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Long-term monitoring of active stars[⋆,⋆⋆]

VIII. $UBV(RI)_c$ photometry collected in February 1992

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Abstract. As a part of an extensive program focusing on the global properties and evolution of active stars, high-precision $UBV(RI)_c$ photometry of 31 selected stars, collected at the European Southern Observatory over the 14-29 February 1992 interval, is presented. Significant evolution of the light curves, period variations and evidence for long-term variability of the global degree of spottedness are found. Some spectral classifications are revised and the inferred photometric parallaxes are compared, whenever possible, with the values measured by the Hipparcos satellite. Flare events were detected for the star HD 16157 = CC Eri, EXO 055609−3804.4 = TY Col and HD 119285 = V851 Cen. Optical variability was discovered for the Pop II binary HD 89499. These observations contribute to the establishment of a time-extended photometric database which can give important clues on topics such as the stability of spotted areas, differential rotation, solar-like cycles and the correlation between inhomogeneities at different atmospheric levels.

Key words: stars: activity — stars: flare — stars: late-type — stars: variables — stars: population II — stars: pre-main sequence

1. Introduction

Photospheric inhomogeneities as cool starspots are one of the most typical features of stellar activity. Their visibility, modulated by the stellar rotation, produces periodic or quasi-periodic light variation typically in the 0.1−0.2 magnitudes range (cf. Rodonò 1992a,b and references therein). In most cases multicolor photometry shows a reddening of the star at minimum luminosity (i.e. the light curve amplitude decreases at longer wavelengths), thus supporting the cool starspot hypothesis. However, anticorrelation of the $U-B$ and $B-V$ color indices with respect to the V-band light modulation has been observed for some stars such as V711 Tau, TW Lep, CC Eri and UX Ari (Cutispoto 1992, 1998; Rodonò & Cutispoto 1992; this paper). The orbital/photometric periods of active stars span from less than one day to several weeks and the photometric waves can undergo noticeable changes over time scales as short as few stellar rotations (cf. Figs. 12, 18 and 23 in Cutispoto 1995; Strassmeier et al. 1997; this paper). Hence, in order to investigate the physical characteristics and evolution of spotted areas and the time scale of activity cycles, active stars must be observed systematically. This continuous monitoring program, already started at Catania Astrophysical Observatory in the early Sixties, is being carried out by using the 0.5 and 1.0 m telescopes of the European Southern Observatory (ESO, La Silla, Chile), the 0.25 m Automatic Photoelectric Telescope of Franklin & Marshall College at Washington Camp. (AZ, U.S.A.) and the 0.8 m Automatic Photoelectric Telescope of Catania Astrophysical Observatory on Mt. Etna (Italy). It is aimed at establishing the time-extended database that is essential to investigate fundamental topics such as the evolution of spotted areas and spot lifetimes, the presence of photospheric solar-like activity cycles and differential rotation (see, among others, Cutispoto & Rodonò 1992; Budding & Zeilik 1995; Rodonò 1992a,b; Lanza et al. 1998), the temporal and/or spatial correlation between inhomogeneities at different atmospheric levels (Pagano et al. 1992, 1993; Pallavicini et al. 1993; Kürster 1996; Kürster et al. 1994, 1997; Catalano et al. 1996; Schmitt et al. 1998). This paper reports on data obtained by using the 0.5 m ESO telescope and is organized as follows: the details on the equipment, observations and

⋆ based on data collected at the European Southern Observatory, La Silla, Chile.
⋆⋆ *Tables and the complete data* set are available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr or via http://cdsweb.u-strasbg.fr/Abstract.html

Table 1. Comparison (c) and check (ck) stars for each program star (v), standard deviations (σ) for the $v-c$ and $ck-c$ V-band differential magnitudes for each series of N nights, peak-to-peak (ΔV) amplitude of the V-band light curve and period (P) of variability

Program star (v)		(c)	(ck)	σ ($v-c$)	σ ($ck-c$)	N	ΔV (mag.)	P (days)
HD 16157	= CC Eri	HD 16371	HD 16591	25	5	10	.06	1.56145
HD 17084	= UX For	HD 16975	HD 17322	12	6	8	.04	0.957
HD 26354	= AG Dor	HD 26779	HD 27274	11	4	9	.04	2.533
HD 32918	= YY Men	HD 33763	HD 33747	47	6	15	.13	9.75
1E 0505−0527	= EZ Eri	HD 33725	HD 34673	23	4	13	.08	9.08
HD 293857		HD 33725	HD 34673	4	4	10	.01	–
HD 34802	= YZ Men	HD 34297	HD 33563	50	4	15	.16	19.310
EXO 0527−3329	= UX Col	SAO 195800	HD 35528	15	4	13	.05	2.29
HD 36705	= AB Dor	HD 35230	HD 36316	28	5	12	.09	0.51479
EXO 0532−0510	= V 1321 Ori	HD 36235	HD 36003	111	4	13	.32	5.6
HD 39917	= SZ Pic	HD 39901	HD 39962	41	5	11	.11	4.905
EXO 0556−3804	= TY Col	HD 40865	HD 39601	32	6	13	.10	3.62
HD 61245	= V 344 Pup	HD 61390	HD 62061	21	3	12	.08	11.761
HD 81410	= IL Hya	HD 81904	HD 80991	75	5	15	.22	12.86833
HD 82558	= LQ Hya	HD 82508	HD 82447	36	4	14	.12	1.61
HD 86005	= LZ Vel	HD 86034	HD 85849	15	3	9	.04	44.57
HD 89499		HD 88351	HD 91682	9	5	13	.03	5.574
HD 98712	= SZ Crt	HD 97977	HD 98251	8	8	12	.03	11.58
SAO 202618	= V 858 Cen	HD 100912	HD 101679	49	5	14	.15	1.04303
HD 101309	= V 829 Cen	HD 101679	HD 101614	30	5	15	.09	11.65
HD 102077	= V 838 Cen	HD 102076	HD 102202	12	3	9	.04	1.848
HD 106225	= HU Vir	HD 105796	HD 106270	57	3	15	.18	10.424
HD 116544	= IN Vir	HD 117635	HD 118330	69	4	15	.21	8.40
HD 119285	= V 851 Cen	HD 119164	HD 119076	5	5	13	.02	12.05
HD 127535	= V 841 Cen	HD 128227	HD 128618	40	5	13	.12	5.929
HD 136905	= GX Lib	HD 136480	HD 137241	32	3	12	.12	11.134
HD 139084	= V 343 Nor	HD 139070	HD 138363	71	3	14	.19	4.32
SAO 121177		HD 141272	HD 140345	4	7	2	.01	–
HD 154338	= V 991 Sco	HD 326583	HD 154312	16	7	10	.05	3.27
HD 155555	= V 824 Ara	HD 156427	HD 154577	11	7	10	.04	1.71
HD 158394/5	= V 1017 Sco	HD 157750	HD 158619	2	3	9	.01	–

reduction procedures are given in Sect. 2, the results and the discussion on individual stars are presented in Sect. 3.

2. The observations

The observations presented in this paper were carried out at the European Southern Observatory (La Silla, Chile) from 14 to 29 February 1992. The 0.5 m ESO telescope, equipped with a single-channel photon-counting photometer, a thermoelectrically cooled Hamamatzu R-943/02 photomultiplier and standard ESO filters matching the $UBV(RI)_c$ system, was utilized. In order to obtain accurate differential photometry, for each program star (v) a comparison (c) and a check (ck) star were also observed (see Table 1). Each measurement of a star consisted in the average of 10-15 1-s integrations in each filter, according to the U–B–V–R_c–I_c color sequence. A complete observation consisted in sequential c–v–v–v–v–ck–c measurements. From these data, after accurate sky subtraction, four $v-c$ and one $ck-c$ differential magnitudes were computed; the four $v-c$ values were finally averaged to obtain one data point. The observations were corrected for atmospheric extinction and transformed into the standard $UBV(RI)_c$ system. The nightly atmospheric extinction coefficients were determined by observing two standards of very different spectral types in the 1−2.5 air mass range. Their mean values over the whole period are reported in Table 2.

Table 2. Mean atmospheric extinction coefficients for La Silla site, obtained over the 14-29 February 1992 period

	U	B	V	R	I
Mag/airmass	.538	.308	.203	.165	.118

These coefficients were obtained about eight months after the 1991 eruption of Mt. Pinatubo and are definitely higher than the values obtained with the same

Table 3. V magnitude and colors for the c and ck stars derived from standard stars. Errors are of the order of 0.01 magnitudes. The symbol ":" denotes errors of the order of 0.02 magnitudes

c or ck	V	$U-B$	$B-V$	$V-R_c$	$V-I_c$	c or ck	V	$U-B$	$B-V$	$V-R_c$	$V-I_c$
HD 16371	8.09	0.55:	0.90	0.48	0.93	HD 88351	6.59	0.54:	0.92	0.50	0.97
HD 16591	7.22	0.67:	0.94	0.51	0.96	HD 91682	8.51	0.26:	0.69	0.39	0.73
HD 16975	5.98	0.65	0.92	0.47	0.90	HD 97977	8.84	1.63:	1.42	0.75	1.43
HD 17322	7.63	0.04	0.58	0.33	0.65	HD 98251	9.20	1.44:	1.30	0.69	1.30
HD 26779	8.58	1.26:	1.23	0.64	1.20	HD 100912	8.63	0.43	0.93	0.51	1.00
HD 27274	7.64	1.11:	1.12	0.69	1.23	HD 101614	6.85	0.00:	0.58	0.34	0.65
HD 33563	7.54	−.04:	0.48	0.30	0.59	HD 101679	8.11	0.79:	1.09	0.59	1.14
HD 33725	8.04	0.42	0.80	0.44	0.84	HD 102076	7.11	0.77	1.01	0.52	0.98
HD 33747	8.75	0.72:	0.99	0.52	1.01	HD 102202	8.86	0.19	0.68	0.39	0.73
HD 33763	8.37	0.50:	0.89	0.49	0.94	HD 105796	8.06	0.94:	1.07	0.55	1.03
HD 34297	7.33	0.07:	0.65	0.38	0.74	HD 106270	7.58	0.29:	0.74	0.40	0.76
HD 34673	7.77	0.91	1.04	0.63	1.21	HD 117635	7.32	0.32:	0.78	0.46	0.86
HD 35230	7.58	0.47	0.88	0.48	0.93	HD 118330	7.04	−.01:	0.53	0.32	0.61
HD 35528	6.81	0.89:	1.06	0.53	0.99	HD 119076	6.87	0.87	1.16	0.60	1.14
SAO 195800	9.18	0.36:	0.85	0.47	0.91	HD 119164	7.20	1.14	1.28	0.64	1.22
HD 36003	7.64	1.13:	1.13	0.69	1.25	HD 128227	8.33	0.81	1.07	0.57	1.10
HD 36235	9.43	−.04:	0.52	0.31	0.61	HD 128618	8.03	1.61:	1.46	0.77	1.47
HD 36316	7.95	1.74:	1.46	0.78	1.51	HD 136480	7.35	1.11	1.16	0.60	1.15
HD 39601	8.18	0.28:	0.78	0.44	0.86	HD 137241	7.35	1.09	1.14	0.58	1.10
HD 39901	6.55	1.62:	1.36	0.71	1.32	HD 138363	7.12	0.94	1.13	0.61	1.15
HD 40865	8.64	0.05:	0.61	0.37	0.71	HD 139070	8.70	0.80	1.11	0.60	1.15
HD 61390	7.92	0.72	1.01	0.53	1.03	HD 140345	8.18	0.11:	0.63	0.35	0.68
HD 62061	7.51	0.08	0.60	0.33	0.65	HD 151272	7.44	0.41:	0.81	0.45	0.84
HD 80991	8.51	0.83:	1.04	0.54	1.02	HD 326583	9.52	0.10:	0.63	0.35	0.69
HD 81904	8.02	0.72:	0.98	0.51	0.98	HD 154312	7.98	0.02:	0.53	0.31	0.61
HD 82477	6.11	1.18	1.19	0.61	1.17	HD 154577	7.40	0.56:	0.88	0.53	0.99
HD 82508	7.58	0.35	0.71	0.40	0.80	HD 156427	7.41	1.69:	1.49	0.81	1.55
HD 85849	8.52	1.06:	1.14	0.58	1.11	HD 157750	8.03	0.17:	0.67	0.37	0.70
HD 86034	7.90	1.33:	1.26	0.63	1.20	HD 158619	6.41	1.26:	1.19	0.60	1.11

method and instrumentation in March 1991 (cf. Table 2 in Cutispoto 1998). Transformation coefficients were inferred by observing E-region standard stars (Menzies et al. 1989). The typical error of the differential photometry is of the order of 0.005 magnitudes, with somewhat larger values (up to 0.01 magnitudes) in the U-band due to the low photon counting level. The standard deviations (σ) for the $v-c$ and $ck-c$ mean differential V-band magnitudes obtained over N nights are reported in Table 1. The V magnitudes and colors of the comparison and check stars were obtained via standard stars (Menzies & Laing 1988; Menzies et al. 1989; Menzies et al. 1991) and are given in Table 3. For each program star the brighest V magnitude and corresponding colors are listed in Table 4. Taking into account the accuracy of the standard stars data and the extinction and transformation errors, the typical accuracy of the absolute photometry in Table 3 and 4 is of the order of 0.01 magnitudes, with somewhat larger values (up to 0.02 magnitudes) for the $U-B$ colors.

3. Results

The present multicolor photometry has been used to investigate light curve evolutions, to search for the presence of photospheric solar-like activity cycles and to infer or further constrain the spectral type and luminosity class of the program star (see Table 4). Color indices of active stars have to be taken prudently when used for spectral classification, as the presence of activity phenomena can modify them by an unknown amount. Cutispoto et al. (1996) developed a method, hereafter referred to as Active Stars Colors (ASC) method, to infer spectral classification from the observed colors. The ASC method was implemented by Cutispoto (1998), taking into account the effects of stellar activity on the $U-B$ index (Amado & Byrne 1997). In this paper, as a further improvement of the method, the recent luminosity calibration of the HR diagram obtained by Houk et al. (1997), Egret et al. (1997) and Gòmez et al. (1997) by using the Hipparcos data have been taken into account. Although the ASC method is better suitable for statistical purpose, as shown by Metanomski et al. (1998) for a large sample of active late-type stars, the last version can be successfully applied also for specific objects. For instance, Fekel (1996) inferred a K1 IV/V + G7 V spectral classification for the active star AR Psc, while Cutispoto (1995) lists the two components as K1/2 IV and F8 V, respectively. This discrepancy leads Fekel (1996) to deduce the non-applicability of the ASC method. On the other hand, the primary component of AR Psc turned out to be less luminous than a typical class IV star, being only 0.75 magnitudes brighter than the secondary component in the V-band (Fekel 1997). Hence, AR Psc cannot be

Table 4. Maximum luminosity ($V_{\rm m}$) and corresponding colors measured for the program stars, inferred spectral classification (Spectral Type), distance range measured by the Hipparcos satellite ($D_{\rm H}$), photometric distance inferred from the adopted spectral classification ($d_{\rm ph}$) and V-band maximum luminosity ever observed ($V_{\rm max}$)

