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Stellar *uvbyβ* photometry in three EUV shadow directions[⋆]

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Abstract. We present the *uvbyβ* data used to locate the dust and derive distances for nearby diffuse interstellar clouds in the EUV shadows lb27−31, lb165−32 and lb329+46 discovered by the Extreme Ultraviolet Explorer. The photometrically derived parallaxes of our program stars are compared to the parallaxes listed in the Hipparcos Catalog. Within the photometric distance limit of 150 pc, the photometric parallaxes of 21 "normal" stars are consistent with the Hipparcos measurements within an uncertainty of 15%. Much as expected for the Strömgren system. Since all program stars are brighter than $V \approx$11.5 most of them are included in the Tycho photometry. For our sample of ∼200 stars we find $V_{\rm by}$ and $V_{\rm T}$ to be consistent. Few stars are common to published *uvbyβ* catalogs, ∼10, V and the indices compare well apart from β where a zero point difference of 11 mmag is noticed[1].

Key words: stars: distances — solar neighbourhood — ISM: clouds

1. Introduction

The Deep Survey instrument of the *Extreme Ultraviolet Explorer* (EUVE) detected three significant absorption features in the Lex/B count rates which were identified with 100 μ emission features, Bowyer et al. (1995), Berghöfer et al. (1997). The calculation of the thermal pressure in these shadows from the emission measure requires information on the extent of the emitting volume. This paper presents the optical data used to assess this volume. The softness of the Lex/B band implies that only a minor column density $N_{\rm H}$ is needed to reach unit optical depth. The situation is thus so simple that all the emission must originate in front of the absorbing clouds and the cloud absorbs all emission produced at larger distances. Therefore the cloud distance provides a limit of the emitting volume.

A description of the EUVE mission and details of the instrumentation are given in Bowyer & Malina (1991). The EUVE scans the complete sky but the Deep Survey is about a factor ten more sensitive than the general survey. Local diffuse interstellar clouds may in principle have their distance determined in two ways. One is the combination of spectral classification and measurement of optical absorption lines in background stars and another is distance and continuum absorption of background stars derived from a precision photometric system. This way an upper distance limit is provided. Lower distance limits are provided from unobscured foreground stars. The approach by means of photometry has the advantage to be relatively fast and to work for a wide spectral and luminosity range. The success rate of confining an absorption feature only a few square degrees and within ∼50 pc is possibly largest by the photometric approach. The Tables 1-3 present the *uvbyβ* data for the three shadow directions lb27−31, lb165−32 and lb329+46. The *uvbyβ* systems are able to provide photometric parallaxes of an accuracy 15% and color excess with an uncertainty $0.008 - 0.010$ in E_{b-y} (Knude 1978). The former of these numbers is confirmed by the stars of this program within $d_{\rm phot} < 150$ pc common to the Hipparcos Catalog. The probability to detect local diffuse clouds with magnitude limited complete samples are discussed in Knude (1981).

2. Observations

The targets were given by the locations of the Lex/B absorption. Four by four square degree regions were centered on the shadows. The clouds were expected to be local due to the small emission in the shadows. Fairly bright stars have to be chosen in the temperature, log(g) and [Fe/H] range where the *uvbyβ* data may be transformed to intrinsic properties. The problem was that no immediate target stars were available, a situation now remedied with

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[⋆] Based on observations at the European Southern Observatory, La Silla, Chile.

[1] Tables 1-3 are also available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

Table 1. lb165−32 shadow direction. Columns 1, 2, 3 are PPM, HD/DM and Tycho numbers. Columns 4 and 5 Right ascension and declination (2000.0). Columns 6, 7, 8, 9 and 11 V, $b-y$, m_1, c_1 and β in magnitudes. Columns 10 and 12 number of $uvby$ and β observations. Last column comments. D: unresolved duplicity in Tycho data, G: listed in GCVS, R: weak indication of duplicity combined with indication of variability in Tycho data, S: suspected duplicity from Tycho data, U: apparent variability, W: suspected variability. Stars without PPM, HD/DM or Tycho identification are listed by a working number in the last column

