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Photometric and spectroscopic studies of cool stars discovered in EXOSAT X-ray images*,**

IV. The northern hemisphere sample

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Abstract. We present high-precision photometry, high- and medium-resolution spectroscopy for a sample of 32 stars likely to be the optical counterparts of X-ray sources serendipitously detected by the EXOSAT satellite. Using also recent results from the Hipparcos satellite, we infer spectral types, compute X-ray luminosities and Li abundances and investigate the single or binary nature of the sample stars. We found eleven new variable stars, whose photometric periods fall in the 1.2-27.5 day range, for most of which the optical variability is consistent with the presence of photospheric cool spots. For our sample of X-ray selected stars we confirm the existence of a strong correlation between the stellar rotation rate and the level of activity, and also between the X-ray and bolometric luminosities. Two stars in our sample are likely to be pre-main sequence objects, one is likely to be a previously unknown M-type star within 25 pc.

Key words: techniques: photometric – techniques: spectroscopic – stars: abundances – stars: late-type – stars: variables: general – X-rays: stars

1. Introduction

This is the fourth paper of a series dealing with optical follow-up observations of EXOSAT serendipitous sources, i.e. sources that have been detected by the X-ray satellite EXOSAT in the field of other pointed objects. The observations by the *Einstein*, EXOSAT, ROSAT and EUVE satellites have provided large samples of stellar X-ray and EUV sources (see among others, Caillault et al. 1986; Fleming et al. 1988,1989a; Giommi et al. 1991; Pounds et al. 1993; Pye et al. 1995; Malina et al. 1994; Bowyer et al. 1996). Optical follow-up studies have shown that these samples are strongly dominated by active stars, pre-main sequence and other very young stars (see, among others, Fleming et al. 1988,1989b; Favata et al. 1993,1995; Jeffries et al. 1995; Neuhäuser et al. 1997; Cutispoto et al. 1999). In order to determine the physical nature of the stellar serendipitous X-ray sources detected by EXOSAT, our group embarked into an extensive optical program which includes multicolor photometry, medium- and high-resolution spectroscopy in various spectral regions and radial velocity determinations. Published results of this program concern medium resolution spectroscopy and optical photometry for a small subsample of EXOSAT sources (Cutispoto et al. 1991), optical photometry for 47 sources (Cutispoto et al. 1996) and an analysis of high-resolution spectroscopy in the Li I 6708 Å region for 23 stars (Tagliaferri et al. 1994). In these papers we have shown that, in addition to dMe flare stars, at least one third of the EXOSAT serendipitous sources is constituted by young stars, with ages comparable to or younger than the Pleiades, a third consists of active BY Dra-type or RS CVn-type binaries, while the remaining sources could be either young stars or very active binaries. Optical variability, probably produced by photospheric cool spots, appears to be rather common. Probably, the most interesting result is that there seems to be an excess of young stars, near the ZAMS or even younger, with respect to what is predicted by Galaxy population models, as recently confirmed by other authors from ROSAT data (Jeffries 1995; Neuhäuser et al. 1997; Cutispoto et al. 1999).

Our already published papers on follow-up observations of serendipitous sources detected by EXOSAT are based on data obtained at the European Southern Observatory, therefore they include stars with $\delta \leq +20°$. In this paper we present results of the observations carried out in the Northern hemisphere. Photometric and spectroscopic observations were collected at the Observatorio Astronomico National, UNAM (San Pedro Martir, BC, Mexico) over the periods: 22 August–2 September 1990, 29 April–11 May 1991, 20 October–2 November 1991, 11–26

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[*] based on data collected at Catania Astrophysical Observatory (Mt. Etna, Italy), at Observatorio Astronomico Nacional (UNAM, S. Pedro Martir, BC, Mexico) and at Kitt Peak National Observatory (Kitt Peak, AZ, USA)

[**] Table 1 is available in the on-line version; Table 3 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

April 1992 and 28 November–2 December 1992. Spectroscopy was also collected with the McMath telescope of the National Solar Observatory (Kitt Peak, AZ, USA) over the periods 13–14 December 1993 and 12–17 October 1994. Finally, eight of the stars in our sample are regularly scheduled at the 0.8-m Automated Photoelectric Telescope of Catania Astrophysical Observatory since late 1992 or summer 1993.

2. Data sample and observations

2.1. The sample

The stars analysed in this paper are a subset of the entire sample of stellar X-ray sources detected serendipitously by the Low Energy Imaging Telescope (LEIT) on board the EXOSAT satellite (White & Peacock 1988). All of the selected stars have $\delta \geq -3°$ and only partial or no information are available in the SIMBAD database. Out of the 32 X-ray sources thus selected, 24 belong to the EXOSAT High Galactic Latitude Survey (HGLS) and were identified as stars by Giommi et al. (1991). The remaining 8 do not belong to the HGLS, either because they are associated with the EXOSAT targets, or because they are at low galactic latitudes ($|b_{II}| < 20°$; see Giommi et al. 1991 for the definition of the EXOSAT HGLS). We assume these 8 stars to be counterparts of the X-ray sources because *(a)* their positions are within the X-ray error circle, *(b)* their X-ray to optical flux ratios are typical of stars (e.g. Stocke et al. 1991), and *(c)* no other plausible candidate is present in the X-ray error circle (whose radius varies between 20″ and 90″ depending on the source position on the detector). Almost all EXOSAT LEIT serendipitous sources were detected using the Thin Lexan filter in front of the Channel Multiplier Array (CMA) detector. Unfortunately, the CMA in conjunction with this filter suffered from UV contamination, which resulted in the detection of bright early-type stars mainly because of their UV emission. However, the expected flux due to UV radiation is a function of both the magnitude and spectral type and can be taken into account. This explains why the B-type star HD 334415 is in our sample. It is inside the X-ray error box, no other plausible optical candidate is present and its expected UV radiation is not sufficient to account for the EXOSAT detection level. Finally, some of the stars studied in this paper (i.e. HD 9902, SAO 130113, EXO 042535.0+1735.2, SAO 80493, EXO 122956.0+2039.8, EXO 125936.0+1238.5, HD 116544, BD+16 4908) were already analysed in previous papers (Cutispoto et al. 1996; Tagliaferri et al. 1994). They are discussed also here because our additional photometric and/or spectroscopic data do improve the knowledge of these targets.

2.2. Photometry

Differential photometric observations of 22 stars in our sample have been performed in order to search for optical variability and to derive magnitudes and colors. At San Pedro Martir photometric observations for 18 stars (see Table 1) were performed by using the 1.5-m telescope feeding the "Danish" simultaneous photometer equipped with a cooled EMI 9789QA phototube and Strömgren uvbyβ filters. A complete observation cycle consisted of five c-v-ck-c-v-c-v-c-ck cycles of simultaneous multiband measurements, where "v" is the program star and "c" and "ck" are a close comparison and check star, respectively. The adopted integration times were in the 15-40 s range, depending on the brightness of the observed star. From these data, corrected for atmospheric extinction, 15 v-c and 10 ck-c differential instrumental magnitudes were derived. The v-c data were then averaged to obtain a single data point. The typical error of our differential photometry in the instrumental system at San Pedro Martir is of the order of 0.002 magnitudes, with slightly larger values for the faintest objects. These observations were used only to investigate the presence of optical variability. UBV absolute photometry, we also used for star classification purpose, was obtained for 8 stars (see Table 1) at Catania Astrophysical Observatory (Mt. Etna, Italy) using the 0.8-m Automatic Photoelectric Telescope (APTCT) feeding a single channel charge-integration photometer equipped with an uncooled Hamamatzu R1414 SbCs phototube and standard UBV filters. A complete APTCT observation cycle consisted of sequential c-v-v-v-c-v-v-v-c-ck-c multiband measurements, with integration times, in the 10-15 s range, depending on the brightness of the observed star. From these data, corrected for atmospheric extinction, six v-c and one ck-c differential magnitudes were derived. The data were then transformed into the standard UBV system and the v-c values averaged to obtain a single data point. The typical error of APTCT differential photometry is of the order of 0.007 magnitudes, with slightly larger values for the U-band observations and for the faintest objects. The accuracy of APTCT absolute UBV photometry is of the order of 0.01 magnitude. Slightly larger errors characterize the absolute photometry of the faintest stars and the U$-$B colors. For the 24 stars we did not observe with the APTCT, the absolute photometry is from the Hipparcos output catalogue or from the literature. Our complete dataset is available in electronic form at the CDS.