Program Star		$V_{\rm m}$	$U-B$	$B-V$	$V-R_{\rm c}$	$V-I_{\rm c}$	Spectral Type	$D_{\rm H}$	$d_{\rm ph}$	$V_{\rm max}$
HD 16157	= CC Eri	8.81	1.10	1.36	0.88	1.86	K7 V + M3 V	11.4 − 11.6	11.5	8.70
HD 17084	= UX For	8.05	0.23	0.75	0.44	0.89	G6 V + K3 V	39 − 42	39	7.95
HD 26354	= AG Dor	8.55	0.63	0.91	0.54	1.03	K1 V + K5 V	34 − 36	35	8.55
HD 32918	= YY Men	7.99	0.69	1.06	0.59	1.14	K1 III	247 − 355	219	7.93
1E 0505 − 0527	= EZ Eri	10.21	0.51	0.92	0.51	1.01	K2 IV + G2 V		290	10.17
HD 293857		9.26	0.21	0.72	0.42	0.82	G6-G9 V	31 − 213	52-63	9.26
HD 34802	= YZ Men	7.70	0.82	1.07	0.61	1.16	K1 III	162 − 201	185	7.52
EXO 0527 − 3329	= UX Col	10.55	0.80	1.07	0.64	1.23	K3/5 PMS		> 43	10.53
HD 36705	= AB Dor	6.84	0.39	0.83	0.49	0.96	K0 V	14.8 − 15.1	14.9	6.75
EXO 0532 − 0510	= V1321 Ori	10.51	0.80	1.24	0.73	1.42	K3 wTTS		500	10.51
HD 39917	= SZ Pic	7.85	0.31	0.81	0.47	0.91	K0 IV/III + G3 IV/III	172 − 224	190	7.81
EXO 0556 − 3804	= TY Col	9.56	0.16	0.68	0.42	0.82	G5 V (PMS ?)		> 83	9.53
HD 61245	= V344 Pup	6.86	0.82	1.04	0.56	1.05	K1 IV/III	105 − 119	102	6.85
HD 81410	= IL Hya	7.28	0.73	1.02	0.57	1.08	K1 III/IV + ?	108 − 133	119	7.20
HD 82558	= LQ Hya	7.80	0.57	0.90	0.53	1.02	K2 V	18.0 − 18.7	18.5	7.77
HD 86005	= LZ Vel	7.19	0.99	1.31	0.70	1.34	K4 III/II + K1 III/II	≥ 650	≥ 315	7.18
HD 89499		8.70	−0.04	0.73	0.47	0.95	G-K IV ?	104 − 122	101-165	8.60
HD 98712	= SZ Crt	8.61	1.16	1.33	0.84	1.67	K7 V + M2/3 V	12.9 − 13.5	12.3	8.59
SAO 202618	= V858 Cen	10.50	0.53	0.90	0.54	1.05	K1 V/IV + M5:V		94	10.50
HD 101309	= V829 Cen	7.86	0.47	0.93	0.54	1.05	K1 IV + G5 V	110 − 135	127	7.82
HD 102077	= V838 Cen	8.95	0.55	0.92	0.56	1.08	K0/1 V + K5 V	44 − 55	42	8.85
HD 106225	= HU Vir	8.69	0.62	1.00	0.58	1.14	K1 IV + ?	108 − 148	170	8.55
HD 116544	= IN Vir	9.08	1.04	1.16	0.65	1.22	K3/4 IV/V	97 − 136	89	9.08
HD 119285	= V851 Cen	7.68	0.80	1.07	0.61	1.20	K3 IV/V	69 − 85	45	7.62
HD 127535	= V841 Cen	8.50	0.81	1.08	0.61	1.18	K3 IV/V	30 − 55	65	8.41
HD 136905	= GX Lib	7.30	0.72	1.03	0.57	1.10	K2 IV + ?	87 − 105	105	7.27
HD 139084	= V343 Nor	7.99	0.36	0.81	0.47	0.91	K0 PMS	38 − 42	> 26	7.98
SAO 121177		9.15	0.40	0.84	0.50	0.96	G9/K0 V + K7 V	45 − 52	48	9.11
HD 154338	= V991 Sco	9.69	0.19	0.68	0.39	0.76	G4/5 PMS	> 27	> 91	9.67
HD 155555	= V825 Ara	6.83	0.36	0.81	0.48	0.91	G7 PMS + K0 PMS	30.7 − 32.2	33	6.63
HD 158394/5	= V1017 Sco	8.38	0.42	0.83	0.59	1.22	K3 III + A5 V	207 − 402	358	8.23

regarded as a typical system and it is not surprising that the ASC method used by Cutispoto (1995) produced a significant different secondary star, as a brighter, and hence hotter, companion was necessary to modify the colors of the primary component that was assumed to be an ordinary class IV object. Now, taking into account the brightness difference between the two components inferred by Fekel (1996), the best fit of the observed colors of AR Psc is given by a K1 IV/V + G5/6 V system, in agreement with the spectroscopic classification given by Fekel (1996). The resulting photometric distance of 46 parsec is in good agreement with the trigonometric value of 45 ± 2 parsec measured by the Hipparcos satellite.

The results for the individual stars are now discussed.

HD 16157 = CC Eri is a BY Dra-type variable that has been detected by the ROSAT and EUVE satellites (Pye et al. 1995; Bowyer et al. 1996) and studied at different wavelengths by several authors (see Byrne et al. 1992; Cutispoto 1991 and references therein).

The observations obtained over the interval 14-24 February are shown in Fig. 1, where phases are reckoned from the 1.56145-day orbital period (Evans 1959). With respect to the single-peaked V-band light curve the $U-B$ color variations are anticorrelated, while the other color indices appear correlated, with the clearest modulation found for the $V-I$. The maximum luminosity is about 0.1 magnitude fainter than the value detected by Cutispoto & Leto (1997) in September 1990. The colors can be well matched by assuming a K7 V primary and a secondary component in the M1−M4 range. The photometric parallax inferred for the K7 V + M3 V classification is the one that results in better agreement with the distance measured by the Hipparcos satellite. A flare event, probably during its rising phase, was observed

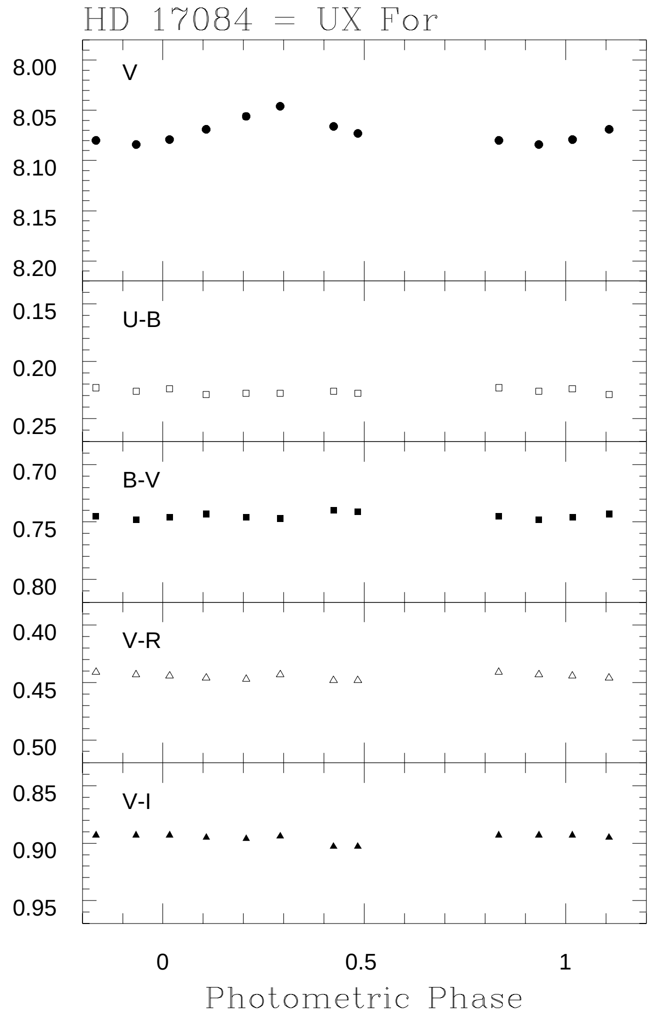

Fig. 1. HD 17084 = UX For V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 0.957 · E (Lloyd-Evans & Koen 1987)

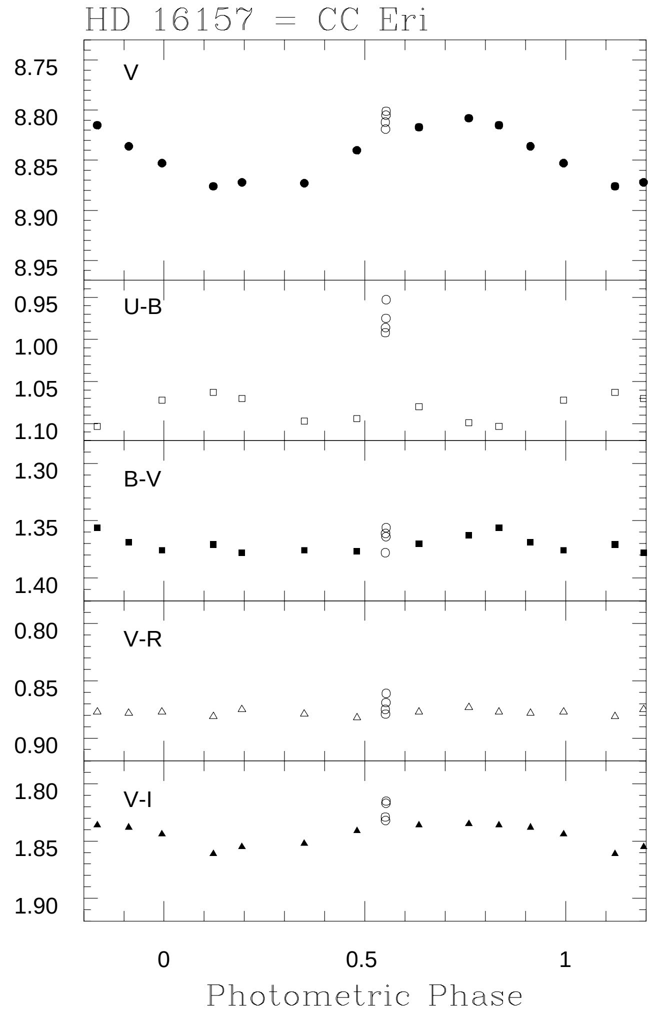

Fig. 2. HD 16157 = CC Eri V-band light curve and colors. Phases are reckoned from the orbital ephemeris 2447129.52934 + 1.56145 · E (Evans 1959). The flares data are represented by the symbol (○)

at HJD = 2448671.5405.

HD 17084 = UX For is a rapidly rotating SB1 spectroscopic binary with an orbital period of 0.95479 days that shows strong Ca II H&K emission lines, moderate Li abundance and 6-cm radio emission (Henry et al. 1996; Randich et al. 1993; Strassmeier et al. 1993 and references therein). It was also detected by the EUVE (Bowyer et al. 1996) and ROSAT (Pye et al. 1995) satellites. Washüttl & Strassmeier (1995) obtained the $v \sin i$ values of the two components. Previous photometric observations have been acquired by Lloyd-Evans & Koen (1987) and by Cutispoto (1992, 1995). The observations presented here were carried out over the 14-28 February interval and are shown in Fig. 2, where phases have been computed by using the 0.957-day photometric period inferred by Lloyd-Evans & Koen (1987). Although incomplete, the low amplitude light curve appears to be single-peaked and no color variation is detected. Tentative spectral classifications have been reported by Cutispoto (1995), who finally opted for a G5 V/IV primary component. However, with such luminosity class the inferred distance does not result in agreement with the value obtained by the Hipparcos satellite. A good fit of both the observed colors and trigonometric parallax is attained by assuming a G6 V + K3 V spectral classification, that results in reasonable agreement with the classification reported by Washüttl & Strassmeier (1995). For such a system the minimum value of the inclination angle for which no eclipses are observed results $i \simeq 70°$. A value that, in turn, leads to radii for the primary and secondary components (0.97 $R_\odot$ and 0.81 $R_\odot$, respectively) that are, within the errors, still consistent with luminosity class V components.

HD 26354 = AG Dor is a SB2 binary with an orbital period of 2.562 days (Balona 1987; Washüttl & Strassmeier 1995) that has been studied by several authors in the past (see Cutispoto 1992, 1996 and references therein) and was recently detected by the EUVE satellite (Bowyer

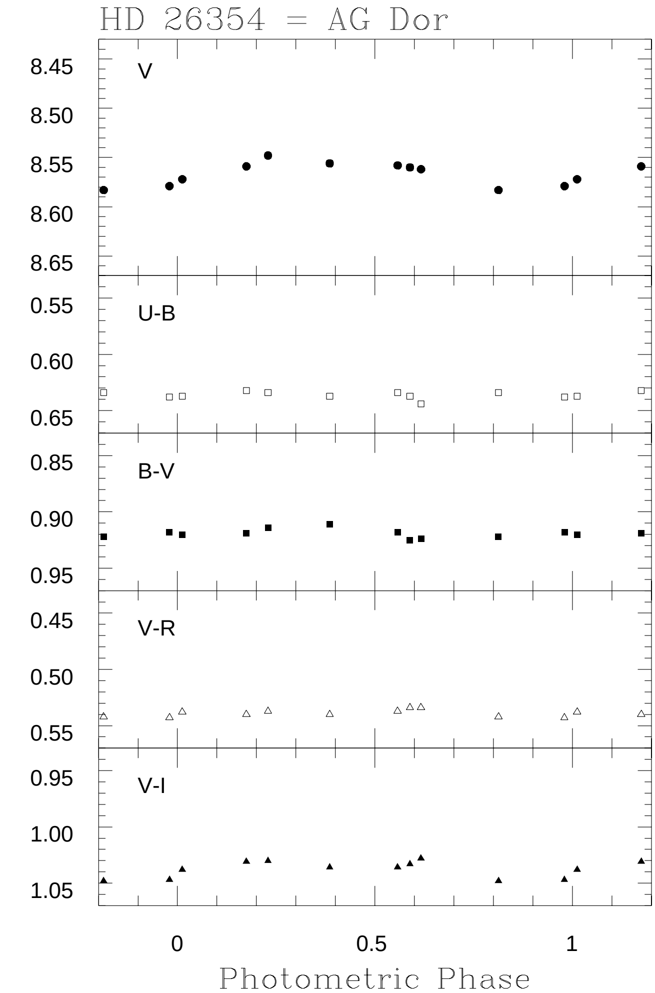

Fig. 3. HD 26354 = AG Dor V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448666.0 + 2.533 $\cdot$ E (Lloyd-Evans & Koen 1987)

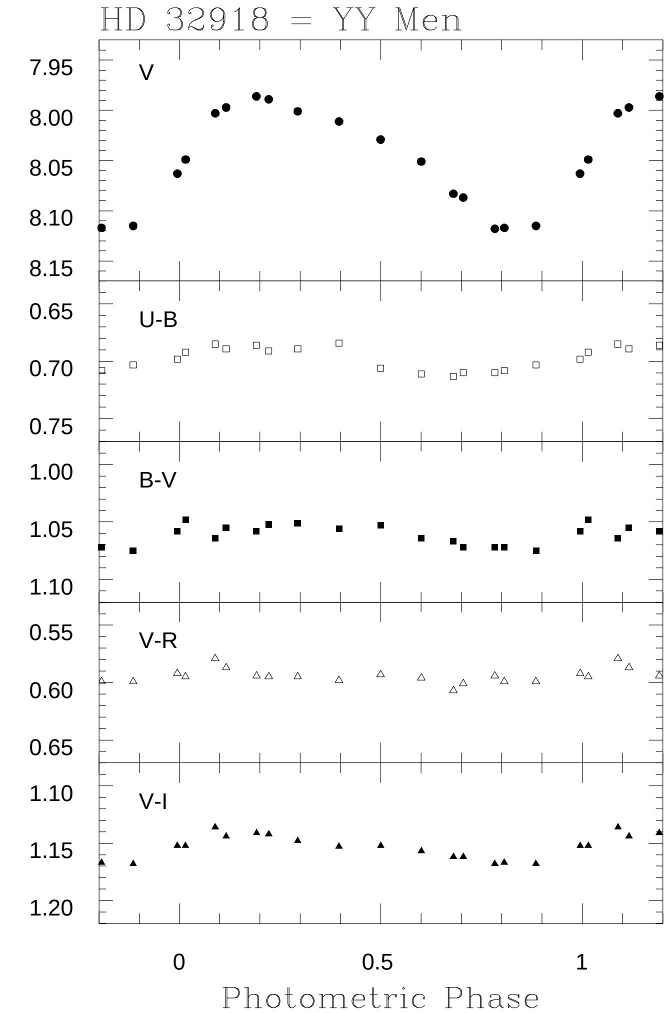

Fig. 4. HD 32918 = YY Men V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 9.75 $\cdot$ E

et al. 1996). Previous photometry has been obtained by Lloyd-Evans & Koen (1987) and by Cutispoto (1992, 1996). The observations presented in Fig. 3 have been carried out over the 14-25 February interval and are reckoned from the 2.533-day photometric period computed by Lloyd-Evans & Koen (1987). The V-band light curve is single-peaked, and its amplitude of about 0.04 magnitudes is the smallest so far observed, and only very weak color variations are detected. The present data show HD 26354 to be brighter, at light maximum, than in any previous epoch (cf. Fig. 2 in Cutispoto 1996), confirming the presence of a long-term variability of the global degree of spottedness. From the trigonometric parallax obtained by the Hipparcos satellite it is evident that the system is formed by two dwarf components. The K1 V + K5 V classification proposed by Cutispoto (1996) is the one that better fits both the observed colors and the trigonometric parallax. Moreover, it results in reasonable agreement with the classification reported by Washüttl & Strassmeier (1995), which also obtained the $v \sin i$ values of the two components. For such a system the minimum value of the inclination angle for which no eclipses are observed is $i \simeq 80°$. A value that, in turn, leads to radii for both components (0.86 $R_{\odot}$ and 0.51 $R_{\odot}$, respectively) that are, within the errors, still consistent with those of luminosity class V stars.