PPM	HD/DM	Tycho	α	δ	V	$b-y$	m_1	c_1	n	β	n	
118989	+18 0455	1240 710 1	03 18 4619	19 01 0100	10.666	0.556	0.323	0.372	3	2.580	3	$\delta m_1 = -0.1$
92384	+19 0501	1240 363 1	03 18 5097	20 00 1640	9.239	0.261	0.141	0.681	3	2.669	3	
92393	20628	1240 399 1	03 19 5221	20 16 3790	8.355	0.153	0.188	0.922	3	2.799	3	
118910	19895	1240 868 1	03 12 3290	18 56 3710	8.417	0.334	0.150	0.354	3	2.632	3	
118928	20065	1236 233 1	03 14 0480	18 18 1570	8.136	0.396	0.176	0.270	3	2.612	3	
118943	+18 0435	1236 568 1	03 14 5377	18 40 0060	9.515	0.382	0.158	0.333	3	2.580	3	
118948	+18 0436	1236 733 1	03 15 0530	18 36 1530	10.300	0.366	0.157	0.476	3	2.605	3	
118966	+18 0445	1240 260 1	03 16 4248	19 23 2690	9.715	0.318	0.149	0.443	3	2.671	3	
118987	20527	1236 182 1	03 18 4123	18 28 2260	8.735	0.437	0.245	0.334	3	2.605	3	
119002	20629	1240 796 1	03 19 4776	19 04 3460	7.409	-.002	0.129	0.497	4	2.718	4	G
		1236 742 1	03 18 2664	18 05 0280	9.835	0.329	0.119	0.480	3	2.622	3	
		1236 855 1	03 19 1365	18 08 5330	10.717	0.421	0.137	0.465	3	2.655	3	
93496	+19 0529	1241 896 1	03 25 5661	20 11 3340	10.332	0.215	0.175	0.841	3	2.753	3	
118880	19647	1225 392 1	03 10 1776	16 48 4870	7.707	0.039	0.120	0.992	4	2.807	4	
118893	19722	1225 80 1	03 11 0476	17 18 1470	8.457	0.341	0.151	0.376	3	2.631	3	
118906	+19 0481	1240 958 1	03 12 2123	19 53 2930	10.035	0.358	0.149	0.351	3	2.613	3	
118915	19957	1236 512 1	03 13 0003	17 07 5610	8.514	0.312	0.152	0.446	3	2.627	3	
118937	+16 0408	1232 64 1	03 14 3448	16 33 4170	10.453	0.322	0.169	0.396	3	2.652	3	
118950	20181	1232 536 1	03 15 0650	16 15 1940	8.443	0.360	0.148	0.472	3	2.645	3	
118981	+15 0462	1232 434 1	03 18 1061	16 10 2840	10.482	0.440	0.168	0.439	3	2.575	3	
118985	20477	1236 260 1	03 18 2003	18 10 1870	7.519	0.399	0.194	0.372	6	2.604	6	
119018	+15 0470	1233 355 1	03 20 3257	16 19 5880	9.206	0.266	0.209	0.827	3	2.799	3	
119037	20922	1233 640 1	03 22 5358	16 21 3530	8.863	0.336	0.170	0.387	3	2.637	3	
119048	20996	1233 299 1	03 23 5252	16 43 1690	8.492	0.260	0.150	0.532	3	2.686	3	
	+17 0545	1237 1095 2	03 24 1431	17 32 5900	8.130	0.387	0.167	0.415	3	2.616	3	
119056		1237 1095 1	03 24 1465	17 32 5620	8.131	0.381	0.174	0.427	3	2.606	3	119055?
119059	+18 0475	1241 1048 1	03 24 3330	19 03 4850	9.107	0.269	0.167	0.472	3	2.690	3	
119060	+18 0476	1241 100 1	03 24 4181	19 24 0660	8.832	0.185	0.207	0.754	3	2.738	3	
119074	+17 0552	1237 220 1	03 25 2666	17 50 0090	9.520	0.249	0.220	0.755	3	2.694	3	
119075	+16 0440	1237 643 1	03 25 3083	17 08 3400	9.445	0.409	0.215	0.302	3	2.578	3	
119077	+19 0527	1241 901 1	03 25 3991	19 32 1560	9.239	0.392	0.133	0.433	3	2.609	2	
		1236 218 1	03 17 0880	17 12 5590	10.527	0.445	0.180	0.358	3	2.620	2	
		1236 222 1	03 19 0350	17 20 1560	10.669	0.433	0.149	0.465	3	2.606	2	
		1236 399 1	03 17 4510	18 37 0060	10.390	0.423	0.126	0.314	3	2.605	2	
			03 17 2990	18 01 1920	10.939	0.349	0.167	0.316	3	2.636	2	16532c037
			03 16 4210	17 46 2130	11.156	0.461	0.123	0.252	3	2.597	2	16532c042
		1236 630 1	03 19 2530	17 15 3180	10.818	0.403	0.180	0.301	3	2.623	2	
		1236 888 1	03 16 1790	17 31 4500	10.136	0.361	0.146	0.310	3	2.593	2	
		1237 275 1	03 20 1060	18 16 0000	10.428	0.343	0.146	0.363	3	2.629	2	
	+17 0535	1237 637 1	03 20 5590	17 37 1270	9.858	0.399	0.125	0.394	3	2.604	2	
		1237 786 1	03 21 0200	17 13 3590	10.819	0.339	0.142	0.423	3	2.639	2	
		1237 1020 1	03 21 0780	17 40 3830	10.414	0.422	0.150	0.310	3	2.601	2	
			03 19 4260	18 28 1220	11.234	0.387	0.185	0.287	3	2.583	2	16532e005
			03 21 3450	17 42 0000	11.510	0.380	0.157	0.386	3	2.656	2	16532e033
		1237 544 1	03 20 0180	18 12 5980	10.971	0.367	0.135	0.397	3	2.608	2	
		1237 938 1	03 22 3820	18 43 3580	10.975	0.371	0.099	0.536	3	2.690	2	
		1241 784 1	03 20 1880	19 25 5450	10.492	0.460	0.175	0.350	3	2.583	2	
		1236 466 1	03 15 5330	17 50 1310	11.005	0.433	0.119	0.451	3	2.620	2	
		1236 682 1	03 15 3550	17 23 4290	10.862	0.441	0.124	0.416	3	2.609	2	
		1236 697 1	03 16 0790	17 50 4030	10.990	0.372	0.147	0.387	3	2.654	2	
		1236 1002 1	03 18 2040	18 35 0320	11.165	0.271	0.194	0.876	3	2.775	2	
		1237 128 1	03 23 1280	18 36 3790	11.106	0.234	0.190	0.699	3	2.816	2	$V - V_{\mathrm{T}} = 0.5$
			03 20 5370	19 06 4510	11.317	0.429	0.125	0.474	3	2.734	2	16532e069
		1236 327 1	03 16 0860	18 38 0550	10.780	0.298	0.149	0.615	3	2.794	2	
		1240 706 1	03 15 4730	19 13 3630	9.799	0.221	0.192	0.683	3	2.735	2	
		1241 207 1	03 20 3410	19 10 4930	8.915	0.208	0.169	0.838	3	2.872	2	*D*
		1236 892 1	03 13 3090	17 13 1980	10.974	0.252	0.173	0.667	3	2.728	2	

Table 2. lb27−31 shadow direction. Columns 1, 2, 3 are PPM, HD/DM and Tycho numbers. Columns 4 and 5 Right ascension and declination (2000.0). Columns 6, 7, 8, 9 and 11 V, $b-y$, m_1, c_1 and β in magnitudes. Columns 10 and 12 number of *uvby* and β observations. Last column comments. D: unresolved duplicity in Tycho data, G: lised in GCVS, R: weak indication of duplicity combined with indication of variability in Tycho data, S: suspected duplicity from Tycho data, U: apparent variability, W: suspected variability. Stars without PPM, HD/DM or Tycho identification are listed by a working number in the last column

