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BRIGHTNESS VARIATIONS OF SAO 53210

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With the aim to test the physical nature of some of the stellar serendipitous X-ray sources detected by EXOSAT (Giommi et al., 1991), our group collected, during the years 1990-1992, several photometric and spectroscopic observations at the Observatorio Astronomico National, UNAM (San Pedro Martir, BC, Mexico). For each star of our sample only few observations were obtained, but in many cases they were sufficient to point out the presence of some photoelectric variability (Cutispoto et al., 2000). So we decided to plan, during the following years, further observations to determine more precisely the variation characteristics and possibly the nature of the stars.

The X-ray source SAO 53210 (EXO 233530.1+4555.4) is classified as BY Dra type variable, with the name V454 And, in the 78th Name List of Variable Stars (Kazarovets et al., 2006), on the basis of our Mexican observations. These observations were very limited: in total five data points on August 1990 and six on October 1991, distributed in seven days for both observing runs. As a consequence, the period suggested in Cutispoto et al. (2000) was inevitably very tentative. The new data discussed here completely superseed this earlier attempt.

Following the ADS Abstract Service (Centre de Données Astronomiques de Strasbourg), no other report about the photometric variability of this star has been published after Cutispoto et al. (2000), except an analysis by Percy (1993), which suggests a variability of SAO 53210 up to $0\overset{m}{.}05$ in V and B on a timescale of months.

The colours derived by the Hipparcos Catalogue are consistent with the spectral type G3/4V.

SAO 53210 was observed during 30 nights in September-October 1992 at the Brera Astronomical Observatory in Merate, using a digital photon-counting photometer at the 50 cm. reflector and a Stromgren y filter. The comparison and check stars were SAO 53147 and SAO 53149, respectively. For details on the observing technique and data handling, see Cereda et al., 1988. As a rule, about ten observations of the variable were performed in alternation with the comparison star: these Δm magnitudes have been averaged to give one or two y-normal points for every night.

Table 1 shows these y-normal points (y-np) with the observational times and the standard errors σ. Also the Mexican observations: J.D. . . . 126-. . . 133 and J.D. . . . 556-. . . 563, related to August 1990 and October 1991 respectively, are reported in this Table.

Figure 1 presents the light curves derived from our 1992 observations: the magnitude differences *variable minus comparison* (top) is compared, in the same scale, with the difference *check minus comparison* (bottom).

Table 1. y-normal points (y-np) with observational times and standard errors σ

J.D.(8000+)	y-np	σ	J.D.(8000+)	y-np	σ
126.8610	0.352	0.003	892.4853	0.336	0.001
127.8660	0.356	0.001	893.4015	0.339	0.003
130.7910	0.356	0.003	893.5812	0.339	0.001
132.8370	0.351	0.001	894.4886	0.344	0.002
133.7990	0.345	0.001	896.4068	0.347	0.003
556.7710	0.338	0.001	896.5714	0.349	0.001
558.7450	0.340	0.004	898.4044	0.323	0.001
559.7390	0.345	0.002	898.4634	0.323	0.004
560.8400	0.327	0.003	899.6105	0.325	0.002
562.8360	0.329	0.002	901.3950	0.344	0.001
563.7190	0.334	0.001	901.5980	0.348	0.003
870.5428	0.341	0.003	909.4569	0.331	0.002
871.5931	0.347	0.002	911.3985	0.320	0.002
872.6163	0.349	0.002	911.5500	0.325	0.001
873.5012	0.337	0.001	914.3890	0.345	0.002
882.5884	0.342	0.004	914.5420	0.364	0.003
883.4500	0.350	0.002	915.4653	0.339	0.004
883.5963	0.351	0.003	917.4243	0.332	0.002
884.4430	0.345	0.002	918.4039	0.340	0.001
884.6137	0.347	0.001	918.5315	0.338	0.003
885.5330	0.331	0.003	919.4419	0.348	0.005
887.4850	0.325	0.001	920.3918	0.346	0.001
887.5830	0.326	0.002	920.5290	0.343	0.002
888.5705	0.333	0.004	922.3873	0.322	0.002
889.5380	0.349	0.002	923.3940	0.322	0.002
890.4740	0.347	0.002	923.5355	0.325	0.003
890.6200	0.346	0.002	925.4335	0.340	0.001

Table 2. The two solutions for the light curve of SAO 53210

Epoch	Period	Amplitude	Phase
1992 only	P_1=11.8d ±0.1	$0\overset{m}{.}0060$ ±0.0005	−3.125 ±0.085
1992 only	P_2=5.9d ±0.2	$0\overset{m}{.}0100$ ±0.0004	−2.596 ±0.056
1990+1991+1992	P_1=12.1d ±0.01	$0\overset{m}{.}0069$ ±0.0009	−2.993 ±0.130
1990+1991+1992	P_2=6.1d ±0.02	$0\overset{m}{.}0009$ ±0.0008	−2.592 ±0.100

Table 3. Details of the frequency analysis for the two different epochs of observation

Epoch	T_o	Initial *r.m.s.* res.	Final *r.m.s.* res.	Total variance
1992 only	JD2448899.5450	$0\overset{m}{.}0096$	$0\overset{m}{.}0031$	89%
1990+1991+1992	JD2448899.5450	$0\overset{m}{.}0099$	$0\overset{m}{.}0041$	83%

