A&A 367, 910–930 (2001)
DOI: 10.1051/0004-6361:20000549

Astronomy & Astrophysics

Long-term monitoring of active stars*,**

IX. Photometry collected in 1993

G. Cutispoto[1], S. Messina[1], and M. Rodonò[1,2]

[1] Catania Astrophysical Observatory, v. S. Sofia 78, 95125 Catania, Italy
e-mail: sme@sunct.ct.astro.it

[2] Department of Physics and Astronomy, Catania University, v. S. Sofia 78, 95125 Catania, Italy
e-mail: mrodono@alpha4.ct.astro.it

Received 25 October 2000 / Accepted 15 December 2000

Abstract. As a part of an extensive program focused on the global properties and evolution of active stars, high-precision $UBV(RI)_c$ and UBV photometry of 31 selected stars is presented. The $UBV(RI)_c$ observations were collected at the European Southern Observatory over the 31 December 1992–18 January 1993 and the 20 November–3 December 1993 intervals. Additional UBV photometry obtained by the "Phoenix" and by the Catania Astrophysical Observatory Automatic Photoelectric Telescopes from 1990 to 1993 is also presented for some of the program stars. 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. These observations are finalized to the construction of an 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: late-type – stars: pre-main sequence – stars: variables – X-ray: stars

1. Introduction

Photospheric inhomogeneities as cool starspots are one of the most typical features of stellar activity. Their visibility on the stellar projected disk is modulated by stellar rotation, and produces periodic or quasi-periodic light variation typically in the 0.1–0.2 magnitude range (cf. Rodonò 1992a, 1992b and references therein). In most cases multicolour photometry shows a reddening of the star at luminosity minimum (i.e. the light curve amplitude decreases at longer wavelengths), thus supporting the cool starspot hypothesis. However, anticorrelation of the $U-B$ and $B-V$ colour indices compared to the V-band light modulation has been observed for some stars such as V711 Tau, TW Lep, CC Eri, V1321 Ori, V829 Cen and UX Ari (Cutispoto 1992, 1998a, 1998b; 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. Such monitoring program was started at Catania Astrophysical Observatory in the early sixties for a few stars, and it is now continuing on a selected sample of about 50 stars by using the 0.8-m Automatic Photoelectric Telescope (APT) of Catania Astrophysical Observatory on Mt. Etna (Italy) and the 0.25-m "Phoenix" APT of Franklin & Marshall College at Washington Camp. (AZ, USA). The 0.5-m and 1.0-m telescopes of the European Southern Observatory (ESO, La Silla, Chile) were also used until December 1996. Our monitoring program aims to acquire an adequate time-extended database, that is essential in order to investigate fundamental topics such as the evolution of spotted areas and spot lifetimes, the presence of photospheric differential rotation

Send offprint requests to: G. Cutispoto,
e-mail: gcutispoto@alpha4.ct.astro.it

* Based on data collected at the European Southern Observatory, La Silla, Chile.

** Tables and the complete data set 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/cgi-bin/qcat?J/A+A/367/910

Table 1. Program star (v), Mean epoch of observation (1900.0 +), comparison (c) and check (ck) stars, standard deviations (in millimagnitudes) for the $v-c$ (σ_v) and $ck-c$ (σ_{ck}) V-band differential magnitudes for each series of N nights, peak-to-peak (ΔV) amplitude of the V-band light curve (in magnitudes) and period (P) of variability

Program star (v)		Epoch	Comparison (c)	Check (ck)	σ_v	σ_{ck}	N	ΔV	P (days)
HD 7172		93.02	HD 7270	HD 7629	22	5	13	.07	3.15
		93.91	HD 7220	HD 7629	15	6	12	.05	3.20
HD 8357	= AR Psc	90.83	HD 7446	HD 7918	33	7	14	.09	12.56
		91.82			21	6	11	.07	12.14
		92.00			39	6	11	.11	12.20
		92.85			18	5	20	.06	12.26
		93.03			30	6	17	.09	12.38
		93.87			29	5	28	.09	12.19
HD 8358	= BI Cet	93.02	HD 8405	HD 8615	26	5	13	.09	0.5195
		93.99			18	10	8	.05	0.5314
HD 16157	= CC Eri	93.02	HD 16371	SAO 215945	23	7	11	.07	1.56145
		93.91			27	5	11	.08	1.56145
SAO 130113	= BY Cet	92.98	SAO 130102	HD 16708	38	4	17	.12	2.60
		93.97		HD 16619	30	6	15	.09	2.61
HD 17925	= EP Eri	93.02	HD 18511	HD 18183	4	2	7	.01	–
HD 20629	= XX Ari	92.99	HD 21335	HD 20512	37	4	26	.11	2.4997
		93.94		HD 22072	37	10	11	.11	2.4997
HD 26354	= AG Dor	93.02	HD 26779	HD 27274	10	5	11	.03	2.533
HD 32918	= YY Men	93.02	HD 33763	HD 33747	60	3	15	.17	9.5476
1E 0505-0527	= EZ Eri	93.02	HD 33725	HD 34673	14	4	8	.04	9.08
HD 293857		93.02	HD 33725	HD 34673	5	4	7	.01	–
HD 34802	= YZ Men	93.02	HD 34297	HD 33563	32	5	15	.09	19.310
HD 35850		93.02	HD 36379	HD 35591	2	2	4	–	–
EXO 0527-3329	= UX Col	93.02	SAO 195800	HD 35322	24	7	14	.10	2.29
HD 36705	= AB Dor	93.02	HD 35230	HD 36316	8	5	8	.03	0.51479
EXO 0532-0510	= V1321 Ori	93.02	HD 294257	HD 36560	58	6	16	.18	5.7
HD 37824	= V1149 Ori	90.92	HD 37741	HD 38529	50	7	19	.13	49.13
		91.15			36	8	14	.11	49.13
		91.86			62	7	22	.19	49.07
		92.80			69	10	19	.22	50.81
		93.01			42	10	31	.16	50.81
		93.83			42	7	26	.15	54.23
		94.06			38	7	20	.13	54.23
HD 37847	= TW Lep	93.02	HD 37653	SAO 170680	20	4	11	.05	28.22
HD 39917	= SZ Pic	93.02	HD 39901	HD 39962	42	5	12	.15	4.905
EXO 0556-3804	= TY Col	93.02	HD 40865	HD 39601	20	5	13	.06	3.82
HD 61245	= V344 Pup	93.02	HD 61390	HD 60574	13	4	11	.05	11.761
HD 72688	= VX Pyx	93.02	HD 73089	HD 72673	4	5	9	.02	19.34
HD 78423		93.02	HD 77640	HD 78612	10	4	4	.03	?
HD 81410	= IL Hya	93.02	HD 81904	HD 80991	61	4	14	.19	12.90522
HD 82558	= LQ Hya	93.02	HD 82508	HD 82477	19	10	12	.07	1.63
HD 98712	= SZ Crt	93.02	HD 97977	HD 98251	9	7	11	.03	11.58
SAO 202618	= V858 Cen	93.02	HD 100912	HD 101679	21	5	13	.06	1.043602
HD 101309	= V829 Cen	93.02	HD 101679	HD 101614	30	3	15	.11	11.65
HD 106225	= HU Vir	93.02	HD 106270	HD 105796	44	4	13	.15	10.424
HD 119285	= V851 Cen	93.02	HD 119164	HD 119076	9	2	7	.03	12.05
HD 197481	= AU Mic	93.91	HD 197237	HD 197339	73	5	9	.22	4.865

and solar-like activity cycles and the time and/or spatial correlation between inhomogeneities at different atmospheric levels (see, among others, Cutispoto & Rodonò 1992; Lanza et al. 1998; Pallavicini et al. 1993; Kürster et al. 1994, 1997; Catalano et al. 1996; Schmitt et al. 1998; Messina et al. 1999; Rodonò et al. 2000). This paper reports on $UBV(RI)_{\rm c}$ data obtained by using the 0.5-m ESO telescope. Additional UBV data obtained with the Phoenix and Catania APTs for some of the program stars are also presented. The paper is organized as follows: the details on the equipment, observations and reduction procedures are given in Sect. 2, the results and the discussion on individual stars are presented in Sect. 3.

2. The observations

Most of the observations presented in this paper were obtained by one of us (GC) by using the 0.5-m ESO telescope. Additional data were obtained by the Phoenix and Catania APTs. Here we describe the equipment used, the observation and reduction procedures and give details on the quality of the data.

2.1. Observations with the 0.5-m ESO telescope

The observations at ESO were carried out from 31 December 1992 to 18 January 1993 (1993.02) and from 20 November to 3 December 1993 (1993.91). 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 $UBV(RI)_{\rm c}$ system, was used. 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 star measurement consisted of 10-15 1-s integrations in each filter. A complete observation cycle 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 then averaged to obtain one data point in each filter. The observations were corrected for atmospheric extinction and transformed into the standard $UBV(RI)_{\rm c}$ 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 periods are listed in Table 2. These coefficients were obtained about 1.5 and more than 2 years, respectively, after the 1991 eruption of Mt. Pinatubo. Comparing these data with the values obtained, with the same method and instrumentation, in March 1991 (cf. Table 2 in Cutispoto 1998a) and in February 1992 (cf. Table 2 in Cutispoto 1998b) a steady variation toward lower mean extinction values is evident. The transformation coefficients were inferred by observing E-region standard stars (Menzies et al. 1989). The typical error of the differential photometry with the 0.5-m ESO telescope is of the order of 0.005 magnitudes, with somewhat larger values (up to 0.01 magnitudes) in the U-band due to the lower photon counting level. The standard deviations for the $v-c$ (σ_v) and $ck-c$ (σ_{ck}) mean differential V-band magnitudes obtained over N nights are reported in Table 1. For each program star the brightest V magnitude and corresponding colours are listed in Table 3. The V magnitudes and colours of the comparison and check stars were obtained via standard stars (Menzies et al. 1989, 1991) and are given 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 Tables 3 and 4 is of the order of 0.01 magnitudes, with somewhat larger values (up to 0.02 magnitudes) for the $U-B$.

Table 2. Mean atmospheric extinction coefficients for La Silla site, obtained over the intervals 31 December 1992–18 January 1993 (1993.02) and 20 November–3 December 1993 (1993.91)

	Epoch	U	B	V	R	I
mag/airmass	1993.02	.522	.294	.203	.163	.117
mag/airmass	1993.91	.429	.210	.128	.088	.058

2.2. Observations with the Phoenix APT

The 0.25-m Phoenix APT (APTPH) has been in operation since 1983 and is managed by M. Seeds as a multi-user telescope (Boyd et al. 1984; Seeds 1995). It feeds a single-channel photon-counting photometer equipped with an uncooled 1P21 photomultiplier and standard filters matching the UBV system. Each measurement consisted of 10 s integrations in each filter for each target. A complete observation consisted in sequential $n-ck-s-c-v-c-v-c-v-c-s-ck$ measurements, where "n" is a bright navigation star and "s" is the sky background usually measured between the "c" and the "v" stars. From these data, after sky subtraction, three $v-c$ and two $ck-c$ differential magnitudes were computed; the $v-c$ and $ck-c$ values were finally averaged to obtain one data point in each filter. The observations were corrected for atmospheric extinction and transformed into the standard UBV system. The coefficients for these corrections are determined quarterly from *"standard-star nights"* (i.e. nights devoted to the observations of standard stars) data. Strassmeier & Hall (1988) have examined the data quality of the first four years of operation of APTPH and found external uncertainties for the differential photometry of the order of 0.028, 0.020 and 0.010 magnitudes for the U, B and V-band data, respectively. Henry (1995) verified the telescope's long-term stability.

2.3. Observations with the Catania APT

The 0.8-m Catania Observatory APT (APTCT) started operation late in 1992. It feeds a single-channel charge-integration photometer equipped with an uncooled Hamamatzu R1414 SbCs photomultiplier and standard filters matching the UBV system. Each measurement consisted of 10–15 s integrations in each filter according to the luminosity of the target. A complete observation consisted in sequential $n-ck-c-v-v-v-c-v-v-v-ck$ measurements. The sky background is measured at a fixed position near each star. From these data, after sky subtraction, six $v-c$ and two $ck-c$ differential magnitudes were computed; the $v-c$ and $ck-c$ values were finally averaged to obtain one data point in each filter. The observations were corrected for atmospheric extinction and transformed into the standard UBV system. The coefficients for these corrections are determined quarterly from *"standard-star nights"* data. The typical standard deviation for the averaged differential photometry is of the order of 0.015, 0.010 and 0.007 magnitudes for the U, B and V-band data, respectively.