PPM	HD/DM	Tycho	α	δ	V	$b-y$	m_1	c_1	n	β	n	
		6335 384 1	20 43 4350	−18 29 049	10.949	0.370	0.149	0.455	3	2.735	3	
		6335 1575 1	20 42 5980	−17 58 360	10.986	0.314	0.145	0.584	3	2.745	3	
		5331 16 1	20 47 0630	−16 42 164	10.934	0.322	0.182	0.368	3	2.750	3	
237983	198320	6344 427 1	20 50 0600	−16 32 583	10.097	0.212	0.166	0.766	3	2.753	3	
			20 38 1500	−17 11 513	11.029	0.406	0.168	0.418	3	2.780	3	2731nw007
		6338 511 1	20 38 3250	−18 56 274	10.887	0.209	0.137	0.772	3	2.830	3	
722091	196582	6338 1763 1	20 38 5270	−19 10 455	9.765	0.111	0.209	0.879	3	2.830	3	
		6339 338 1	20 44 2870	−19 06 086	10.821	0.372	0.136	0.469	3	2.651	3	
722149		6339 365 1	20 42 3110	−18 51 376	10.470	0.380	0.135	0.414	3	2.607	3	
		6339 567 1	20 44 2010	−18 53 025	10.817	0.272	0.171	0.493	3	2.700	3	
722156		6339 860 1	20 42 4740	−19 08 237	10.273	0.380	0.163	0.414	3	2.667	3	
		6339 1742 1	20 44 3560	−19 08 427	10.924	0.391	0.168	0.419	3	2.621	3	
			20 48 0210	−18 49 177	10.805	0.328	0.136	0.391	3	2.647	3	27−31c042
722165		6335 235 1	20 43 2360	−17 46 183	10.438	0.382	0.151	0.370	3	2.624	3	
		6335 807 1	20 45 2580	−18 00 451	10.729	0.351	0.153	0.382	3	2.593	3	
722210		6335 1000 1	20 46 2630	−17 29 537	10.563	0.484	0.155	0.384	3	2.634	3	
722180		6335 1037 1	20 44 1630	−17 46 336	10.137	0.368	0.151	0.449	3	2.632	3	*D*
			20 42 5660	−17 55 499	10.507	0.388	0.158	0.336	3	2.607	3	27−31c084
722224	−17 6085	6331 35 1	20 47 3420	−16 43 563	10.314	0.379	0.140	0.404	3	2.630	3	
722248	198276	6344 871 1	20 49 4250	−16 33 144	10.358	0.313	0.124	0.438	3	2.685	3	
722231		6344 1292 1	20 48 1900	−16 51 483	10.750	0.420	0.182	0.336	3	2.592	3	
722244		6344 1574 1	20 49 1530	−16 30 075	10.320	0.421	0.140	0.419	3	2.634	3	
		6334 743 1	20 39 1380	−17 03 457	10.548	0.349	0.125	0.461	3	2.660	3	
		6334 1515 1	20 38 0320	−17 20 410	10.788	0.339	0.128	0.538	3	2.618	3	
722115		6335 1022 1	20 40 2980	−17 16 140	11.036	0.324	0.126	0.444	3	2.639	3	
722058	196286	6338 1786 1	20 36 5800	−19 08 422	10.130	0.354	0.160	0.439	3	2.620	3	
		6335 620 1	20 40 1280	−18 27 122	10.584	0.318	0.109	0.500	3	2.673	3	
237685	196350	6334 935 1	20 37 1982	−16 52 327	8.832	0.155	0.188	0.819	4	2.770	4	
237691	196353	6338 617 1	20 37 2801	−19 15 099	9.516	0.150	0.165	0.860	3	2.805	3	
237708	196470	6334 1011 1	20 38 0981	−17 30 064	9.732	0.192	0.304	0.616	3	2.843	3	
237732	−19 5876	6338 1832 1	20 39 1334	−19 20 243	10.005	0.099	0.206	0.924	3	2.855	3	
237753	196760	6330 805 1	20 39 5828	−16 18 596	9.872	0.288	0.162	0.615	3	2.769	3	
237775	196934	6335 1720 1	20 40 5838	−17 47 445	8.496	0.064	0.173	1.087	3	2.862	3	
237799	197091	6335 1400 1	20 41 5846	−17 52 513	8.968	0.098	0.210	0.896	3	2.844	3	
237803	197145	6335 136 1	20 42 1571	−18 35 407	9.023	0.171	0.177	0.803	3	2.794	3	
237812	197187	6335 1160 1	20 42 3979	−18 06 348	7.348	0.188	0.195	0.817	6	2.752	6	
237827	197298	6331 140 1	20 43 2149	−16 50 249	10.102	0.136	0.197	0.876	3	2.830	3	
237862	197522	6339 48 1	20 44 4722	−18 49 205	10.259	0.127	0.200	0.984	3	2.880	3	
237906	197859	6335 1470 1	20 46 5137	−17 59 480	9.814	0.307	0.141	0.535	3	2.730	3	
237956	198182	6348 1234 1	20 49 0436	−16 57 006	9.628	0.147	0.196	0.815	3	2.827	3	
237962	198187	6348 1238 1	20 49 1190	−17 04 311	9.858	0.190	0.163	0.775	3	2.770	3	
237996	198432	6348 1105 1	20 50 4909	−18 13 570	9.194	0.225	0.161	0.683	3	2.750	3	
271784	−20 6066	6352 1661 1	20 54 2767	−20 09 504	10.586	0.333	0.112	0.530	3	2.732	3	
	198030	6348 1237 1	20 48 0858	−16 55 245	9.879	0.209	0.200	0.709	3	2.776	3	*U*, *R*
237679	196311	6338 789 1	20 37 0634	−19 26 519	10.132	0.296	0.144	0.461	3	2.666	3	
237689	196352	6334 1457 1	20 37 2401	−17 46 466	9.447	0.288	0.153	0.470	3	2.664	3	
237709	196471	6338 1177 1	20 38 1195	−18 47 353	8.670	0.254	0.146	0.553	4	2.690	4	
237716	196510	6334 1720 1	20 38 2778	−18 38 306	8.878	0.253	0.149	0.535	3	2.698	3	
237729	196617	6330 1249 1	20 39 0431	−16 33 343	7.182	0.311	0.146	0.463	5	2.662	5	
237740	196678	6338 459 1	20 39 2994	−19 00 382	9.908	0.361	0.161	0.388	3	2.624	3	
237771	196892	6339 372 1	20 40 4940	−18 47 334	8.245	0.347	0.103	0.340	4	2.612	4	
237781	196980	6335 730 1	20 41 1319	−17 41 009	9.720	0.269	0.141	0.563	3	2.627	3	*W*
237785	196996	6335 1332 1	20 41 1941	−17 35 549	9.298	0.330	0.146	0.374	3	2.601	3	
237819	197212	6339 299 1	20 42 5769	−19 29 131	8.571	0.481	0.123	0.322	4	2.625	4	
237825	−17 6064	6335 1356 1	20 43 1846	−17 01 086	10.134	0.410	0.189	0.326	3	2.623	3	
237832	197318	6339 384 1	20 43 3051	−19 06 515	9.551	0.360	0.181	0.349	3	2.636	3	S, $V - V_\mathrm{T} = -0.3$
237838		6339 881 1	20 43 4245	−19 14 173	10.278	0.400	0.150	0.377	3	2.596	3	
237842	197381	6331 132 1	20 43 5292	−16 45 422	9.646	0.276	0.129	0.616	3	2.711	3	
237843	197401	6335 961 1	20 43 5396	−17 43 050	9.799	0.313	0.107	0.525	3	2.651	3	
237879	197710	6335 1577 1	20 45 5907	−18 18 074	9.701	0.378	0.141	0.442	3	2.647	3	