HD 32918 = YY Men is an active giant classified as a member of the FK Com-type stars (see Cutispoto et al. 1992 and references therein). Flare events detected at optical (Cutispoto et al. 1992) and radio (Slee et al. 1987a; Bunton et al. 1989) wavelengths are among the most intense and longest duration events ever recorded for any class of active stars. The data obtained over the 14-29 February interval are shown in Fig. 4, where phases are reckoned from the 9.75 ± 0.20-day photometric period computed from a Fourier analysis of the VRI data. The very asymmetric V-band light curve

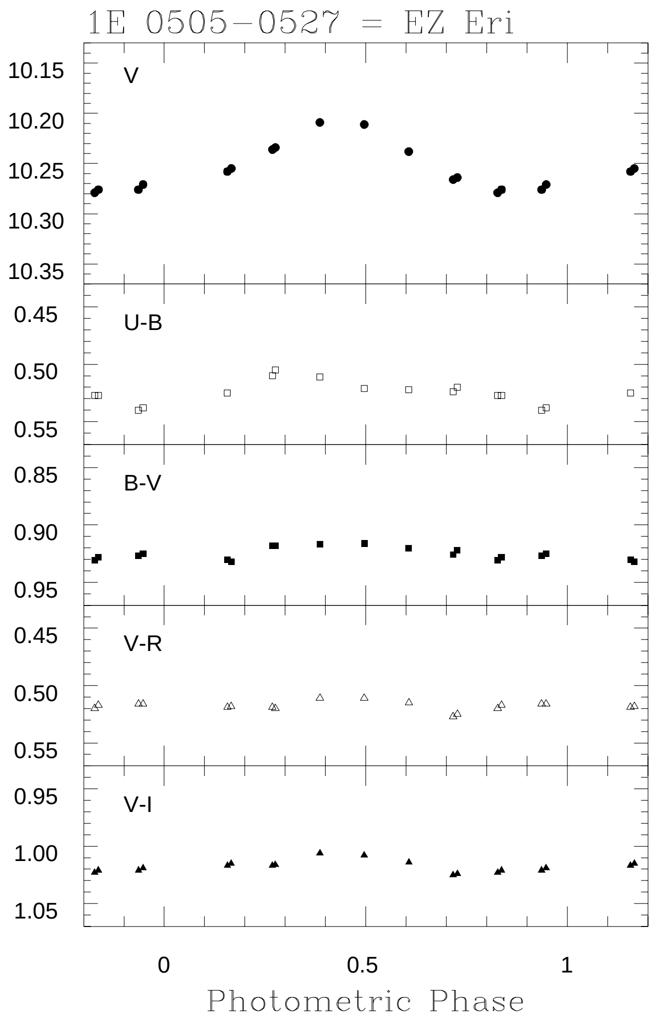

Fig. 5. 1E 0505.0−0527 = EZ Eri V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660 + 9.08 · E (Cutispoto & Tagliaferri 1996)

is single-peaked and its maximum results about 0.055 magnitudes fainter than the brightest values observed to date (cf. Fig. 7 in Cutispoto & Leto 1997). Clear color variations, well correlated with the V-band modulation, show the star to be redder at light minimum. The K1 III spectral classification agrees well with the observed colors. However, assuming such a classification and the absolute magnitude inferred by Egret et al. (1997) the photometric parallax results in 219 parsec, that is outside the 247−355 parsec range measured by Hipparcos. This difference clearly reflects the high dispersion of the M_V for late type giants (cf. Fig. 2 in Egret et al. 1997). From the trigonometric parallax the absolute magnitude of YY Men can be estimated in the 0.18−0.97 range.

1E 0505.0−0527 = EZ Eri is a serendipitous X-ray source detected by the Einstein satellite and classified as a suspected RS CVn system by Fleming et al. (1989). The presence of optical variability, high Li abundance and a partially filled-in Hα line was reported by Cutispoto & Tagliaferri (1996). The photometric data attained over the 14-28 February interval are shown in Fig. 5, where phases have been computed by using the 9.08-day photometric period inferred by Cutispoto & Tagliaferri (1996). The light curve is single-peaked and color variations, almost in phase with the V-band modulation, can be noted. Comparing the present data with previous photometric observations (cf. Fig. 2 and Fig. 3 in Cutispoto & Tagliaferri 1996) sizeable variations of the light curve shape and amplitude and of the maximum luminosity show up. The spectral classification that better match the observed colors is here revised to K2 IV + G2 V, to which a distance of 290 parsec corresponds. Assuming a photospheric temperature of 4750 K, the 9.08-day photometric period as representative of the rotational period and the $v \sin i$ value of 14 km s^{-1} computed by Fleming et al. (1989), the radius of the primary component and the inclination angle results in $R_{\rm K2IV} = 5.9 \pm 0.1\,R_\odot$ and $i = 25^{+5}_{-4}$ degrees, respectively.

HD 293857 is the optical counterpart of a serendipitous X-ray source discovered by the EXOSAT satellite (Giommi et al. 1991). It has been previously studied by Tagliaferri et al. (1994), who found a very high Li abundance, and by Cutispoto et al. (1996), who reported on optical multiband photometry. The observations carried out over the 14-27 February interval show no optical variability, with the brightest and faintest V-band values differing by only 0.012 magnitudes. However, the main V-band luminosity results about 0.06 magnitides brighter than any previous observation, while the mean colors appear definitively bluer (cf. Table 2 in Cutispoto et al. 1996). The spectral classification G9 V was inferred by Tagliaferri et al. (1994) and by Cutispoto et al. (1996). The present $V-R$ and $V-I$ colors are still consistent with such a classification, while the $U-B$ and $B-V$ agree much better with those of an active G6 V star.

HD 34802 = YZ Men is a SB1 spectroscopic binary with a 19.310-day orbital period (Balona 1987) for which weak Ca II H&K and X-ray emission have been recorded (see Strassmeier et al. 1993 and references therein). Optical variability has been observed by Lloyd-Evans & Koen (1987); Collier Cameron (1987) and by Cutispoto (1995). Low Li abundance and a $v \sin i$ value of 20 km s^{-1} were derived by Randich et al. (1993). The observations carried out over the 14-29 February interval are shown in Fig. 6, where phases are reckoned from the 19.310-day orbital period. Though not complete, the V-band light curve appears strongly asymmetric, showing a flat mimimum extending for more than 0.2 phase interval. The $U-B$ color curve is double-peaked, while the other indices undergo variations well correlated with the V-band modulation. The present data, showing a V-band maximum luminosity about 0.04 magnitudes fainter than any

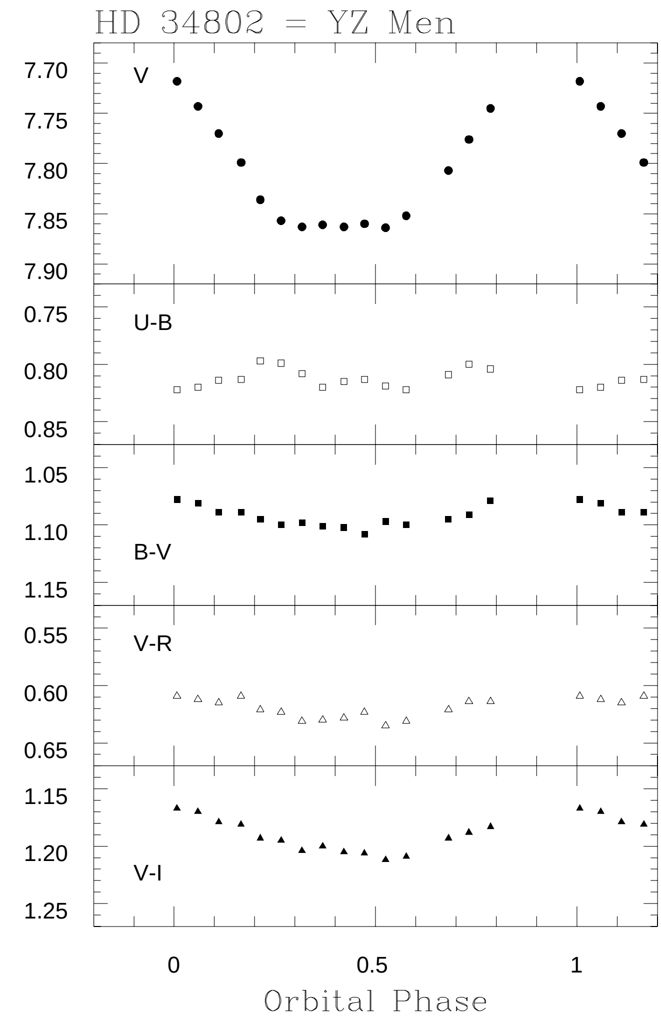

Fig. 6. HD 34802 = YZ Men *V*-band light curve and colors. Phases are reckoned from the orbital ephemeris 2448666.5 + 19.310 · E (Balona 1987)

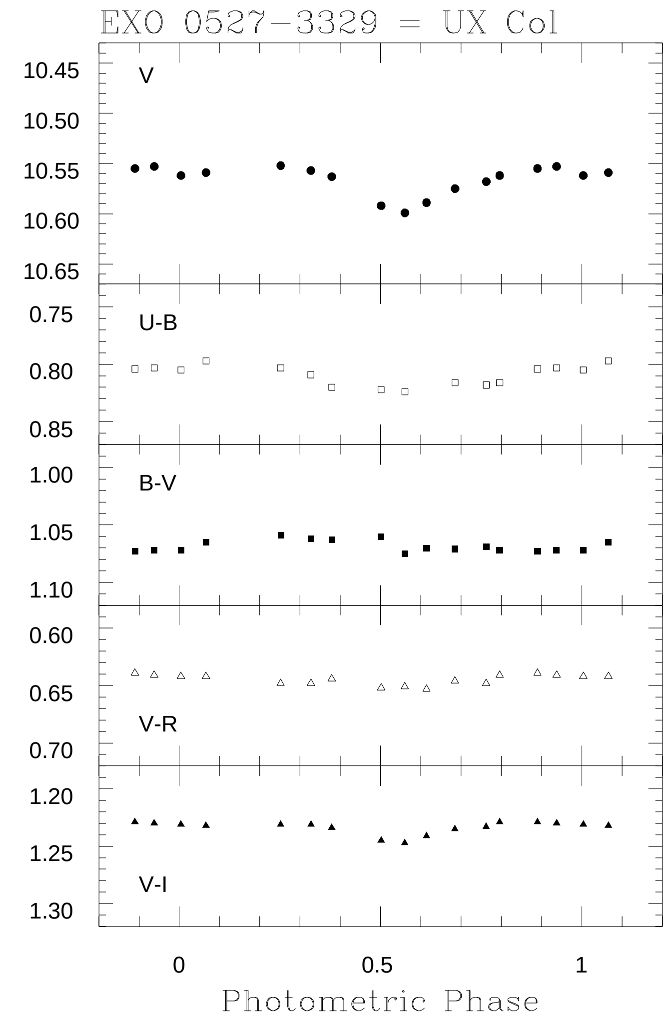

Fig. 7. EXO 052707 − 3329.2 = UX Col *V*-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 2.29 · E

previous observations, confirm the presence of a long-term variability of the global degree of spottedness (cf. Fig. 17 in Cutispoto 1995). The colors agree pretty well with those of a K1 III active star and also the photometric parallax matchs the trigonometric one measured by the Hipparcos satellite.

EXO 052707−3329.2 = UX Col is the optical counterpart of a serendipitous X-ray source discovered by the EXOSAT satellite (Giommi et al. 1991). It has been studied by Tagliaferri et al. (1994), who found high Li abundance, and by Cutispoto et al. (1996), who discovered optical variability with a 2.22-day period. The observations carried out over the 14-28 February interval are shown in Fig. 7, where phases are reckoned from the 2.29 ± 0.02-day photometric period inferred from a Fourier analysis of the *VRI* data. The light curve is single-peaked and color variations are evident. Comparing the present data set with previous observations (cf. Fig. 7 in Cutispoto et al. 1996) a noticeable evolution of the light curve shape and of the maximum luminosity can be inferred. On the basis of the minimum stellar radius and Li abundance Cutispoto et al. (1996) classified UX Col as a possible PMS star. Hence, a mimimum distance of 43 parsec is derived, as the $V-R$ and $V-I$ colors can be matched by those of a K5 V star.

HD 36705 = AB Dor is one of the most studied active stars as can be inferred from the papers listed in the SIMBAD database (see, among the most recent, Kürster et al. 1997; Schmitt et al. 1997, 1998; Micela et al. 1997; Unruh et al. 1995; Kürster et al. 1994 and references therein). The data obtained over the 15-28 February interval are plotted in Fig. 8, where phases are reckoned from the 0.51479-day photometric period computed by Innis et al. (1988). The *V*-band and the color curves exhibit two maxima, that have about the same amplitude in the $U-B$ and $B-V$ color curves, while one of the

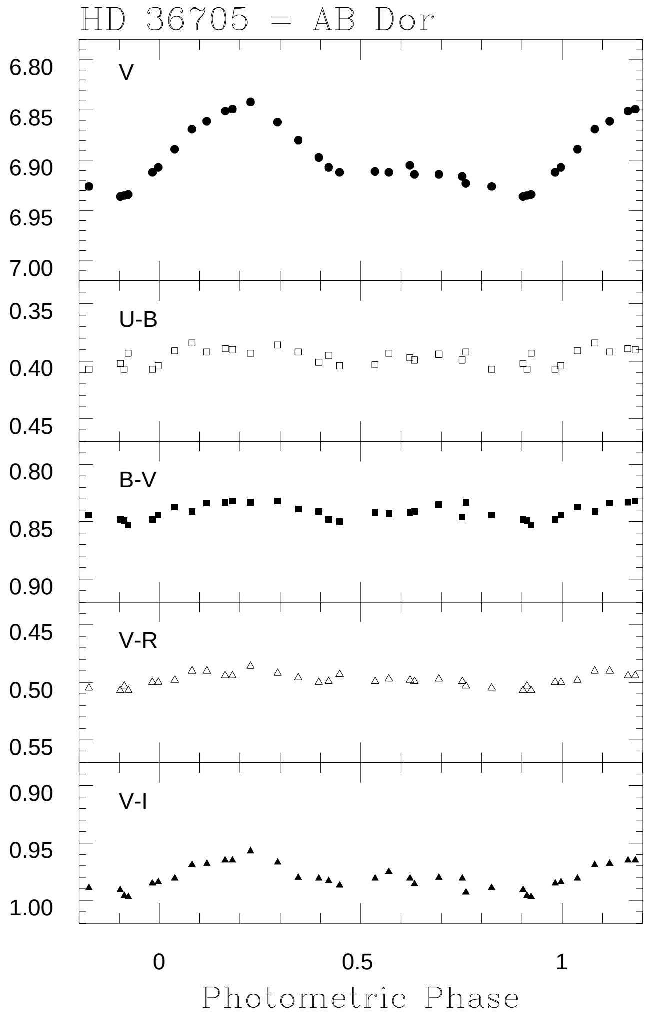

Fig. 8. HD 36705 = AB Dor V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2444296.575 + 0.51479 · E (Innis et al. 1988)

two is much more evident in the V-band and in the $V-R$ and $V-I$ curves. The brightness evolution of AB Dor over the 1978-1996 interval, that includes the present data, is shown in Kürster et al. (1997). From the $v \sin i$ value computed by Randich et al. (1993) a minimum stellar radius of about 0.86 $R_\odot$ is inferred, apparently in agreement with the conclusion, reached by Rucinski (1985) and by Innis et al. (1986), that HD 36705 has not arrived on the main sequence yet. However, the PMS classification for AB Dor has been questioned by Micela et al. (1997) on the basis of the 14.9 parsec distance measured by the Hipparcos satellite. The observed colors agree fairly well with those of an active K0 V star, with the exception of the $V-I$ index that is about 0.1 magnitudes redder than expected. Moreover, taking into account that the brightest luminosity so far observed for AB Dor turns out to be $m_V = 6.75$ (cf. Fig. 1 in Kürster et al. 1997), that is definitively brighter than the 6.88 value assumed by Micela et al. (1997), the absolute magnitude of AB Dor results in $M_V = 5.89$, that is in excellent agreement with the value inferred by Houk et al. (1997) for a K0 V star. This result implies that the value of *"i"* has to be very close to 90°.