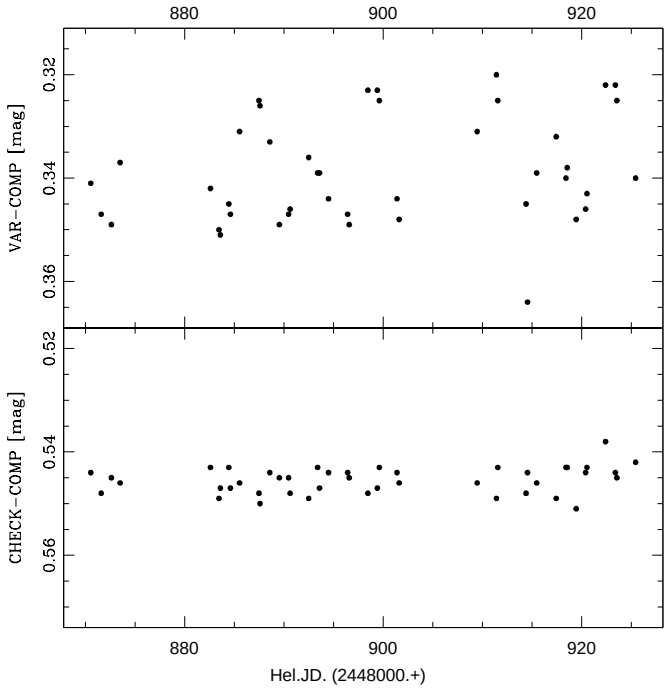

Figure 1. The light curves derived from our 1992 observations: the magnitude differences *variable minus comparison* (top) is compared with the difference *check minus comparison* (bottom).

The data of Table 1 were analysed in two steps: at first considering only the more meaningful group of 1992 observations and then all the data together (1990+1991+1992). The analysis was performed by means of the "Multifre code" (Bossi et al., 2009), which searches for the least squares best fit of a time series using a finite number of sinusoids.

In Figure 2 the periodogram related to the complete data set is presented, while Tables 2 and 3 show the results of the two separate analyses.

Finally, Figure 3 shows the synthetized light curve and the phased y-normal points, computed according to the data of Tables 2 and 3, and related to the whole set of observations reported in Table 1. Here open and filled circles represent the 1990 and 1992 measures, while crosses describe the 1991 data. A similar plot using only the 1992 observations does not show significant differences.

As a preliminary conclusion, Table 2 and 3 show that the light curve parameters based on the 1992 observations represent quite well also the 1990 and 1991 light variations. This could indicate that the same periodic physical phenomenon acted continuously over at least three years.

As a second important point, the light variations of SAO 53210 are satisfactorily explained by means of a double wave in which the two frequencies are not independent, but represent the fundamental frequency and its first harmonic.

The deviations of the 1990 observations (open circles in Figure 2) from the fit could be explained by a modulation of the light variation amplitude.

This picture seems to agree with the classification of SAO 53210 as a BY Dra type variable (Kazarovets et al., 2006), or as some other type of rotating variable stars. Further observations would clearly be important in order to improve the model of the star.

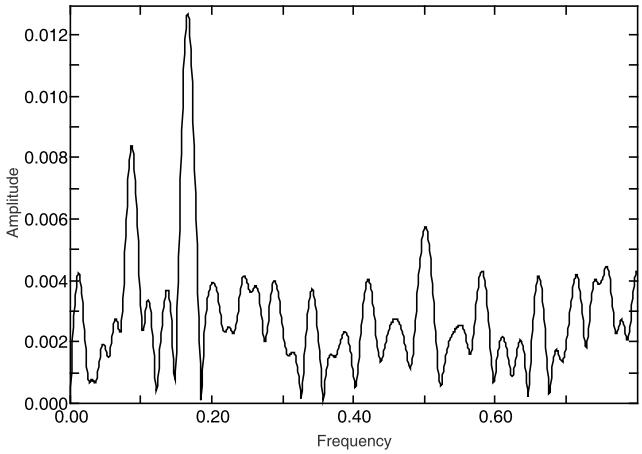

Figure 2. The periodogram of the complete set of observations

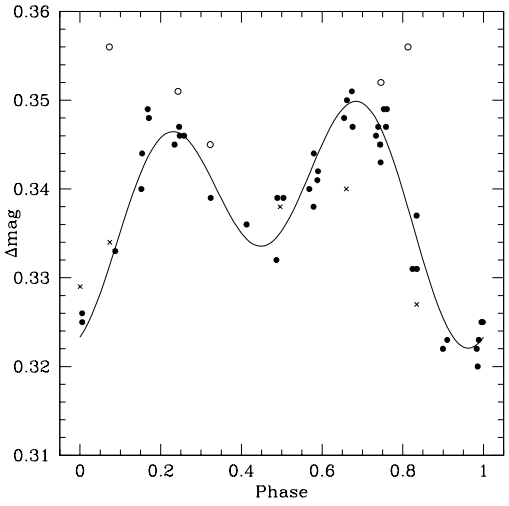

Figure 3. The light curve of SAO53210. The solid line is the synthetized light curve obtained according to to the data of Tables 2 and 3, and related to the whole set of observations. The open and filled circles represent the 1990 and 1992 observations, while the crosses correspond to 1991 data.

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