	8.70	-1.0	0.8	8.3	1	52	11	3	3	214	15	9	2	11	3	2
97634	8.75	8.65	-4.5	0.8	8.3	1	118	38	36	17	220	19	-1	7	36	11	2
99177			-5	3	8.3	1	223	292	43	120	180	98	29	85	80	138	2
99580			-3	1	8.4	1	52	12	15	18	184	18	17	8	42	11	2
100751	8.48	8.35	-1.9	0.1	8.5	1	-12	3	3	1	220	15	5	1	12	1	2
103089		8.80	-1.3	0.2	8.5	1	19	3	4	1	217	15	0	1	3	1	2
103371	8.48	8.00	-5.6	1.6	8.5	1	14	6	19	21	225	22	0	18	30	22	2
104316			-4	3	8.3	1	-252	343	46	138	237	91	-46	94	67	111	2
105091		8.30	-4.4	1	8.6	1	108	38	36	8	217	16	6	7	27	8	2
106032		8.06	-3.2	0.2	8.6	1	64	5	-1	1	221	15	3	1	3	1	2
106886		8.40	-1.7	0.6	8.6	1	41	7	18	3	227	15	2	3	18	3	2
107533		8.70	-3.9	0.4	8.5	1	9	5	7	1	219	13	1	2	8	3	2
108073	8.60	7.60	-4	1	8.7	1	101	12	25	16	209	16	7	8	28	15	2
108476			-6	7	9.8	5	1	66	76	362	193	345	-19	315	87	336	2
110817		8.80	-6	1	8.8	1	106	37	18	14	223	17	1	5	19	14	2
113281	8.20	8.00	-2.5	1.6	8.6	1	-84	27	17	115	229	60	3	27	11	109	2
115990		8.70	-1.6	0.2	8.6	1	12	3	-1	1	218	15	6	1	6	1	2

The average value of the absolute height on the plane is 60 pc and only 3 runaway OBN stars could have been ascertained. OBN's evolve in the same space and with akin kinematics of OB stars (Stone 1979). Some OBN's with emission lines and seen against PN or within nebulae may be precursors either of PN or of SNII beside the two known supergiant precursors of SN 1987a and SN 1993j. The velocity with respect to the LSR is labelled V(lsr) in Table 1, with its error eV. The last column M labels single stars with 1

Table 3. ONf stars and subluminous OBN stars towards the sdO stage.

HIP	Sp	ΔM_v	RV	Notes: $\Delta M_v = M_v - M_{vsp}$
29216	ON6.5Vf	3 ± 1	23±2	NIII em.; subluminous; in nebula Sh 252: PN precursor?
31646	ON7fp	—	23.1	NIII HeII em.; in nebula Sh Mon OB2; PN precursor?
41882	BN2Iape	4 ± 1	20±10	HeII em.; subluminous; RB.
58898	ON7Iapo	4 ± 1	-13±2	HeII em.; subluminous
68995	ON9.7Iab	4 ± 1.5	-33±5	Subluminous
90320	ONfa	—	-7±7	NIII em.; no nebula detected.
99580	ON5.5ofp	3 ± 1	-44±5	NIII HeII em. in rosette nebula [illegible]. No PNR comp.. PN precursor?
-56/2511	ON6.5V(f)	—		NIII em.; N rich [illegible]

and binaries with 2. A few data show uncomfortably large errors. We performed multivariate analyses in the parameter space, some omitted from Table 1 (see Oliva 1998). After some trials the following parameters appear significant: M_v, Sp (spectral type), Cl (luminosity class), $|Z|$, X_g, Y_g, Z_g, M (multiplicity). The principal components pc1 and pc2 of a linear combination of these variables for all objects in Table 1 were obtained. By rotating the axes in order to get the maximum variance with the SPSS 1993 VARIMAX algorithm, we projected the multi-space distribution on the fact1/fact2 plane as represented in Figure 1.

