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UBV PHOTOMETRY OF THE SYMBIOTIC STAR Z And DURING ITS 2000 OUTBURST

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Z Andromedae is considered as a prototype symbiotic star. This system consists of an M4.5 giant and a hot compact star of $T_\star \sim 10^5$ K (Nussbaumer & Vogel 1989, Mürset et al. 1991). The orbital period of the binary is 758.8($\pm$2) days (Mikolajewska & Kenyon 1996). The inclination of the orbital plane was determined by Schmid & Schild (1997) to $47 \pm 12°$. Photometric activity of Z And has been recorded since 1887 (Mattei 1978). The top panel of Fig. 1 shows its historical 1895–2001 photographic/B-band/visual light curve (LC). The LC is characterized by phases of activity with up to 2-3 mag increase of the star's brightness, alternating with periods of quiescence. Sharp brightness oscillations of even larger amplitude are also often present during outburst phases (also Formiggini & Leibowitz 1994). The mid panel of Fig. 1 shows the Z And LC in the last 20 years. This portion of the LC is dominated by the 1984 active phase, which lasted about 2 years and consisted of two consecutive outbursts. The second one peaked around 9 mag in U and V. During this outburst an optically thick shell was ejected at moderately high velocities of the order of 200–300 km s^{-1} (Fernández-Castro et al. 1995). The quiescent phase of Z And is characterized by a complex wave-like brightness variation as a function of the orbital phase, well pronounced in the U band. The nature of this type of variability was recently discussed by Skopal (1998) and Skopal (in press). The bottom panel of Fig. 1 shows the most recent evolution of the LC, which indicates that Z And has entered a new bright outburst at the end of August 2000. During the current active phase, Z And reached its maximum around 8.4 mag in U, and is thus brighter than in the 1984-85 main outburst.

Our U, B, V measurements of Z And were performed in the standard Johnson system using single-channel photoelectric photometers mounted in the Cassegrain foci of 0.6-m reflectors at the Skalnaté Pleso (hereafter SP in Table 1) and Stará Lesná observatories (SL). The results of our photometric measurements of Z And (HD 221650, BD +48°4093) are in Table 1. Stars SAO 53150 ($V = 8.99$, $B-V = 0.41$, $U-B = 0.14$) and SAO 63189 ($V = 9.17$, $B-V = 1.36$, $U-B = 1.11$), were used as a comparison and a check star, respectively. We obtained the magnitudes of both standards by their long-term measuring (1997–1999) with respect to the previous comparison star (SAO 35642, $V = 5.30$, $B-V = -0.06$, $U-B = -0.15$). The measurements were conducted in short cycles 'comparison–check–Z And–comparison–Z And–. . . ' in U, B, V filters for each star individually and in total duration approximately of 60 minutes. The data in Table 1 represent means of such measurements and are shown in Fig. 2. Their inner uncertainty is $\leq 0\overset{m}{.}01$ and $\leq 0\overset{m}{.}02$