EXO 053237−0510.1 = V 1321 Ori = P 1724 is the optical counterpart of a serendipitous X-ray source discovered by the EXOSAT satellite (Giommi et al. 1991). It is located near the Orion nebula region and has been previously studied by Tagliaferri et al. (1994), who found very high Li abundance, high rotation velocity and no spectroscopic indication for binarity, and by Cutispoto et al. (1996), who discovered optical variability with a 5.6-day period and inferred a minimum stellar radius in the 8.0 − 8.6 $R_\odot$ range. These authors concluded that V 1321 Ori is a very young, possibly a T-Tauri, star. Further detections at X-ray wavelengths have been obtained by the ROSAT (Alcalà et al. 1996; Geier et al. 1995) and ASCA (Yamauchi et al. 1996) satellites. The occurrence of a giant X-ray flare in September 1992, detected by ROSAT, has been investigated by Preibisch et al. (1995). The membership of V 1321 Ori to the Orion nebula and, hence, its distance has been studied by several authors with quite different results. The most recent measurements by Van Altena et al. (1988) and by Tian et al. (1996) indicate that V 1321 Ori is not a proper motion member of Orion. On the other hand, in their detailed study Preibisch et al. (1995) infer a K3 *weak-line* TTS classification and Orion complex membership. Their results have been included in Table 4. The photometric observations carried out over the 14-28 February interval are shown in Fig. 9, where phases have been computed by using the 5.6-day photometric period given by Cutispoto et al. (1996). The very large amplitude light curve is single-peaked and remarkable color variations, especially unusual for the $U-B$ index, are seen. Comparing the present data with the March 1991 light curve (cf. Fig. 8 in Cutispoto et al. 1995) a remarkable evolution can be seen, showing V 1321 Ori much brighter at light maximum and much fainter at light minimum than in March 1991.

HD 39917 = SZ Pic is an SB2 spectroscopic binary with an orbital period of about 4.96 days (Kürster 1994) that has been detected by the ROSAT satellite and by the VLA (Fox et al. 1994). It shows strong Ca II H&K emission from both components (Andersen et al. 1980; Henry et al. 1996), low Li abundance (Pallavicini et al. 1992) and photometric variability (Andersen et al. 1980; Bell et al. 1983; Cutispoto 1995, 1998). SZ Pic was observed over the 14-29 February interval and the data, folded by using the 4.905-day period inferred by Cutispoto (1995), are presented in Fig. 10. The V-band light curve, though incomplete, appears quite different from those obtained in previous epochs (cf. Fig. 21 in Cutispoto 1995 and Fig. 4 in Cutispoto 1998). This confirms that, though most of the variability is due to

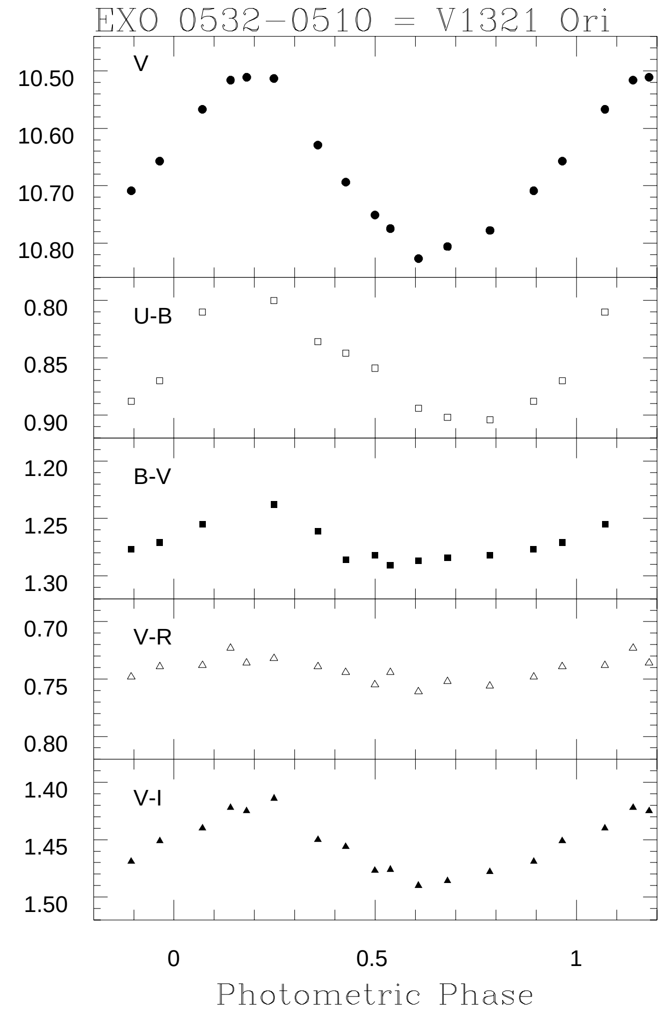

Fig. 9. EXO 053237 − 0510.1 = V 1321 Ori *V*-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 5.6 · E (Cutispoto et al. 1996)

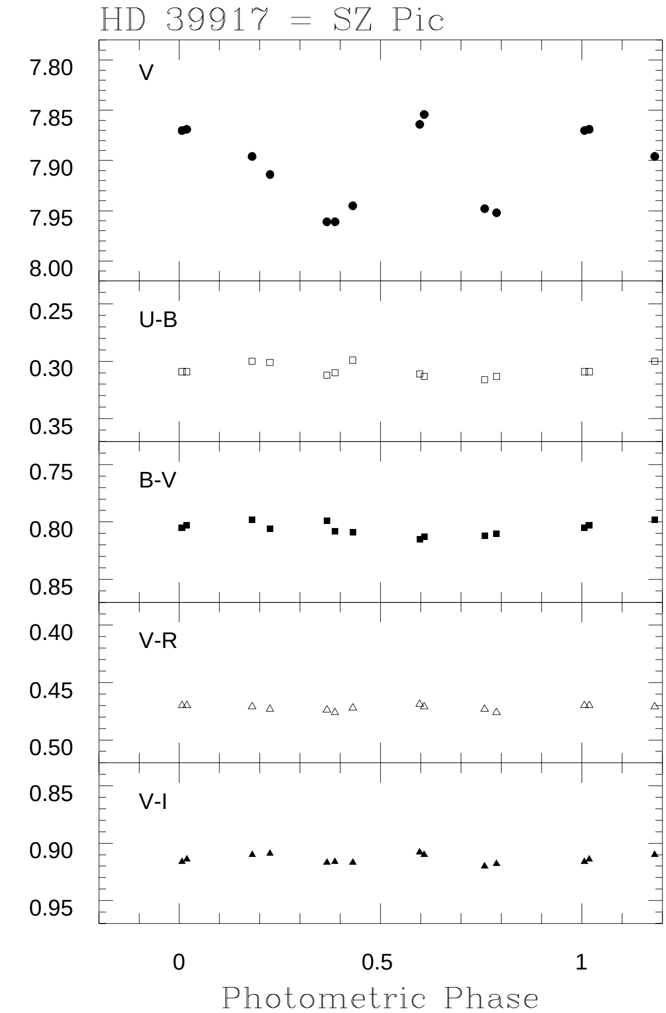

Fig. 10. HD 39917 = SZ Pic *V*-band light curve and colors. Phases are reckoned from the photometric ephemeris 2443931.54 + 4.905 · E (Cutispoto 1995)

ellipticity effect, part of it can be ascribed to the presence and evolution of spots groups. The color variations are marginal. Both components were assumed to be evolved stars by Cutispoto (1995), following the results of Kürster (1994) and Andersen et al. (1980). This is confirmed by the Hipparcos satellite, that measured the distance of HD 39917 to be in the 172−224 parsec range. However, to assume mean class IV components results in a distance that is smaller than 172 parsec. Consequently, in order to fit both the observed colors and the trigonometric parallax, two stars 0.8 magnitudes brighter than two typical class IV objects of the same spectral type have to assumed. Hence, the inferred spectral classification results in K0 IV/III + G3 IV/III.

EXO 055609−3804.4 = TY Col is the optical counterpart of a serendipitous X-ray source discovered by the EXOSAT satellite (Giommi et al. 1991) that has been detected also by the ROSAT satellite (Kreysing et al. 1995; Pye et al. 1995). It has been previously studied by Cutispoto et al. (1991), who discovered optical variability with a period of 3.72 days and rapid light curve changes, and by Tagliaferri et al. (1994), who found a very high Li abundance. Further photometry has been published by Cutispoto et al. (1996). The observations collected over the 14-29 February interval are presented in Fig. 11, where phases are reckoned from the 3.62 ± 0.04-day photometric period inferred by a Fourier analysis of the *VRI* data. From an inspection of the color curves it is clear that the observation at HJD = 2448666.6521 was obtained during the development of a flare event. The maximum and mimimum luminosities of TY Col undergo noticeable changes, as shown in Fig. 12, though the few available data do not allow to investigate the periodicity of such variability yet. The spectral classification of TY Col is quite puzzling. From the $v \sin i$ and the high Li abundance reported by Tagliaferri et al. (1994), a minimum stellar radius in the 3.9 − 4.0 $R_{\odot}$ range can be

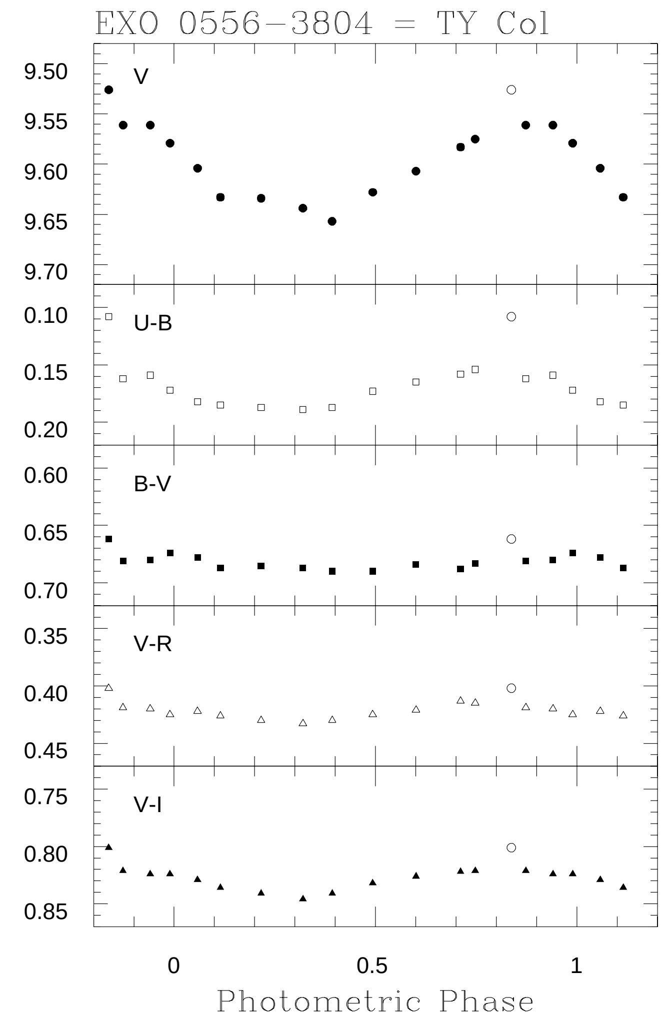

Fig. 11. EXO 055609 − 3804.4 = TY Col V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 3.62 · E. The flares data are represented by the symbol (○)

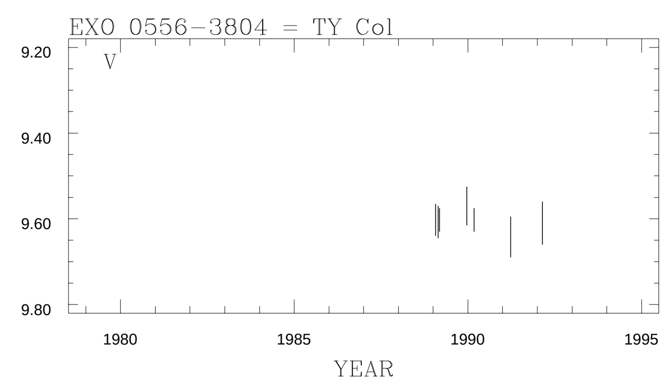

Fig. 12. EXO 055609−3804.4 = TY Col V-band long-term variability. The vertical bars indicate the peak-to-peak amplitude of the light curve

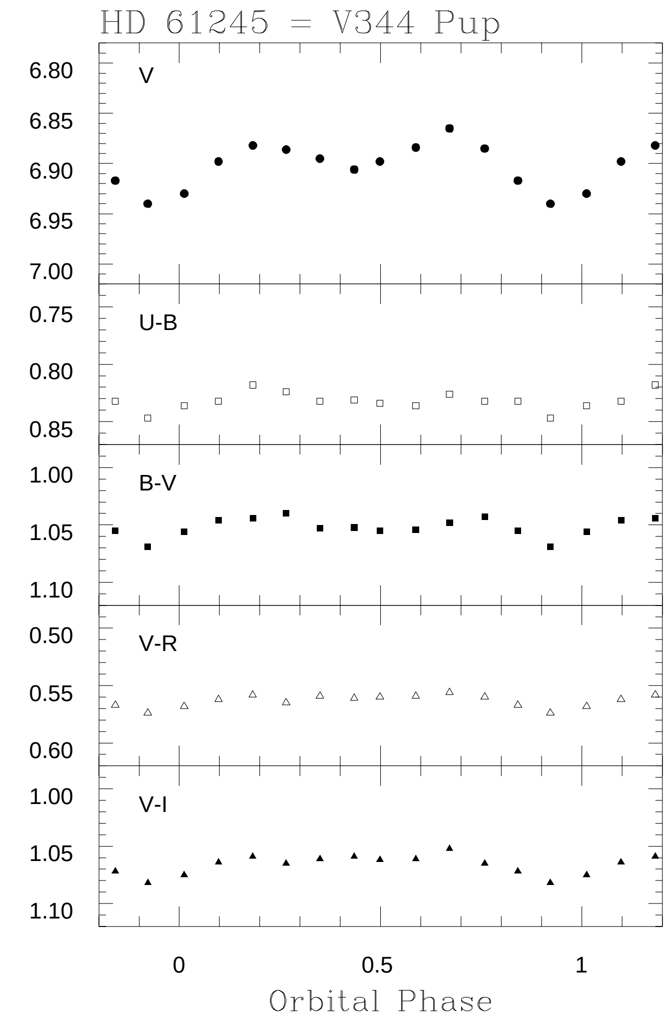

Fig. 13. HD 61245 = V 344 Pup V-band light curve and colors. Phases are reckoned from the spectroscopic ephemeris 24448331.5 + 11.761 · E (Balona 1987)

computed and the star classified as a PMS object. On the other hand, the position of TY Col in a two color diagram appears very close to the main sequence (cf. Fig. 1 in Cutispoto et al. 1996). The colors can be fitted quite well by those of a G5 V star, with the noticeable exception of $V-I$ that results about 0.1 magnitudes redder than expected, similary to what is observed for AB Dor. A better fit of the colors could be obtained by assuming TY Col to be a binary star, but only one system of lines is visible in the spectra (Tagliaferri et al. 1994).

HD 61245 = V 344 Pup is an SB1 spectroscopic binary that shows weak Ca II H&K emission lines and Hα absorption (Bopp & Hearnshaw 1983) and for which low Li abundance has been reported by Randich et al. (1993). The optical variability was discovered by Lloyd-Evans & Koen (1987), further photometric observations were acquired by Cutispoto (1992, 1995, 1998). The data presented in this paper, obtained over the 14-25 February interval, are shown in Fig. 13, where the 11.761-day orbital period inferred by Balona (1987) has been used for phase computation. The double-peaked *V*-band light curve and the color variations appear to be in phase. Though a remarkable evolution of the light curve of HD 61245 is evident when the data obtained in different periods are compared, the persistence of two maxima at about 0.5 phase distance is observed. This kind of light curves is typical for those systems, as for instance SZ Pic, in which the light variability is dominated by ellipticity effects. However, it should be noted that the color curve amplitudes of V 344 Pup are much larger than those of SZ Pic, showing that in the former system the contribution to the light variability due to the spots is much more important. Hence, in case most of the light variability should be ascribed to photospheric spots, the presence of two long-living groups located in opposite hemispheres has to be invoked. V 344 Pup has been classified as K1 III and as K2 III by Bopp & Hearnshaw (1983) and Houk (1978), respectively. However, the spectral classification that best fits both the observed colors and the trigonometric parallax estimated by the Hipparcos satellite results in K1 IV/III.