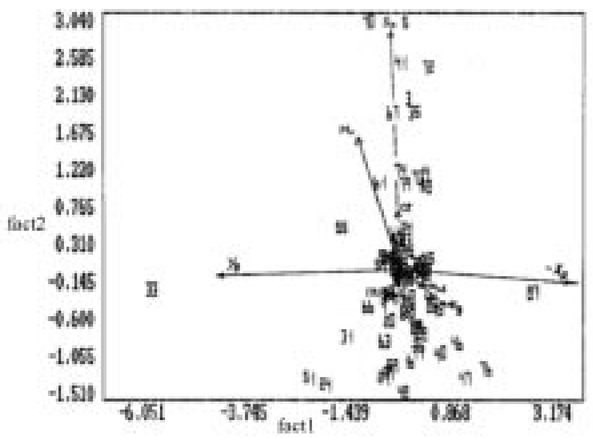

Figure 1. Factor variables of the multivarite analysis for the labelled parameters. Numerical labels refer to the ordinal positions of objects in Table 1.

In order to infer common properties of OBN stars we removed the following stars with the help of Figure 1: HIP 516811, 68995, 70574, 1415, 11099, 18614, 22783, 99177, 108476. Then we performed a statistical analysis on the parameters of the remaining 81 objects from Table 1 as reported in Table 2. Table 3 lists a few *bona fide* subluminous OBN or ONf stars (with N emission lines) together with other ONf stars to be discussed in the next section.

2. DISCUSSION

For the sample of 81 normal OBN stars in Table 1, the absolute visual magnitudes tabulated by Lang 1992 according to spectral type and luminosity class, M_{vsp}, when plotted versus M_v, show a correlation coefficient of 0.70 with significance 0.0000. M_v versus $|Z|$ gives a correlation coefficient -0.37, and significance = 0.008 by using the normal OBN stars from Table 1 (see Figure 2).

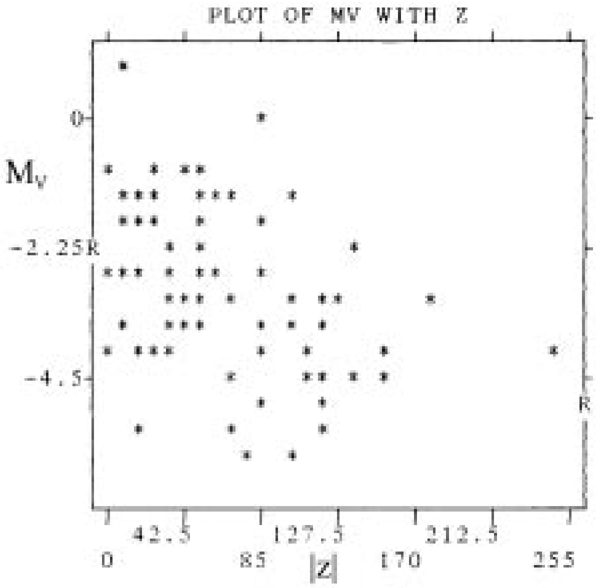

Figure 2. Regression plot of absolute height $|Z|$ versus absolute visual magnitude for OBN stars in Table 1 (see text). Correlation = -0.37, significance = 0.008. Intercept 29±10 (s.e.); slope -10±3 (s.e.).

We will now discuss whether subluminous OBN stars in Table 3 may be related to intrinsically faint O-B stars. Subluminous O-B stars are found among the subdwarf O stars (Dreizler 1993). These are further distinguished between faint and luminous sdO. The absolute magnitude of the latter ranges from -0.5 to -1 ± 1. Their N enrichment is due to stripping of the external layers. However sdO stars are hotter and less luminous than the five subluminous OBN stars in Table 3, having on the average $M_v = -2.4 \pm 0.3$ (s.e.). A few WN objects show absolute visual magnitude comparable to that of the five subluminous OBN stars in Table 3 with $M_v = -2.4$ (Lang 1992).

A new class of stars is the Of/WN class noted by Wolf et al. 1987 and by Walborn et al. 1996, that possess NIII emission lines. Since at least 2/5 of subluminous OBN stars in Table 3 possess the f–feature common to the Of/WN class (NIII emission lines) it would be tempting to suggest that: subluminous OBN stars in Table 3 are evolving towards the Of/WN stage. However, the absolute visual magnitude of Of/WN stars ranges from -4 to -7 (e.g. Crouther & Smith 1997). Then, the subluminous OBN stars in Table 3 may be the precursors of sdO stars in their way towards the WD stage. A few PN precursor candidates among OBN stars within nebulae are suggested in Table 3 according to a list of Lozinskaya & Lomovskii 1982.

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