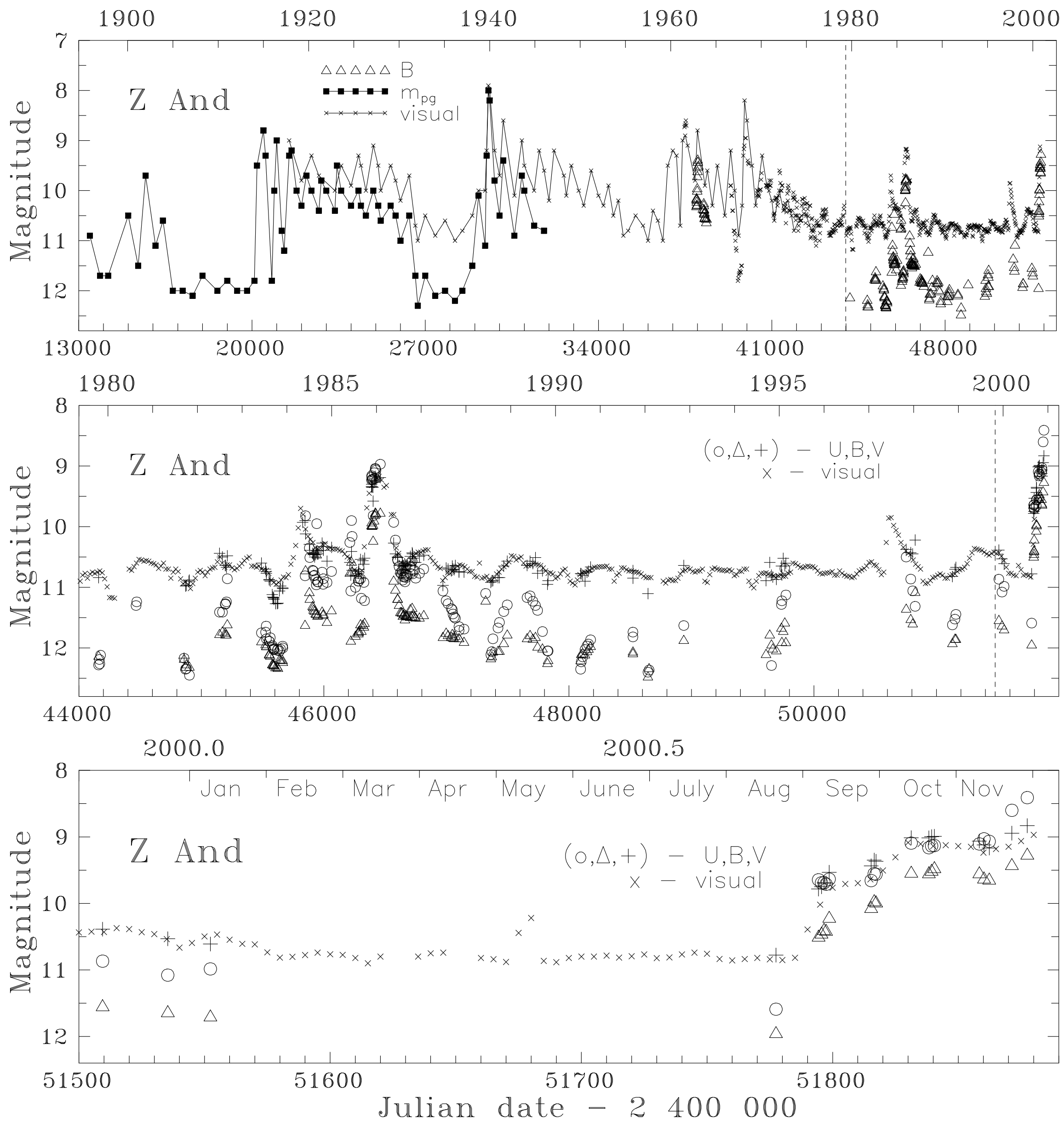

Figure 1. Top: The historical 1894.5–2000.9 photographic/B-band/visual LC of Z And. It is compiled from photographic data (Payne-Gaposchkin 1946), visual AAVSO estimates (Mattei 1978), smoothed visual data gathered by the VSNET and AFOEV observers, and B-band photoelectric measurements as published by Belyakina (1965, 1992), Hric et al. (1991, 1993, 1996), Skopal et al. (1992) and Mikolajewska & Kenyon (1996). **Middle:** A part of the LC from 1980. In addition to the data referred above, there are U-band measurements of Belyakina (1985), and between 30/07/97 and 26/11/99 there are some our unpublished UBV data. Visual LC in these panels represents smoothed data (VSNET + AFOEV) by the filter with the resolution of 40 days and the step of 20 days (40/20). **Bottom:** A detail of the LC from 2000 covering the current outburst. Here the visual data were smoothed by the 10/5 filter. Note a very good agreement between the photoelectric V and the smoothed visual LC. Parts of the LC from the broken vertical line to the end of the panel are shown in the following panel in detail.

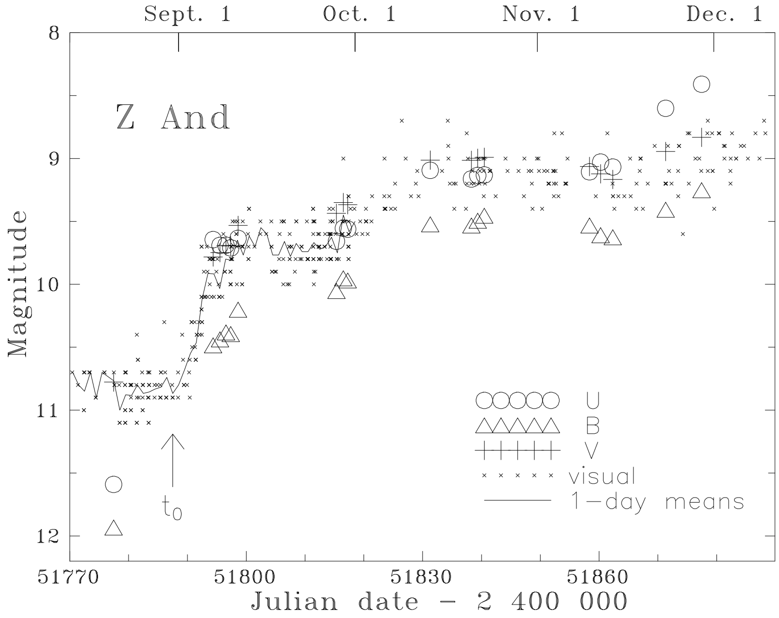

Figure 2. A detail of the LC covering the current outburst, which began on 2000 August 31.0 ± 1.5 UT. The solid line connects the means of visual estimates in 1-day bins, in order to see better the beginning of the outburst, t_0. From JD 2451818, only the VSNET data were available. The latest brightening, at the end of November 2000, indicates a strong outburst of Z And, which reached over that observed in 1984-85.

in V, B and U band, respectively. For a comparison, we used also the visual magnitude estimates gathered by the VSNET observers and the members of Association Francaise des Observateurs d'Etoiles Variables (AFOEV).