Table 3. Maximum luminosity (V_m) and corresponding colours measured for the program stars at the given Epoch (1900.0+), inferred spectral classification (Spectral Type), distance measured by the Hipparcos satellite (D_H), photometric distance inferred from the adopted spectral classification (d_ph) and V-band maximum luminosity ever observed (V_max)

Program Star	Epoch	V_m	$U-B$	$B-V$	$V-R$	$V-I$	Spectral Type	D_H	d_ph	V_max
HD 7172	93.02	9.66	0.04	0.63	0.35	0.68	G2/3 V	>27	100	9.64
	93.91	9.64	0.05	0.63	0.34	0.68				
AR Psc	90.83	7.30	0.37	0.83			K1 IV/V + G5/6 V	45	46	7.24
	91.82	7.34		0.82						
	92.00	7.30	0.36	0.84						
	92.85	7.31	0.38	0.83						
	93.03	7.29	0.37	0.85	0.50	1.01				
	93.87	7.29	0.37	0.83						
BI Cet	93.02	8.18	0.16	0.71	0.42	0.85	G6 V/IV + G6 V/IV	66	65	8.08
	93.99	8.28	0.21	0.72						
CC Eri	93.02	8.82	1.12	1.37	0.88	1.85	K7 V + M3 V	11.5	11.5	8.70
	93.91	8.80	1.10	1.38	0.87	1.84				
BY Cet	92.98	9.54	0.28	0.78	0.48	0.94	G7 V + K5: V	>23	76	9.54
	93.97	9.59	0.29	0.79	0.48	0.94				
EP Eri	93.02	6.05	0.58	0.87	0.49	0.91	K0/1 V	10.4	10	6.00
XX Ari	92.99	7.34	−.41	−.05	−.01	−.03	B9 V SiCr	238	257	7.34
AG Dor	93.02	8.55	0.63	0.91	0.54	1.03	K1 V + K5 V	35	35	8.55
YY Men	93.02	7.99	0.70	1.04	0.58	1.14	K1 III	292	219	7.93
EZ Eri	93.02	10.17	0.53	0.91	0.51	1.00	K2 IV + G2 V		290	10.17
HD 293857	93.02	9.26	0.24	0.73	0.42	0.82	G7 V	53	61	9.26
YZ Men	93.02	7.75	0.78	1.09	0.61	1.17	K1 III	180	185	7.52
HD 35850	93.02	6.30	0.03	0.55	0.33	0.62	F8/9 V	26.8	29	6.29
UX Col	93.02	10.50	0.81	1.06	0.64	1.24	K3/5 PMS		>43	10.50
AB Dor	93.02	6.86	0.39	0.83	0.49	0.96	K0 V	14.9	15	6.75
V1321 Ori	93.02	10.62	0.85	1.25	0.74	1.45	K3 wTTS		500:	10.50
V1149 Ori	90.92	6.78	0.94	1.12			K2/3 III +F8 V	144	126	6.59
	91.15	6.80	0.92	1.13						
	91.86	6.77		1.12						
	92.80	6.75	0.94	1.13						
	93.01	6.75	0.94	1.14	0.63	1.18				
	93.83	6.81	0.96	1.14						
	94.06	6.80	0.96	1.13						
TW Lep	93.02	7.35	0.74	1.06	0.60	1.16	K2/3 III + F6 IV	170	177	7.27
SZ Pic	93.02	7.81	0.31	0.81	0.46	0.90	K0 IV/III + G3 IV/III	195	190	7.81
TY Col	93.02	9.56	0.17	0.69	0.42	0.82	G5 V PMS		>83	9.53
V344 Pup	93.02	6.89	0.82	1.04	0.56	1.06	K1 IV/III	111	102	6.85
VX Pyx	93.02	6.36	0.68	0.95	0.49	0.94	K0 III + F6 IV	131	117	6.32
HD 78423	93.02	7.82	0.00	0.04	0.01	0.03	A1/2 III:	345	334:	7.82
IL Hya	93.02	7.24	0.73	1.02	0.56	1.08	K1 III/IV + ?	120	119	7.20
LQ Hya	93.02	7.78	0.56	0.91	0.53	1.02	K2 V	18.3	18.5	7.77
SZ Crt	93.02	8.62	1.19	1.33	0.84	1.67	K7 V + M2/3 V	13.2	12	8.59
V858 Cen	93.02	10.52	0.54	0.90	0.54	1.08	K1 V/IV + M5:V		94	10.50
V829 Cen	93.02	7.80	0.48	0.92	0.54	1.05	K1 IV + G5 V	122	127	7.80
HU Vir	93.02	8.70	0.61	1.00	0.58	1.14	K1 IV + ?	125	170	8.55
V851 Cen	93.02	7.67	0.80	1.08	0.62	1.20	K3 IV/V	76	76	7.62
AU Mic	93.91	8.59	1.10	1.47	0.95	2.01	M1 Ve	9.9	7.6	8.59

3. Results

The present multicolour photometry has been used to investigate the light curves' evolution and to search for the presence of photospheric solar-like activity cycles. The periods of photometric variability were computed by a Fourier analysis and/or by fitting sine waves to the VRI-band data and searching for the minimum χ^2 (see Cutispoto et al. 1995 for further details). For several stars we detected variation of the photometric period. Cutispoto et al. (1996) developed a method, hereafter referred to as Active Stars Colours (ASC) method, to infer spectral classification from the observed colours. The ASC method was implemented by Cutispoto (1998a, 1998b), taking into account the effects of stellar activity on the $U-B$ index computed by Amado & Byrne (1997), and the luminosity calibration of the HR diagram obtained by Houk et al. (1997), Egret et al. (1997) and Gòmez et al. (1997). Although the ASC method is better suitable for statistical purpose, as

Table 4. V magnitude and colours for the *c* and *ck* stars obtained at ESO. Errors are of the order of 0.01 magnitudes. The symbol ":" denotes errors of the order of 0.02 magnitudes; the epochs of observation are given in Table 1

c or *ck*	V	$U-B$	$B-V$	$V-R$	$V-I$	*c* or *ck*	V	$U-B$	$B-V$	$V-R$	$V-I$
HD 7220	8.42	1.08:	1.13	0.57	1.08	HD 36560	8.26	−.35	−.08	−.03	−.08
	8.42	1.08:	1.13	0.57	1.08	HD 36316	7.95	1.74	1.46	0.79	1.51
HD 7446	6.04	1.05:	1.08	0.54	1.02	HD 294257	9.81	0.03	0.48	0.29	0.56
HD 7629	7.13	0.04:	0.31	0.18	0.36	HD 37653	8.24	0.50:	0.88	0.48	0.93
	7.14	0.05:	0.30	0.17	0.36	HD 37741	8.20	0.91:	1.07	0.57	1.06
HD 7918	8.01	1.02:	1.11	0.56	1.07	SAO 170680	8.96	0.91:	1.04	0.53	1.01
HD 8405	9.14	0.64	0.96	0.50	0.98	HD 38529	5.93	0.45:	0.77	0.42	0.76
HD 8615	8.88	0.81:	1.03	0.53	1.03	HD 39601	8.17	0.29	0.79	0.44	0.86
SAO 215945	9.73	−.03:	0.38	0.24	0.45	HD 39901	6.55	1.64:	1.37	0.70	1.32
	9.72	−.03:	0.38	0.21	0.45	HD 39962	7.97	−.05:	0.40	0.25	0.50
HD 16371	8.09	0.56:	0.90	0.48	0.93	HD 40865	8.62	0.06	0.63	0.36	0.70
	8.09	0.54:	0.90	0.47	0.93	HD 60574	6.53	0.56	0.92	0.49	0.95
HD 16619	7.82	0.14:	0.66	0.36	0.70	HD 61390	7.92	0.72	1.01	0.53	1.03
HD 16708	7.07	0.72:	1.01	0.53	1.02	HD 72673	6.38	0.35:	0.78	0.43	0.84
SAO 130102	10.11	0.08:	0.60	0.34	0.65	HD 73089	6.70	1.59:	1.38	0.71	1.37
	10.11	0.08:	0.60	0.33	0.64	HD 77640	6.82	−.19	−.05	−.03	−.06
HD 18511	6.52	0.82:	1.03	0.54	1.04	HD 78612	7.16	0.07	0.63	0.33	0.67
HD 18183	7.08	0.09:	0.33	0.21	0.41	HD 80991	8.50	0.83:	1.04	0.53	1.02
HD 20512	7.42	0.41:	0.79	0.44	0.85	HD 81904	8.02	0.71:	0.98	0.51	0.98
HD 21335	6.54	0.06:	0.17	0.10	0.21	HD 82477	6.13	1.18	1.19	0.62	1.17
HD 26779	8.58	1.26:	1.23	0.63	1.19	HD 82508	7.58	0.35	0.71	0.41	0.80
HD 27274	7.64	1.11:	1.12	0.68	1.22	HD 97977	8.85	1.67	1.42	0.75	1.43
HD 33563	7.53	−.04:	0.49	0.30	0.58	HD 98251	9.21	1.49	1.31	0.69	1.30
HD 33725	8.04	0.44:	0.80	0.44	0.84	HD 100912	8.63	0.44	0.93	0.51	1.02
HD 33747	8.76	0.74:	0.98	0.52	1.01	HD 101614	6.86	0.02	0.58	0.34	0.67
HD 33763	8.38	0.50:	0.89	0.48	0.94	HD 101679	8.11	0.81	1.09	0.59	1.15
HD 34297	7.33	0.07:	0.65	0.38	0.74	HD 105796	8.07	0.94:	1.06	0.56	1.05
HD 34673	7.77	0.93:	1.04	0.63	1.21	HD 106270	7.60	0.30:	0.73	0.41	0.78
HD 35230	7.58	0.48	0.88	0.48	0.93	HD 119076	6.87	0.90	1.16	0.61	1.15
HD 35322	8.42	−.03:	0.41	0.26	0.49	HD 119164	7.20	1.15	1.29	0.65	1.23
HD 35591	6.54	1.05:	1.09	0.55	1.01	HD 197237	9.00	0.83:	0.99	0.51	0.97
SAO 195800	9.17	0.37:	0.84	0.47	0.92	HD 197339	7.40	1.43:	1.30	0.66	1.23
HD 36379	6.94	0.03:	0.56	0.33	0.63						

shown by Metanomski et al. (1998), the last version can be successfully applied also for specific objects (see par. 3 in Cutispoto 1998b). We used our $UBV(RI)_{\rm c}$ photometry and, if available, the trigonometric distance ($D_{\rm H}$) listed in the Hipparcos satellite output catalogue (Perryman et al. 1997) to infer or further constrain the spectral classification of our targets (Table 3). We also present (Table 5) revised spectral classification for stars observed by our group in previous runs. For each star studied in this paper the photometric distance ($d_{\rm ph}$) was computed from the adopted spectral classification (see Tables 3 and 5) and compared, whenever possible, to $D_{\rm H}$. Due to the intrinsic dispersion of absolute magnitudes, errors in the photometric distances are of the order of 15–20%, with somewhat larger values for class IV and class III stars.

The results for the individual stars are now discussed.

HD 7172 = EXO 010919.0-2613.5 ($D_{\rm H} > 27$ pc) is a serendipitous X-ray source discovered by the EXOSAT satellite. It was studied by Cutispoto et al. (1996), who discovered low amplitude optical variability with a period of 3.10 ± 0.08 days, and by Tagliaferri et al. (1994). Here we revise the spectral classification to G2/3 V ($d_{\rm ph} = 100$ pc), which leads to an inclination angle (i) of about 57°. As already noted by Cutispoto et al. (1996), the ASC method gives also an alternative G1/2 IV ($d_{\rm ph} = 167$ pc; $i \sim 22°$) classification. From the January 1993 (Fig. 1) and November 1993 observations we infer photometric periods of 3.15 ± 0.04 and 3.20 ± 0.06 days, respectively. Significant modifications of the light curve shape and amplitude were also observed.