2.3. Spectroscopy

For each star of our sample we collected at least one medium or high resolution spectrum in the Ca II H & K or Hα or Li I 6708 Å regions (see Table 2). The Ca II H & K and Hα lines are well-known and excellent indicators of chromospheric activity. Moreover, although the presence of a strong Li I 6708 Å is *per se* not sufficient to determine unambiguously the evolutionary state of a star, it can provide useful constraints when used in conjunction with other diagnostics like binarity, spectral class, rotation rate and X-ray luminosity.

The spectroscopy at San Pedro Martir was obtained with the 2.12-m telescope feeding a Boller & Chivens grating spectrograph equipped with a Thomson 7882 CDA (384x576 pixels) CCD detector. We used the available cameras and gratings, in various combinations, in order to cover the wavelength ranges 6000-7650, 6400-6950, 3750-4600 and 3780-4280 Å, with a nominal resolving power in the 1000 - 3000 range. We also used the McMath telescope equipped with the Solar-Stellar spectrograph and an 800x800 CCD detector with a 15x15 μm pixel size. The set-up was fixed to cover the wavelength ranges 6670-

Table 2. Summary of stellar data: star name, V-band magnitude (V), inferred spectral type, trigonometric or photometric (values indicated by ":") distance (D) in pc, Li I 6708 Å equivalent width (Li) in mÅ or detection flag, Hα and Ca II H & K (Ca II) lines detection flag, Period of photometric variability (P) in days, *v sin i* (vsini) in km s^{-1}, log L_X (where L_X is in 10^{30} erg s^{-1} units) from the ROSAT PSPC (PSPC) and the EXOSAT CMA (CMA), Li abundance (A_{Li}) in logaritmic scale (H abundance = 12), the symbol ‡ indicates the faint stars whose spectral types were evaluated from photographic plates data

star name	V	spectral type	D	Li	Hα	Ca II	P	vsini	PSPC	CMA	A_{Li}
SAO 11215	9.36	G8IV/V+G3V	111	65	pf			10	30.6	30.0	2.2
HD 9902	8.63	G3V/IV + G4V/IV	116:	55^1	a	a	7.30	12^1	30.4	30.3	2.7^1
BD+30 397 A	10.19	K6 PMS	42	260	e		9.38	5	30.0	29.9	2.0
SAO 130113	9.53	G7V + K5:V	76:	n	pf	a	2.63	18	30.3	30.3	1.1
EXO 041429.5+1206.7 ‡	13.4:	M4:Ve	24:	n	e				28.9	28.9	
EXO 042220.4+1709.3	13.21	M3V + M3V + M4:V	48:	n	e		?		29.5	29.2	
EXO 042535.0+1735.2	12.16	M1V + M3:V^2	47:	n	e				29.5	29.2	
HD 32199	8.91	G5V + M:V	63:	<3	a	a		2		29.4	<0.8
EXO 051342.5+4547.5	10.11	M0/1V + M5:V	13:		f				28.3	28.1	
EXO 073049.3+3156.4 ‡	12.3:	K0:V:	190:	n	pf	e				30.6	
BD+26 1682	10.14	K4:V	40:	<7	a	e?		10		28.8	<0.1
EXO 080731.0+2758.5 ‡	11.6:	K1:Ve	125:	n	e					29.9	
SAO 80493	8.58	F5V	99	65	a	a	<2.7	23		29.6	2.8
HD 95976	7.50	F4/5V	68	n	a	a	8.8			29.7	
HD 99900	8.58	F0IV +?	157	n	pf	a	1.2	80	30.4	30.5	
HD104753	9.26	G2/3IV +?	151	<10	pf	a		17		30.1	<1.5
EXO 122956.0+2039.8	12.89	M3Ve	26:	n	e				28.9	28.5	
EXO 125936.0+1238.5	12.77	M2.5Ve	27:	n	e				29.0	29.0	
EXO 130944.0+3229.3 ‡	14.3:	M1:V	85:	n	f					29.7	
HD 116544	9.08	K3/4IV/V +?	113			e	8.13	27	30.9	30.6	0.3
EXO 143138.3+3637.8 ‡	14.0:	M1:Ve	65:	n	e					29.0	
HD 143271	8.48	G4III	330	<5	a	a	27.46	12		30.8	<0.8
HD 167605	8.50	K1/2V + M4:Ve	31	n	pf	e	8.54	5	29.2	29.2	
HD 167389	7.38	G3V + K7:V	33	65	a	a		3		28.8	2.5
HD 234601	8.93	G2/3V	73:	115	a	a	7.35	7		29.3	2.7
EXO 181915.4+5038.7 ‡	14.4:	M3:V	35:	n	f					28.2	
HD 170527	6.81	G9: PMS	160	370	pf	e	25.5	23	30.8	30.9	3.5
HD 189733	7.67	K2V	19	<5	a	a		4	28.4	28.2	<-0.04
HD 334415	8.81	B5:Ve + B6:Ve	980:	n	pf		2.60	$50:^3$		31.9	
BD+16 4908	10.96	G5V + K2V	181:	y	pf		2.27			30.2	
HD 220091	6.67	F0/1IV	66	n	a	a				29.2	
HD 222143	6.58	G3/4V	23	50	a	a	7.5	6	29.1	29.1	2.2

Notes: n=line not detectable; y=line detectable; a=absorption line; pf=line partially filled-in by emission; f=line filled-in by emission; e=emission line; **1**: SB2 system, Li EW = 55 mÅ for both components, *v sin i* = 12 and 7 km s^{-1}, A_{Li} = 2.7 and 2.6; **2**: visual binary, both stars are constituted by M1V + M3:V components; **3**: SB2, *v sin i* = 50: and 30: km s^{-1}

6745 and 6530-6605 Å with a nominal resolving power of about 42000. Almost all integrations have a typical signal-to-noise in the 100 - 150 range. The spectroscopic data reduction was performed by using the IRAF package. After bias subtraction, the spectra were flat-fielded by using the spectrum of a quartz lamp. A Th-Ar lamp was used for wavelength calibration.