Table 2. continued

PPM	HD/DM	Tycho			α	δ	V	$b-y$	m_1	c_1	n	β	n	
237884	−19 5918	6339	1724	1	20 46 0785	−19 04 496	10.119	0.274	0.131	0.601	3	2.712	3	*W*
237895	197782	6335	1148	1	20 46 2542	−16 52 553	9.104	0.364	0.151	0.330	3	2.636	3	
237902	197818	6335	529	1	20 46 3428	−17 09 465	7.670	0.404	0.170	0.317	5	2.604	5	
237915	197930	6335	114	1	20 47 2293	−18 37 164	8.164	0.366	0.151	0.377	4	2.619	3	
237927	198002	6331	1788	1	20 47 5705	−16 28 085	9.483	0.371	0.136	0.363	3	2.631	3	*W*
237934	198029	6344	1304	1	20 48 1318	−16 44 201	7.867	0.304	0.140	0.441	4	2.651	3	
237965	198220	6348	1547	1	20 49 2038	−18 13 035	8.435	0.386	0.157	0.400	4	2.623	3	
237977	198277	6348	1230	1	20 49 4596	−18 06 254	9.930	0.426	0.159	0.368	3	2.612	3	
237979	198304	6352	1215	1	20 50 0042	−19 43 242	9.357	0.375	0.136	0.356	3	2.622	3	
237980	198303	6348	154	1	20 50 0117	−16 57 021	9.711	0.372	0.152	0.428	3	2.656	3	
237987	198382	6352	456	1	20 50 2959	−19 41 257	9.569	0.320	0.127	0.495	3	2.640	3	
238018	198602	6352	925	1	20 51 5854	−19 50 500	9.299	0.449	0.208	0.273	3	2.587	3	
238022	198631	6352	23	1	20 52 0918	−19 04 285	9.187	0.381	0.157	0.442	3	2.619	3	
238053	238053	6352	395	1	20 53 3625	−19 45 599	9.778	0.373	0.152	0.377	3	2.639	3	
238059	198850	6348	246	1	20 53 4511	−17 14 174	9.503	0.336	0.159	0.412	3	2.644	3	
238061	198866	6344	841	1	20 53 5008	−16 43 160	10.015	0.446	0.171	0.389	3	2.609	3	
238066	198902	6352	384	1	20 54 0574	−18 59 489	7.467	0.368	0.164	0.426	4	2.635	4	
271439	196680	6338	954	1	20 39 3622	−20 05 228	9.661	0.257	0.150	0.525	3	2.653	3	
271518	197235	6339	1210	1	20 43 0549	−20 13 306	9.140	0.340	0.130	0.462	3	2.657	3	
237747	196732	6338	1757	1	20 39 4659	−18 45 269	10.066	0.457	0.202	0.250	3	2.577	3	
	197299	6339	558	1	20 43 2671	−19 28 589	9.202	0.274	0.151	0.476	3	2.658	3	
237908	197860	6335	278	1	20 46 5209	−18 37 572	9.916	0.442	0.164	0.247	3	2.597	3	*W*
237923	197982	6331	1502	1	20 47 4241	−15 41 521	9.311	0.377	0.172	0.350	3	2.618	3	
722262	198395	6352	344	1	20 50 3528	−18 58 511	9.816	0.395	0.134	0.292	3	2.601	3	
722266	198408	6352	318	1	20 50 3991	−18 58 176	9.841	0.372	0.136	0.333	3	2.616	3	
238033	198687	6352	1256	1	20 52 3872	−19 43 305	9.935	0.469	0.188	0.312	3	2.587	3	
722296	198712	6348	1436	1	20 52 4528	−18 37 423	9.805	0.390	0.104	0.366	3	2.614	3	

the publication of the Tycho Catalog, ESA (1997). The PPM Catalog , Röser & Bastian (1993), provides a rough one dimensional spectral classification and all stars with a classification earlier than G5 were included but PPM is of course not complete. The PPM candidates were supplemented with all stars from the Space Telescope Guide Star Catalog brighter than $V \approx 11.5^{\mathrm{m}}$. The GSC provides, however, only a magnitude and a position but no color information, (Lasker et al. 1990). The resulting observing lists ended up containing hundreds of stars for each region. Most of the stars have been identified in the recently published Tycho Catalog, ESA (1997).