HD 8357 = AR Psc ($D_{\rm H} = 45^{+2}_{-2}$ pc) is an SB2 RS CVn-type variable whose orbital and photometric periods differ by about 17%. It has been studied at different wavelengths and shows the typical signatures of a very active system (see, among others, Montes et al. 1997; Mitrou et al. 1997; Fekel 1996; Cutispoto 1995, and reference therein). Its classification from the ASC method was revised by Cutispoto (1998b), and agrees quite well with the spectroscopic classification inferred by Fekel (1996). Here we present the observations we obtained at ESO in January 1993 and the data collected over the 1990–1993 period with the APTPH and the APTCT (see Tables 1 and 3). We note that changes in the photometric

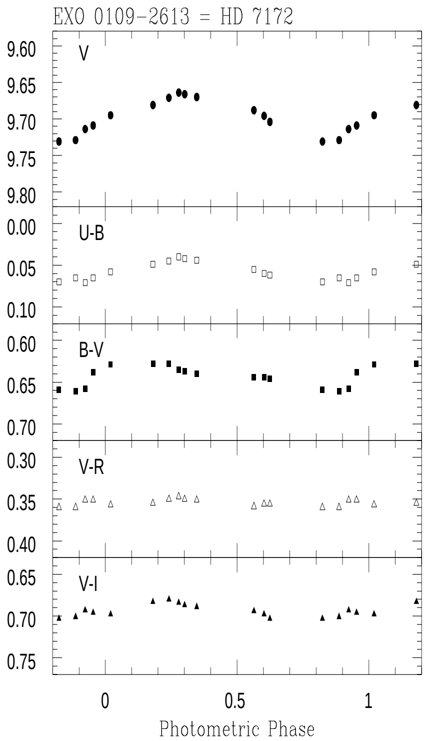

Fig. 1. HD 7172 V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448987.5 + 3.15 $\cdot E$

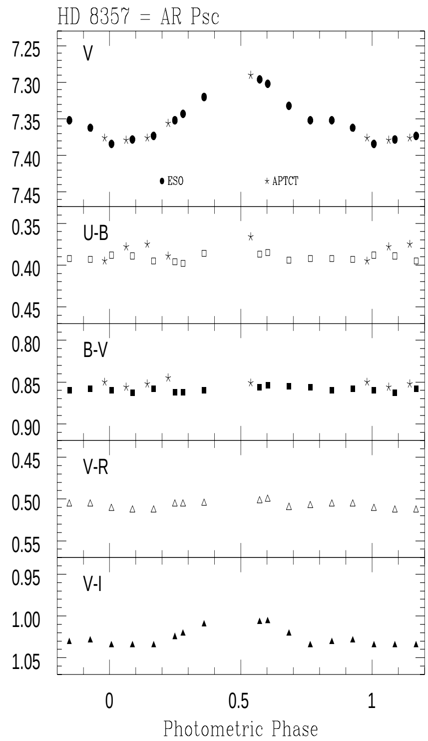

Fig. 2. HD 8357 = AR Psc V-band and colour light curves for the mean epoch 1993.03; phases are reckoned from the photometric ephemeris HJD = 2444453.0 + 12.38 $\cdot E$

period and in the shape of the light curve have occurred on timescales of the order of a few stellar rotations. A period of 12.38 ± 0.15 days was derived from the ESO and APTCT data (1993.03) shown in Fig. 2. A collection of the available photometry of AR Psc is shown in Fig. 3.

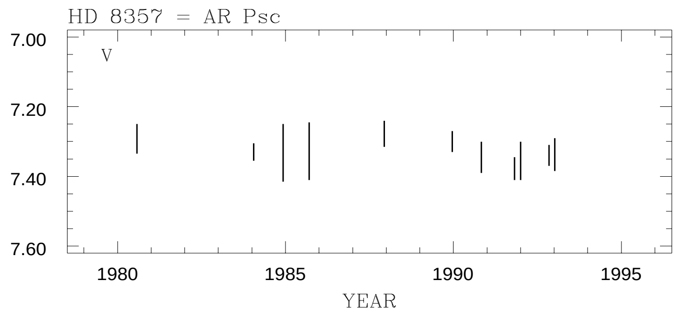

Fig. 3. HD 8357 = AR Psc V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

HD 8358 = BI Cet ($D_{\rm H} = 66^{+4}_{-4}$ pc) is a very active RS CVn-type system (see Cutispoto 1991 and reference therein) that has been detected by the ROSAT (Pounds et al. 1993; Pye et al. 1995) and EUVE (Malina et al. 1994) satellites. Our observations at ESO are shown in Fig. 4, where the data are folded by using the newly determined 0.5195 ± 0.0012 day photometric period. The light curve is double-peaked, a pattern that has been observed at least since late 1984 (Barksdale et al. 1985; Cutispoto 1990, 1991, 1995) suggesting that two long-living spot groups are present. Low amplitude colour variations are also observed. Further data were collected late in 1993 by the APTCT (see Tables 1 and 3). A collection of the available photometry of BI Cet is shown in Fig. 5. The maximum luminosity, that has been monotonically decreasing since late 1982, appeared about 0.1 magnitude brighter in early in 1993 than in late 1989, but dropped again of about 0.1 magnitude at the end of 1993. Due to its rotational broadening the spectral classification of BI Cet is rather uncertain. The G5 V + G5 V spectral type proposed by Bopp et al. (1985) yields $d_{\rm ph} = 60$ pc, which appears in reasonable agreement with $D_{\rm H}$. However, we note that by assuming two slightly evolved G6-type stars, about 0.5 magnitudes brighter than two typical G6 V stars ($R \simeq 1.1\ R_{\odot}$; $35° < i < 40°$), a better fit of both the colours and trigonometric distance ($d_{\rm ph} = 65$ pc) is obtained.

HD 16157 = CC Eri ($D_{\rm H} = 11.5^{+0.1}_{-0.1}$ pc) is a BY Dra-type variable that has been detected by ROSAT and EUVE (Pye et al. 1995; Bowyer et al. 1996; Huensch et al. 1999), and studied at different wavelengths by several authors (see Cutispoto & Leto 1997; Amado et al. 2000, and references therein). The data we obtained at ESO late in 1993 are shown in Fig. 6, where phases are reckoned from the 1.56145-day orbital period (Evans 1959). The single-peaked V-band light curve is anticorrelated with the $U-B$ colour variations, while the other colour indices appear to be correlated, with the clearest modulation for the $V-I$. The collection of the available photometry of CC Eri is presented in Fig. 7. The K7 V + M3 V

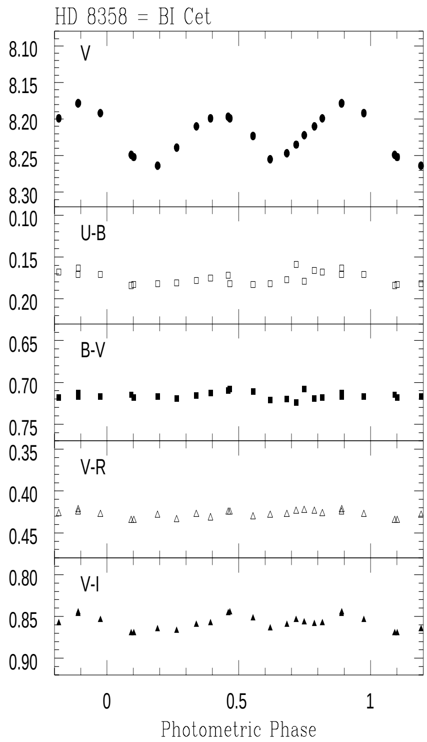

Fig. 4. HD 8358 = BI Cet V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448987.5 + $0.5195 \cdot E$

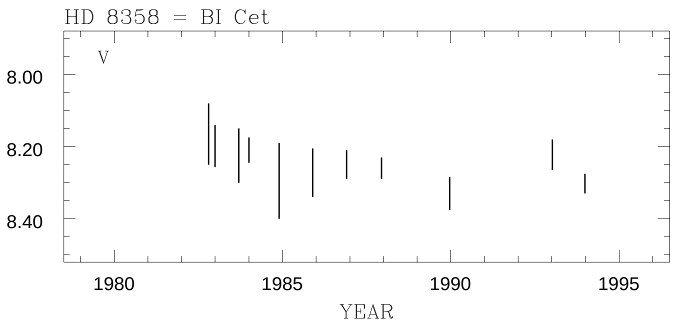

Fig. 5. HD 8358 = BI Cet V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

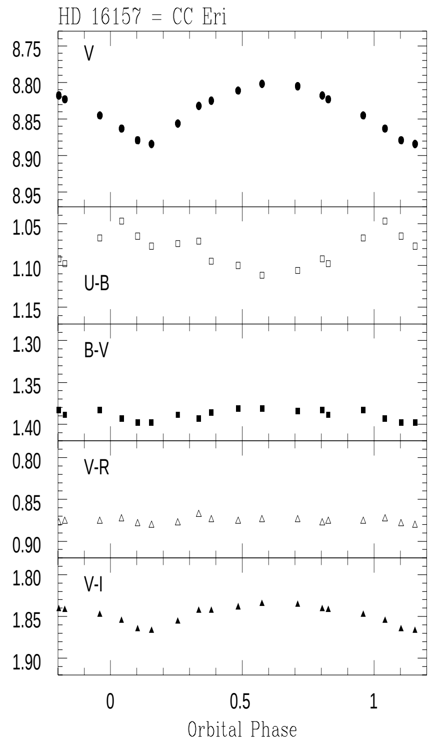

Fig. 6. HD 16157 = CC Eri V-band and colour light curves for the mean epoch 1993.91; phases are reckoned from the spectroscopic ephemeris HJD = 2449311.5 + $1.56145 \cdot E$

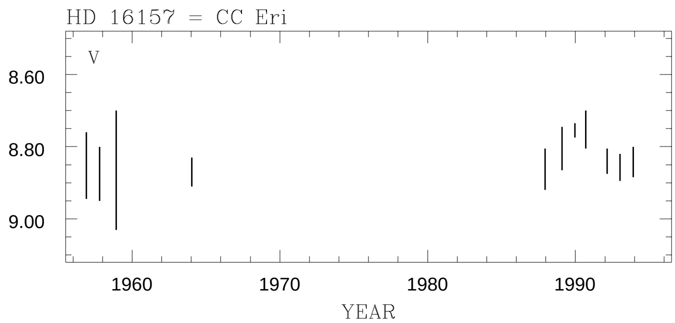

Fig. 7. HD 16157 = CC Eri V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

($d_{\rm ph} = 11.5$ pc) classification was discussed by Cutispoto (1998b).

SAO 130113 = BY Cet ($D_{\rm H} > 23$ pc) is an SB2 system detected by the *Einstein* (Fleming et al. 1989) and EXOSAT (Giommi et al. 1991) satellites. It has been studied by Cutispoto et al. (1996), who discovered optical variability with a period of 2.62 days, and by Tagliaferri et al. (1994), who determined Li abundance and the X-ray luminosity. An orbital period of 2.634 days has been found by Duquennoy (1993) and Baker et al. (1994). Here we present the observations carried out at ESO early (Fig. 8) and late in 1993, complemented by observations carried out with the APTCT. Photometric periods of 2.60 ± 0.01 and 2.61 ± 0.01 days were derived for the two data sets, respectively. Our observations confirm that the shape and amplitude of the light curve and the luminosity at light maximum are variable, stressing the importance of a long-term study of this star. Further photometric data obtained by our group are presented by Cutispoto et al. (2000). Here we revise the two spectral classifications given by Cutispoto et al. (1996) to G7 V + K5: V ($d_{\rm ph} = 76$ pc; $M_2/M_1 \sim 0.7$) and to K0 IV + F6 V ($d_{\rm ph} = 290$ pc; $M_2/M_1 \sim 0.9$), respectively, and retain the former also on the basis of the $M_2/M_1 = 0.74$ value found by Duquennoy (1993).