3. Results

3.1. Optical variability

Of the 22 stars included in our photometric sample, 11 new variable stars were discovered: EXO 042220.4+1709.3, SAO 80493, HD 95976, HD 99900, HD 143271, HD 167605, HD 234601, HD 170527, HD 334415, BD+16 4908 and HD 222143. Out of the 32 X-ray sources optical counterparts we studied, 31 are cool stars (i.e. not earlier than F0), and, among these, 14 are variable. For most of these stars the observed variability is likely to be due to the presence of photospheric cool spots whose visibility, modulated by the star rotation, produces periodic or quasi-periodic light variations. The observed color variations, which show the stars to become redder at light minimum, are consistent with this interpretation. We cannot exclude the presence of low amplitude optical variability for 12 of the remaining 17 cool stars in our sample, because the number of available data (from our observations or from the literature) is scarce. Moreover, in the case of spot-induced variability, it is possible that some stars may have been observed during an interval in which their light curve exibited a very low amplitude. The B-type star HD 334415 shows a low amplitude optical variability. The photometric periods have been determined from the V-band data both by a Fourier analysis and by fitting sine waves and searching for the minimum χ^2. The errors in the periods (ΔP) were estimated from the sine-fitting procedure and are given by the relation $\Delta P = P^2/(4\pi\ \Delta T)$, where ΔT is the time interval between the first and the last observation.

3.2. Rotational velocities

We computed the projected rotational velocity *(v sin i)* values from our high resolution spectra in the Li region by using the cross correlation task *"FXCORR"* of the IRAF package. The obtained FWHMs of the lines are used to estimate the *v sin i* (Soderblom et al. 1989). The method was calibrated by using six stars of known *v sin i* leading to reliable results in the 5-60 km s^{-1} range. In fact, for values lower than 5 km s^{-1} the intrinsic line width is larger than the rotational broadening, while for values higher than 60 km s^{-1} the Gaussian fit we used is not adequate anymore, as the rotational broadening of the line represents a large fraction of the observed spectral range. In particular, from the stars HD 82159 B (*v sin i* = 6 km s^{-1}), HD 82159 A (13), HD 25457 (17), BD+09 73 (18), HD 171488 (40) and HD 291095 (47) we got the calibration relation: *v sin i* = 0.699 $\times$ FWHM - 6.820, with a correlation coefficient of 0.98. The *v sin i* errors result of the order of $\pm$ 2 km s^{-1}. Only for HD 334415 we have an error of 5-10 km s^{-1}. Further details on this method are given in Tagliaferri et al. (2000). Additional data were obtained from the CORAVEL spectrometer database (Baranne et al. 1979) by using the standard calibrations (Benz & Mayor 1984; De Medeiros & Mayor 1999). The resulting errors are of the order of $\pm$ 1 km s^{-1}, with a few values up to $\pm$ 3 km s^{-1}. Finally a few values of rotational velocities were also obtained from the literature. The rotational velocity data are given in Table 2.

3.3. Radial velocities

We performed radial velocity (RV) measurements from our high resolution spectra to ascertain the single or binary nature of the stars in our sample. Our results are in Table 3. Unfortunately, we have high resolution spectra for only 13 stars and for most of them we have got only one spectrum. Details on the method we used for the RV determination are given in Cutispoto et al. (1999).

3.4. Inferred spectral classification

Spectral types are unknown for most of the stars in our sample. We used our UBV photometry, RVs, intensities of Ca I 6717.7 Å line from our high resolution spectra and the distances listed in the Hipparcos satellite output catalogue to infer or further constrain the spectral type and the luminosity class of our targets, as described in Cutispoto (1998) and Cutispoto et al. (1999). We are confident that the spectral classifications derived by the quoted method are very reliable, with uncertainties of the order of a few spectral subclasses (larger uncertainties are indicated with the symbol ":"), and in the case of stars already classified in our previous papers they represent our new best estimate. For some faint late-type stars (indicated in Table 2 with the symbol ‡) the only available information useful for spectral classification is found in the APM Sky Catalogue (www.aao.gov.au) or in other digitized photographic sky surveys accessible via SIMBAD. We used these data to infer preliminary color indices and V magnitudes. These tentative spectral classifications are much uncertain, up to several sub-classes. Incidentally, we note that most of the V magnitudes listed in the SIMBAD database for the stars indicated in Table 2 with the symbol ‡ were obtained by Giommi et al. (1991) using B and R photographic plates and, hence, they cannot be regarded as V magnitudes. Whenever multiple spectroscopic classifications are compatible with our data, they are discussed in Sect. 4.

3.5. X-ray luminosities

In order to compute the X-ray luminosities of the stars in our sample we converted into flux the EXOSAT CMA count rate using as conversion factor $ECF = 1 \times 10^{-10}$ erg cm^{-2} in the 0.05-2 keV energy band (see Pallavicini et al. 1988 for a discussion about this conversion factor). We also searched the ROSAT bright source catalog and, in case of detection, we give the ROSAT PSPC X-ray luminosity in the 0.2-2.5 keV energy band. The conversion from count rates to X-ray fluxes for the ROSAT data has been done using the conversion factor $ECF = (8.31 + 5.30HR) \times 10^{-12}$ erg cm^{-2} given by Fleming et al. (1995). The absolute magnitudes (M_V) were computed from the trigonometric parallax obtained by the Hipparcos satellite (D_H). When this value was not available we used the photometric parallax (d_{ph}). The adopted distances are reported in Tables 2 and 3, where the photometric values are marked with the symbol ":". The precision of the distances measured by the Hipparcos satellite, which usually are below 10%, are given in Sect. 4 for each star. Typical errors in the photometric distance determination are at least of the order of 15-20%.

For the X-ray vs. *v sin i* and X-ray vs. M_{bol} relations, we attributed the measured X-ray luminosity to the primary component in case of SB1 systems, while for the SB2 systems (SAO 11215, HD 9902 and HD 334415) the X-ray luminosity was equally divided between the two components.

3.6. Line equivalent width

We have computed the equivalent width (EW) for the Li, Hα and Ca II H & K lines and have listed the results in Table 2. For the stars observed with the McMath telescope, we give the EW of the Li line in mÅ. For the stars observed at S.Pedro Martir, we just annotate in the list whether the Li line was not detectable (n) or detectable (y). The latter circumstance should correspond to an EW of the order of 100 mÅ or larger. For the Hα line, for both the observations carried out at the McMath and at S.Pedro Martir, we have defined four regimes comparing the strength of the line to that of non-active stars of known spectral type. We have listed the Hα line as in absorption (a), partially or totally filled-in by emission (pf and f, respectively), or in emission (e). For the Ca II H & K lines, for which we only have medium-resolution data, we just report the presence of emission (e) or absorption (a). Finally, from high-resolution spectra, we have computed Li abundances (A_{Li}, see Table 2) in NLTE, following the procedure described in Carlsson et al. (1994). We used the "corr_nlte" routine made available from "*ftp.astro.uio.no*". This routine requires as input data: LTE, T_{eff}, log g, and [Fe/H]. In the few cases where one or more of the above parameters are out of the range allowed by the above mentioned routine (BD+30 397A, HD 32199, BD+26 1682 and HD 189733), we list the Li abundance computed in LTE condition. Anyway, the differences between NLTE and LTE values are always smaller than 0.1. We have not calculated A_{Li} from medium-resolution spectra, owing to the uncertainty of the measurements of the Li EW from these spectra.

4. Discussion of individual stars

The results and discussion on the individual stars are now presented. Our work has benefited greatly from the data collected by the Hipparcos satellite and presented by Perryman et al. (1997). In particular, the trigonometric parallax was often the key parameter to choose between two or more possible spectral classifications. The magnitude difference between the components was very useful in the case of visual binaries and the Variability Annex was useful to study some of our targets.