The observations were carried out with the SAT, La Silla. SAT is a 50 cm telescope with a permanent six channel photometer designed for efficient work in the *uvbyβ* system. The telescope may be operated in a fully automated mode but was used in a semiautomatic way. Only letting the telescope center the star in a diaphragm. The integrations were followed manually since the temperature of most of the candidate stars were unknown. Any standard error or minimum count condition in all four bands could have left the telescope measuring only a few K, M stars in a night. The *uvby* observations were performed first in order to select a list of stars to have β observations, β looses its sensitivity in the mid G star range.

On *uvby* nigths ∼50 standards from the lists of Crawford & Barnes (1970), Grønbech et al. (1976), Olsen (1983, 1993) were observed. The large number is necessary to cover the B, A, F, G, K, M range for dwarfs and evolved stars and with a spread in metallicity. Special care was taken to determine the atmospheric extinction since the lb165−32 shadow has a rather northern latitude.

After the *uvby* observations the β data were taken. In principle much simpler but a little hampered but the narrowness ∼30 Å of the narrow band. In the March 1995 run there were some further problems with the wide band running wild at times due to sparks caused by oil leaking into the multiplier's socket. Apart from standards taken from the uvby standards mentioned above primary standards from Crawford & Mander (1966) were observed. In a β night ∼25 standards are observed.

The observations were carried out during three observing runs in December 1993, November 1994 and March 1995. A total of seven weeks were spent at the telescope. The bulk of stars from the original list turned out to be later than the validity of the accurate distance, intrinsic color calibration of the *uvbyβ* system. It is hoped that these late type stars eventually may be used to determine lower distance limits for the three shadowing clouds. Their location in front of the clouds will be confirmed by the absence of polarization and with one parameter less, E_{b-y} is known to be zero, their distance may be determined from the uvby photometry alone. Data for these late type stars are not included in the present catalog.

Table 3. lb329+46 shadow direction. Columns 1, 2, 3 are PPM, HD/DM and Tycho numbers. Columns 4 and 5 Right ascension and declination (2000.0). Columns 6, 7, 8, 9 and 11 V, $b-y$, m_1, c_1 and β in magnitudes. Columns 10 and 12 number of $uvby$ and β observations. Last column comments. D: unresolved duplicity in Tycho data, G: listed in GCVS, R: weak indication of duplicity combined with indication of variability in Tycho data, S: suspected duplicity from Tycho data, U: apparent variability, W: suspected variability. Stars without PPM, HD/DM or Tycho identification are listed by a working number in the last column