HD 17925 = EP Eri ($D_{\rm H} = 10.4^{+0.1}_{-0.1}$ pc) is a young star belonging to the Scorpio-Centaurus complex that has been observed by several authors (see the list of references in the SIMBAD database). It was detected by ROSAT (Huensch et al. 1999) and EUVE (Malina et al. 1994). The presence of a strong Li line has been

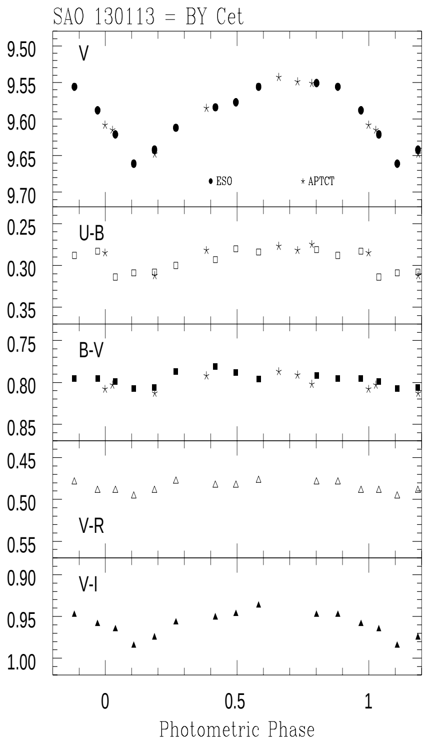

Fig. 8. SAO 130113 = BY Cet V-band and colour light curves for the mean epoch 1992.98; phases are reckoned from the photometric ephemeris HJD = 2447956.5 + $2.60 \cdot E$

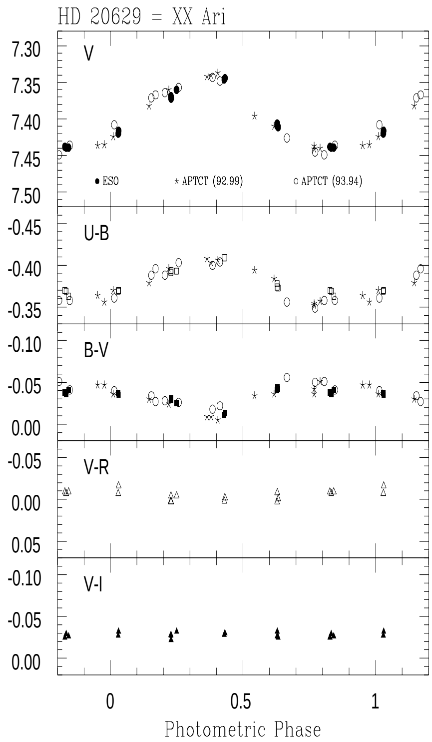

Fig. 9. HD 20629 = XX Ari V-band and colour light curves; phases are reckoned from the photometric ephemeris HJD = 2448953.0 + $2.4997 \cdot E$

reported by Pallavicini et al. (1992) and Cayrel de Strobel & Cayrel (1989). Radial velocity data, showing the star to be single, have been published by Tokovinin (1992), Beavers & Eitter (1986) and Young et al. (1987). Photometric variability was reported by Cutispoto (1992) and by Henry et al. (1995). Small light curve variations on time-scales of a few stellar rotations were observed by Cutispoto (1995). No variability was detected during the present observations, with the brightest and the faintest V-band luminosities differing only by 0.012 magnitudes. From the observed colours we infer a K0/1 V classification ($d_{\rm ph}$ = 10 pc). Several authors have obtained rather different values of $v \sin i$, ranging from 3.3 (Benz & Mayor 1984) to 8.1 (Cayrel de Strobel & Cayrel 1989) km s^{-1}. Because of this discrepancy, Henry et al. (1995) speculated that HD 17935 could be an unresolved spectroscopic binary with similar components and an orbital period of months or years. However, any combination of two late-type stars reproducing the observed colours would lead to a $d_{\rm ph}$ definitely larger than $D_{\rm H}$. For instance, a binary constituted by two K2 V stars, whose colours are about 0.05 magnitude (i.e. well outside the errors of our absolute photometry) redder than observed, would give $d_{\rm ph}$ = 11.9 pc. Hence, the binary hypothesis does not seem to be consistent with the Hipparcos and photometric data.

HD 20629 = XX Ari ($D_{\rm H} = 238^{+72}_{-45}$ pc) is an early-type star detected by EXOSAT (Giommi et al. 1991). It was first studied by Cutispoto et al. (1990) who discovered its optical variability and classified it as a CP star. Further observations were collected by Cutispoto et al. (1996). Here we present (Fig. 9) the data we obtained at ESO early in 1993, complemented by those carried out by the APTCT from 27 November 1992 to 25 January 1993 and from 16 October 1993 to 30 January 1994. The light curve has been stable over the entire observational interval, thus we computed the photometric period of 2.4997 ± 0.0012 from the whole data set. XX Ari was studied by Leone & Catanzaro (1998) that inferred a B7 V Si Cr spectral type ($d_{\rm ph}$ = 387 pc), while, from the observed colours, we confirm the B9 V ($d_{\rm ph}$ = 257 pc) classification given by Cutispoto et al. (1996) that seems to be in better agreement with $D_{\rm H}$. However, due to the large dispersion of the B-type stars' absolute magnitudes (Gòmez et al. 1998), also the B7 V classification gives a $d_{\rm ph}$ within the error of the trigonometric measurements. An X-ray luminosity of $10^{31.5}$ erg s^{-1} was computed by Cutispoto et al. (1990). It is still not clear if CP stars are X-ray emitters at such levels, or if, alternatively, the observed X-ray flux is due to a late-type unseen companion. Three radial velocity measurements for XX Ari have been obtained by Fehrenbach et al. (1997). The first and the second values, obtained about 654 days apart, differ by 24 km s^{-1}, while the second and the third values, obtained about 25 days apart, give the same result. Hence, XX Ari may not be a close binary, and the available data are not enough to speculate on the nature of a possible companion.

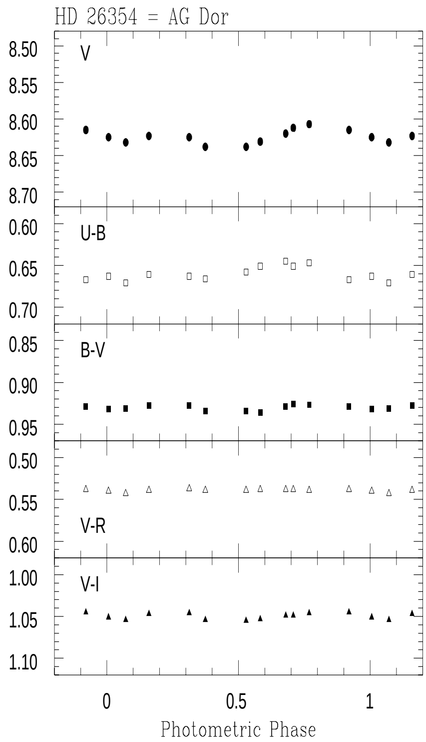

Fig. 10. HD 26354 = AG Dor V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448666.0 + 2.533 $\cdot E$

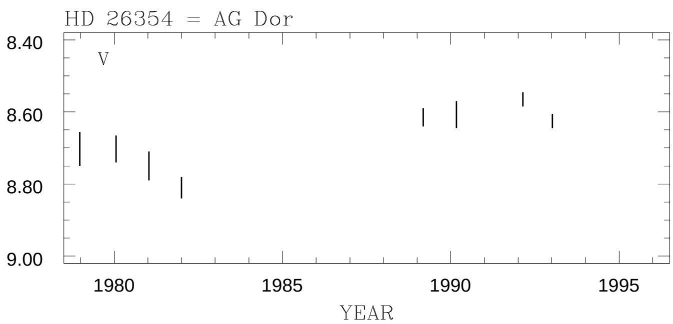

Fig. 11. HD 26354 = AG Dor V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

HD 26354 = AG Dor ($D_{\rm H} = 35^{+1}_{-1}$ pc) is an SB2 system with an orbital period of 2.562 days (Balona 1987; Washüttl & Strassmeier 1995), which has been studied by several authors (see the list of references in SIMBAD) and detected by EUVE (Bowyer et al. 1996). Photometry was obtained by Lloyd-Evans & Koen (1987) and by Cutispoto (1992, 1996, 1998b). The K1 V + K5 V ($d_{\rm ph}$ = 35 pc) classification was discussed by Cutispoto (1998b). The observations carried out at ESO are presented in Fig. 10, where phases are computed by using the 2.533-day photometric period by Lloyd-Evans & Koen (1987). The V-band light curve is double-peaked and only very weak colour variations are detected. Our data confirm the presence of a long-term variability of the global degree of spottedness, as shown in Fig. 11.

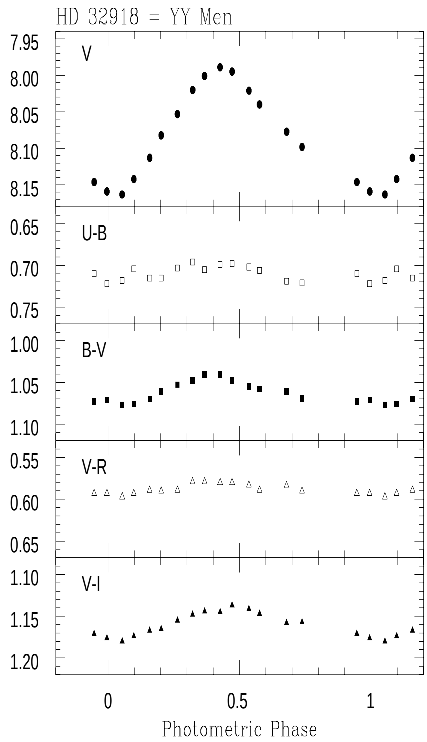

Fig. 12. HD 32918 = YY Men V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448660.0 + 9.5476 $\cdot E$

HD 32918 = YY Men ($D_{\rm H} = 292^{+63}_{-45}$ pc) is an active giant classified as a member of the FK Com-type stars. Some flares detected for this star at optical (Cutispoto et al. 1990) 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 we obtained at ESO are shown in Fig. 12, where phases are reckoned from the 9.5476-day photometric period computed by Collier (1982). The asymmetric V-band light curve is single-peaked and its maximum is about 0.06 magnitudes fainter than the brightest values observed to date, as can be inferred from Fig. 13, where a collection of the available photometric data of YY Men is presented. Clear colour variations, well-correlated with the V-band modulation, show the star to be redder at light minimum. The K1 III ($d_{\rm ph}$ = 219 pc) classification was discussed by Cutispoto (1998b).

1E 0505.0-0527 = EZ Eri is a serendipitous X-ray source detected by the *Einstein* satellite and classified as a suspected RS CVn-type system by Fleming et al. (1989). The presence of optical variability, high Li abundance and a partially filled-in Hα line were reported by Cutispoto & Tagliaferri (1996). Further photometry was collected by Cutispoto (1998b), who also inferred the K2 IV + G2 V ($d_{\rm ph}$ = 290 pc) classification. The data we obtained at ESO are shown in Fig. 14, where phases have been computed by using the 9.08-day photometric period by Cutispoto & Tagliaferri (1996). The low amplitude light

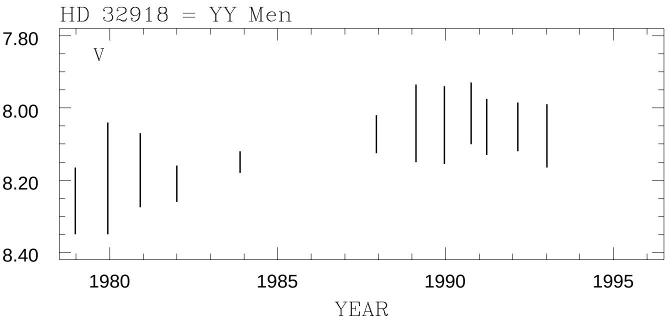

Fig. 13. HD 32918 = YY Men V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

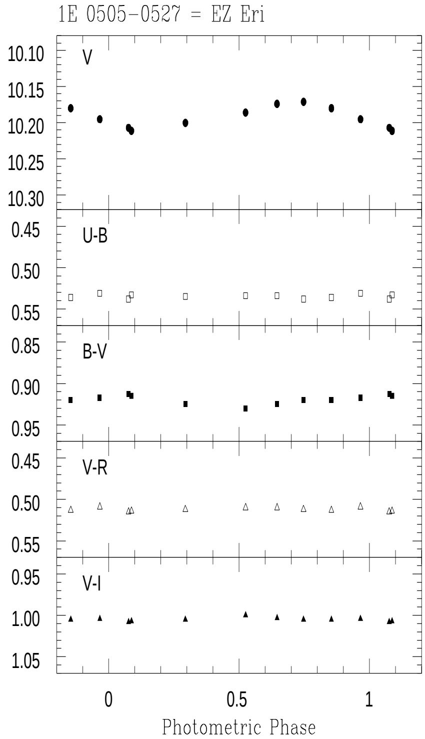

Fig. 14. 1E 0505-0527 = EZ Eri V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448660.0 + 9.08 $\cdot\, E$

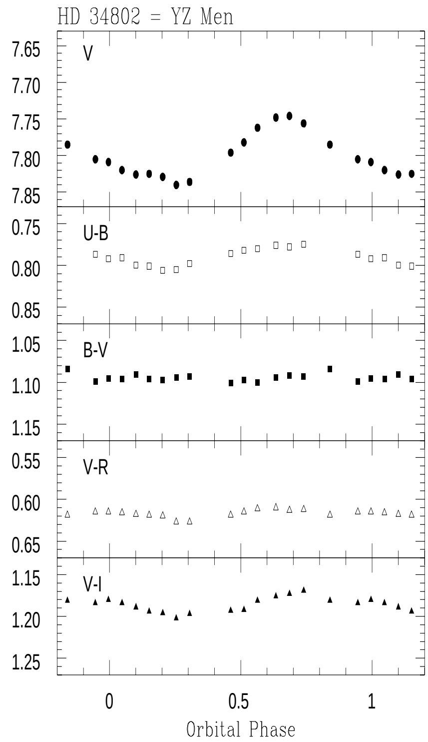

Fig. 15. HD 34802 = YZ Men V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448666.5 + 19.310 $\cdot\, E$

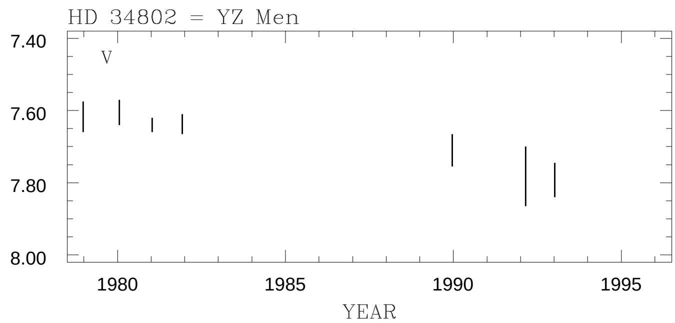

Fig. 16. HD 34802 = YZ Men V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

curve is single-peaked and the colour curves are almost flat, except for $B-V$. Comparing the present data with previous observations (cf. Figs. 2 and 3 in Cutispoto & Tagliaferri 1996; Fig. 5 in Cutispoto 1998b) sizeable variations of the light curve shape and amplitude and of the maximum luminosity show up. In particular, early in 1993 EZ Eri reached its maximum luminosity level ever observed.