EXO 002527.1+6327.5 = SAO 11215: a visual binary (ADS 371) with 0.″522 angular separation, magnitude difference between the components of 0.43 (V_A=9.92, V_B=10.35) and distance within the 83-167 pc range, as reported by the Hipparcos satellite. The two spectral combinations G6V + G9V (d_{ph}=85 pc) and G8IV/V + G3V (d_{ph}=139 pc) fit well the above characteristics and the observed colors. However, from the spectral signatures the G8IV/V + G3V classification seems more adequate. The Hα is partially filled-in by emission. The RV of the primary component seems to be constant.

EXO 013424.7+2026.8 = HD 9902 = BG Psc: an SB2 RS CVn-type system already studied by us (Cutispoto et al. 1996; Tagliaferri et al. 1994). Here we present the collection of the available photometry, including the observations obtained by the APTCT since late 1992 (Fig. 1). There is a clear evidence of a long-term, though small amplitude, variability of the photospheric spottedness. From the Ca I line strength and from the *v sin i* computed by Tagliaferri et al. (1994) and inferred from CORAVEL data (12±1 and 7±1 km s^{-1} for the two components, respectively), the spectral classification and the photometric distance are revised to G3 V/IV + G4 V/IV and 116 pc, respectively. The trigonometric parallax is listed in the Tycho catalogue and the distance falls in the 44-85 pc range. The photometric periods computed by us, that fall in the 7.30(±0.09) - 7.60(±0.14) day range, are quite different from the orbital period of 25.364 days given by Baker et al. (1994), the latter always producing poorly defined light curves. Moreover, by assuming the orbital period as the stellar rotational period very large stellar radii and a giant classification for both components would be implied, a result not consistent with the parallax. We also note that one of the two stars rotates faster, which cannot be attributed to a different radius. This is a quite unexpected result and could imply that such star is itself a spectroscopic binary.

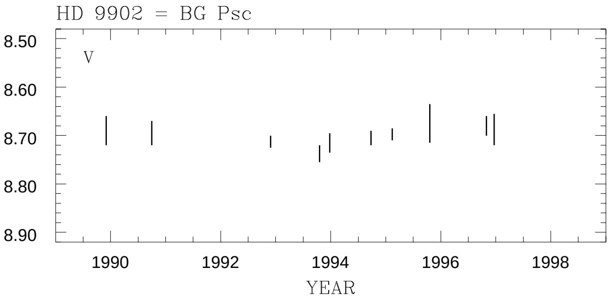

Fig. 1. HD 9902 = BG Psc V-band long-term variability; the vertical bars indicate the peak-to-peak amplitude of the light curves

EXO 022427+3045.4 = BD+30 397: a visual binary (V_A=10.12, V_B=12.55) with a separation of about 23″. The brighest component (BD+30 397 A = AG Tri) is listed in the Hipparcos Variability Annex as a variable star with a period of 9.3784 days and an amplitude of at least 0.1 magnitudes. Our y-band observations carried out in October 1991 show an almost monotonic increase in luminosity ($\Delta y \geq 0.045$) over an interval of about 8 days. Previous ground-based photometry has been obtained for both components by Weis (1991,1993), that probably observed the secondary component during a flare event, and by Ianna (1979). It is not clear if this visual pair is a true binary system (Ianna 1979). The colors and the spectroscopic signatures are consistent with a K6V and an M1/2:V classification for the A and B components, respectively. Such classification implies d_{ph}=29 pc, that it is not in agreement with the value measured by Hipparcos (39 pc $< D_H <$ 46 pc). From the two available RV measurements (Table 3) AG Tri seems to be single. Its mimimum radius is about 0.93 $R_\odot$, that is definitely larger than the typical radius of a K6V star. In our McMath spectra there is a very strong Li line with an EW of about 260 mÅ. From the above characteristics we argue that AG Tri is a K6 PMS star, with a radius of about 1$R_\odot$ (d_{ph}=42 pc). AG Tri also shows a variable Hα line, that was seen in strong emission on 20 October 1991, while the following night the emission was hardly visible. If BD+30 397 B formed a physical pair with AG Tri, it would be an M1/2: PMS with a radius of about 0.7 $R_\odot$, otherwise it would be just an M1/2: V field star (d_{ph}=29 pc).

EXO 024453.3-0024.9 = SAO 130113 = BY Cet: has been studied by Cutispoto et al. (1996), who discovered its optical variability and by Tagliaferri et al. (1994), who classified SAO 130113 as an SB2 system and measured a *v sin i* of 18 km s^{-1} for both components. An orbital period of 2.634 days was independently found by Duquennoy (1993) and Baker et al.

(1994). Here we revise the two possible spectral classifications given by Cutispoto et al. (1996) to G7V + K5:V (d_{ph}=76 pc) and to K0IV + F6V (d_{ph}=290 pc). Finally, we retain the G7V + K5:V classification also on the basis of the $M_2/M_1 = 0.74$ mass ratio value found by Duquennoy (1993). The Hα line is partially filled-in by emission, the Ca II H & K lines are in absorption. Photometric observations of SAO 130113 had been carried out both at San Pedro Martir in August 1990 and by the APTCT since late 1992. The collection of the available V-band data, which shows clear evidence of a long-term variability of photospheric spottedness, is presented in Fig. 2. The APTCT data are consistent with a photometric period of 2.627 ($\pm$0.007) days. Further photometry of this star is in Cutispoto et al. (2000).

EXO 041429.5+1206.7: has a very strong Hα emission line (EW$\sim$6Å). For this star we have further spectra, taken at the 1.52-m ESO telescope for a different program, with a resolution of about 2Å, from which we infer an M4 V classification, in good agreement with the result obtained from the APM Sky Catalogue data.

EXO 042220.4+1709.3 = VA 351: a member of the Hyades cluster that has also been detected by the ROSAT satellite (Stern et al. 1995). Stauffer et al. (1997) reported that it is an SB3 system with all components being M-type stars showing Hα emission. Moreover, they infer that two of the components should be tidally locked with an orbital period of about 3 days, and that such system should be an eclipsing binary. Franz (1996) resolved the two main components, that resulted to have an orbital period of about 3.36 years. Pesch (1972) detected flare and out-of-flare optical variability. Ca II emission and the absence of a detectable Li line has been observed by Hartmann et al. (1987). A trigonometric parallax of about 48 pc has been obtained by Hanson (1975) and by Eggen (1989). Our y-band photometric observations carried out in two different nights (November 1 and 2, 1991) differ by 0.05 magnitudes, while the ck-c values differ by only 0.006 magnitudes. In the spectrum we detected Hα emission (EW$\sim$5 Å) but no signature of the Li line. From the observed colors, the spectral characteristics and the trigonometric parallax, it is likely that the system consists of a pair of almost identical M3V stars, plus a lower mass companion with spectral type M4:V or slightly later.

EXO 042535.0+1735.2 = VA 486 = V1102 Tau: a member of the Hyades cluster (van Altena 1969) which was also detected by the *Einstein* (Micela et al. 1988) and ROSAT (Stern et al. 1995) satellites. The presence of Hα emission (Stauffer et al. 1991) is confirmed in our spectra, where an EW $\sim$3 Å was measured. The Ca II H & K lines appear in emission, as reported by Herbig et al. (1986). Photometry and a preliminary spectral classification have been already presented by our group (Cutispoto et al. 1996), that classified VA 486 as a binary system. However, taking into account the 49 pc trigonometric distance obtained by Hanson (1975), the spectral classification appears somewhat more complicated. In fact, assuming a simple M1V + M4V system, a photometric distance of 33 pc results. Griffin et al. (1988) reported that this system is an SB with a period longer than 5 years. Prosser et al. (1995) noted that VA 486 is a visual binary with the two components separated by about 1$''$. They also inferred that one of the two stars, although it is not clear which one, is an SB with an orbital period of 2.42 days. From these pieces of information we infer that VA 486 is indeed formed by two almost equal SB systems, both constituted by M1V and M3:V components. The photometric distance of such system is 47 pc, in good agreement with the trigonometric value.