PPM	HD/DM	Tycho			α	δ	V	$b-y$	m_1	c_1	n	β	n	
228282	123102	5560	1469	1	14 05 5750	−13 04 120	9.081	0.215	0.176	0.676	3	2.771	3	multiple
228281	123103	5560	1470	1	14 05 5750	−13 04 250	9.074	0.227	0.157	0.664	3	2.758	3	
228076	121784	5557	1457	1	13 57 4750	−11 32 117	8.131	0.116	0.218	0.900	4	2.847	4	
228279	123088	5560	1168	1	14 05 5570	−13 15 525	10.138	0.409	0.164	0.345	3	2.631	3	
					14 09 5130	−13 15 481	11.317	0.444	0.172	0.294	3	2.584	3	32946e014
717492	123765	5561	1310	1	14 09 5270	−12 49 412	9.863	0.419	0.186	0.295	3	2.609	3	
228253	−11 3661	5560	3	1	14 04 4940	−12 30 098	10.492	0.447	0.226	0.248	3	2.592	3	
228278	123087	5560	565	1	14 05 5210	−12 42 117	8.305	0.302	0.141	0.420	3	2.680	4	
282222	−12 3949	5560	1030	1	14 03 3990	−13 05 489	10.613	0.360	0.158	0.400	3	2.644	3	
228200	−12 3947	5560	1200	1	14 02 5640	−12 43 050	10.716	0.423	0.216	0.273	3	2.580	3	
228134	122124	5560	1079	1	14 00 0430	−12 42 242	9.483	0.367	0.146	0.318	3	2.648	3	
228089	121866	5560	1135	1	13 58 1810	−12 37 313	9.567	0.363	0.146	0.431	3	2.685	3	
228175	122390	5557	651	1	14 01 5270	−11 28 214	9.080	0.333	0.141	0.363	3	2.662	3	
228184	−10 3807	5557	740	1	14 02 2590	−11 19 498	10.401	0.316	0.151	0.455	3	2.690	3	*W*
228147	−10 3799	5557	947	1	14 00 4740	−11 26 071	10.427	0.436	0.151	0.352	3	2.617	3	
228132	122107	5560	178	1	14 00 0250	−13 43 009	9.556	0.292	0.144	0.639	3	2.757	3	
228201	122565	5557	798	1	14 02 5695	−10 27 564	8.707	0.191	0.171	0.788	4	2.770	3	
228217	122658	5557	627	1	14 03 2727	−10 58 023	7.636	0.162	0.228	0.899	4	2.815	3	
228281	123103	5560	1470	1	14 05 5737	−13 04 251	9.028	0.227	0.163	0.670	3	2.788	3	
228456	124249	5561	229	1	14 12 4341	−13 11 560	9.669	0.172	0.197	0.798	3	2.848	3	
228461	124275	5561	829	1	14 12 5452	−14 10 205	8.866	0.169	0.208	0.796	3	2.860	3	
228069					13 57 3545	−11 06 485	10.781	0.393	0.151	0.371	3	2.625	2	
228080	121830	5557	1426	1	13 58 0313	−10 05 265	9.396	0.282	0.147	0.502	3	2.710	3	
228084	−13 3800	5560	526	1	13 58 1093	−14 01 365	10.201	0.340	0.145	0.432	3	2.691	3	
228091	121882	5557	1372	1	13 58 2554	−11 09 267	9.538	0.317	0.134	0.458	3	2.658	3	
228116	122025	5557	205	1	13 59 2299	−10 44 043	9.779	0.414	0.177	0.338	3	2.598	3	
228133	122123	5557	694	1	14 00 0364	−11 47 088	8.650	0.345	0.150	0.353	3	2.618	3	
228139	122170	5560	1176	1	14 00 2397	−14 13 202	9.785	0.335	0.153	0.380	3	2.637	3	
228157		5557	1148	1	14 01 1401	−10 22 384	8.864	0.314	0.128	0.485	3	2.655	3	
228158	122304	5560	879	1	14 01 2310	−12 55 063	9.843	0.366	0.163	0.398	3	2.624	3	
228171	122347	5560	4	1	14 01 4156	−13 12 451	10.037	0.346	0.138	0.374	3	2.668	3	
228183	122485	5557	941	1	14 02 2536	−11 42 428	9.978	0.375	0.155	0.369	3	2.628	3	
228190	−09 3836	5557	710	1	14 02 3192	−10 27 435	9.550	0.293	0.158	0.466	3	2.676	3	*W*
228222	−12 3949	5560	1030	1	14 03 3989	−13 05 474	10.587	0.367	0.149	0.362	3	2.637	3	
228224	122701	5560	188	1	14 03 4264	−13 17 197	9.373	0.372	0.148	0.288	3	2.605	3	
228235	122800	5557	128	1	14 04 1210	−12 07 474	7.921	0.266	0.146	0.622	4	2.725	4	
228269	123036	5557	340	1	14 05 3276	−11 29 131	9.595	0.294	0.148	0.462	3	2.689	3	
228277	123066	5560	260	1	14 05 5174	−14 14 336	9.351	0.312	0.158	0.426	3	2.684	3	
228325	123381	6137	36	1	14 07 4122	−15 46 544	10.390	0.431	0.187	0.291	3	2.616	3	
228328	123411	5558	1536	1	14 07 5019	−12 03 099	10.608	0.289	0.140	0.441	3	2.652	3	
228332	123453	5561	1076	1	14 08 0393	−12 55 420	7.623	0.382	0.174	0.333	3	2.625	3	
228336	123455	5561	1066	1	14 08 1053	−14 20 427	9.402	0.389	0.135	0.455	3	2.663	3	
228339	−12 3968	5561	1196	1	14 08 1622	−12 47 158	10.746	0.402	0.167	0.412	3	2.606	3	
228345	123524	5558	1082	1	14 08 3017	−12 26 059	10.270	0.393	0.157	0.374	3	2.622	3	
228351	−11 3674	5558	1051	1	14 08 4507	−12 22 141	10.803	0.310	0.155	0.407	3	2.641	3	
228372	123677	5558	1048	1	14 09 2329	−12 23 446	9.892	0.273	0.124	0.603	3	2.729	3	*W*
228378	123729	5558	1253	2	14 09 4060	−11 04 197	9.643	0.271	0.147	0.516	3	2.718	3	
228388	123829	5561	228	1	14 10 0982	−13 20 456	9.093	0.400	0.159	0.283	3	2.608	3	
228390	123849	5561	653	1	14 10 1984	−14 13 166	7.585	0.572	0.199	0.324	3	2.579	3	
228392	−12 3984	5561	61	1	14 10 2637	−13 09 436	10.694	0.475	0.212	0.288	3	2.592	3	
228396	123900	5558	919	1	14 10 3435	−11 23 299	8.878	0.283	0.126	0.498	4	2.714	3	
228400	123932	5561	496	1	14 10 4912	−14 48 043	10.178	0.305	0.157	0.460	3	2.680	3	
228425	−12 3995	5561	113	1	14 11 4543	−12 55 513	10.332	0.391	0.161	0.426	3	2.617	3	
228428	124119	5558	161	1	14 11 4876	−10 58 356	10.371	0.319	0.139	0.402	3	2.687	3	
228432	−11 3685	5561	144	1	14 11 5988	−12 31 266	10.177	0.375	0.135	0.348	3	2.664	3	
228438	124161	6138	45	1	14 12 0840	−15 20 049	9.963	0.332	0.160	0.398	3	2.652	3	
228444	−10 3843	5558	955	1	14 12 2279	−11 24 551	10.710	0.339	0.131	0.439	3	2.633	3	

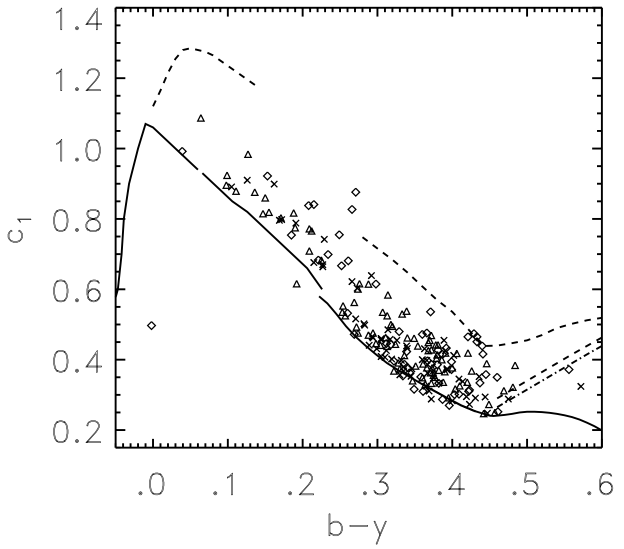

Fig. 1. Combined $b-y-c_1$ diagram for the three shadow directions. lb165−32 (◇), lb27−31 (△), lb329+46 (×). Solid curves are standard lines, δm_1 and δc_1 both equals 0. Dashed curves BHB, RHB and the AGB. GB indicated for two metallicities

3. Results

The $uvby\beta$ data are presented as plain averages of the values obtained in individual nights. Since a complete standard system is set up each night no night corrections are applied. Tables 1-3 contain the observations for the three directions, but only for stars with $\beta > 2.580$.