HD 81410 = IL Hya is an SB1 spectroscopic binary that has been observed by several authors at different wavelengths (see Weber & Strassmeier 1998; Strassmeier et al. 1993; Cutispoto 1998 and references therein). It has been detected by the ROSAT and EUVE satellites (Pye et al. 1995; Bowyer et al. 1996; Mitrou et al. 1997). The data presented in this paper were obtained over the 14-28 February interval and are shown in Fig. 14, where phases are reckoned from the 12.86833-day orbital period computed by Raveendran et al. (1982). The observations collected by Manfroid et al. (1995) in early 1992 are also shown. The *V*-band light curve is single-peaked and very clear color variations, showing the star redder at light minimum, are present. Though the light curve obtained by Manfroid et al. (1995) is not complete, it is clear that the photospheric spotted regions were evolving on time scales of the same order as the orbital period. The collection of the available photometry of IL Hya, that spans over a baseline of about 26 years, is shown by Strassmeier et al. (1997). The present data complete the information about the light curve amplitude in early 1992, showing, in particular, that IL Hya was about 0.09 magnitudes fainter at light mimimum in the *V*-band than the value observed by Manfroid et al. (1995). A detailed study of the stellar properties of IL Hya has been published by Weber & Strassmeier (1998), who infer a K0 III/IV primary component and a less well defined, late F - G0 V/IV, secondary component. The colors agree very well with those of a K1 III/IV active star, and the corresponding photometric parallax of 119 parsec is in excellent agreement with the value obtained by the Hipparcos satellite. Actually, to include a class V/IV secondary yields a less good fit of the colors and the best fit is then obtained by assuming a K1/2 III/IV + G5 V/IV system, to which a photometric parallax of 126 parsec corresponds.

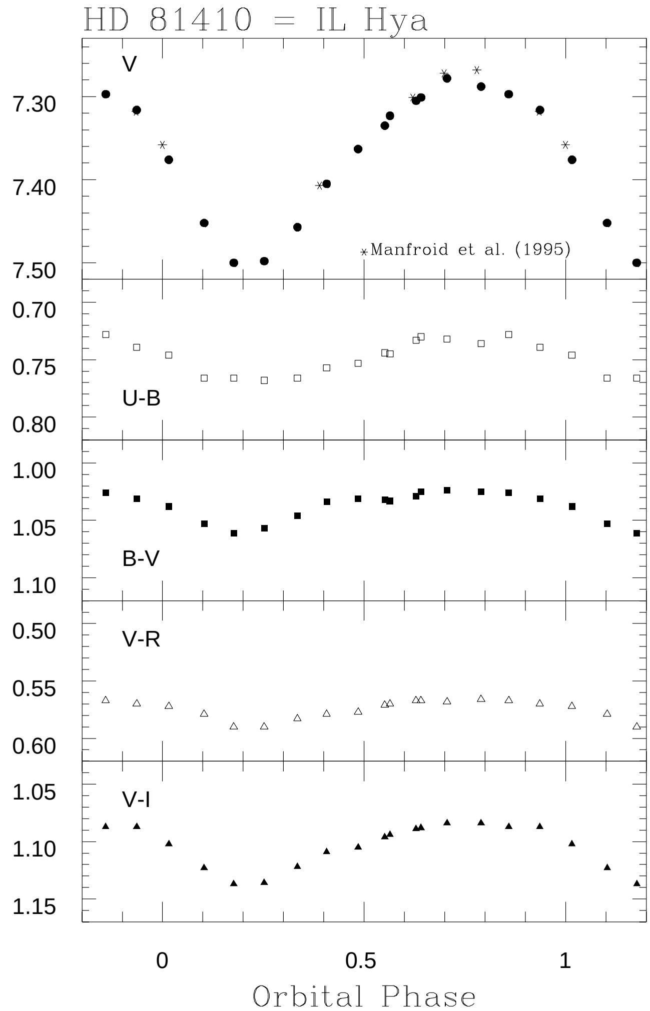

Fig. 14. HD 81410 = IL Hya *V*-band light curve and colors. Phases are reckoned from the spectroscopic ephemeris 2441466.213 + 12.86833 · E (Raveendran et al. 1982)

HD 82558 = LQ Hya is a very active rapidly rotating single star. It has been studied by several authors and classified as a very young star, just arrived on the ZAMS, or even as a PMS star (see Vilhu et al. 1991; Strassmeier et al. 1990; Fekel et al. 1986 and references therein). It has been detected by the ROSAT (Pye et al. 1995) and EUVE (Lampton et al. 1997; Bowyer et al. 1996) satellites. A collection of the photometric observations of LQ Hya from late 1982, from which the presence of an activity period of about 7 years can be inferred, has been displayed by Strassmeier et al. (1997). The data acquired over the 15-29 February interval are shown in Fig. 15, where phases have been reckoned from the 1.61 ± 0.01-day photometric period computed by a

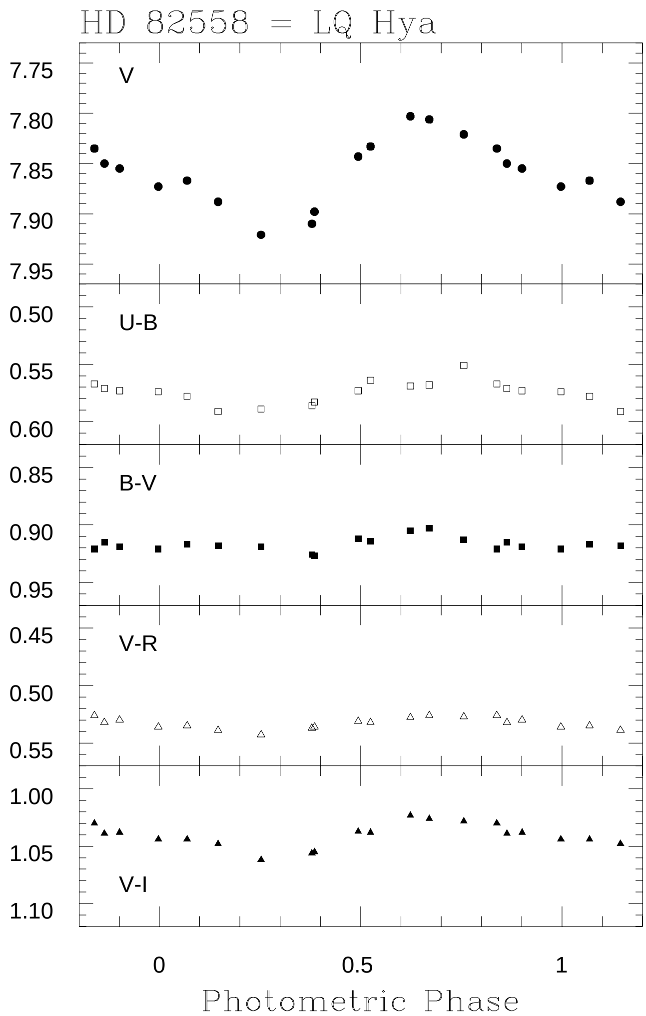

Fig. 15. HD 82558 = LQ Hya V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660 + 1.61 · E

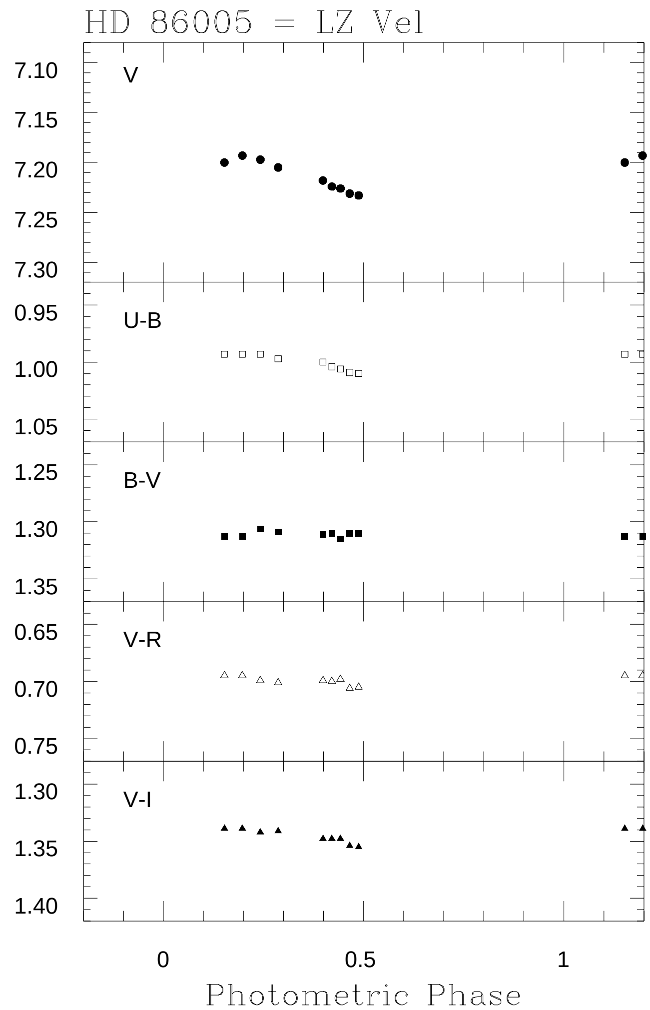

Fig. 16. HD 86005 = LZ Vel V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 44.57 · E (Scott et al. 1992)

Fourier analysis of the *VRI* data. The light curve is double-peaked and the color variation appears in phase with the V-band modulation, showing the star to be redder at light mimimum. The colors are consistent with those of an active K2 V star, and the corresponding photometric parallax results in excellent agreement with the value measured by the Hipparcos satellite.

HD 86005 = LZ Vel was reported as a possible very active star by Bopp & Hearnshaw (1983) because of Hα and Ca II H&K emission lines and by Verma et al. (1983) because of a strong infrared excess. Scott et al. (1992) performed a Fourier analysis of photometric observations collected over a 800-day interval. They found a fundamental and a second harmonic frequency corresponding to photometric periods of 89 and 44.57 days, respectively. The present observations were obtained over the 14-29 February interval. They cover only a small part of the light curve and are shown in Fig. 16, where the photometric period of 44.57 days was used for phase computation. Houk (1978) classified HD 86005 as K2 III, recording the possibility that the star is indeed a close double. Randich (1997) confirmed that the lines profiles in the Li I 6708 Å region are consistent with those of a close binary. Pallavicini et al. (1992) and Randich et al. (1993) reported a very low Li abundance and a $v \sin i$ in the $25 - 28$ km s^{-1} range. This leads to a minimum stellar radius in the $44 - 49$ $R_{\odot}$ or in the $22 - 25$ $R_{\odot}$ range, by using the 89-day or the 44.57-day period, respectively. Cutispoto (1998) noted that these values of the radius appear too large for luminosity class III stars, although the high value of the $v \sin i$ could be due to a partial merging of the lines of the two components. There are several combinations that can reproduce the observed colors of HD 86005, but only the systems K4 III + K1 III and K4 III + G3 IV/III could give origin to a composite spectrum. The corresponding photometric distances result in 316 parsec and 292 parsec, respectively.

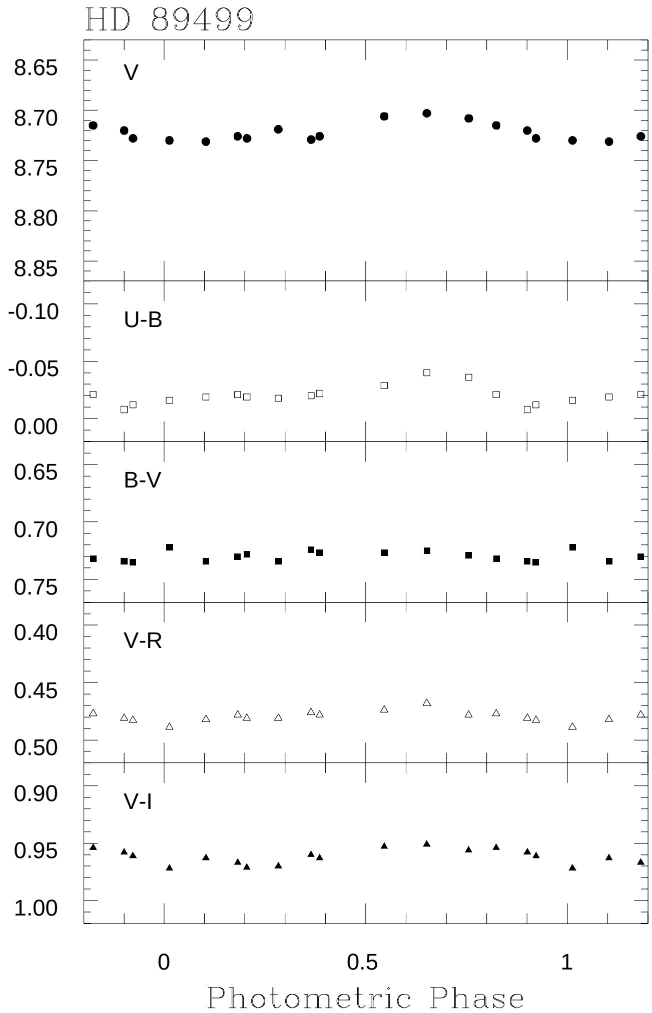

Fig. 17. HD 89499 V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 5.574 · E

The Hipparcos satellite inferred a minimum distance of about 650 parsec, so that it is likely that both components of HD 86005 belong to the III/II luminosity class, in agreement with the very high values of the radii inferred above.

HD 89499 is a population II single line spectroscopic binary with an orbital period of 5.573974 days (Ardeberg & Lindgren 1991). It is, to date, the most metal-poor star known to have a corona, that was detected by the ROSAT (Ottmann et al. 1997) and by the ASCA (Fleming & Tagliaferri 1996) satellites. Unusually large Li abundance, [Fe/H] = −2.08 and a $v \sin i$ of 22 km s^{-1} were inferred by Balachandran et al. (1993). The first evidence for optical variability with a photometric period very close to the orbital one is given in this paper. The multicolor observations collected over the interval 14-29 February are shown in Fig. 17. The low amplitude single-peaked V-band light curve and the color variations are well correlated. The larger color amplitudes occur for the $U-B$ and the $V-I$ indices. The spectral classification, distance and evolutionary status of HD 89499 have been debated by several authors in the past (see the discussion and the references in Ardeberg & Lindgren 1991 and Balachandran et al. 1993). From the trigonometric parallax measured by the Hipparcos satellite a value of $M_V = 3.35^{+0.16}_{-0.18}$ is obtained, confirming that HD 89499 is an evolved star, in agreement with the minimum stellar radius of 2.4 $R_\odot$ resulting from the $v \sin i$ value and the stellar rotational period. The colors of HD 89499 are peculiar. In fact, the $V-R$ and $V-I$ agree well with those of a K star, the $B-V$ is typical of a middle G-type star while the $U-B$ indicates a F-G object. It is not possible to obtain a fit of such colors by assuming a binary system constituted by stars with normal colors. This could be due to the anomalous colors of the evolved pop II primary component or to the presence of a peculiar companion such as a WD.

HD 98712 = SZ Crt is a BY Dra-type variable whose coronal emission has been detected by the ROSAT satellite (Hempelmann et al. 1995). It is a visual binary (ADS 8138) whose primary component shows a variable Hα line that has been observed sporadically in emission (Torres et al. 1985; Bopp 1987), while the secondary component shows strong Hα emission (Torres et al. 1985). The presence of optical variability was first reported by Torres et al. (1985), further observations have been collected by Cutispoto (1993, 1996, 1998). The observations presented in this paper were obtained over the 14-25 February interval and are shown in Fig. 18, where phases have been reckoned from the 11.58-day photometric period computed by Torres et al. (1985). Due to the angular distance of about 4$''$.52 both components were always observed simultaneously. The light curve has a low amplitude and clear color variation are visible only for the $V-I$ and the $U-B$ indices, the latter showing a clear double-peaked modulation. The spectral classification K7 V + M2/3 V results in reasonable agreement with the observed colors and the distance measured by the Hipparcos satellite.