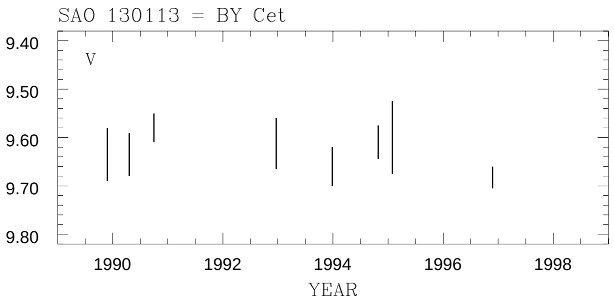

Fig. 2. SAO 130113 = BY Cet V-band long-term variability; the vertical bars indicate the peak-to-peak amplitude of the light curves

EXO 045921.5+2425.2 = HD 32199: a star observed by the Hipparcos satellite with a measured distance in the 22-61 pc range. Such a measurement, in spite of the quite large error, is good enough to ensure that HD 32199 has not yet evolved significantly from the MS. The star has been observed photometrically over a period of eight nights and no sign of variability was revealed. Two spectra, one in the Hα region and the other, acquired three nights later, in the Li region, were obtained with the McMath telescope. The RV seems to be constant and an upper limit of 3 mÅ was obtained for the Li line EW. We also got a medium-resolution spectrum in the Ca II H & K region and no emission was observed. HD 32199 is a slow rotator, if fact the *v sin i* inferred from the McMath spectra is $<$5 km s^{-1} and it is of the order of 2$\pm$2 km s^{-1} from the CORAVEL data, which also suggest its SB nature. From the spectroscopic signatures we infer a G5V + M:V classification (d_{ph}= 63 pc). However, the RV measurements indicate that this star is not a close binary

EXO 051342.5+4547.5 = GL 195: a visual binary ($\rho \simeq 3''$ in 1958) with an orbital period of about 300 years (Fischer & Marcy 1992). It was also detected by the ROSAT (Tsikoudi & Kellett 1997) and by the EUVE (Malina et al. 1994; Bowyer et al. 1996) satellites. The presence of Hα emission was noted by Stauffer & Hartmann (1986), while in our spectra the Hα is fully filled-in but never in emission. Several spectral classifications are reported in the literature, with the primary ranging from M1V (Johnson 1983) to M2.5 (Doyle 1989) and the secondary, that is about 3.5 magnitudes fainter in the V-band (Bidelman 1985), ranging from M4V (Bidelman 1985) to M5V (Agrawal et al. 1986). From the parallax measurements and the observed colors, we infer the M0/1V + M5:V classification (d_{ph}=13 pc), that results in good agreement also with the masses of the two components (0.53 $M_{\odot}$ and 0.19 $M_{\odot}$, respectively) computed by Fisher & Marcy (1992).

EXO 073049.3+3156.4: a star for which partially filled-in Hα line and very weak emission CaII K line were observed. No Li line was detected in our medium-resolution spectra.

EXO 075329.0+2559.0 = BD+26 1682: a star for which a minimum value for the distance of 27 pc has been obtained by the Hipparcos satellite. From the spectral signatures and the B$-$V we infer a K4:V spectral type. The Li line seems to be absent or very weak (EW $<$ 7mÅ). The Hα line is in absorption, while the presence of a very weak CaII K emission seems possible.

EXO 080731.0+2758.5: the Hα line appears in emission and strongly variable in our low-resolution spectra. In fact, the remarkable emission (EW$\sim$1Å) detected on 21 October 1991, disappeared the next night, when the line was completely filled-in but not in emission. No Li line was detected.

EXO 085108.9+2025.2 = SAO 80493: a star also detected by the *Einstein* satellite and studied by Cutispoto et al. (1996). Here we revise the spectral type to F5V. The corresponding photometric distance of 112 pc is in agreement with the upper limit of the distance range (88-114 pc) measured by Hipparcos. Stocke et al. (1991) report a $v \sin i$ of 26$\pm$2 km s^{-1}, in good agreement with the value inferred by us. Our photometric observations, carried out in May 1991 over an interval of 4 nights, reveal low amplitude optical variability with an amplitude $\geq$0.02 magnitude in the y-band. Given the spectral classification and the $v \sin i$, the photometric period of SAO 80493 should be shorter than 2.8 days. Although our few photometric data do not allow us a precise determination of the period, they are in agreement with a value shorter than 2.7 days.

EXO110157.4+3831.0 = HD 95976: is the C component of the visual multiple system ADS 8046. The photometric distance (d_{ph}=72 pc) is within the trigonometric distance range (52 pc $< D_H <$ 99 pc). From the RV data reported by Abt (1970), the presence of a low mass companion is possible. From our y-band photometry carried out in April 1992 optical variability with a photometric period of 8.8 $\pm$ 0.6 days was discovered (Fig. 3).

EXO 112714.2+4632.0 = HD 99900: was discovered by us to be a variable star with a y-band amplitude of about 0.04 magnitudes and a period of 1.16 $\pm$ 0.02 days. The variability is also confirmed in the Hipparcos Variability Annex where HD 99900 is listed as an unsolved variable. The spectral classification is given as A7IV by Slettebak et al. (1968), that also list $v \sin i$ = 80 km s^{-1}. However, neither the B$-$V and V$-$I colors of an A7IV star, nor the corresponding photometric distance (203 pc), appear in agreement with the Hipparcos data (135 pc $<$ D_H $<$ 189 pc), that are better fitted by an F0IV (d_{ph}=164 pc) star. For such a star an inclination angle of about 70° can be computed. Further photometry by Bossi et al. (2000) confirms the photometric period inferred by us. RV variability has been reported by Grenier et al. (1999).

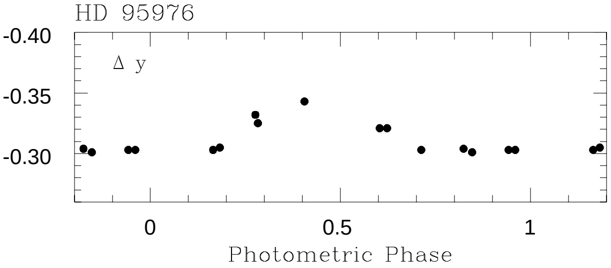

Fig. 3. HD 95976 instrumental y-band light curve for the mean epoch 1992.30; phases are reckoned from the photometric ephemeris HJD = 2448700.0 + 8.8 · E

EXO 120119.4+4508.3 = HD 104753: a star observed by Hipparcos (127 pc $<$ D_H $<$ 187 pc). A weak Li line (EW $<$ 10 mÅ), a partially filled-in Hα and Ca II H & K absorption lines were observed by us, but no optical variability was detected. The colors are consistent with a G2/3IV star (d_{ph}=143 pc). However, from the Ca I line strength we infer the presence of a late-type companion. For the primary component we got the $v \sin i$ values of 15$\pm$2 and 19$\pm$3 km s^{-1} from the McMath spectra and the CORAVEL data, respectively.