The characteristics of the sample is demonstrated in Figs. 1-4. The first of which is the $(b-y) - c_1$ diagram. Standard lines are drawn as solid curves, the small gaps mark discontinuities between imA and A, and between A and F stars, and are taken from Crawford (1975, 1978, 1979), Hilditch et al. (1983) and Olsen (1984). The dashed curves indicate, from blue to red, blue horizontal branch , red horizontal branch rising in the asymptotic giant branch, the gap between is populated by RR Lyrae stars. The BHB is from Hill et al. (1982), the RHB, AGB and GBs are from Anthony-Twarog & Twarog (1994). The reddening free $[m_1] - [c_1]$ diagram is displayed in Fig. 2 and we notice that the F stars are shifted to the metal weak side and that the A star range contains a number of metal rich candidates. Due to the presence of the shadows the three regions are known to contain reddening material and Fig. 3 accordingly shows that most of the stars are shifted to the red side of the standard relation in the $\beta-(b-y)$ diagram. There is however a number of F stars shifted to the blue side, this could be due to a low metal content. So a substantial number of metal weak stars is expected, this was perhaps to be anticipated from the three fields galactic latitude. Figure 4, a reddening free diagram, confirms that the sample contains many metal weak stars among the late Fs, they have small $[m_1]$ values compared to the value on the standard curve for a given β value. More surprisingly, the sample contains quite a number of metal rich candidates in the A star range. Metal rich A stars have larger $[m_1]$ than the standard curve values. A very extreme one is noticed.

The precision of the data is evaluated from multiple observations. Most stars are observed three times in $uvby$ and β. The error of the mean of V, $b-y$, m_1, c_1 and β for one star is 0.011, 0.005, 0.008, 0.009 and 0.006 mag respectively. σ_V and σ_{c_1} are marginally smaller than usual: 0.016 and 0.012. Error propagation of such errors provide $\sigma_{E(b-y)}$ of the order of 0.008 and $\sigma_{dst}/dst = 15\%$, (Knude 1978). The distance precision is in agreement with the result from a comparison of photometric distances to

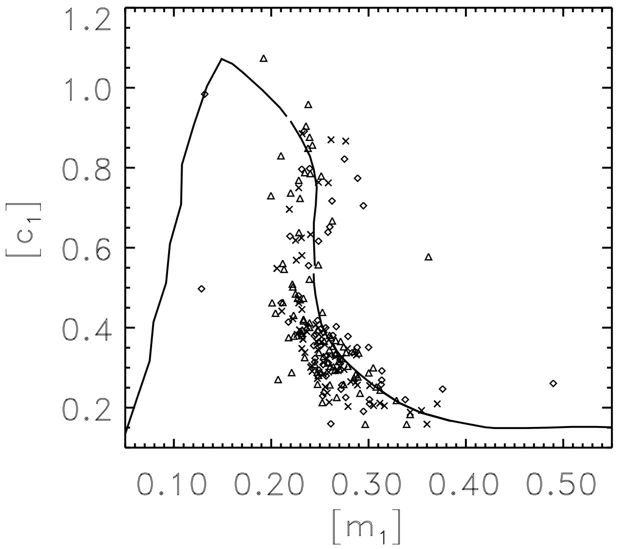

Fig. 2. Reddening free $[m_1] - [c_1]$ diagram. Coding as in Fig. 1

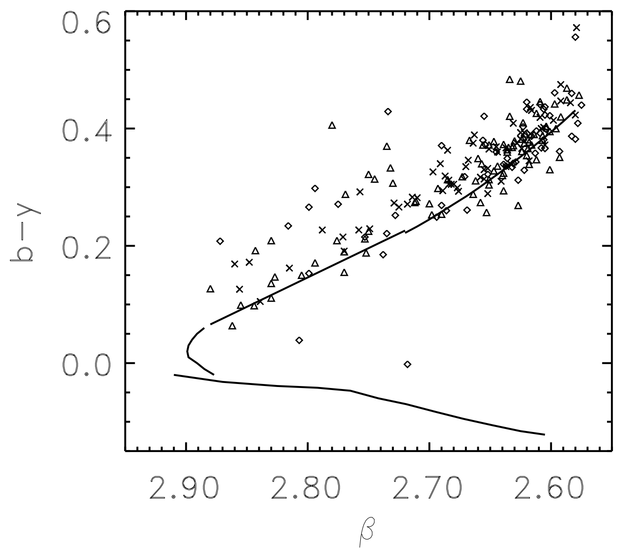

Fig. 3. $\beta - b - y$ diagram. β reddening free

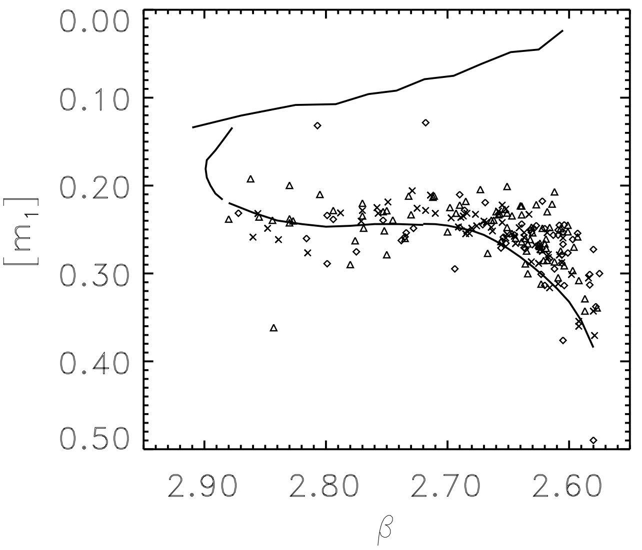

Fig. 4. $\beta - [m_1]$ diagramme. Stars with small $[m_1]$ values compared to the standard curve are metal weak, those with larger $[m_1]$ values may be metal rich. The A star range apparently contains a number of metal rich candidates