SAO 202618 = V 858 Cen is the optical counterpart of a serendipitous X-ray source discovered by the EXOSAT satellite (Giommi et al. 1991). It has been previously studied by Cutispoto et al. (1991), who discovered photometric variability with a period of 1.042 days, and by Cutispoto et al. (1996) who found SAO 202618 to be an eclipsing binary with an orbital period of 1.04303 days. Low Li abundance and a $v \sin i$ of 50 km s^{-1} were reported by Tagliaferri et al. (1994). The observations collected over the 14-29 February interval are presented in Fig. 19. Comparing the present data with the previous photometric observations (cf. Fig. 5 in Cutispoto et al. 1991 and Fig. 10 in Cutispoto et al. 1996) the presence of large and evolving photospheric spotted regions is

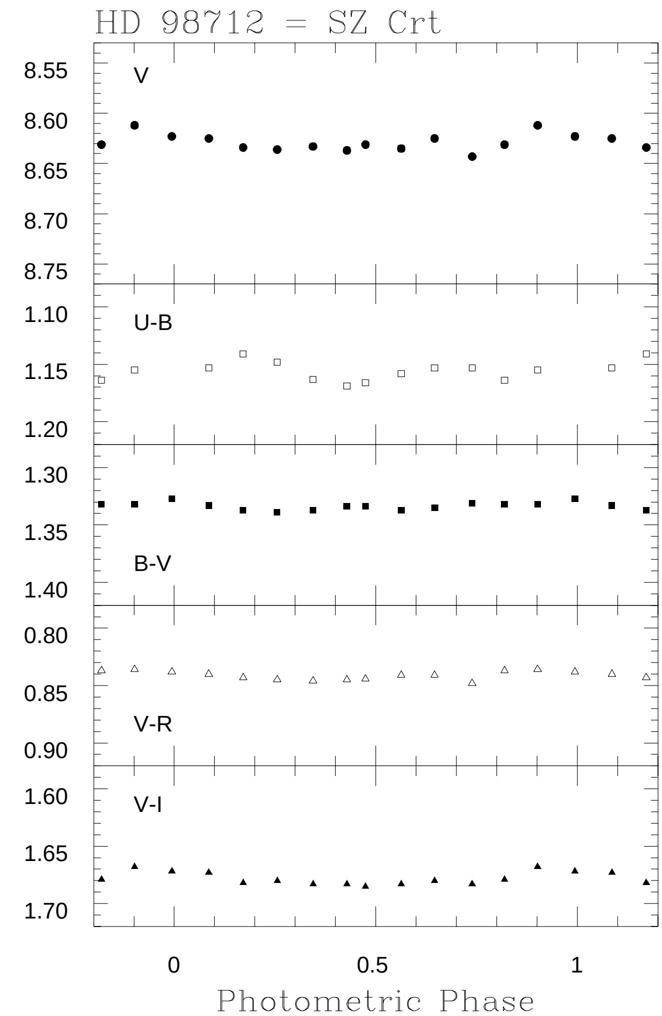

Fig. 18. HD 98712 = SZ Crt *V*-band light curve and colors. Phases are reckoned from the photometric ephemeris 2441389.0 + 11.58 · E (Torres et al. 1985)

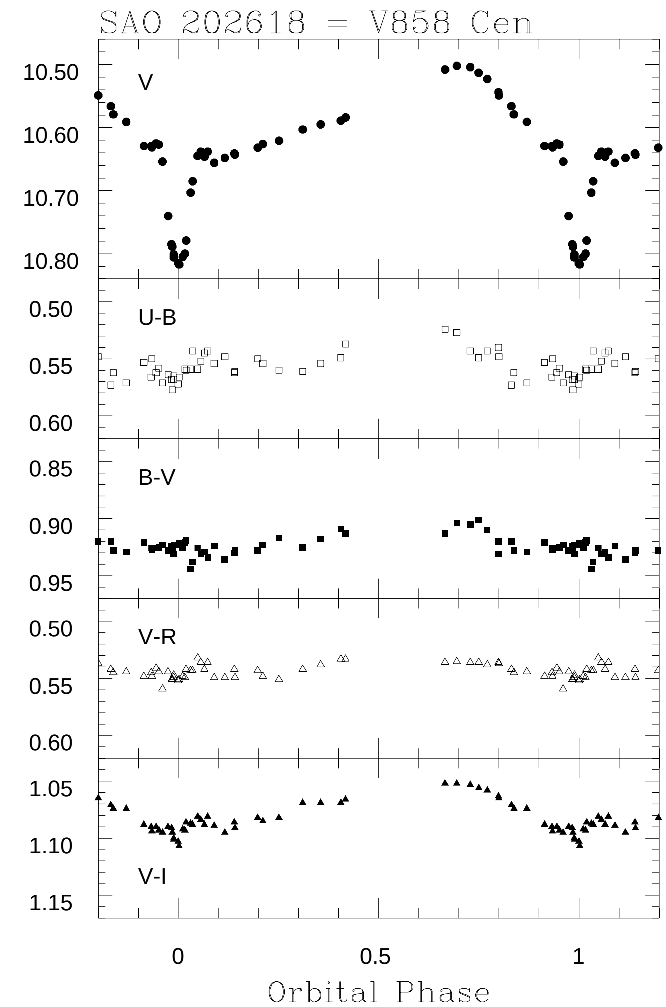

Fig. 19. SAO 202618 = V 858 Cen *V*-band light curve and colors. Phases are reckoned from the orbital ephemeris 2448666.324 + 1.04303 · E (Cutispoto et al. 1996)

discernible. Moreover, the spot's location has a remarkable influence on the depth of the primary eclipse and no secondary eclipse is seen. Tentative spectral classifications have already been given by Cutispoto et al. (1996), who noted how the observed colors can be fitted by several combinations of active stars. Unfortunately, no reliable trigonometric parallax is available for SAO 202618, so that no firm conclusion on the luminosity class of the primary component can be inferred. However, the present light curve has been fitted by using the *"Binary Maker 2.0"* program (Bradstreet 1993) and the best solution is obtained by assuming $i \simeq 85°$, a slightly evolved ($R \simeq 1.03\,R_\odot$) but heavily spotted K1 V/IV primary component and a middle-to-late M-type secondary star. For such a system an absolute magnitude $M_V = 5.64$ was computed, which, in turn, corresponds to a distance of about 94 ± 3 parsec.

HD 101309 = V 829 Cen is a SB2 system with an orbital period of 11.71 days (Balona 1987) that shows Ca II H&K and Hα emission lines (Collier et al. 1982). It has been detected during a microwave survey of active stars (Slee et al. 1987b) and by the ROSAT satellite (Dempsey et al. 1993). A rather high Li abundance in both components has been reported by Randich et al. (1993). The photometric variability, discovered by Lloyd-Evans & Koen (1987), has been later investigated by Collier Cameron (1987) and by Cutispoto (1993, 1996, 1998). The present observations were collected over the 14-29 February interval and are presented in Fig. 20, where the 11.65-day photometric period, inferred independently by Lloyd-Evans & Koen (1987) and by Cutispoto (1993), was used for phase computation. The strongly asymmetric light curve is single-peaked. Clear $V - I$ and $U - B$ color variations, in phase and almost anticorrelated, respectively with the *V*-band modulation are present. The maximum *V*-band luminosity is about 0.035 fainter

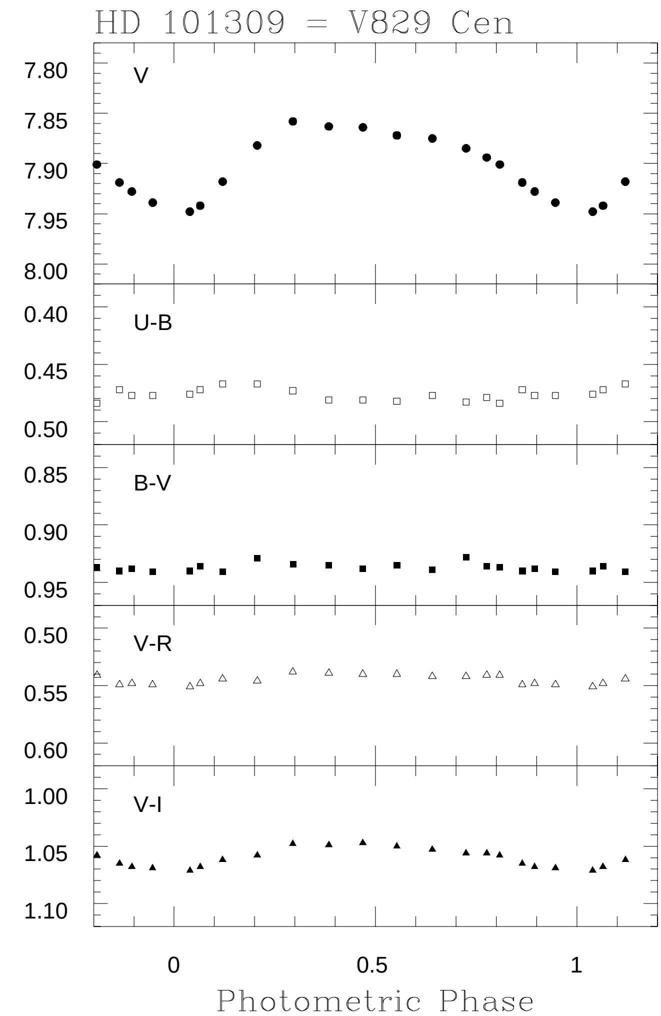

Fig. 20. HD 101309 = V 829 Cen V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448331.5 + 11.65 · E (Lloyd-Evans & Koen 1987)

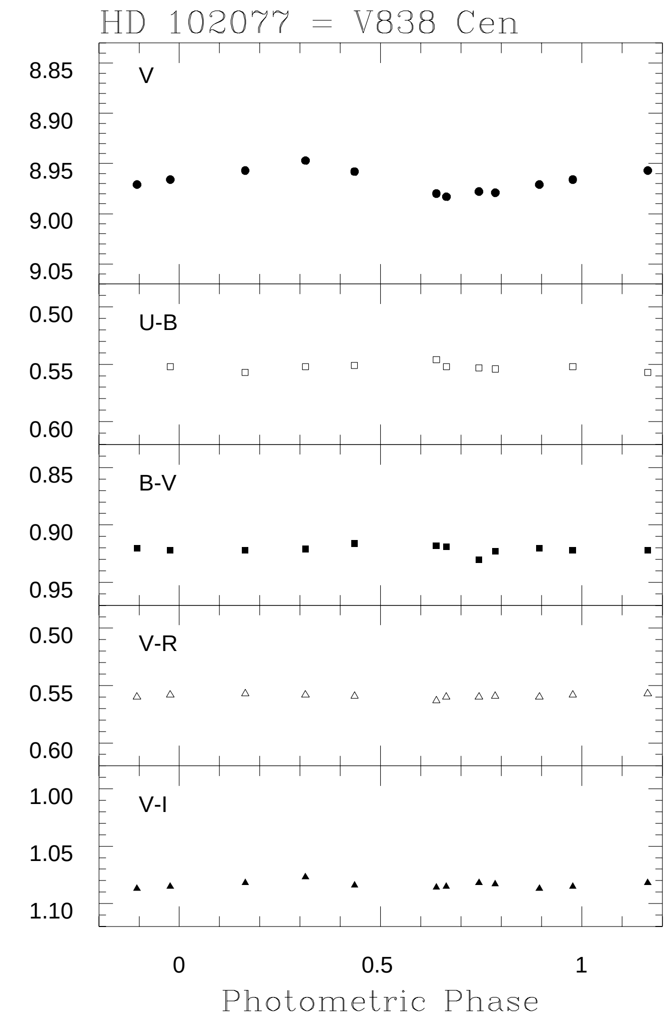

Fig. 21. HD 102077 = V 838 Cen V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 1.848 · E (Cutispoto 1998)

than the brightest luminosity ever observed (cf. Fig. 11 in Cutispoto 1998). The colors are consistent with those of a K1 IV + G5 V active system, in perfect agreement with the spectral classification listed by Collier et al. (1982). The corresponding photometric parallax results in very good agreement with the distance measured by the Hipparcos satellite. Assuming a photospheric temperature of 4750 K (Randich et al. 1993) the radius of the subgiant component results in $5.2 \pm 0.1\,R_{\odot}$. Balona (1987) and Randich et al. (1993) evaluated the $v \sin i$ to 15 and 20 km s^{-1}, respectively. Hence, the values of the inclination results in the range $41^\circ \leq i \leq 64^\circ$, and is consistent with the circumstance that no eclipses are observed.

HD 102077 = V 838 Cen is a close visual binary that shows moderate Ca II H&K emission lines and a filled-in Hα line (Bopp et al. 1986). Its photometric variability was first reported by Udalski & Geyer (1985a). Further photometry has been collected by Bopp et al. (1986); Cutispoto (1990, 1993, 1996, 1998) and by Anders et al. (1991). The observations presented in Fig. 21 were obtained over the 14-29 February interval. Phases have been computed by using the 1.848-day photometric period inferred by Cutispoto (1998). Both components were always observed simultaneously. The low-amplitude light curve is single-peaked and the color curves are almost flat. Turon et al. (1992) list HD 102077 as consisting of two almost identical ($\Delta V = 0.1$) stars about $0\farcs2$ apart, leading Cutispoto (1998) to classify HD 102077 as a K1/2 V + K2 V system with active components. However, in the Hipparcos satellite catalogue a separation of about $0\farcs43$ and a magnitude difference of $\Delta H_{\rm p} = 1.29$ are given. The colors of HD 102077 are also very well matched by those of a K0/1 V + K5 V system with active components. This solution, that was not reported by Cutispoto (1998) because of the magnitude difference between the two components $\Delta V \simeq 1.35$), seems in better agreement with

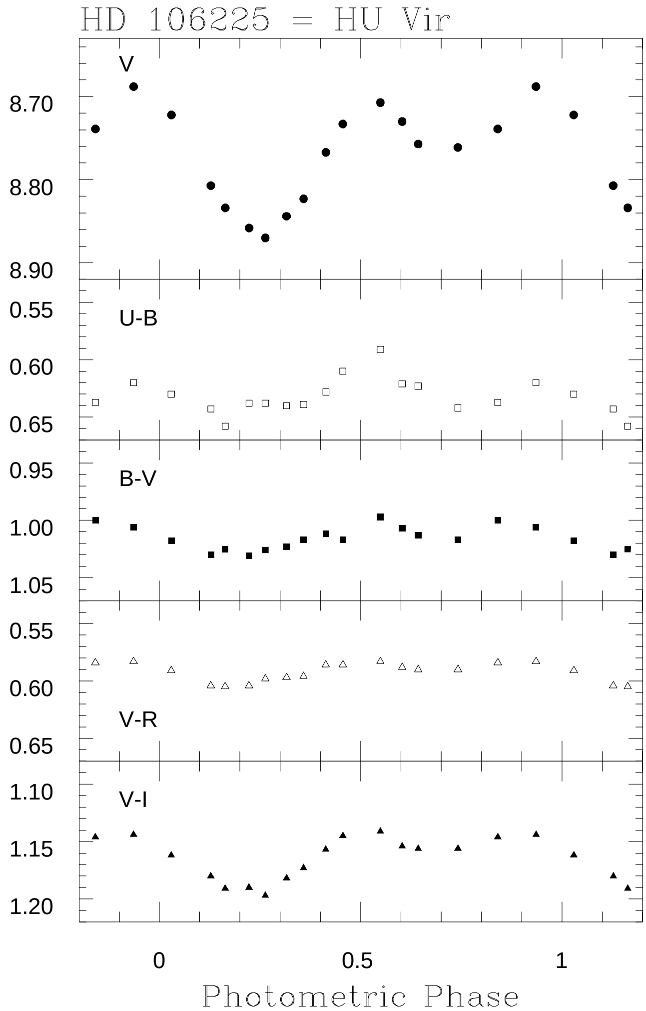

Fig. 22. HD 106225 = HU Vir V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448331.5 + 10.424 $\cdot$ E (Strassmeier et al. 1997)

the K0/1Vp classification of the composite spectrum given by Houk (1978). Its photomteric parallax results in 42 parsec, in good agreement with the value measured by the Hipparcos satellite that falls in the 44−55 parsec range.

HD 106225 = HU Vir is a SB1 spectroscopic binary with an orbital period of 10.38758 days (Strassmeier 1994) showing very strong Ca II H&K emission lines (Montes et al. 1996) and a variable Hα line (Strassmeier 1994). It has been detected in a radio survey of RS CVn-type systems (Morris & Mutel 1988; Drake et al. 1989) and a huge X-ray flare, lasting about two days, was observed by the ROSAT satellite (Endl et al. 1997). For a detailed study of the physical parameters of HD 106225 see Strassmeier (1994). The optical variability has been investigated by several authors in recent years (see Strassmeier et al. 1997, 1993; Cutispoto 1996, 1998; Hall & Henry 1992 and references therein). The observations presented here were obtained over the 14-29 February interval and are shown in Fig. 22, where phases are computed by using the 10.424-day photometric period inferred by Strassmeier et al. (1997). The light curve is double-peaked and large amplitude color variations, showing the star redder at both light minima, are present. It is interesting to note that the primary maximun in the $U-B$ color curve corresponds to the secondary maximum in the V-band curve. The collection of the available photometry of HU Vir, that spans over a baseline of about 14 years, is shown by Strassmeier et al. (1997). The present data complete the information about the light curve shape and maximum luminosity in early 1992 and were obtained just before a remarkable light curve amplitude increase (cf. Fig. 14 in Strassmeier et al. 1997). The colors agree well with those of an active K1 IV or K1 IV/III star, in good agreement with the results by Strassmeier (1994). However, it is now possible, from the results obtained by the Hipparcos satellite, to better constrain the luminosity class of the primary component of HD 106225. In fact, the trigonometric parallax is not consistent with a luminosity class IV/III star and clearly points to a K1 IV classification.

