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ON THE PERIOD OF HR 1362

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ABSTRACT

Photoelectric *UBV* observations, made in 1981 and 1982, of the active star HR 1362 are presented. A period analysis reveals many (all greater than 100 days) probable periods because of the large gaps in the data. If the most probable period around 330^d is true and represents the rotation period, as it does in all other active stars, then HR 1362 would be an extreme case of slow rotation.

Key words: period analysis–variable star

1. Introduction

HR 1362, a bright ($V = 6^m.3$) late-type star, was put on a list of suspected variables (Hall 1983) as a probable RS Canum Venaticorum type binary, because it shows "uncertain" emission of Ca II H and K (Bidelman and MacConnell 1973) and "certain" coronal soft X-rays (Walter and Bowyer 1981). Bidelman and MacConnell determined the spectral type as G8 IV and noted a slight indication of a composite spectrum implying that the star is possibly a moderately close spectroscopic binary. Eggen (1978) carried out intermediate-band photometry of HR 1362 and he determined the absolute magnitude as $M_V = 0^m.65$, which is somewhat brighter than typical even for a G8 III star (Allen 1973). In the color-color diagram (Fig. 4) of Eggen's paper HR 1362 appears in the midst of a group of giant stars. The photometric variability was reported first by Lake (1964) based on only five *UBV* observations. Lake found that the variations in V, $(B-V)$, and $(U-B)$ are $0^m.07$, $0^m.05$ and $0^m.04$, respectively. Boyd *et al.* (1985) reported that they obtained 140 mean differential *UBV* magnitudes of HR 1362 between 1979–84, but none of their observations obtained between 1979–82 have appeared anywhere in tabular or graphical form. They found the total amplitude of the presumably cyclic variation in V is $0^m.10$ and that the ratio of the amplitudes in DV / DB / DU = 1.00 / 1.21 / 1.52. The period of the photometric variation was determined as 154^d, although Hall (1983) gave a suspected period of $33^d.6$ with no cited reference. Kholopov *et al.* (1987) included HR 1362 with the new designation EK Eridani in the 68th name list of variable stars.

We observed HR 1362 in 1981 and 1982 and used our observations together with the existent ones for a period analysis. We describe our observations in Section 2 and give the results of our period analysis in Section 3. The final section is devoted to a discussion on the type of variability.

2. *UBV* Observations

We observed HR 1362 with *UBV* filters on 16 nights in 1981 and on 12 nights in 1982, using an EMI 6256 S photomultiplier attached to the 30-cm Maksutov telescope of the Ankara University Observatory. Observations were made differentially with respect to the comparison star BD −06°873. By checking against nearby check star BD −06°878, the comparison was found to be sensibly constant during the observations: $DV = 2.26 \pm 0.03$, $DB = 1.76 \pm 0.03$, and $DU = 0.96 \pm 0.06$, where the errors are standard deviations of all measures from the means. A sequence (comparison) - comparison sky - variable - variable sky - variable - comparison - comparison sky) in each of the three filters was followed to secure one differential observation in the sense of comparison minus variable. Thus, altogether 54 differential magnitudes in each bandpass (31 in 1981 and 23 in 1982) were obtained. The individual observations were corrected for differential extinction, but not transformed to the standard system, and are given in Table 1. The light and color variations against heliocentric Julian Date are shown in Figure 1 and Figure 2. It is seen in the figures that the observations are not regularly distributed in time but are concentrated in three intervals: September–October 1981, January 1982, and October 1982. During the first interval HR 1362 fades steadily, but the differential observations form large scatters around different mean levels during the other two shorter intervals. Although the extreme levels were not observed, the overall light variation is probably sinusoidal, being at minimum around HJD2444990. The color curves show slight reddening during the minimum light. The $(U-B)$ colors scatter

about twice as much as the $(B-V)$ colors. The amplitudes of the light variation are estimated to be around 0.20, 0.15, and 0.14 in U, B, and V, respectively.