EXO 122956.0+2039.8 = 1E 1229.9+2039: was already studied by Cutispoto et al. (1996). Here we slightly revise the photometric distance and confirm the presence of Hα emission (EW = 550 mÅ).

EXO 125936.0+1238.5: a dMe star already studied by our group (Cutispoto et al. 1996) and by Caillault et al. (1986), Caillault (1990), Stocke et al. (1991) and Gizis & Reid (1997). Here we slightly revise the spectral type and the photometric distance as well as we confirm the presence of Hα emission (EW$\sim$2.5 Å).

EXO 130944.0+3229.3: a star also detected by the *Einstein* satellite (McDowell 1994). It shows a filled-in Hα.

EXO 132149.3-0203.2 = HD 116544 = IN Vir: a well-studied (Cutispoto et al. 1996; Cutispoto 1998; Strassmeier et al. 1997; Strassmeier 1997 and references therein) RS CVn-type variable (97 pc $<$ D_H $<$ 136 pc). We detected strong emission in the core of Ca II H & K lines. IN Vir has been observed by the APTCT since 1993. A $v \sin i$ of 27$\pm$3 has been obtained by CORAVEL. Such value is consistent, within the errors, with the values listed by Tagliaferri et al. (1994) and by Strassmeier (1997). The APTCT data are consistent with a mean photometric period of 8.13$\pm$0.08 days.

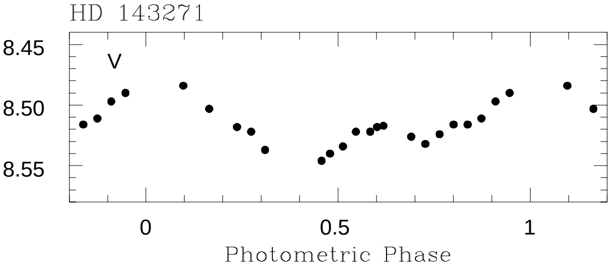

Fig. 4. HD 143271 V-band light curve for the mean epoch 1996.52; phases are reckoned from the photometric ephemeris HJD = 2449149.0 + 27.46 · E

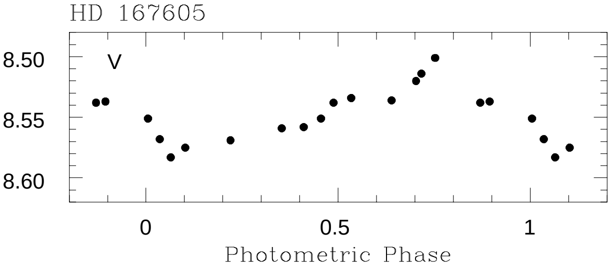

Fig. 5. HD 167605 V-band light curve for the mean epoch 1994.60; phases are reckoned from the photometric ephemeris HJD = 2449162.0 + 8.54 · E

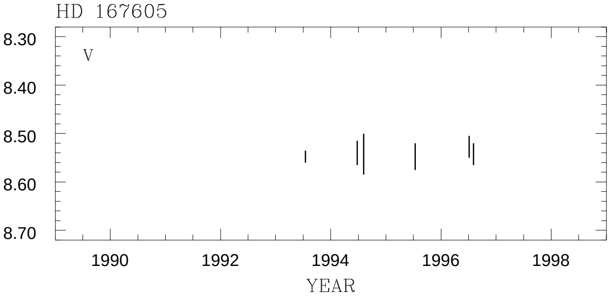

Fig. 6. HD 167605 V-band long-term variability; the vertical bars indicate the peak-to-peak amplitude of the light curves

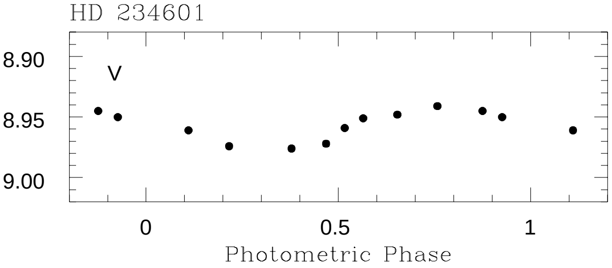

Fig. 7. HD 234601 V-band light curve for the mean epoch 1995.55; phases are reckoned from the photometric ephemeris HJD = 2449181.0 + 7.35 · E

EXO 143138.3+3637.8: a late-type star for which we detected a strong Hα emission line (EW $\sim$ 2 Å).

EXO 155625.8+2659.7 = HD 143271: it shows weak or no Li line (EW <5mÅ) and Hα and Ca II H & H absorption lines. The colors are consistent with a G4III classification (d_{ph}=328 pc), that results somewhat earlier than the spectral type listed in SIMBAD. Despite the large error (242 pc $<$ D_H $<$ 521 pc), the parallax is precise enough to ensure that HD 143271 is a giant. From the May 1991 observations at San Pedro Martir we obtained marginal indication of optical variability, while in April 1992 the star was constant. HD 143271 has been observed by the APTCT since 1993 and optical variability with a mean period of 27.46±0.86 days (Fig. 4) and clear indication of a long-term variation of the photospheric spottedness were found. We also measured a $v \sin i$ of 12 km s^{-1}, which is consistent with a G4III star having a rotational axis inclination i $\sim$ 68°.

EXO 181022.2+6939.9 = HD 167605: a high proper-motion star also detected by the *Einstein* satellite (Stocke et al. 1991). It has been classified as a K2V + M4V close binary ($\rho \simeq 1.2''$) by Arribas et al. (1998), that also detected Hα emission from the secondary component. Very low Li abundance was measured by Favata et al. (1993) in the spectrum of the primary component, that also shows a low rotation rate (Stocke et al. 1991; Favata et al. 1995). The mean colors are consistent with a K1/2V + M4:V classification (d_{ph}=28 pc). HD 167605 (30 pc $<$ D_H $<$ 32 pc) is listed as an unsolved variable in the Hipparcos Variability Annex. The observations carried out by the APTCT revealed optical variability with a photometric period of 8.54± 0.10 days (Fig. 5) and the presence of a long-term modulation of the photospheric spottedness (Fig. 6). Our low resolution spectra of the primary component show no Li line, partially filled-in Hα and Ca II H & K emission lines. The CORAVEL data indicate that the primary component is single with $v \sin i$ = 5±1 km s^{-1}, which yields i $>$ 60°.

EXO 181132.2+4127.7 = HD 167389: a star showing quite a strong Li line (EW = 65 mÅ) and Hα and Ca II H & K absorption lines in our spectra. There is no indication of optical variability. From the colors and the spectroscopic signatures we infer a G3V + K7:V classification. The photometric parallax (d_{ph}=35 pc) is in good agreement with the Hipparcos data (32.8 pc $<$ D_H $<$ 34.1 pc). We note that our classification is quite different from the spectral type reported in SIMBAD, the latter being inconsistent with D_H. This star seems to be a slow rotator. In fact the $v \sin i$ is smaller than 5 km s^{-1}from the McMath spectra and of the order of 3±2 km s^{-1} from the CORAVEL data.