HD 116544 = IN Vir is an SB1 system identified as the optical counterpart of a serendipitous X-ray source discovered by the EXOSAT satellite (Giommi et al. 1991), that was also detected as a radio source by Slee et al. (1987b). Cutispoto et al. (1996) discovered photometric variability with a period of about 8 days. Weak-to-moderate Li abundance and a $v\sin i$ of 22 km s^{-1} were reported by Tagliaferri et al. (1994). From a detailed study Strassmeier (1997) inferred an orbital period of 8.1895 days, a $v\sin i$ of 24 km s^{-1}, a K2/3 IV spectral classification and a photospheric temperature of 4600 K. The observations collected over the 14-29 February interval are presented in Fig. 23, where phases are reckoned from the 8.40 $\pm$ 0.15 days photometric period inferred by a Fourier analysis of the VRI data. The light curve is single-peaked and presents an almost flat maximum. Large amplitude color variations, almost in phase with the V-band modulation, are seen. The collection of the available photometry of IN Vir, that spans over a baseline of about 6.5 years, is shown by Strassmeier et al. (1997). The present data contribute to the information about the light curve shape and amplitude evolution (cf. Fig. 18 in Strassmeier et al. 1997) and photometric period variability. Tentative spectral classifications have been given by Cutispoto et al. (1996) and by Tagliaferri et al. (1994). From the results by Amado & Byrne (1997) it is now clear that no contribution from a hot secondary companion is needed and the observed colors can be fitted by those of an active K3/4 IV star. Such a classification differs by only one subclass from the one inferred by Strassmeier (1997). However, the distance of HD 116544 measured by the Hipparcos satellite results in the 97−136 parsec

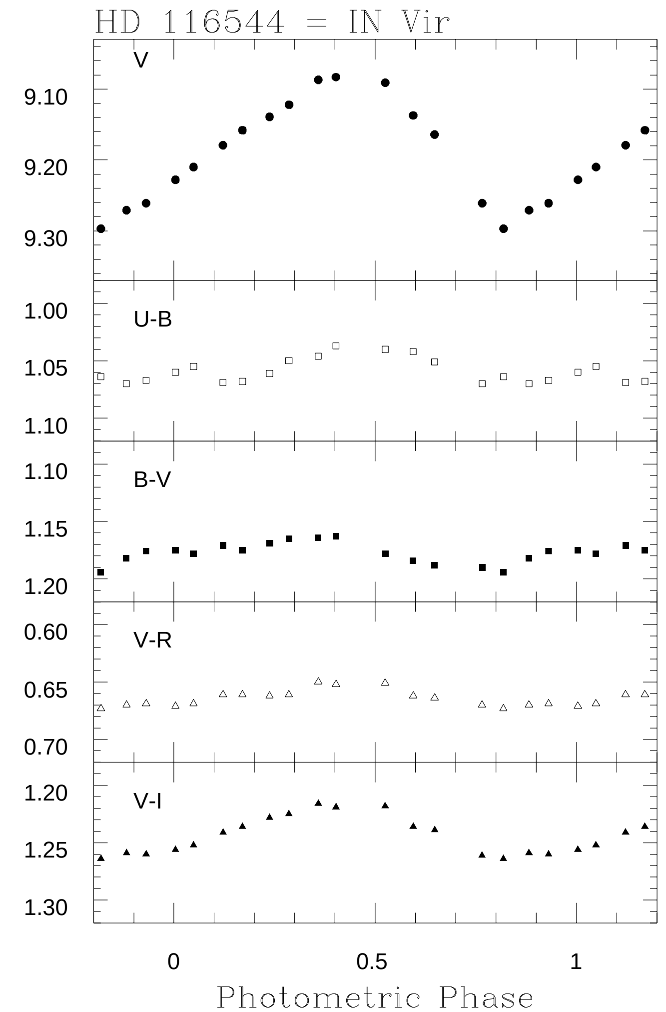

Fig. 23. HD 116544 = IN Vir V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 8.40 $\cdot$ E

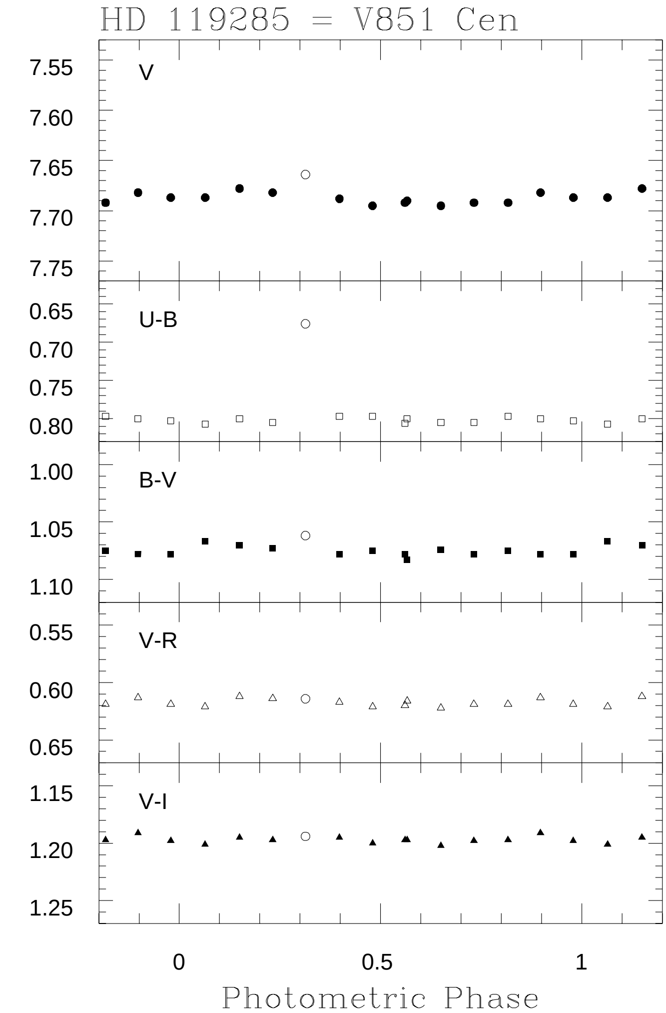

Fig. 24. HD 119285 = V 851 Cen V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 12.05 $\cdot$ E (Lloyd Evans & Koen 1987). The flares data are represented by the symbol ($\circ$)

range and, corresponding to an absolute magnitude in the 4.15−3.4 range, seems in better agreement with a luminosity class IV/V. The above values lead to compute the radius of the primary component in the $2.9 - 4.3\ R_\odot$ range and $i \geq 62° \pm 6°$, still in agreement, within the errors, with the 60° value obtained by Strassmeier (1997).

HD 119285 = V 851 Cen is an SB1 system with an orbital period of 11.9886 days (Saar et al. 1990) that has been studied by several authors in recent years (see Saar et al. 1990; Cutispoto 1993, 1996, 1998 and references therein). It has been also detected by the ROSAT satellite (Pye et al. 1995) and quite high Li abundance has been reported by Randich et al. (1993) and by Saar et al. (1990). The optical variability was first discovered by Udalki & Geyer (1984) and by Lloyd-Evans & Koen (1987). The data presented in Fig. 24 were collected over the 14-26 February interval. The 12.05-day photometric period reported by Lloyd-Evans & Koen (1987) was used for phase computation. The V-band and color curves are almost flat. A flare event occurred at HJD = 2448675.8241, as clearly visible from the plot of the $U - B$ color. A collection of the available photometry of HD 119285 was presented by Cutispoto (1998). The present data show the star to be about 0.05 magnitudes fainter in the V-band than the maximum luminosity observed in early 1990. A luminosity class IV or IV/V for the primary component of HD 119285 was deduced by Cutispoto (1996) and the colors are consistent with those of an active K3 IV/V or K2/3 IV star. The trigonometric parallax obtained by the Hipparcos satellite leads to compute an absolute magnitude ($M_V = 3.22$) that seems in better agreement with the K3 IV/V classification. Adopting a photospheric temperature of 4650 K (Randich et al. 1993) and the $v \sin i$ value reported by Saar et al. (1990), the radius of the primary component and the

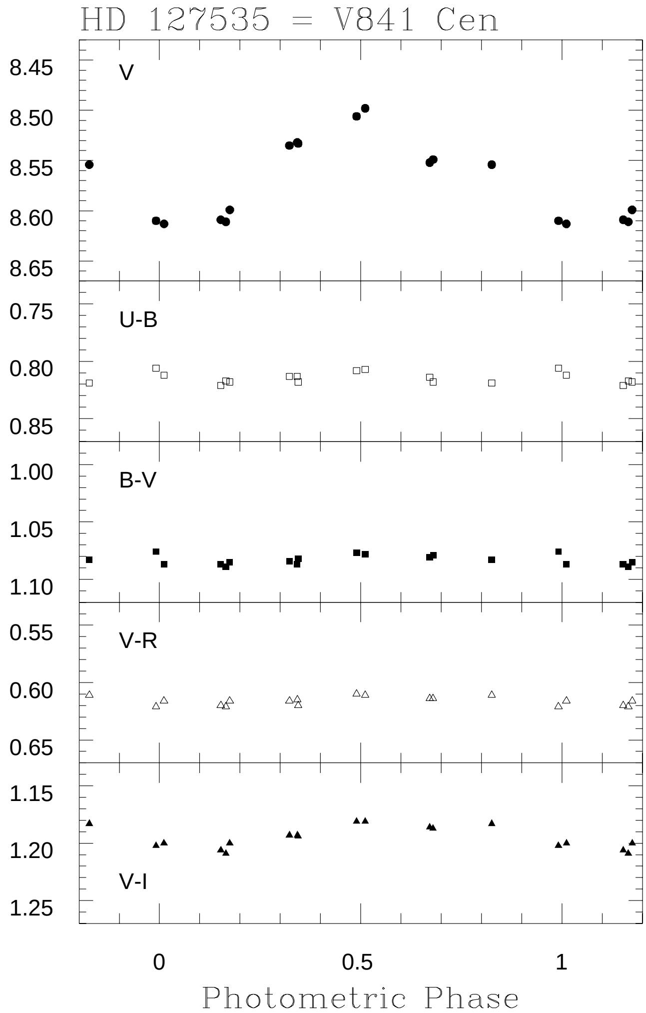

Fig. 25. HD 127535 = V 841 Cen V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 5.929 · E (Cutispoto 1990)

inclination angle are $R \simeq 4.0\,R_{\odot}$ and $i \simeq 23°$, respectively.

HD 127535 = V 841 Cen is an SB1 system with an orbital period of 5.998 days (Collier 1982b) showing strong Ca II H&K and Hα emission lines (Houk & Cowley 1975; Weiler & Stencel 1979; Collier et al. 1982). It was detected at radio (Innis et al. 1985; Slee & Stewart 1989) and EUV (Pye et al. 1995; Mitrou et al. 1997) wavelengths. High Li abundance was reported by Randich et al. (1993). The photometric variability was discovered by Collier (1982a) and by Udalski & Geyer (1984). The observations obtained over the 14-29 February interval are shown in Fig. 25, where the 5.929-day photometric period given by Cutispoto (1990) was used for phase computation. The light curve is single-peaked and shows an almost flat region in the 0.65−0.85 phase interval. The low amplitude color variations show the star to be redder at light mimimum. The collection of the available photometry of HD 127535 was presented by Cutispoto (1998), the present data confirms a progressive decrease in the spottedness after the minimum luminosity observed during the 1985-87 interval. Cutispoto (1996) inferred a luminosity class IV for the primary component. The colors are consistent with those of an active K2/3 IV or K3 IV/V star. The trigonometric parallax obtained by the Hipparcos satellite leads to an absolute magnitude in the 4.71−6.02 range, that seems in better agreement with the K3 IV/V classification. Assuming a photospheric temperature of 4650 K (Randich et al. 1993) the radius of the primary component results in the $1.11 - 2.07\,R_{\odot}$ range. Two authors have computed the $v \sin i$ of HD 127535, obtaining very different values. Randich et al. (1993) report 33 km s^{-1}, a value that, implying a minimum radius of $3.86\,R_{\odot}$, is not consistent with the values reported above. On the other hand, De Medeiros et al. (1997) computed the much smaller 10 km s^{-1} value, that is consistent with any inclination angle in the $34° - 90°$ range.

HD 136905 = GX Lib is an SB1 binary that shows moderate Ca II H&K emission (Bidelman & MacConnell 1973; Strassmeier et al. 1994b), strong Hα absorption (Eker et al. 1995) and very low Li abundance (Randich et al. 1993). It was detected by the *Einstein* (Fleming et al. 1989; Gioia et al. 1990) and by the ROSAT (Dempsey et al. 1993) satellites. Its photometric variability is thought to be mainly due to ellipticity effects, on which distortions due to starspots are superimposed (Burke et al. 1982; Kaye et al. 1995 and references therein). In this paper the observations obtained over the 14-27 February interval are presented. The data are shown in Fig. 26, where the 11.13448-day orbital period deduced by Kaye et al. (1995) was used for phase computation. The light curve is double-peaked and clear color variations showing the star redder at minimum luminosity are present. It is interesting to note that the primary maximum in the $U - B$ color curve corresponds to the secondary maximum both in the V-band and in the other color curves. Comparing these data with previous observations (cf. Fig. 18 in Cutispoto 1998) an evolution of the light curve is evident, thus confirming the presence of large and evolving spotted regions. From the $v \sin i$ values computed by Randich et al. (1993) and by Favata et al. (1995) the minimum stellar radius results in the $7.7 - 9.7\,R_{\odot}$ range, suggesting a luminosity class III for the primary component, in agreement with the K1 III + [G-K V] classification given by Strassmeier et al. (1993) and the K1 III + F classification given by Bidelman & MacConnell (1973). Consequently, Cutispoto (1998) found that the two best fits of the observed colors assuming a class III primary component are given by the systems K1 III + G5 IV and K1/2 III + G0 IV with active components. On the other hand, the trigonometric parallax obtained by the Hipparcos satellite, that falls in the 87−105 parsec range, corresponds to an absolute magnitude in the 2.16−2.57 range, that is characteristic of a class IV star.