3. A Period Analysis of the Light Variation

Our observations in the V filter have been combined with the V observations of Boyd *et al.* (1985) and used together in the period analysis. Although the observations are not continuous in time, they cover important parts of the light variation between September 1981 and December 1984. In the combination, only the mean levels of the light variation were matched, which we think does not affect the period analysis much. The combined light variation in the V filter plotted versus the heliocentric Julian Date is shown in Figure 3. A sinusoidal freehand curve was also drawn among the observations. Unfortunately, the singularities in time do not allow a meaningful polynomial fit to the data. The freehand curve reveals that the probable period of the light variation is not 154 days, as derived by Boyd *et al.* (1985), but is around 330 days.[1] Thus, it looks like the time interval between two well-defined light minima at HJD2445690 and HJD2445995 is not a double but rather one full period of the light variation.

We further searched for the period by using the method of Shell-Metzner, which is similar to the sorting method of Lafler and Kinman (1965). The algorithm was adapted by one of us (E.D.) from a paper by Belserene (1982). The algorithm computes phases by using one period after another in the probable range and compares the resulting light curves to indicate the most probable period. We applied the algorithm to the combined V light curve. The resulting periodogram is shown in Figure 4. Because of the large gaps in the data, the criterion index draws not just one but six prominent distinct minima around the trial periods of 150^d, 175^d, 200^d, 330^d, 500^d, and 700^d. Unfortunately, the periodogram is not decisive in singling out the true period. In fact, many small dips occur at the bottom of the well-defined minima (for exam-

TABLE 1
UBV Observations of HR 1362

HJD 2440000 +	DV_0	DB_0	DU_0	HJD 2440000 +	DV_0	DB_0	DU_0
4867.5977	3.330	3.043	2.421	4904.5122	3.292	2.943	2.485
4867.6023	3.312	2.993	2.456	4904.5157	3.301	2.950	2.483
4871.5882	3.337	2.987	2.446	4905.5000	3.332	2.945	2.397
4871.5926	3.331	2.972	2.464	4905.5046	3.318	2.905	2.399
4873.5650	3.337	2.969	2.461	4974.2464	3.198	2.789	2.276
4873.5700	3.344	2.954	2.445	4974.2566	3.203	2.875	2.313
4877.5253	3.320	2.964	2.479	4985.2855	3.220	2.832	2.296
4877.5331	3.331	2.968	2.502	4985.2946	3.193	2.823	2.248
4878.5193	3.316	2.968	2.467	4986.1956	3.221	2.851	2.266
4878.5243	3.299	2.969	2.439	4986.2007	3.199	2.796	2.276
4879.4699	3.296	2.971	2.429	4987.2271	3.175	2.819	2.312
4879.4760	3.309	3.007	2.434	4987.2301	3.176	2.827	2.324
4883.4757	3.335	2.986	2.484	4989.2951	3.197	2.831	2.270
4883.4799	3.299	2.975	2.448	4989.3025	3.183	2.924	2.236
4884.4340	3.322	2.956	2.444	5262.5999	3.258	2.928	2.390
4884.4384	3.328	2.959	2.449	5262.6039	3.257	2.911	2.387
4886.4989	3.314	2.966	2.454	5264.5739	3.270	2.938	2.376
4886.5075	3.326	2.939	2.465	5264.5780	3.281	2.770	2.399
4887.4127	3.290	2.969	2.470	5265.6228	3.236	2.918	2.523
4887.4234	3.348	2.951	2.411	5267.3839	3.292	2.915	2.328
4894.4707	3.308	2.953	2.383	5267.3898	3.301	2.893	2.345
4894.4760	3.294	2.976	2.394	5268.5108	3.251	2.893	2.407
4895.4728	3.355	2.946	2.426	5268.5159	3.251	2.865	2.403
4895.4783	3.284	2.956	2.405	5271.3460	3.280	2.885	2.484
4896.5801	3.298	2.938	2.456	5271.3515	3.316	2.851	2.429
4897.5821	3.318	2.948	2.444	5300.5139	3.217	2.852	2.218
4897.5864	3.311	2.949	2.467	5300.5192	3.239	2.997	2.216

[1]One of the referees of this paper informed us about a recent paper by Strassmeier and Hall (1988). They also arrive at the same conclusion, by a completely different approach, that the photometric period of HR 1362 is probably not 155 days but rather twice that: 310 days.