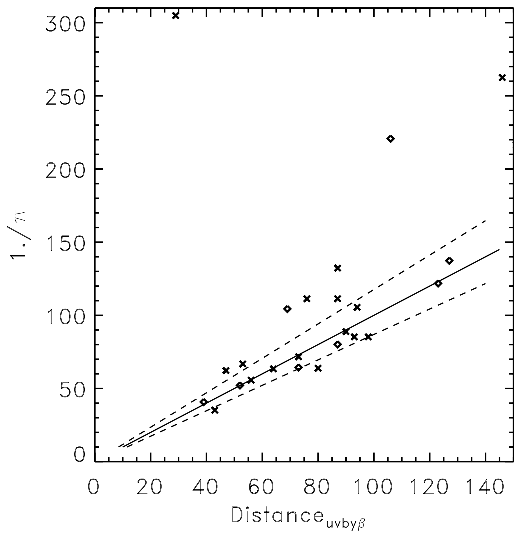

Fig. 5. Photometric distance versus $1./\pi$ for stars in the shadow directions within a photometric distance of 150 pc. The three deviant points are more or less understandable. A 15% accuracy in the photometric distances are confirmed for this small sample

Table 4. Differences in the sense this catalog - Hauck & Mermilliod (1990). In 0.001 mag

	V	$b-y$	m_1	c_1	β
Δ	2	3	−5	−7	11
σ	12	8	12	21	9
#	11	12	12	12	10

Hipparcos parallaxes for the ~20 stars in common, see Sect. 4.

Our data accuracy may be checked to published data, Hauck & Mermilliod (1990). Table 4 displays the outcome, for a small number of stars though. There is one outlayer in c_1 and the mean deviation in β is a little large. Assuming identical intrinsic standard deviations in our data and the published ones, we may check our intrinsic accuracy: 0.008, 0.006, 0.008, 0.015 and 0.006 in V, $b-y$, m_1, c_1 and β respectively. σ_V is lower than expected, otherwise these numbers confirm the accuracy expected from integration time and number of observations decided at the telescope. c_1 and β are both essential for the derivation of M_V and E_{b-y}.

4. Discussion

The main goal by the present undertaking is to locate the interstellar material responsible for the extreme ultraviolet absorption in space. Meaning that we need color excesses and stellar distances. A priori we expect distances with an accuracy of 15% depending on the validity of the absolute calibration of the $uvby\beta$ system of course. The color excesses may be checked with the polarimetry in progression, polarimetry is an order of magnitude more accurate than photometry. Preliminary results from the 2.5 m Nordic Optical Telescope for the lb329+46 shadow indicate that the ratio of polarization to reddening is large, Knude and Bowyer (in preparation). The distances uncertainty may be confirmed by the recently published Hippacos Catalog, ESA (1997). The most essential is of course to confirm the small distances found for the shadowing clouds, if possible. The Hipparcos Catalog is complete to $V \approx 7.5$, depending on color. We have compared the list of stars in Tables 1-3 to the Hipparcos Catalog. Within $D_{uvby\beta} < 150$ pc, without the application of any lower limit to δc_1. The search was performed according to the positions from the observing lists. 24 stars were found in Hipparcos. Figure 5 shows the photometric distance versus $\frac{1}{\pi}$. The solid curve is the one – one relation and the dashed curves indicates the ±15% accuracy expected in the photometric distances. No Hipparcos error applied. There are three large deviations. All with an excuse though. One is an CN star whose luminosity is not calibrated and thus may have a deviant δc_1. Another example is the super metal rich A star candidate mentioned before and the third is probably a misidentification by SAT. The difference between the PPM and Hipparcos position is 10 arcsec. The SAT centers the stars automatically and if they are not located at once it scans a small box and is satisfied by any star so the photometry of the star identified is correct but it is probably not the star with the PPM number in the list. With a standard deviation of 15% 14 of the 21 remaining stars are expected within the dashed lines. $13-14$ are found. The remaining

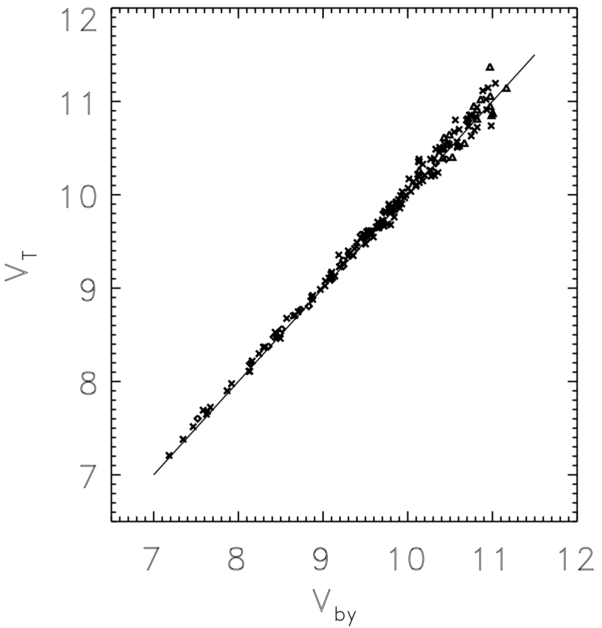

Fig. 6. $V_{by} - V_{\rm T}$. The abscissa is compatible to $V_{\rm Johnson}$ and the ordinate is a V magnitude measured by the Tycho experiment and is *n ot* transformed to $V_{\rm Johnson}$

stars but one are within $\pm 2\sigma$ and only one just outside the $\pm 2\sigma$ limits – just as expected with $\sigma = 15\%$.

In Fig. 6 we show our V versus the observed Tycho magnitude $V_{\rm T}$, ESA (1997). The increasing scatter is mainly due to the Tycho photometry. The limiting magnitude noticed in Tables 1-3 is determined by the automatic centering and is about $V \approx 11.5$. Six stars are not plotted in Fig. 6: 1237 1095 1, 5560 1460 1, 6339 558 1 because there are stars nearby influencing the observations by stray light; 1240 710 1 and 1237 128 1 deviate for no obvious reason and finally 6339 384 1 has suspected duplicity.

The resulting distance – E_{b-y} diagrams and distribution of color excess across the shadow regions together with the thermal pressure of the hot ISM phase in the three directions may be consulted in Berghöfer et al. (1997). A first estimate of the hot phase pressure in the $(l, b) = (165, -32)$ shadow, $P/k \approx 19\,000$ cm^{-3} K was given in Bowyer et al. (1995).

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