EXO 181511.2+5013.1 = HD 234601: a star showing a significant Li line (EW = 115 mÅ) and absorption Hα and Ca II H & K lines. We found optical variability with a mean photometric period of 7.35±0.08 days (Fig. 7) and clear evidence for a long-term variability of the photospheric spottedness. From the observed V-band magnitude and B$-$V color G2/3V (d_{ph} = 73 pc) and G1IV (d_{ph} = 121 pc) spectral classifications are possible. We prefer the dwarf classification because it gives a d_{ph} rather close to the central value of the trigonometric range (41 pc $<$ D_H $<$ 123 pc). The $v \sin i$ inferred

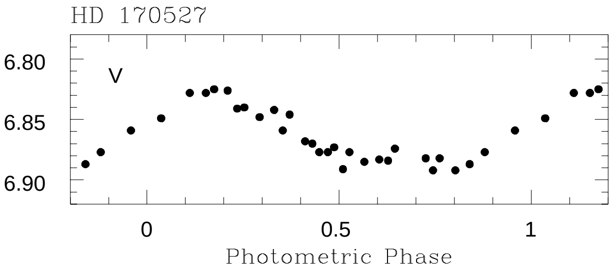

Fig. 8. HD 170527 V-band light curve for the mean epoch 1995.60; phases are reckoned from the photometric ephemeris HJD = 2449161.0 + 25.5 · E

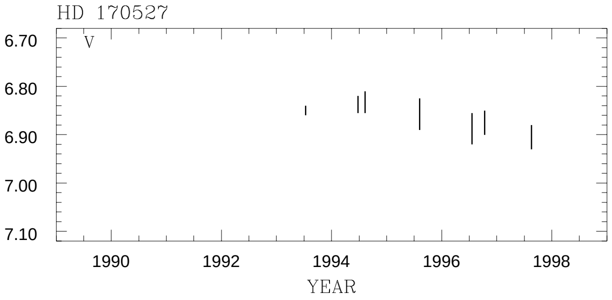

Fig. 9. HD 170527 V-band long-term variability; the vertical bars indicate the peak-to-peak amplitude of the light curves

from our high-resolution spectra yields a minimum stellar radius $\simeq 1\,R_\odot$, consistent with a G2/3V star having i $\simeq$ 90°.

EXO 181915.4+5038.7: a late-type star which shows no Li line and a filled-in Hα.

EXO 182457.6+6448.4 = HD 170527: a star showing a strong Li line (EW = 370 mÅ), a partially filled-in Hα line and Ca II H & K emission lines. X-ray emission was also detected by ROSAT (Kolman et al. 1993). HD 170527 (146 pc $<$ D$_H$ $<$ 177 pc) is listed as an unsolved variable (6.81$<$ V $<$6.87) in the Hipparcos Variability Annex. The APTCT revealed optical variability with a mean photometric period of 25.5±0.9 days (Fig. 8) and clear evidence of long-term variability of the photospheric spottedness (Fig. 9). Further photometry is in Gunn & Stryker (1983), who classified HD 170527 as a G5IV star, but such a classification is not in agreement with D$_H$. We got *v sin i* measurements of 22±2 km s^{-1} and of 24±2 km s^{-1} from the McMath and CORAVEL spectra, respectively. The CORAVEL data also indicate that HD 170527 is single. The *v sin i* values lead us to compute a minimum stellar radius of the order of 10 R$\odot$. Hence, this star is not on the MS, in fact a G9:III classification (d$_{ph}$=150 pc) would fit reasonably well both the observed colors and D$_H$. Finally, we note that the high rotation rate and the strong Li line we observed are both pretty unusual for a single giant star, therefore we propose that HD 170527 is a PMS star.

EXO 195834.1+2234.6 = HD 189733: a high proper-motion star. Our medium-resolution spectra reveal the presence of Hα and Ca II H & K absorption lines. In the high resolution spectra the EW of the Li line is smaller than 5 mÅ. From the observed colors and the spectral signatures we infer a K2V classification, whose photometric parallax (d$_{ph}$=18 pc) is in excellent agreement with the value measured by Hipparcos (18.9 $<$ D$_H$ $<$ 19.6). We have no indication of optical variability from our observations carried out in August 1990, while in the Hipparcos catalogue HD 189733 is listed as a possible micro variable (i.e. a variable with an amplitude $\leq$ 0.03 magnitude). The *v sin i* is 4±1 km s^{-1} from the CORAVEL data, and 9±2 km s^{-1} from the McMath data.

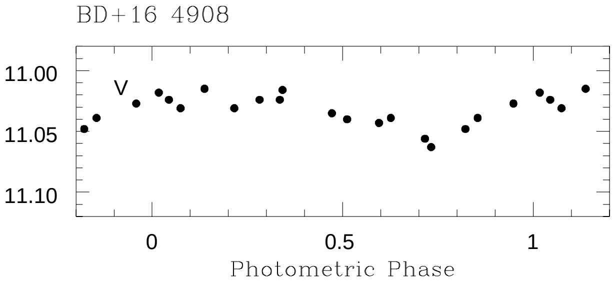

Fig. 10. BD+16 4908 V-band light curve for the mean epoch 1994.68; phases are reckoned from the photometric ephemeris HJD = 2449541.0 + 2.30 · E

EXO 202513.7+2809.8 = HD 334415: the A component of the triple visual system IDS 20221+2800 (Jeffers et al. 1963). Components A (HD 334415, V = 8.81) and B (BD+27 3728B, V ∼ 11.2) are separated by about 39″; components B and C (BD+27 3738C, V ∼ 11.3) are about 4″ apart. Our uvbyβ photometry carried out in October 1991 shows clear indication of optical variability with an amplitude of at least 0.05 magnitudes and possible periods of 2.60±0.08 and 6.0±0.4 days. This star was classified as B8 by Nesterov et al. (1995). In our medium-resolution spectra the Hα line shows a large profile with narrow central absorption, typical of the Be-type stars. Our high resolution spectra show that HD 334415 is an SB2 system and from the strength of the He I 6678 lines we infer a B5:Ve + B6:Ve classification.

EXO 231752.9+1630.9 = BD+16 4908: was already studied by Cutispoto et al. (1996), who inferred its binary nature. Here we revise its spectral type to K0IV + F5V (d$_{ph}$= 586 pc) and note that also a system G5V + K2V (d$_{ph}$= 181 pc), whose primary component is in very good agreement with the classification listed in SIMBAD, fits equally well the observed colors. We find evidence for optical variability (Fig. 10), with a period in the 2.27±0.01 - 2.47±0.01 day range, and for long-term variability of the photospheric spottedness (Fig. 11). Strong Li line and partially filled-in Hα line were also detected by us.

EXO 231827.4+1658.7 = HD 220091: a star, classified as A9 III in the SIMBAD database, also detected by the ROSAT satellite (Simon et al. 1995). Our observations show Hα and Ca II H & K absorption lines and no Li line. In the Hipparcos cata-

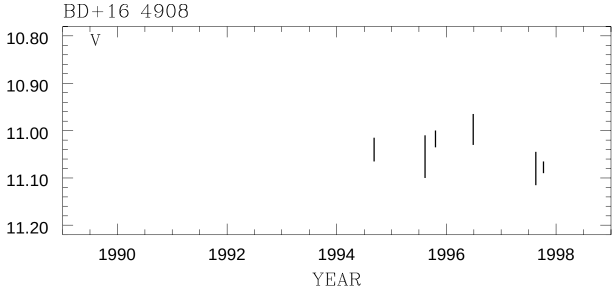

Fig. 11. BD+16 4908 V-band long-term variability; the vertical bars indicate the peak-to-peak amplitude of the light curves

logue a 62-70 pc distance range is reported, and the star is listed as a possible micro variable. Our photometric observations carried out at San Pedro Martir in August 1990 show an almost constant luminosity. Only one observations showed the star almost 0.04 magnitudes fainter than in any other. The observed colors (Oja 1983) are best matched by an F0/1 star and the distance by a luminosity class IV or IV/V. We exclude the A9III classification that would imply a photometric distance of 116 pc.