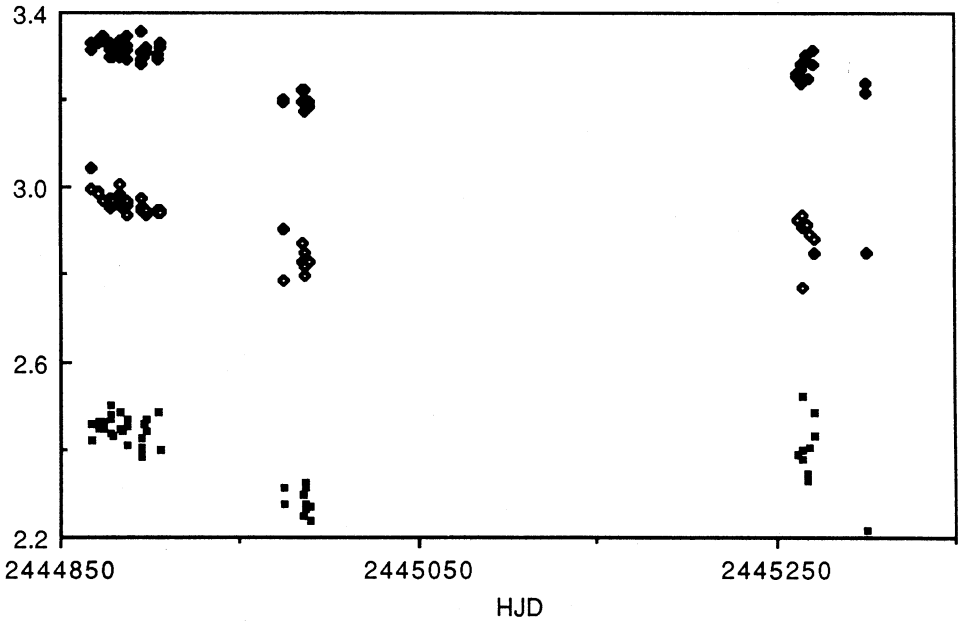

FIG. 1–The *UBV* observations (full squares, open diamonds, and full diamonds, respectively) of HR 1362 vs. Julian Date.