HD 293857 ($D_{\rm H}$ = 53^{+160}_{-22} pc) is a serendipitous X-ray source discovered by EXOSAT (Giommi et al. 1991). It has been studied by Tagliaferri et al. (1994), who found a very high Li abundance, and by Cutispoto et al. (1996) and Cutispoto (1998b), who reported multiband photometry. Our observations at ESO show no optical variability, with the brightest and faintest V-band values differing only by 0.014 magnitudes. The maximum V-band luminosity is equal to the brightest value ever observed. Here we revise the spectral classification to G7 V ($d_{\rm ph}$ = 61 pc).

HD 34802 = YZ Men ($D_{\rm H}$ = 180^{+21}_{-18} pc) is an SB1 system with a 19.310-day orbital period (Balona 1987) weak Ca II H&K and X-ray emissions (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, 1998b). Low Li abundance and a $v \sin i$ of 20 km s^{-1} were measured by Randich et al. (1993). Our observations at ESO are shown in Fig. 15, where phases are reckoned from the 19.310-day orbital period. The V-band light curve appears asymmetric, and the $U-B$ and $V-R$

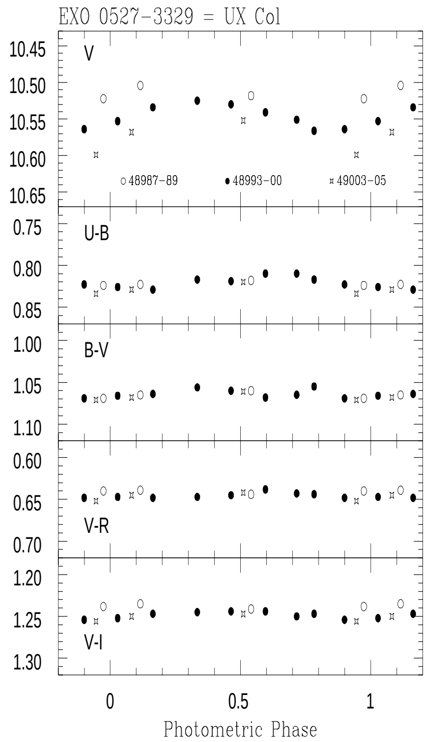

Fig. 17. EXO 0527-3329 = UX Col V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448660.0 + 2.29 $\cdot E$

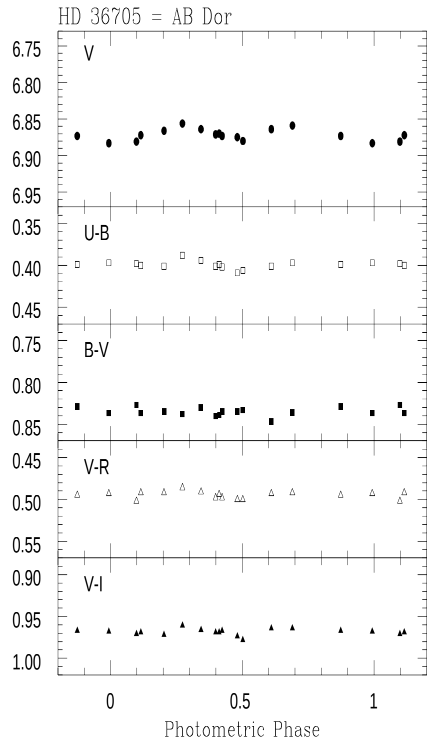

Fig. 18. HD 36705 = AB Dor V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2444296.575 + 0.51479 $\cdot E$

colour indices undergo variations well-correlated with the V-band modulation. The present data, showing a V-band maximum luminosity about 0.05 magnitudes fainter than any previous maximum, confirm the presence of a long-term variability of the global degree of spottedness (Fig. 16), which has been steadily increasing since the late seventies. The K1 III ($d_{\rm ph}$ = 185 pc) classification has been inferred by Cutispoto (1998b).

HD 35850 ($D_{\rm H} = 26.8^{+.7}_{-.6}$ pc) is a bright star detected by EXOSAT (Giommi et al. 1991), ROSAT (Pounds et al. 1993; Pye et al. 1995), EUVE (Bowyer et al. 1996; Malina et al. 1994) and ASCA (Tagliaferri et al. 1997) satellites. Optical studies were carried out by Tagliaferri et al. (1994), that inferred a very high Li abundance, and by Cutispoto et al. (1996) that found the star to be constant. Mathioudakis & Mullan (1999) found HD 35850 to be in a near-continuous state of flare-like activity in the EUV, Gagne et al. (1999) inferred solar Fe abundance for the corona and Tagliaferri et al. (1997) fitted the ASCA and ROSAT data obtaining coronal metal abundance. No optical variability was detected by us in January 1993. From the ASC method we derive an F8/9 V ($d_{\rm ph}$ = 29 pc) classification. Although the alternative F7 V + G5 V ($d_{\rm ph}$ = 38 pc) classification proposed by Tagliaferri et al. (1994) fits well the observed colours, the resulting $d_{\rm ph}$ does not agree with the trigonometric parallax.

EXO 052707-3329.2 = UX Col is a serendipitous X-ray source discovered by EXOSAT (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. Further photometry has been obtained by Cutispoto (1998b). Our observations at ESO are shown in Fig. 17, where phases are reckoned from the 2.29-day photometric period inferred by Cutispoto (1998b). We note a remarkable evolution of the single-peaked light curve, with a clear decrease of the mean luminosity level over an interval of a few stellar rotations. Apart from the noticeable evolution of the light curve shape (cf. Fig. 7 in Cutispoto et al. 1996 and Fig. 7 in Cutispoto 1998b) the present data show the star at the maximum luminosity ever observed. The K3/5 PMS classification was inferred by Cutispoto (1998b).

HD 36705 = AB Dor ($D_{\rm H} = 14.9^{+.2}_{-.1}$ pc) is one of the most studied active stars, as can be inferred from the papers listed in SIMBAD. A low mass companion ($0.08\,M_\odot < M < 0.11\,M_\odot$) has been detected by Guirado et al. (1997) by using VLBI and Hipparcos data. The observations we obtained at ESO are plotted in Fig. 18, where phases are reckoned from the 0.51479-day photometric period computed by Innis et al. (1988). The low amplitude V-band and colour curves exhibit two maxima. These data contribute to study the long-term brightness evolution of AB Dor (Fig. 19). The K0 V ($d_{\rm ph}$ = 15 pc) classification has been discussed by Cutispoto (1998b).

Table 5. Revised spectral classification, based on the latest version of the ASC method, for some active stars previously observed by our group; the previous classification and the corresponding reference, the distance range measured by the Hipparcos satellite ($D_{\rm H}$) and the photometric distance inferred from the adopted spectral classification ($d_{\rm ph}$) are also listed

Program Star	Revised classification	Previous classification	Reference	$D_{\rm H}$	$d_{\rm ph}$
HD 17144 = UY For	K2/3 III	K2/3 III + F6 V	A	202–382	258
HD 26913 = V891 Tau	G5 V	G5/6 IV/V	A	20.4–21.4	25
HD 31738 = V1198 Ori	G5/6 IV/V + ?	G6 IV + G1V	B	32–35	39
HD 46697 = TZ Pic	K1 III	K2 III/IV	B	159–196	120
HD 71071 = LU Hya	K1 IV/V	K1 IV + G5 V ?	C	47–52	41
HD 117860	G3 V	G3/4 V	D	31–33	34
HD 147633	G2/3 V + G4 V	K0 IV + F2/3 V	D	40–52	47
HD 159808	F4/5 V + F5 V	F6 V	D	118–196	125
HD 170196	B9 III	B9 V	D	394–1190	485
HD 217344 = TZ PsA	G5 V + K3 V + K9:V	G5/6 IV + ?	E	59–74	56
HD 218515	A0/1 V	A1/2 V	D	178–265	222
HD 219025 = BI Ind	K3 III + K1 IV/III	K3 III + F4 V	B	246–410	272
HD 220096	G4 III	G8 IV	D	93–110	90

References: A = A&AS 89, 435; B = A&AS 111, 507; C = A&AS 102, 655; D = A&AS 115, 41; A&AS 121, 369.

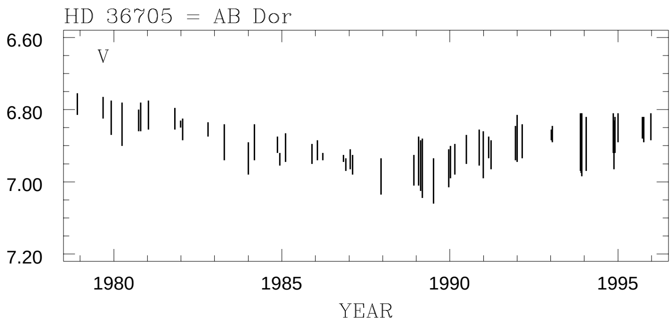

Fig. 19. HD 36705 = AB Dor V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

EXO 053237-0510.1 = P 1724 = V 1321 Ori is a serendipitous X-ray source discovered by EXOSAT (Giommi et al. 1991). Further detections have been recorded by ROSAT (Geier et al. 1995) and ASCA (Yamauchi et al. 1996). The development of a giant X-ray flare, detected by ROSAT in 1992, has been investigated by Preibisch et al. (1995). V1321 Ori is located near the Orion nebula and has been previously studied by Tagliaferri et al. (1994), who found very high Li abundance, high rotation velocity and no spectroscopic indication of binarity, and by Cutispoto et al. (1996), who discovered optical variability with a 5.6-day period. These authors concluded that V1321 Ori is a very young, possibly a T-Tauri, star. A detailed study on V1321 Ori, concerning also its long-term photometric variability, was published by Neuhäuser et al. (1998), further photometry was obtained by Cutispoto (1998b). The membership of V1321 Ori to the Orion nebula has been studied by several authors with quite different results (see discussion in Cutispoto 1998b). Here we assume, after Preibisch et al. (1995), a K3 *weak-line* TTS classification and Orion complex membership. Our observations at ESO are shown in Fig. 20, where phases have been computed by using a 5.7 ± 0.1-day photometric period. The large amplitude light curve is single-peaked and remarkable colour variations are seen. In particular, the $U-B$ curve shows a secondary maximum at the phase of the V-band minimum and a much larger and wider maximum at the V-band maximum. It is not possible to ascertain whether these maxima are due to low-level continuous flare-like activity or to high-temperature plages. The other colour indices show a noticeable secondary maximum around