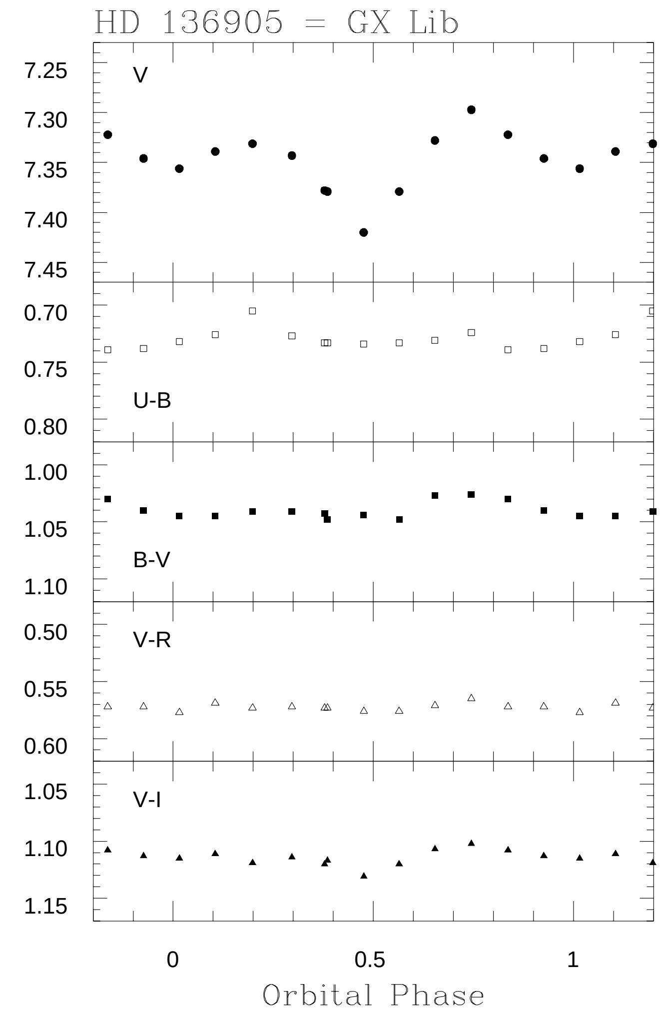

Fig. 26. HD 136905 = GX Lib V-band light curve and colors. Phases are reckoned from the spectroscopic ephemeris 2444678.4 + 11.13448 · E (Kaye et al. 1995)

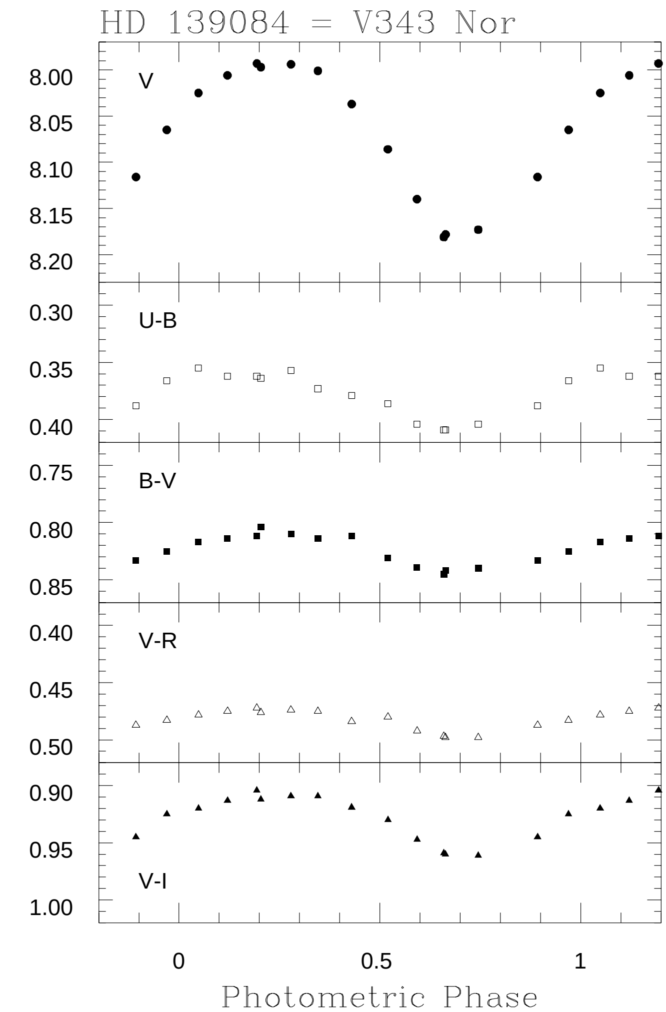

Fig. 27. HD 139084 = V 343 Nor V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 4.32 · E

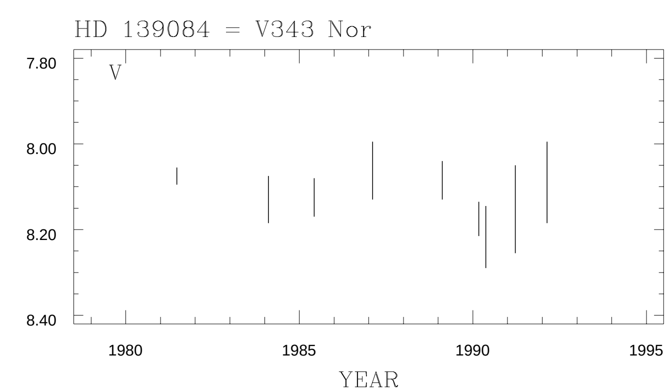

Fig. 28. HD 139084 = V 343 Nor V-band long-term variability. The vertical bars indicate the peak-to-peak amplitude of the light curve

In fact, the colors are very well matched also by those of a single active K2 IV star, whose radius results, assuming a photospheric temperature of 4600 K, in the $5.2 - 6.3\,R_{\odot}$ range.

HD 139084 = V 343 Nor is a very active single star (Balona 1987) belonging to the Pleiades group (Anders et al. 1991). It shows Ca II H&K emission (Bidelman & MacConnell 1973) and a filled Hα line (Bopp & Hearnshaw 1983). A very high Li abundance was observed by Anders et al. (1991) and Randich et al. (1993). HD 139084 was detected during microwave (Slee et al. 1987b) and EUV (Pye et al. 1995; Bowyer et al. 1996; Lampton et al. 1997) surveys. The presence of photometric variability was ascertained by Udalski & Geyer (1985b). The observations carried out over the 14-29 February interval are presented in Fig. 27, where phases have been reckoned from the 4.32 ± 0.09-day photometric period obtained from a Fourier analysis of the *VRI* data. The light curve is single-peaked and the remarkable color variations show the star to be redder at light minimum. As it can be seen from the collection of all the available photometry of HD 139084 in Fig. 28, the mean brightness has undergone noticeable changes. In particular, after the minimum luminosity observed in middle 1990 the star has reached the maximum luminosity already observed in early 1978. Cutispoto (1998) noted that an active K0 IV/V star fits well the observed colors, in agreement with the minimum stellar radius that results $R_{\rm min} \simeq 1.34\,R_\odot$. Consequently, taking also into account the very high Li abundance, HD 139084 was listed as a possible PMS star. The measurements made by the Hipparcos satellite confirm this result. In fact, the parallax of HD 139084 corresponds to an absolute magnitude in the 4.88−5.10 range, that is definitely brighter than the value expected for a K0 V star. The radius can then be computed in the $1.22 - 1.35\,R_\odot$ range and implies a value of the inclination angle $i \simeq 90°$.

SAO 121177 is an old disk SB1 active binary with an orbital period of 9.9429 days (Latham et al. 1988) that has been studied by several authors in the past (see for instance Pasquini & Lindgren 1994; Spite et al. 1994). Photometric observations have been reported by Ryan (1989) and by Latham et al. (1988). SAO 121177 was observed during two nights of the present run (13 and 14 February) and the mean color indices agree very well with the published ones. The two *V*-band observations differ by only 0.007 magnitudes, being their mean value 0.01 and 0.04 magnitudes fainter than the values reported by Latham et al. (1988) and by Ryan (1989), respectively. Hence, it is not possible at present to infer definitive conclusions about the photometric variability of this star. The mean colors can be reproduced by assuming a G9/K0 V + K7 V system with active components, a classification that is also in agreement with both the *V*-band magnitude difference between the two components (Pasquini & Lindgren 1994) and the distance measured by the Hipparcos satellite. Assuming synchronization between the orbital and stellar rotational periods and adopting the $v \sin i$ value reported by Fekel (1997), the radius of the primary component results in $R \geq 1.1\,R_\odot$, a value that is too high for a late-G dwarf. The reason of this inconsistent result deserves further investigation.

HD 154338 = V 991 Sco is the optical counterpart of a serendipitous X-ray source discovered by the EXOSAT satellite (Giommi et al. 1991). Cutispoto et al. (1991, 1996) ascertained photometric variability. Very high Li abundance and a $v \sin i$ of 30 km s^{-1} were reported by Tagliaferri et al. (1994). The observations presented in Fig. 29 were obtained over the interval 16-27 February, phases are reckoned from the 3.27-day photometric period computed by Cutispoto et al. (1996). The light curve is double-peaked, the color curves are in phase with the *V*-band modulation and noticeable light curve changes are evident with respect to previous observations (Cutispoto et al. 1991, 1996). The colors are consistent with those of a G5 V, of a G5 IV/V and of a G4/5 IV star. The corresponding distances result in 88, 128 and 184 parsec, respectively. However, from the $v \sin i$ value computed by Tagliaferri et al. (1994) the minimum stellar radius results in the $1.91 - 1.97\,R_\odot$ range, that better agrees with the luminosity class IV classification. Finally, the very high Li abundance (Tagliaferri et al. 1994) suggests that the large radius can be due to the fact that HD 154338 is still approaching the main-sequence.

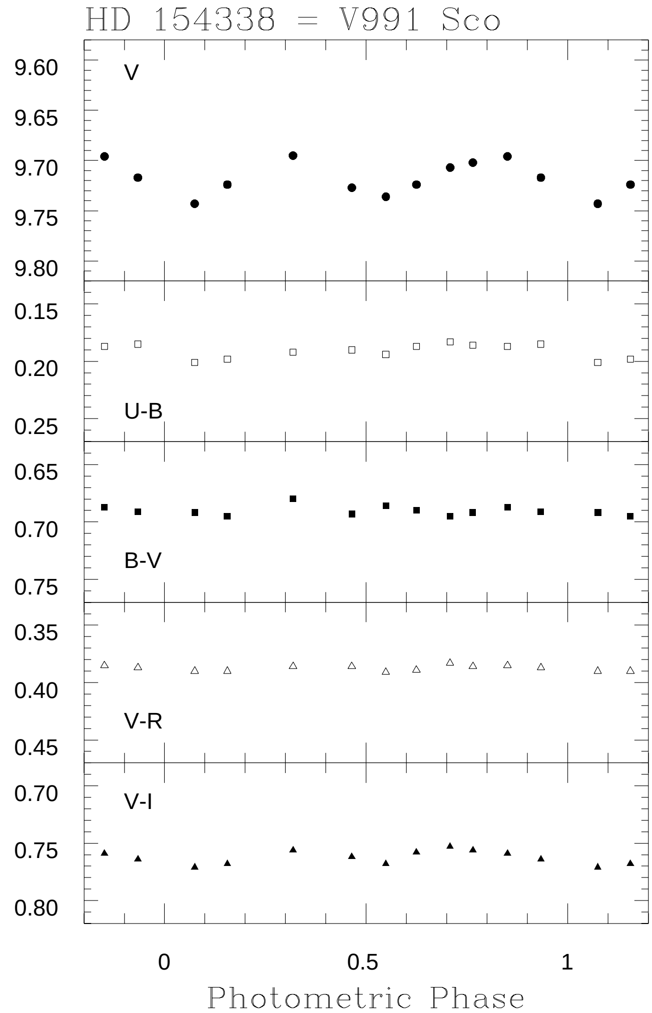

Fig. 29. HD 154338 = V 991 Sco *V*-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 3.27 · *E* (Cutispoto et al. 1996)

HD 155555 = V 824 Ara is a rapidly rotating SB2 binary that has been classified as a pre-main sequence star by Pasquini et al. (1991) and by Martin & Brandner (1995). Detection at EUV wavelengths has been obtained by the ROSAT (Pye et al. 1995; Lampton et al. 1977) and EUVE (Bowyer et al. 1996; Mitrou et al. 1997;

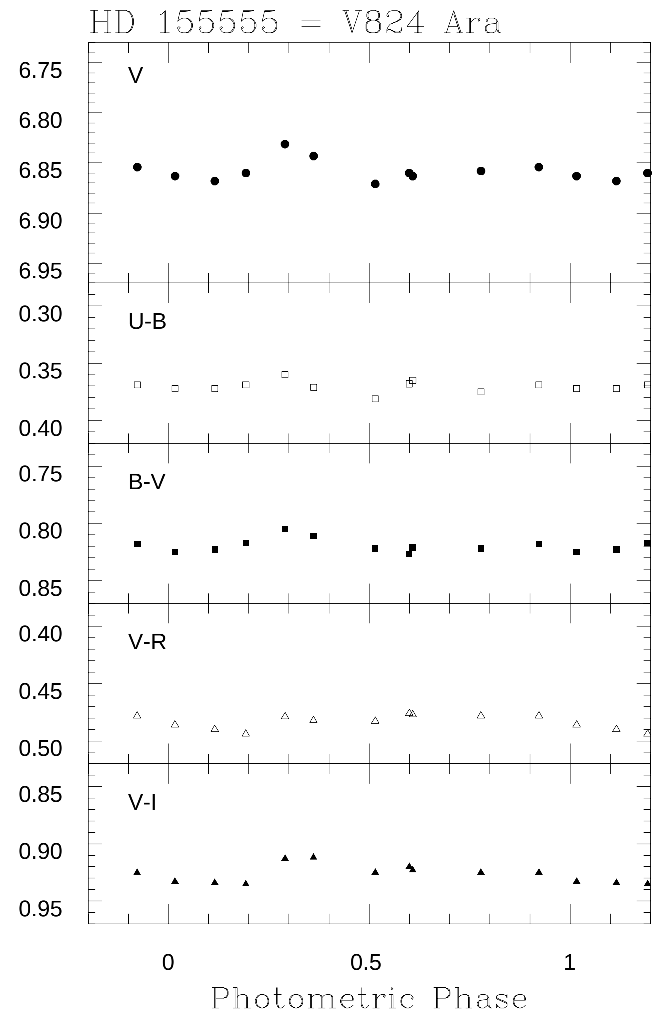

Fig. 30. HD 155555 = V 824 Ara V-band light curve and colors. Phases are reckoned from the photometric ephemeris 2448660.0 + 1.71 $\cdot$ E

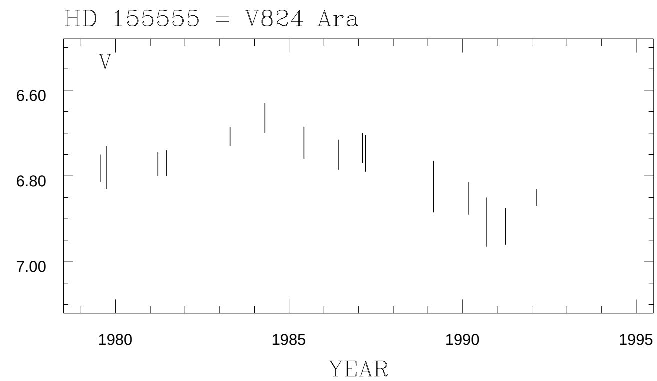

Fig. 31. HD 155555 = V 824 Ara V-band long-term variability. The vertical bars indicate the peak-to-peak amplitude of the light curve

Lampton et al. 1997) satellites. Photometric observations have been carried out from late 1979 by several authors (see Cutispoto & Leto 1997; Cutispoto 1996, 1998 and references therein). The observations presented in Fig. 30 were acquired over the 15-27 February interval. Any light contribution from the M4.5 V optical companion LDS587 B, that lies 32.″6 apart, was avoided. Phases have been reckoned from the 1.71 $\pm$ 0.01-day photometric period computed by a Fourier analysis of the VRI data. The light curve is double-peaked and exhibits the smallest amplitude ever observed for this star. The low-amplitude color variations are in phase with the V-band modulation and show the system to be redder at minimum luminosity. From the collection of all the available photometry of HD 155555 presented in Fig. 31, it seems that after the minimum luminosity attained in late 1990-early 1991 a decrease in the global degree of spottedness occured. A detailed study of the physical properties of HD 155555 was presented by Pasquini et al. (1991). More recently, an accurate determination of the $v \sin i$ of both components was obtained by Donati et al. (1997) and the measurements made by the Hipparcos satellite have given a very precise value of the distance. A good match of the observed colors is attained by assuming a G7 IV/V + K0 IV/V system with active components. In this case the luminosity class IV/V indicates that none of the two stars has reached the main sequence yet. Assuming $i = 55°$ (Pasquini et al. 1991), that corresponds to radii of $1.38\,R_\odot$ and $1.29\,R_\odot$ and photospheric temperatures of 5400 and 4900 K (Pasquini et al. 1991) for the G and K components, respectively, the distance of HD 155555 results in 3 $\pm$ 3 parsec, in good agreement with the value measured by the Hipparcos satellite.

HD 158394/5 = V 1017 Sco is the optical counterpart of a serendipitous X-ray source discovered by the EXOSAT satellite (Giommi et al. 1988). Cutispoto et al. (1991, 1996) detected photometric variability, whose nature is still unclear, and the occurrence of flare-like events. Moderate Li abundance and a $v \sin i$ of 15 km s^{-1} were reported by Tagliaferri et al. (1994). The presence of Hα emission is reported by Tagliaferri (1998). The photometric observation of HD 158394/5, obtained over the interval 14-26 February, shows the star to be constant with a mean magnitude ($V = 8.38$) that is close to the faintest value ever observed (Cutispoto et al. 1996). HD 158394/5 has been classified as G8 III: + A2 V by Houk (1982). However, as already noted by Cutispoto et al. (1996), such a system is very far from reproducing the observed colors, that are instead well matched by a K3 III + A5 V binary. The resulting photometric distances are 391 and 358 parsec for the two systems, respectively. The Hipparcos satellite measured the distance of HD 158394/5 to fall in the 207-402 parsec

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