Timing of the last U, B, V observation prior to the brightening (made on 20/8/00) and the first one during it (6/9/00) define the beginning of the outburst, t_0, to JD 2451786$\pm 8^{\rm d}$ (cf. Table 1). However, a very good agreement between the photoelectric V and the visual magnitude estimates (cf. Figs. 1 and 2) enable us to determine the t_0 time more precisely. Combining the visual data available on CDS (AFOEV data), on the VSNET web site and those of Mattei (2000), we determined the beginning of the current outburst of Z And as

$$t_0 = \text{JD } 2451787.5 \pm 1\overset{\rm d}{.}5$$

i.e. on 2000 August 31.0 ± 1.5 UT (see Fig. 2). An interesting feature of the current outburst is a *cascade* profile of the LC observed in the period from the beginning of the outburst to its maximum. The cascade nature can be clearly seen in the visual and U data, but it is less definite in V and it is marginal in B (cf. Fig. 2). Between October 13 and November 13 brightening has stopped and Z And standed at the plateau of $U \sim 9.05$, $B \sim 9.54$ and $V \sim 9.10$, which was comparable with the brightness maximum of Z And during its last major outburst in 1984-85 (Fig. 1). However, our observations made at the end of November indicate a further increase in the star's brightness up to $U \sim 8.4$, $B \sim 9.3$ and $V \sim 8.8$. These values reached over those of the 1984-85 outburst. Therefore it is possible that the duration of the current outburst will be comparable with the previous one, and thus we can expect its continuation in 2001/2002.

Z And is currently included in the observing programme of the Skalnaté Pleso Observatory. The further data will be published in *Contrib. Astron. Obs. Skalnaté Pleso.*

Table 1: U, B, V observations of Z And during the current outburst.

Date	JD 24...	U	B	V	Obs.
Nov 26, 1999	51509.430	10.867	11.530	10.388	SP
Dec 22	51535.364	11.078	11.620	10.532	SP
Jan 8, 2000	51552.321	10.984	11.684	10.610	SP
Aug 20	51777.449	11.590	11.933	10.777	SP
Sep 6	51794.368	9.645	10.485	9.783	SL
Sep 7	51795.531	9.691	10.438	9.748	SP
Sep 8	51796.555	9.689	10.383	9.691	SP
Sep 9	51797.363	9.711	10.396	9.695	SL
Sep 10	51798.612	9.635	10.202	9.532	SP
Sep 27	51815.331	9.658	10.054	9.436	SP
Sep 28	51816.510	9.555	9.952	9.350	SP
Sep 29	51817.263	9.562	9.970	9.367	SP
Oct 13	51831.276	9.094	9.524	9.013	SL
Oct 20	51838.286	9.163	9.533	9.015	SL
Oct 21	51839.369	9.135	9.495	8.998	SL
Oct 22	51840.475	9.131	9.455	8.991	SP
Nov 9	51858.360	9.106	9.533	9.064	SP
Nov 11	51860.249	9.029	9.610	9.122	SL
Nov 13	51862.372	9.068	9.627	9.167	SP
Nov 22	51871.313	8.601	9.408	8.944	SL
Nov 28	51877.428	8.410	9.252	8.832	SP

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References:

Belyakina, T.S., 1965, *Izv. Kr. Astr. Obs.*, **33**, 226
Belyakina, T.S., 1985, *IBVS*, No. 2698
Belyakina, T.S., 1992, *Izv. Kr. Astr. Obs.*, **84**, 45
Fernández-Castro, T., González-Riestra, R., Cassatella, A., Taylor,A.R., Seaquist E.R., 1995, *ApJ*, **442**, 366
Formiggini, L., Leibowitz, E.M., 1994, *A&A*, **292**, 534
Hric, L., Skopal, A., Urban, Z. et al., 1991, *Contrib. Astron. Obs. Skalnaté Pleso*, **21**, 303
Hric, L., Skopal, A., Urban, Z. et al., 1993, *Contrib. Astron. Obs. Skalnaté Pleso*, **23**, 73
Hric, L., Skopal, A., Urban, Z. et al., 1996, *Contrib. Astron. Obs. Skalnaté Pleso*, **26**, 46
Mattei, J.A., 1978, *J. Roy. Astron. Soc. Can.*, **72**, 61
Mattei, J.A., 2000, *IAU Circ.*, No. 7489
Mikolajewska, J., Kenyon, S.J., 1996, *AJ*, **112**, 1659
Mürset, U., Nussbaumer, H., Schmid, H.M., Vogel, M., 1991, *A&A*, **248**, 458
Nussbaumer, H., Vogel, M., 1989, *A&A*, **213**, 137
Schmidt, H.M., Schild, H., 1997, *A&A*, **327**, 219
Skopal, A., Hric, L., Urban, Z. et al., 1992, *Contrib. Astron. Obs. Skalnaté Pleso*, **22**, 131
Skopal, A., 1998, *A&A*, **338**, 599
Skopal, A., 2001, *A&A*, in press