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PHOTOELECTRIC PHOTOMETRY OF  
SIGMA GEMINORUM AND HR 4665

Hall (1976) has characterized the group of binary stars with periods longer than two weeks and with G-K spectra displaying CaII in emission as being related to such well known eclipsing binaries as RS Canum Venaticorum and AR Lacertae. Two recently discovered members of this group are Sigma Geminorum and HR 4665. Although both of these systems are binaries, neither displays eclipses. During the present year this investigator has observed these systems, both at Kitt Peak National Observatory and at the Kutztown State College Observatory.

Sigma Geminorum is a single-lined spectroscopic binary, one of whose components is of spectral type K1 III. The orbital period was determined by Harper (1935) as 19.603 days. Observations were made by me with the 40-cm telescope no. 4 of KPNO during January, 1978. An RCA 1P21 photomultiplier, refrigerated with dry ice, was used together with a pulse-counting photometer. Observations were made with an intermediate-band y-filter. The observations at Kutztown State College were made with a 46-cm Cassegrain reflector from February to May, 1978. The photomultiplier was an unrefrigerated EMI 6256 SA (S-13 surface), and the observations were measured with a strip-chart recorder. Observations were made with a standard-band V-filter, but the KPNO and KSC observations were found to be similar enough to allow them to be combined together without using transformation equations.

The comparison star used was HR 2896 (KO III). As a check star Iota Geminorum (KO III) was used. The magnitude difference (  $\sigma$  Gem - HR 2896 ) was found to be  $-1.558$  with  $\pm 0.003$  as a mean residual for the KPNO observations, and  $-1.548$  with  $\pm 0.011$  as a mean residual for the KSC observations. Each observation of  $\sigma$  Gem

is the mean of two individual readings. The phases of these observations have been calculated by the ephemeris given by Hall (1977a)

$$\text{Hel. JD} = 2418967.33 + 19^{\text{d}}.603 \text{ E.}$$

The observations are as follow:

KPNO - Hel. JD	Phase	$\sigma$ Gem - HR 2896
2443508.675	0.918	-1.110
10.816	0.027	1.080
11.782	0.076	1.060
12.843	0.130	1.063
15.923	0.287	1.142
16.846	0.334	1.170
21.659	0.580	1.153
22.727	0.634	1.149
KSC		
2443563.569	0.718	-1.133
567.562	0.922	1.097
574.536	0.278	1.111
578.721	0.491	1.141
597.650	0.457	1.123
607.657	0.967	1.048
613.603	0.271	1.131
621.605	0.679	1.181
623.571	0.779	1.149
627.569	0.983	1.057
629.565	0.085	1.046

These observations are shown plotted in Figure 1. This figure resembles the one published by Hall, but the amplitude which I find is larger than that reported by him. The amplitude of the light variation is about  $0^{\text{m}}.12$ , and minimum light occurs between 0.00 and 0.10 phase according to the ephemeris used.

HR 4665 was reported to be variable by Hall (1977b). It is a double-lined spectroscopic binary, both components having spectral types of about K0 with CaII in emission. The orbital period has not yet been determined, but evidence indicates that it differs from the period of the light variation.

Observations were made using the same equipment as was used for  $\sigma$  Gem. The only difference was that a standard V-filter was used for the KPNO observations instead of an intermediate-band y-filter. The comparison star chosen was HR 4659 (K2 III). HR 4740 (G8 III) was used as a check star. For the KPNO observations the mean magnitude difference (HR 4740 - HR 4659) was found to be  $+0.616$  with a mean residual of  $\pm 0^{\text{m}}.009$ . For the KSC obser-

variations these values were  $+0.600$  and  $\pm 0.009$ , respectively. The observations of HR 4665 are as follows:

KPNO - Hel. JD	HR 4665 - HR 4659
2443511.001	+0.486
16.046	0.506
17.060	0.505
KSC	
2443567.655	+0.418
574.769	0.476
578.735	0.484
597.669	0.560
607.681	0.580
612.584	0.556
613.634	0.527
621.631	0.457
623.585	0.434
627.614	0.426
629.589	0.441
648.587	0.509
650.669	0.502

Each of these observations is the mean of two individual readings. The KSC observations are shown plotted in Figure 2. These indicate an amplitude of about  $0.15^m$ . Hall has stated that the photometric period of HR 4665 is in the range 60 to 70 days. My observations confirm this period, but allow it to be refined. Hall's light curve shows a maximum at ca. JD 2443304 and a minimum at ca. JD 2443350. Figure 2 shows a maximum at ca. JD 2443626 and a minimum at ca. JD 2443605. Both of these intervals indicate a period of 64 days. Additional observations of HR 4665 will enable its period to be more precisely determined. The apparent difference between the spectroscopic and photometric periods remains to be verified.

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Fig. 1

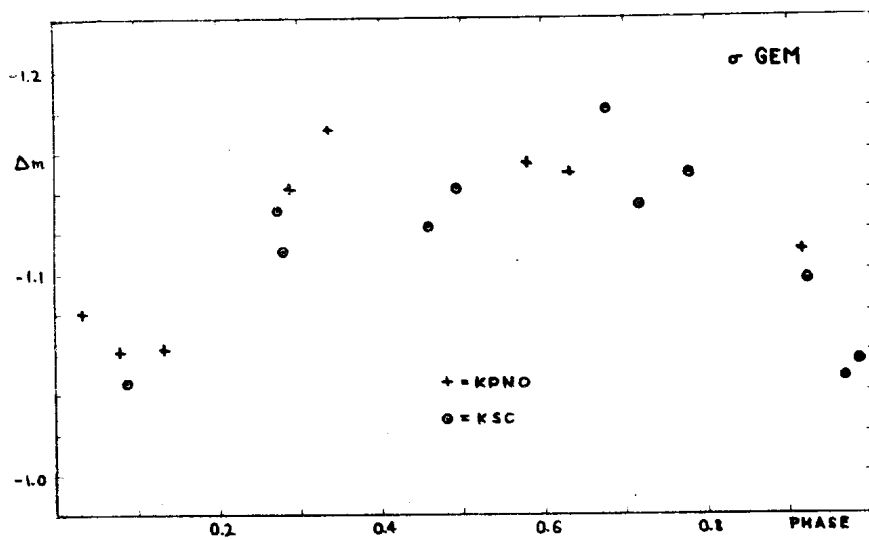


Fig. 2