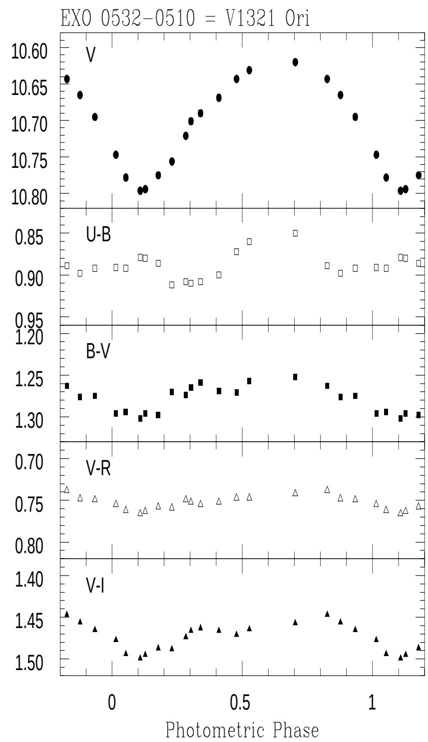

Fig. 20. EXO 0532-0510 = V1321 Ori V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448987.0 + $5.7 \cdot E$

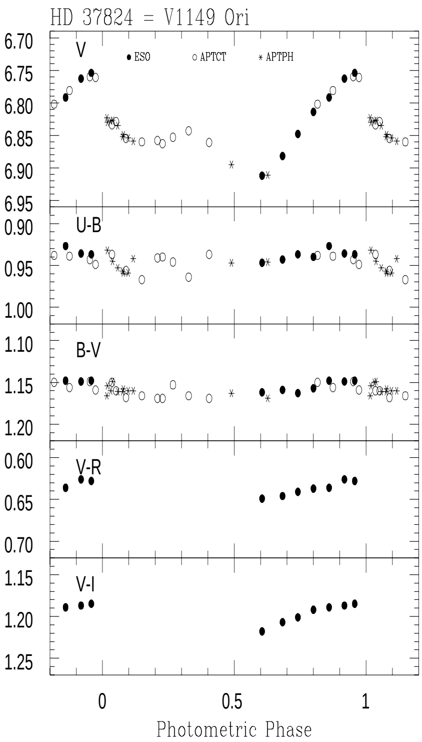

Fig. 21. HD 37824 = V1149 Ori V-band and colour light curves for the mean epoch 1993.01; phases are reckoned from the photometric ephemeris HJD = 2448957.0 + 50.81 $\cdot E$

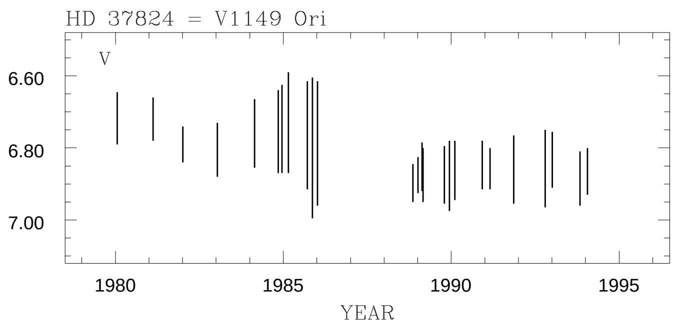

Fig. 22. HD 37824 = V1149 Ori V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

phase 0.3, just at the phase of a definite slope change in the rising part of the V-band light curve and of a mimimum in the $U-B$ curve, whose nature is similarly unclear.

HD 37824 = V1149 Ori ($D_{\rm H} = 144^{+28}_{-20}$ pc) is a bright SB1 system with an orbital period of 53.58 days (Balona 1987; Fekel et al. 1986), which has been studied by several authors (see the list of references in SIMBAD). Photometric observations have been collected since early 1980 (Lloyd-Evans & Koen 1987; Strassmeier et al. 1989; Hall et al. 1991; Cutispoto 1992). Here we present the data we collected in early 1993 at ESO, complemented with those obtained by the APTPH and by the APTCT (Fig. 21). Further data obtained with the APTs from late 1990 to early 1994 are listed in Tables 1 and 3. The photometric period undergoes noticeable changes:

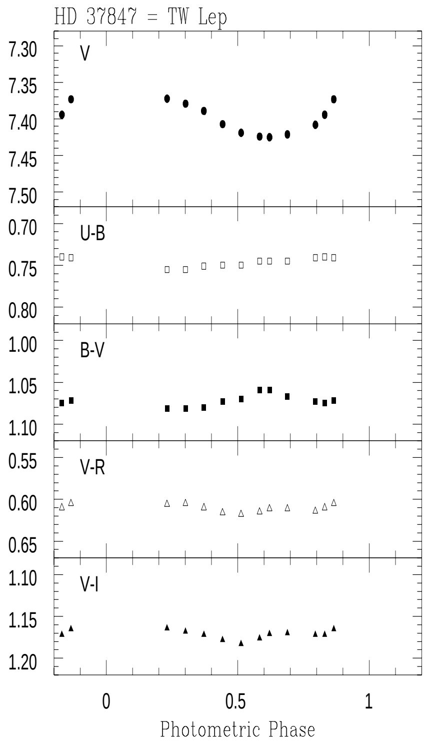

Fig. 23. HD 37847 = TW Lep V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2444155.64 + 28.22 $\cdot E$

49.13 ± 0.6 days for the epochs 1990.92 and 1991.15, 49.07 ± 1.6 days for the epoch 1991.86, 50.81 ± 1.02 days for the epochs 1992.80 and 1993.01 and 54.23 ± 0.6 days for the epochs 1993.83 and 1994.06. The collection of the available photometry of V1149 Ori (Fig. 22) clearly shows a definite increase of the photospheric spot coverage late in 1988, that has remained fairly constant since then. The spectral classification K1 III + F was given by Bidelman & MacConnell (1973). However, according to Fekel et al. (1986), the UV spectrum shows no evidence of an F-type companion. The observed colours match reasonably well those of an active K2 III star ($d_{\rm ph}$ = 105 pc). Better colour fits are obtained by assuming K2/3 III + F8 V ($d_{\rm ph}$ = 126 pc) or K3 III + F4 V ($d_{\rm ph}$ = 149 pc) systems. The secondary component of the former system would give a smaller contribution to the UV band, more consistently with Fekel et al. (1986) observations.

HD 37847 = TW Lep ($D_{\rm H} = 170^{+44}_{-28}$ pc) is an SB2 system with an orbital period of 28.344 days (Balona 1987) that has been studied by several authors (e.g. Strassmeier & Fekel 1990; Strassmeier et al. 1993; Fox et al. 1994; Cutispoto 1995, and references therein) and detected by ROSAT (Pounds et al. 1993; Pye et al. 1995). Photometric observations have been collected by Henry et al. (1982), Lloyd Evans & Koen (1987) and Cutispoto (1992, 1995, 1998a). The observations we obtained at ESO are shown in Fig. 23, where phases have been computed by using the 28.22-day photometric period given by Henry et al. (1982). Due to the quite long

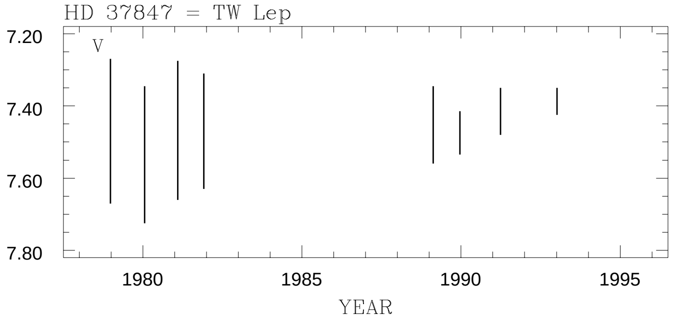

Fig. 24. HD 37847 = TW Lep V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

variability period the light curve is not complete and the luminosity maximum is missing. However, due to the rather simple and almost sinusoidal light curve, the value $V_\mathrm{m} \simeq 7.35$ can be extrapolated. The $B-V$ curve is clearly anticorrelated with the V-band modulation, as previously observed by Cutispoto (1992, 1998a). What is peculiar, instead, are the secondary maxima for the $V-R$ and $V-I$ colour curves, that appear close to the phase of light minimum in the V-band. Cutispoto (1998a) inferred the K2/3 III + F6 IV (d_ph = 177 pc) classification by using the ASC method, a result that agrees very well with the K2 III + F6 IV spectral type obtained by Strassmeir & Fekel (1990). From the collection of the available photometry, shown in Fig. 24, we note that the faintest seasonal magnitude of TW Lep has become monotonically brighter since early 1980, thus suggesting the presence of an activity cycle whose length, at present, cannot be evaluated.

HD 39917 = SZ Pic (D_H = 195^{+29}_{-23} pc) is an SB2 system with an orbital period of about 4.96 days (Kürster 1994) that has been detected by ROSAT 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, 1998a, 1998b). The observations we collected at ESO, folded by using the 4.905-day photometric period inferred by Cutispoto (1995), are shown in Fig. 25. The V-band light curve appears quite different from those obtained in previous epochs (cf. Fig. 21 in Cutispoto 1995 and Fig. 4 in Cutispoto 1998a), thus confirming that, although most of the variability is due to the ellipticity effect, part of it can be ascribed to the presence and evolution of spot groups. The colour variations are marginal. The K0 IV/III + G3 IV/III (d_ph = 190 pc) classification was inferred by Cutispoto (1998b).

EXO 055609-3804.4 = TY Col is a serendipitous X-ray source discovered by EXOSAT (Giommi et al. 1991) and also detected by ROSAT (Kreysing et al. 1995). It has been studied by Cutispoto et al. (1991), who discovered its optical variability with a period of 3.72 days

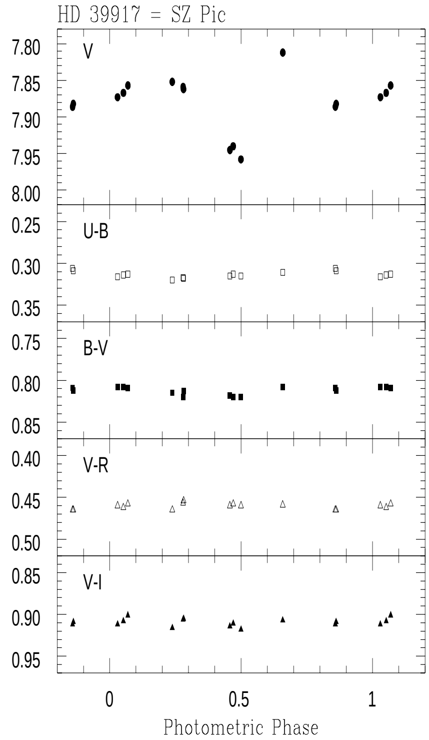

Fig. 25. HD 39917 = SZ Pic V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2443931.54 + 4.905 $\cdot E$

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) and by Cutispoto (1998b). The data we obtained at ESO are presented in Fig. 26. They are folded with the 3.82 ± 0.06-day photometric period inferred by a Fourier analysis of the VRI data. When compared with the value observed less than one year before by Cutispoto (1998b), the photometric period appears to have changed by more than 5%. The maximum and mimimum luminosities of TY Col undergo noticeable changes (cf. Fig. 12 in Cutispoto 1998b), and the present data contribute to investigate their long-term variability. The spectral classification of TY Col is quite puzzling, and has been discussed by Cutispoto (1998b).