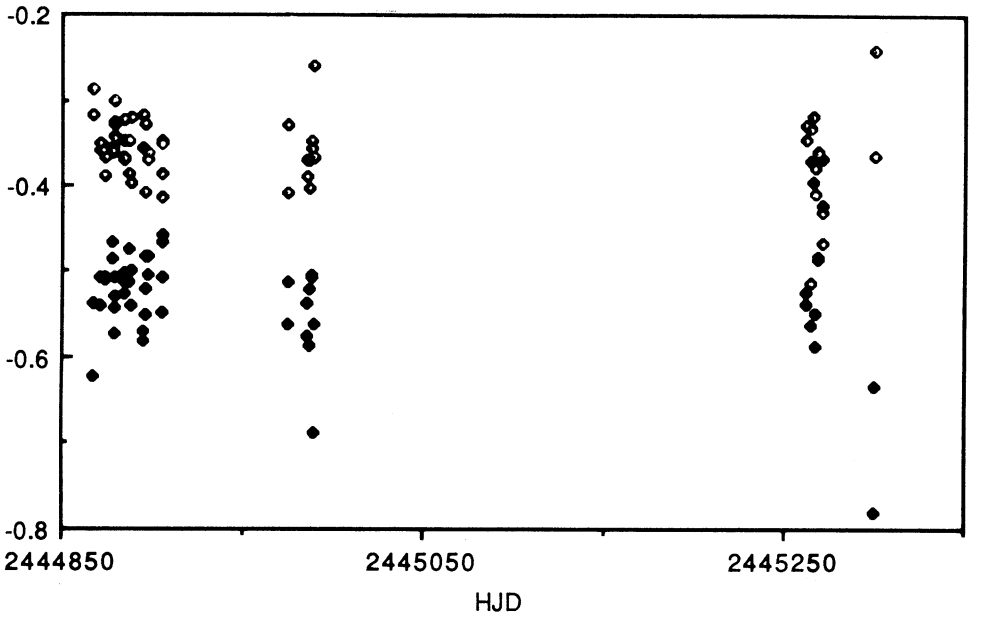

FIG. 2–The $(B-V)$ (open diamonds) and $(U-B)$ color (solid diamonds) of HR 1362 vs. Julian Date.

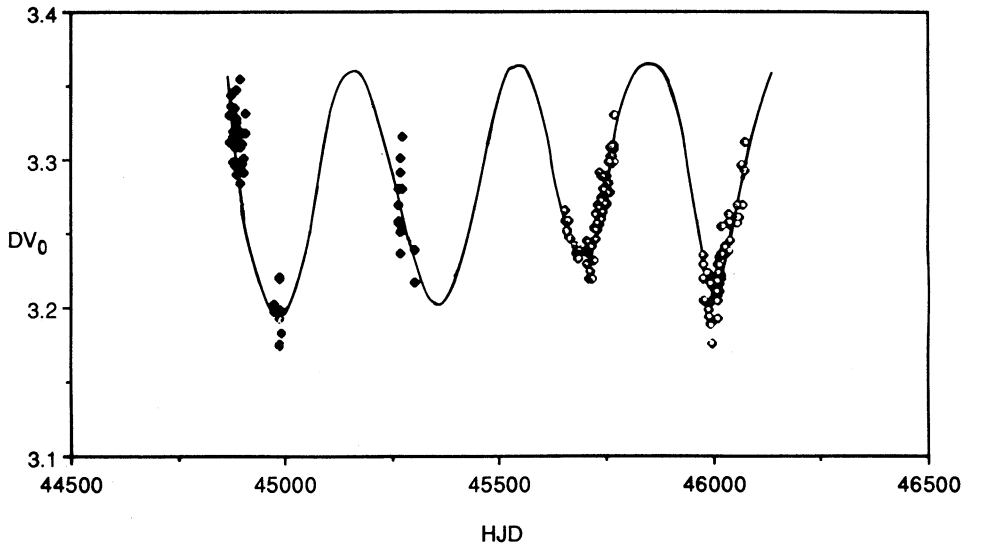

FIG. 3–The light variation (in V) of HR 1362 between September 1981 and December 1984. Our observations and observations by Boyd *et al.* (1985) are shown by open and full diamonds, respectively. A freehand curve drawn among the observations is also shown.

ple, at 309^d, 316^d, 472^d, and 512^d). The trial period of 316^d has the smallest criterion index in the periodogram. Thus, it may well be the most probable photometric period of HR 1362. However, the middle line of this well-defined deeper fourth minimum reads about 330^d which is surprisingly the same period as estimated above from the freehand curve drawn through the observations. We, thus, tend to assume that the photometric period of HR 1362 is around 330^d. Confirmation that this is the true period will require more continuous observations covering longer observing seasons.

4. Discussion

HR 1362 shows solar-type atmospheric activity with Ca II H and K soft X-ray emissions. With the absolute magnitude of $M_V = 0.^m65$ it is most probably a G8 giant. As was noted by Boyd *et al.* (1985), it cannot be called an RS CVn binary because there is no evidence of duplicity: a composite spectrum, double lines, or radial-velocity variations. The surprising thing about this active giant is not the periodic light variation but the period itself (probably around 330^d) which is considerably longer than for