EXO 233530.1+4555.4 = HD 222143: a high proper-motion star, also detected by the ROSAT (Huensch et al. 1998) and EUVE (Bowyer et al. 1996) satellites, for which the metallicity [m/H]=0.02 was measured by Carney et al. (1994). The colors reported in the Hipparcos catalogue and by Oja (1991) are consistent with those of a G3/4V star, whose photometric parallax (d_{ph}=23 pc) is in excellent agreement with the trigonometric value (22.7 pc $<$ D_H $<$ 23.6 pc). In August 1990 and October 1991 we revealed optical variability, with an amplitude of about 0.02 magnitudes in the y-band and a tentative period of 7.5 ± 0.6 days. This low amplitude variability is confirmed in the Hipparcos catalogue. Our low resolution spectra revealed a weak Li line, and Hα and Ca II H & K absorption lines. From our high resolution spectra the RV appears to be constant, and we measured an EW of 50 mÅ for the Li line.

5. Discussion and conclusions

Although our sample is quite heterogeneous, some interesting results can be drawn. First, we have observed 16 stars, with spectral types from F to M, for which no extensive photometry devoted to optical variability studies had been previously obtained. We have indeed detected variability for 10 of them. This is a lower limit, but it is already a significantly high fraction. The periods so far determined are all between 1 and 28 days, and the amplitude of the detected variability is typical of spotted active stars. The rotation rates are much larger than for “*normal*” stars of the same spectral type, consistently with the expectation that active coronal sources are also fast rotators (Pallavicini et al. 1981).

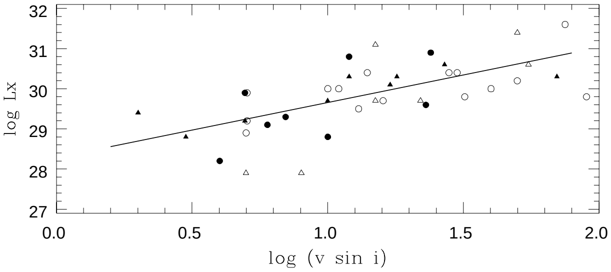

Fig. 12. EXOSAT X-ray luminosity vs. projected rotational velocity for single (dots) and binary stars (triangles). Filled symbols are for stars presented in this paper, open symbols are for stars from the Southern sample (Tagliaferri et al. 1994). The solid line represents the L_X vs. $v \sin i$ relation which was fitted to the sample ($\log L_X = 28.3 + 1.37 \log vsini$)

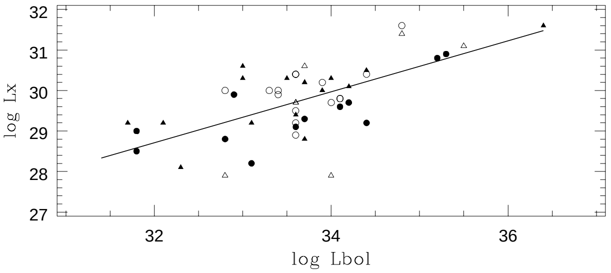

Fig. 13. EXOSAT X-ray luminosity vs. bolometric luminosity; symbols are as above. Note the strong correlation that is present also bewteen L_X and L_{Bol} ($\log L_X = 8.58 + 0.63 \log L_{Bol}$)

The level of activity in cool stars is linked to their rotation rate up to a “*saturation*” level (Fleming et al. 1989a; Stauffer et al. 1994; Randich et al. 1996). Namely, there seems to be an upper limit to the coronal activity exhibited by any late-type star, which depends on the star’s surface. In fact, in a regime of “*saturation*”, the level of activity per unit area is constant (because at the maximum level) and the total stellar activity can only be increased by increasing the stellar surface (and not the star rotation). A flux-limited X-ray selected sample of late-type stars should preferably contain stars close to this upper limit. With our data we can now check if this is also true for the EXOSAT sample of cool stars. We considered the 17 stars in our Northern sample (we excluded the B star from this analysis) plus another 22 stars from the Southern sample (Tagliaferri et al. 1994) for which we have determined the $v \sin i$. In Fig. 12 we plot the X-ray luminosities against the projected rotational velocities. Although there is a large scatter at any given values, probably also due to the hetereogeneity of our sample, a clear correlation is apparent, as expected. By considering a simple linear fit we obtain a coefficient of r=0.64 for 39 points (the null hypothesis can be rejected with a confidence level higher than 0.999).

In Fig. 13 we plot the X-ray luminosities against the bolometric luminosities. Again, a clear correlation is apparent, with a linear correlation coefficient of r=0.66 for 49 points (also in this case the null hypothesis can be rejected with a confidence level higher than 0.999). Thus, we confirm the existence of a correlation between the stellar rotation rate and activity level and also between the X-ray and the bolometric luminosities for our sample of X-ray selected active stars. These stars are likely close to their activity saturation level.

In recent years, many authors have studied the presence (or lack) of correlations between lithium, activity and rotation. Younger stars are faster rotators, thus being more active than older stars, and should have higher lithium abundances. Clearly, in a flux limited X-ray selected sample of cool stars, one would expect to detect preferably either young stars or stars in close binary systems (e.g. Fleming et al. 1989a; Favata et al. 1993; Tagliaferri et al. 1994). For 13 stars in our sample we were able to determine the Li abundances or the Li abundance upper limits. As already found in previous works (Favata et al. 1993; Tagliaferri et al. 1994), the sample contains stars with very high Li abundance, with values similar to that measured for the Pleiades. Actually, for two of them (HD 170527 and BD+30 397A) these values are well above the maximum values in Pleiades. These stars have not probably reached the main sequence yet, although they are not associated with star forming regions. About one third of the sample has instead very low Li abundance, again a common feature in samples of X-ray selected late type stars (Favata et al. 1993; Tagliaferri et al. 1994). They are probably older stars, few of them are binaries and their high level of activity can be explained by tidally induced high rotation rate. However, three of them (BD+26 1682, HD 143271, HD 189733) seem to be single and the first two, in particular, have high X-ray luminosity and rotation rate. The relatively high level of rotation and activity of HD 143271 could be explained by the giant nature of the star. The case of BD+26 1682 is more difficult to explain, unless a fainter companion, not detectable by us, is present, sustaining the high rotation rate of the primary.

An interesting result of our work with the Southern sample was the finding of 7 nearby, previously unknown, M-type dwarfs (Cutispoto et al. 1996). In the present sample we have found an additional previously unkown M-type star within 25 pc.

One of our stars, HD 334415, is a binary system made of two Be stars. It is known that stars of spectral type B5-A5 are not X-ray emitters (Rosner et al. 1985; Pallavicini 1989; Schmitt 1992), while HD 334415 has a strong X-ray emission of about 10^{32} erg s^{-1}. Again this is puzzling, unless there is a third cooler companion that is responsible of the X-ray emission. We also note that HD 334415 is variable in the optical.

To conclude, our sample of EXOSAT serendipitous sources appears to contain a variety of active stars, including very young objects, RS CVn-type binaries and dMe stars. Extensive follow-up optical observations of serendipitously detected X-ray stars appear to be essential in order to identify the content of the X-ray samples.

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