HD 61245 = V344 Pup (D_H = 111^{+8}_{-6} pc) is an SB1 system, showing weak Ca II H&K emission lines, Hα absorption (Bopp & Hearnshaw 1983) and low Li abundance (Randich et al. 1993). It was detected by ROSAT (Dempsey et al. 1997). Optical variability was discovered by Lloyd-Evans & Koen (1987), further photometry was acquired by Cutispoto (1992, 1995, 1998a, 1998b). The data we obtained at ESO are shown in Fig. 27, where the 11.761-day orbital period inferred by Balona (1987) has been used to fold the data. The double-peaked V-band light curve and the colour variations appear to be in phase. Their amplitudes are much smaller than those observed less than one year before (Cutispoto 1998b), thus confirming the remarkable evolution of the spot

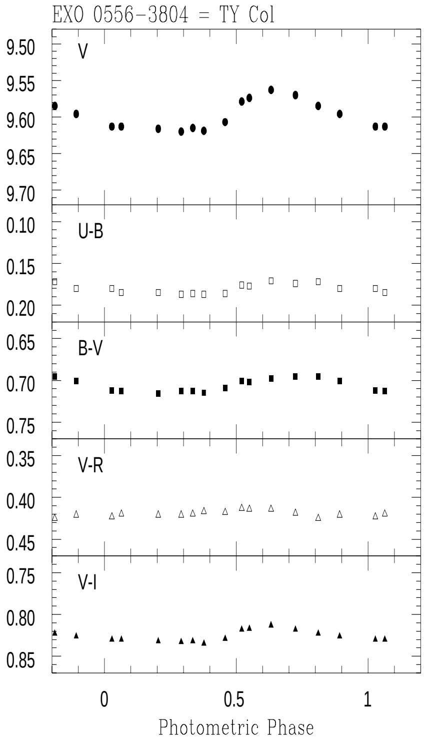

Fig. 26. EXO 0556-3804 = TY Col V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448987.0 + 3.82 $\cdot E$

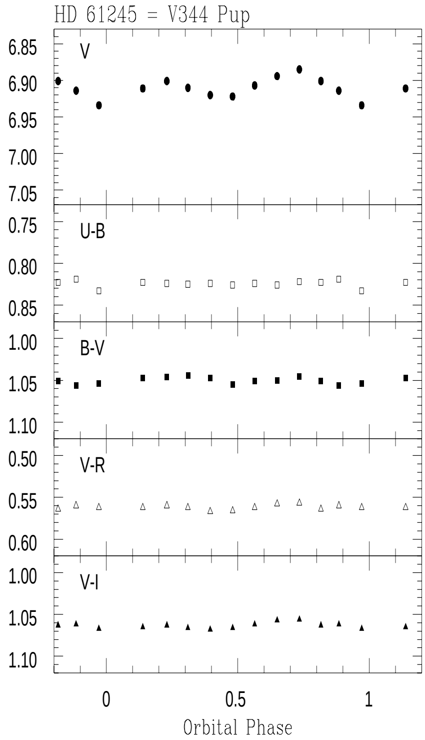

Fig. 27. HD 61245 = V344 Pup V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the spectroscopic ephemeris HJD = 2448331.5 + 11.761 $\cdot E$

groups. V344 Pup has been classified as K1 III and as K2 III by Bopp & Hearnshaw (1983) and Houk (1978), respectively. However, Cutispoto (1998b) found that the classification that best fits both the observed colours and $D_{\rm H}$ is K1 IV/III ($d_{\rm ph} = 102$ pc).

HD 72688 = VX Pyx ($D_{\rm H} = 131^{+11}_{-10}$ pc) is an SB1 system with an orbital period of 45.13 days (Balona 1987) that shows weak Ca II H&K emission lines, a strong Hα absorption line and a moderate Li abundance (Fekel et al. 1986; Randich et al. 1993; Barrado y Navascues et al. 1998). It was detected by ROSAT (Huensch et al. 1999; Dempsey et al. 1997). A photometric period of 19.34 days, which is very different from the orbital one, was obtained by Lloyd Evans & Koen (1987). Our observations show the star to be almost constant, with the brighest and faintest V-band luminosities differing by only 0.02 magnitudes. The colours are consistent with a G8 III classification ($d_{\rm ph} = 123$ pc). However, Bidelmann & MacConnell (1973) classified HD 72688 as a K0 III + F system. Assuming a binary, the best fit of the colours is obtained by considering K0 III + F6 IV components ($d_{\rm ph} = 117$ pc). The photometric period is in agreement with both the K0 III classification of the primary star and the $v \sin i$ of 8 km s^{-1} by Balona (1987) and Fekel et al. (1986).

HD 78423 ($D_{\rm H} = 345^{+207}_{-95}$ pc) is a serendipitous X-ray source discovered by EXOSAT (Giommi et al. 1991) and already observed by our group. Here we note that there is a typo in the $V-I$ value listed in Table 2 of Cutispoto et al. (1991), the correct value being 0.04 magnitudes. We observed this star at ESO during four nights, with the brighest and faintest V-band magnitudes differing by 0.026. The colours are consistent with both A1 V ($d_{\rm ph} = 230$ pc) and A1/2 III ($d_{\rm ph} = 334$ pc) classifications. The trigonometric parallax is in better agreement with the giant classification, though its lower limit is still consistent with the dwarf classification.

HD 81410 = IL Hya ($D_{\rm H} = 120^{+13}_{-12}$ pc) is an SB2 system that has been observed by several authors (see the list of references in SIMBAD). It has been detected by ROSAT and EUVE (Pounds et al. 1993; Pye et al. 1995; Malina et al. 1994; Bowyer et al. 1996; Mitrou et al. 1997). The data we collected at ESO are shown in Fig. 28, where phases are reckoned from the 12.90522-day orbital period computed by Raveendran & Mekkaden (1998). The V-band light curve is single-peaked and well-defined colour variations, showing the star redder at light minimum, are present. The available photometry of IL Hya, spanning almost 26 years, is shown in Fig. 29 (see also Fig. 10 in Strassmeier et al. 1997). The present data integrate the information about the light curve amplitude and shape for early 1993. 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. A K1 III/IV + ? classification ($d_{\rm ph} = 119$ pc) was obtained by Cutispoto (1998b).

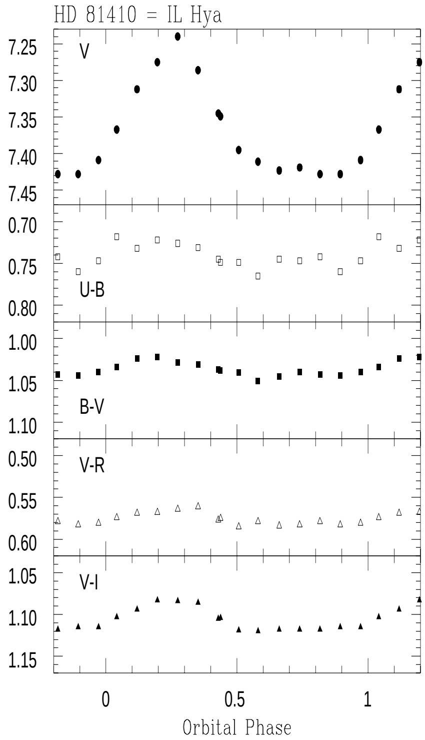

Fig. 28. HD 81410 = IL Hya V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the spectroscopic ephemeris HJD = 2448987.319 + 12.90522 $\cdot E$

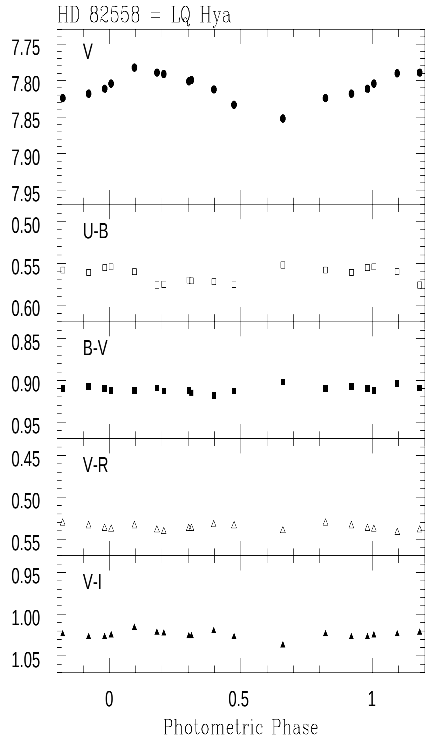

Fig. 30. HD 82558 = LQ Hya V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448988.0 + 1.63 $\cdot E$

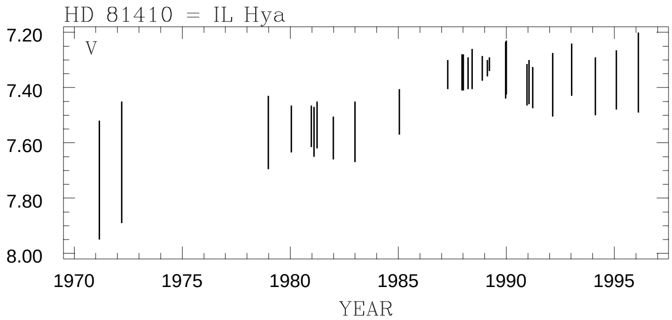

Fig. 29. HD 81410 = IL Hya V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

Recently, Fekel et al. (1999) presented an updated SB2 orbit.

HD 82558 = LQ Hya ($D_{\rm H}$ = $18.3^{+.4}_{-.3}$ pc) 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, and the list of references in SIMBAD). It has been detected by ROSAT (Huensch et al. 1999; Pye et al. 1995) and EUVE (Lampton et al. 1997; Bowyer et al. 1996). A collection of the photometric observations of LQ Hya since late 1982, from which the presence of an activity cycle of about 7 years can be inferred, has been presented by Strassmeier et al. (1997). More recent data are in Strassmeier et al. (1999). The data we acquired at ESO are shown in Fig. 30, where phases are computed using the 1.63 ± 0.01-day period from a Fourier analysis of the VRI data. The light curve is single-peaked. The weak $U-B$ and $B-V$ colour variation appears to be in anti-phase with the V-band modulation. We note that our data were obtained shortly before those presented by Strassmeier et al. (1997). Comparing the light curves from these two data sets, it is evident that several flare events occurred during the Strassmeier et al. (1997) observations. Cutispoto (1998b) inferred a K2 V ($d_{\rm ph}$ = 18.5 pc) classification. It is worth to note that there was a misprint in previous papers of this series, where the *ck* star used for LQ Hya was erroneously reported to be HD 82447.

HD 98712 = SZ Crt ($D_{\rm H}$ = $13.2^{+.3}_{-.3}$ pc) is a BY Dra-type variable whose coronal emission has been detected by ROSAT (Hempelmann et al. 1995; Huensch et al. 1999). It is a visual binary (ADS 8138) whose primary component shows a variable Hα line (Torres et al. 1985), 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 were collected by Cutispoto (1993, 1996, 1998a, 1998b). The data we obtained at ESO are shown in Fig. 31, where phases are computed by using the 11.58-day photometric period given by Torres et al. (1985). Due to the angular distance of about 4$''$.52, both components of the visual binary were observed. The light curve shows a low amplitude and weak colour variations are present. The mean and maximum luminosities

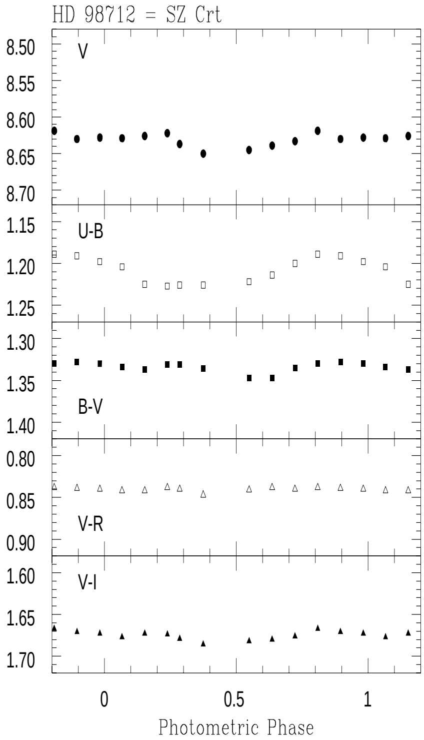

Fig. 31. HD 98712 = SZ Crt V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2441389.0 + $11.58 \cdot E$

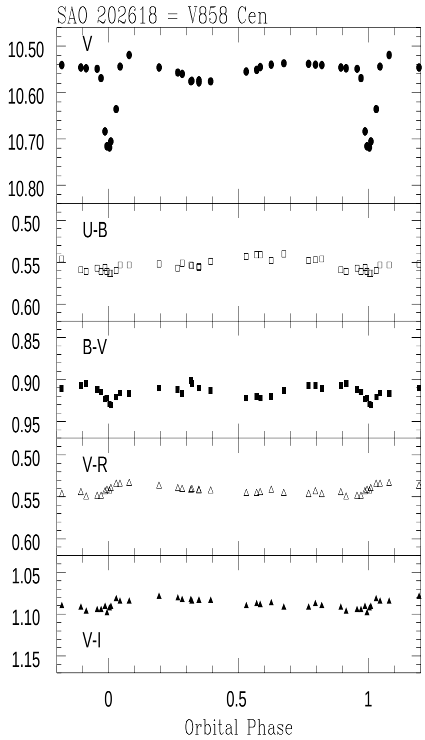

Fig. 32. SAO 202618 = V858 Cen V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the spectroscopic ephemeris HJD = 2448666.324 + $1.043602 \cdot E$

have not changed significantly compared to previous observations. The spectral classification K7 V + M2/3 V ($d_{\rm ph}$ = 12 pc) inferred by Cutispoto (1998b) results in reasonable agreement with the observed colours and $D_{\rm H}$.