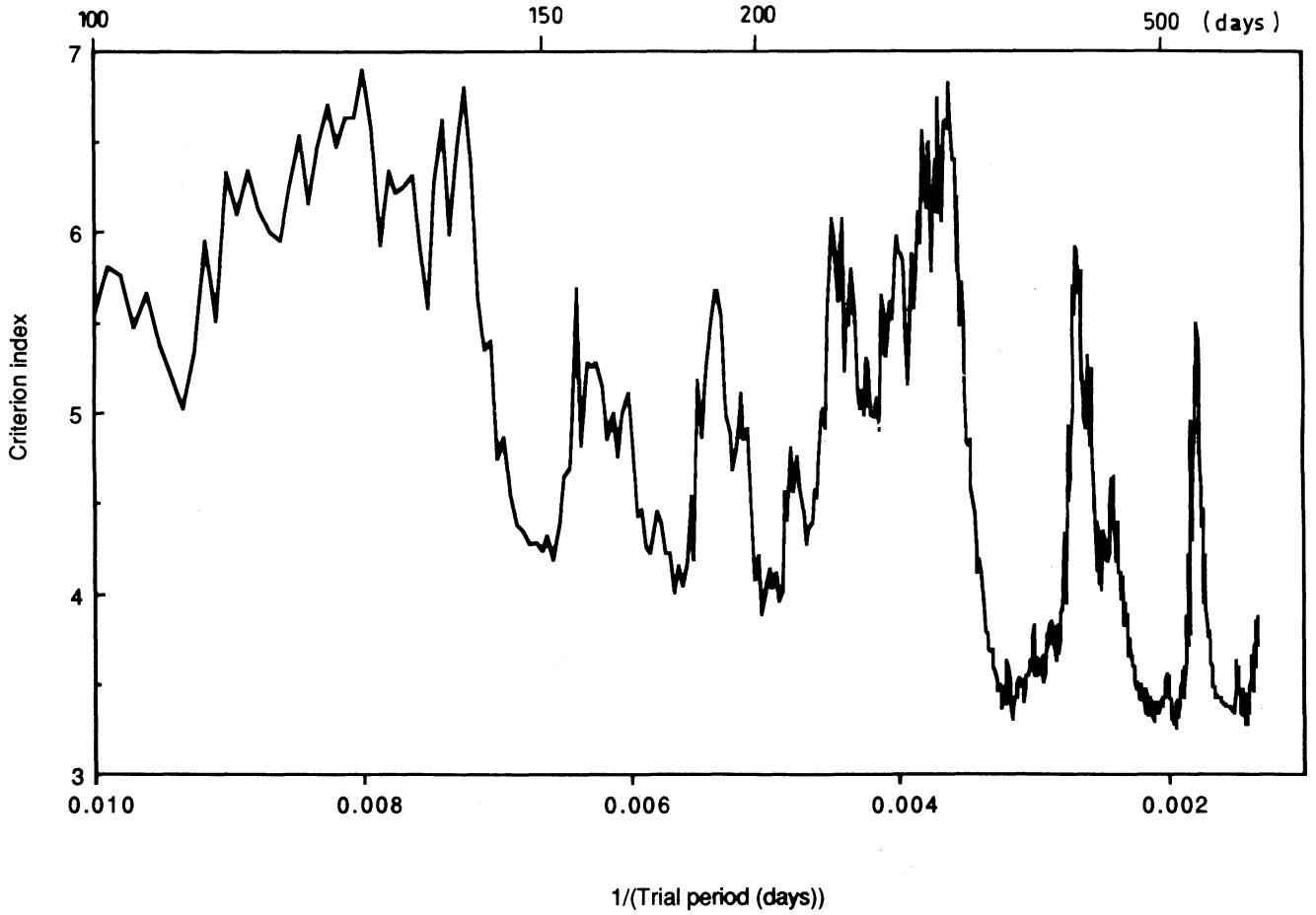

FIG. 4–A periodogram for the combined *V* observations. The criterion index is relatively small for the true period and its harmonics or aliases.

any other known active star. If this period represents the rotation period, as it does in all other active stars, then HR 1362 would be an extreme case of slow rotation. Thus HR 1362, of potential interest for the evolution of rotation in active stars and the role of rotation in activity, deserves more attention.

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