SAO 202618 = V858 Cen is a serendipitous X-ray source discovered by EXOSAT (Giommi et al. 1991). It has been previously studied by Cutispoto et al. (1991), who discovered photometric variability, and by Cutispoto et al. (1996), who disclosed its eclipsing binary nature 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 we collected at ESO are presented in Fig. 32, where they are folded with the new 1.043602 ± 0.0048 day orbital period that was computed from present data. Comparing the observations in Fig. 32 with previous light curves (see for instance Fig. 19 in Cutispoto 1998b) the presence of large and evolving photospheric spotted regions is apparent. Moreover, the spot's location has a remarkable influence on the depth of the primary eclipse, while the secondary eclipse is not seen. The spectral classification reported in Table 3 has been inferred by Cutispoto (1998b).

HD 101309 = V829 Cen ($D_{\rm H}$ = 122^{+13}_{-12} pc) is an SB2 system with an orbital period of 11.71 days (Balona 1987), showing 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 ROSAT (Dempsey et al. 1993). A rather high Li abundance in both components has been reported by Randich et al. (1993). Photometric variability, discovered by Lloyd-Evans & Koen (1987), has been investigated by Collier Cameron (1987) and by Cutispoto (1993, 1996, 1998a, 1998b). The observations we collected at ESO are presented in Fig. 33, where the 11.65-day photometric period, inferred independently by Lloyd-Evans & Koen (1987) and by Cutispoto (1993), was used to phase fold the data. The light curve is asymmetric and single-peaked. Clear $V-I$ and $U-B$ colour variations, in phase and almost in anti-phase, respectively, with the V-band modulation, are present. The maximum V-band luminosity is the brightest ever observed, as shown in Fig. 34, where a collection of the available photometric data of V829 Cen is presented. The K1 IV + G5 V ($d_{\rm ph}$ = 127 pc) spectral classification was inferred by Collier et al. (1982) and by Cutispoto (1998b).

HD 106225 = HU Vir ($D_{\rm H} = 125^{+23}_{-17}$ pc) is an SB1 system 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 ROSAT (Endl et al. 1995). A detailed study of the physical parameters of HD 106225 can be found in Strassmeier (1994). Quite recently, Fekel et al. (1999) presented a new orbit determination and inferred the presence of a third component. Optical variability

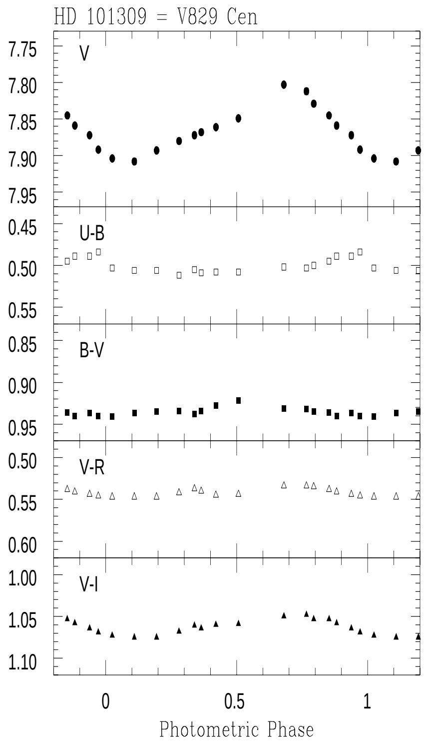

Fig. 33. HD 101309 = V829 Cen V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448331.5 + 11.65 $\cdot E$

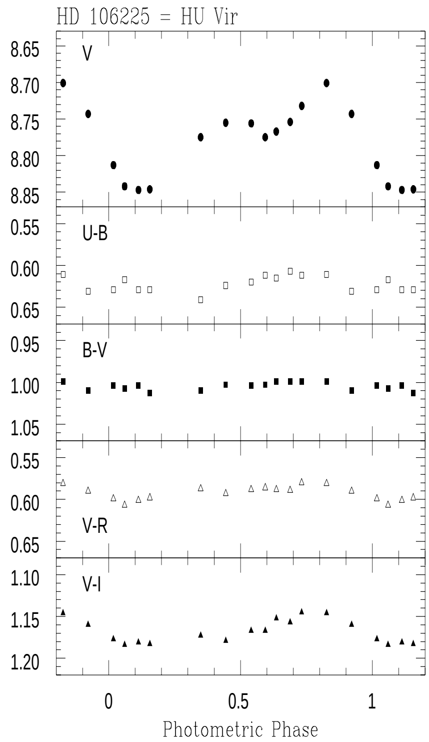

Fig. 35. HD 106225 = HU Vir V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448331.5 + 10.424 $\cdot E$

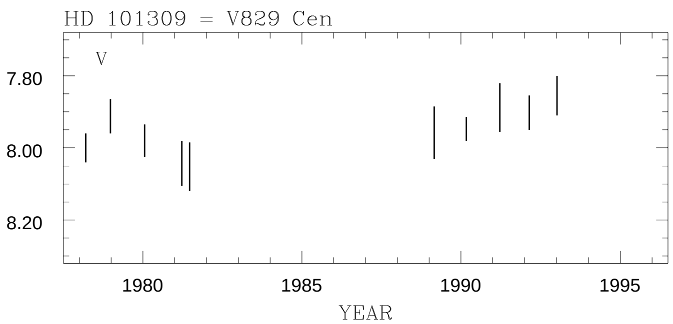

Fig. 34. HD 101309 = V829 Cen V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

has been investigated by several authors (see Strassmeier et al. 1993, 1997, 1999; Cutispoto 1996, 1998a, 1998b; Hall & Henry 1992, and references therein). The observations we obtained at ESO are shown in Fig. 35, where phases are computed by using the 10.424-day photometric period given by Strassmeier et al. (1997). The light curve is double-peaked and large amplitude colour variations, the system being redder at both light minima, are present. The collection of the available photometry of HU Vir, spanning about 14 years, has been presented by Strassmeier et al. (1997). Our data complete the information on the light curve shape and luminosity maximum early in 1993. Cutispoto (1998b) inferred a K1 IV ($d_{\rm ph}$ = 170 pc) classification for the primary component.

HD 119285 = V851 Cen ($D_{\rm H} = 76^{+9}_{-7}$ pc) is an SB1 system with an orbital period of 11.9886 days (Saar et al. 1990) recently studied by several authors (see Saar et al. 1990 and the list of references in SIMBAD). It has been detected by ROSAT (Pye et al. 1995) and quite high Li abundance has been reported by Randich et al. (1993) and by Saar et al. (1990). Optical variability was discovered by Udalski & Geyer (1984) and by Lloyd-Evans & Koen (1987). The data we obtained at ESO are presented in Fig. 36, where the 12.05-day photometric period reported by Lloyd-Evans & Koen (1987) was used to phase fold the data. Although the V-band curve is incomplete the phase coverage seems sufficient to ensure that the light amplitude is not much larger than 0.03 magnitudes. The corresponding colour variations are marginal. A collection of the available photometry of HD 119285 was presented by Cutispoto (1998a). Our data show the star to be about 0.04 magnitudes fainter in the V-band than the maximum luminosity observed early in 1990. From mean colours and the trigonometric distance we infer a K3 V/IV classification ($R \sim 2.3\,R_\odot$; $M_V \simeq 3.21$; $d_{\rm ph} = 76$ pc).

HD 197481 = AU Mic ($D_{\rm H} = 9.9^{+.2}_{-.1}$ pc) is a flare star that is also a BY Dra-type variable. It shows the typical spectral features suggesting the presence of an active atmosphere (see Linsky et al. 1982; Pagano et al. 2000 and the list of references in SIMBAD). Very strong X-ray and EUV emission has been measured by the

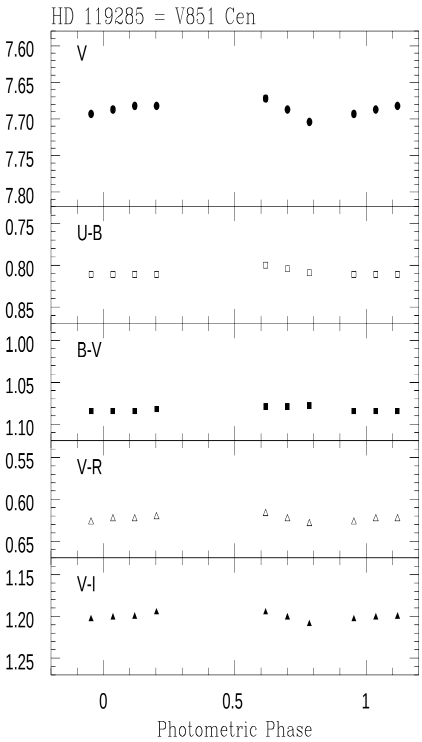

Fig. 36. HD 119285 = V851 Cen V-band and colour light curves for the mean epoch 1993.02; phases are reckoned from the photometric ephemeris HJD = 2448660.0 + 12.05 $\cdot E$

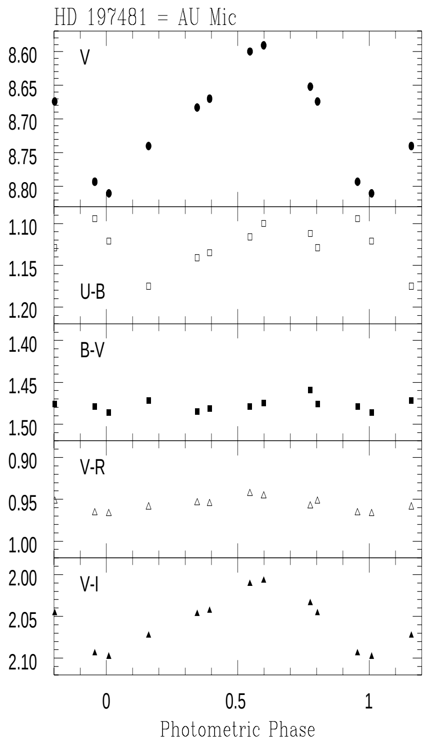

Fig. 37. HD 197481 = AU Mic V-band and colour light curves for the mean epoch 1993.91; phases are reckoned from the photometric ephemeris HJD = 2441054.0 + 4.865 $\cdot E$

Einstein (Golub 1983), ROSAT (Pye et al. 1995; Huensch et al. 1999) and EUVE (Bowyer et al. 1996) satellites. The optical variability was discovered by Torres et al. (1972). Our observations at ESO are shown in Fig. 37, where phases are reckoned from the 4.865-day photometric period given by Torres et al. (1972). The large amplitude light curve is single-peaked. The $U-B$ and $B-V$ colour curves are not well-correlated with the V-band modulation, a circumstance rather common for this star (see for instance Fig. 23 in Cutispoto 1998a) that could be due to the presence of micro-flaring activity. From the collection of the available photometry shown in Fig. 38, we note that the maximum luminosity level to date was observed late in 1993. The colours are consistent with the M1 Ve spectral classification reported by Houk (1982). However, the corresponding photometric distance ($d_{\rm ph}$ = 7.6 pc) is definitely smaller than the very accurate $D_{\rm H}$. This difference could be due either to the very large dispersion of the absolute magnitudes of the stars at the faint end of the main sequence, or to the circumstance that, with an estimated age of 600–800 Mys (Barrado y Navascues 1998), HD 197481 has not yet arrived on the main sequence.

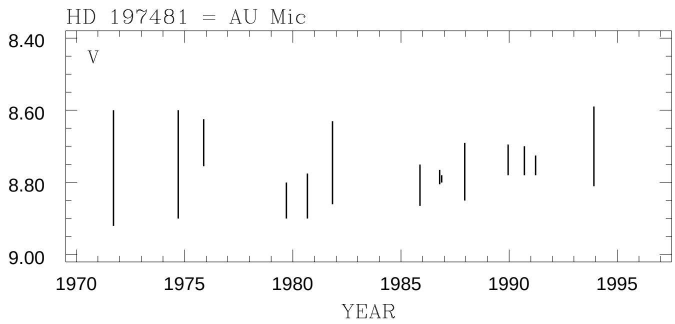

Fig. 38. HD 197481 = AU Mic V-band long-term variability; vertical bars indicate the peak-to-peak amplitude of the light curves

Acknowledgements. Stellar activity research at Catania Astrophysical Observatory and at the Department of Physics and Astronomy of Catania University is supported by the Italian MURST ("Ministry for Universities, Research and Technology") and by the regional government of Sicily ("Regione Sicilia") that are gratefully acknowledged. The data acquisition with the Catania APT has been possible thanks to the dedicated and technical assistance of a number of people, notably S. Sardone, P. Bruno and E. Martinetti. We thank the referee, Dr. S. V. Berdyugina, for her useful comments and Ms. L. Santagati for revising the manuscript. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France. A special thank is also due to the ESO staff for the collaboration and technical support offered to one of us (GC) during the observations.

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