colors. A preliminary calibration, using such a procedure, has been given by Crawford (1970).

Figure 3 shows the relation between the β index and the c_0 index, c_0 being the c_1 index corrected for interstellar reddening effects. Again, data for the B stars brighter than $5^m.0$ are included. As β is primarily a measure of absolute magnitude for B stars and c_0 a measure of temperature, such a relation is a type of H–R diagram or color–magnitude diagram. However, the β versus c_0 data are independent of distance, and nearly independent of interstellar reddening or photometric effects of double stars.

Figure 4 shows the relation between color excess due to interstellar reddening, $E(b-y)$, and the distance modulus, V_0-M_V. Here again, data for the B stars brighter than $5^m.0$ are included. We have assumed the preliminary calibration of Crawford (1970), and have excluded data for stars with $\beta \leq 2^m.590$ (i.e., with M_V brighter than $-4^m.6$). The preliminary calibration should be fairly accurate [$\pm 0^m.3$ in M_V and $\pm 0^m.02$ in $E(b-y)$?] for the type of stars with data plotted in Fig. 4. Clearly, many southern B stars, even at distances of 1000 pc, are nearly unreddened. A detailed discussion of color excess will be made when the calibrations are firm, and when data for all the B stars brighter than $m_V=6.5$ have been published.

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Photoelectric Observations of Magnetic Stars. III. HD 124224, HD 140160, and HD 224801

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Photoelectric observations in three colors of the magnetic stars HD 124224, HD 140160, and HD 224801 are reported. An improved period is given for HD 224801. For all three stars the oblique rotator model seems to be reliable.

I. OBSERVATIONS

OBSERVATIONS of the magnetic stars HD 124224, HD 140160, and HD 224801 were carried out at the stellar station of the Catania Astrophysical Observatory, in our natural system using telescopes equipped with EMI 6256 photomultipliers and Schott filters U(UG2, 1 mm), B(BG12, 1 mm+GG13, 2 mm), and V(GG14, 2 mm). The comparison stars and telescopes that were used are listed in Table I. The observations were corrected for atmospheric extinction using statistically determined mean absorption coefficients.

The data referring to the points reported in the figures were sent to the I.A.U. Commission 27 depository of observations on variable stars in care of the Library of the Royal Astronomical Society, Burlington House, London W.1.

II. HD 124224

HD 124224 (CU Vir=HR 5313, B9p, $5^m.0$) is a peculiar spectrum variable in which the Si II lines are abnormally strong and vary out of phase with the He I lines (Deutsch 1952a). During 25 nights from February to June 1968 we obtained 105 observations in U, 95 in B, and 85 in V light. The difference in magnitude between the comparison stars HD 125489 and HD 121607 showed an unusual scatter due to not yet well-established variations of HD 125489. Referring to the elements given by Hardie (1958) and from our V observations we obtain the following light elements:

$$\text{Light Min. at J.D.}\odot = 2439995.4413 + 0^d.52067688E. \quad (1)$$

This period agrees quite well with that given by Deutsch for the spectrum variations. The magnitude differences HD 124224 minus HD.121607 for the ultraviolet, blue, and visible observations and the curves of color index all versus phase are given in Fig. 1. The amplitude of the light variation goes from $0^m.14$ in U to $0^m.11$ in B and to about $0^m.08$ in V. No differences in the times of minima are evident between the B and V light curves, while a little shift is present in the U light curve with respect to the others. Although a small shift seems to be present in the time of minimum observed

TABLE I. Data on program stars, comparison stars, and the telescopes used: The V magnitude, color indices, and spectral type are taken from Photoelectric Catalogue (Blanco *et al.* 1968) and Catalogue of Bright Stars (Hoffleit 1964).

Program star					Comparison star					Telescope aperture
Catalog No.	V	$B-V$	$U-B$	Sp.	Catalog No.	V	$B-V$	$U-B$	Sp.	
HD 124224	$5^m.00$	$-0^m.12$	$-0^m.40$	B9p	HD 121607 HD 125489	$5^m.90$ 6.18	$+0^m.21$ +0.20	$+0^m.12$ +0.07	A3 A3	30 cm
HD 140160	5.33	+0.04		A1p	HD 141187 HD 141458	5.72 6.80	+0.09	+0.06	A2 V A0	30 cm
HD 224801	6.37	−0.08	−0.35	A0pv	HD 224166 HD 224720	6.84 7.25	−0.10	−0.63	B9 A2	91 cm

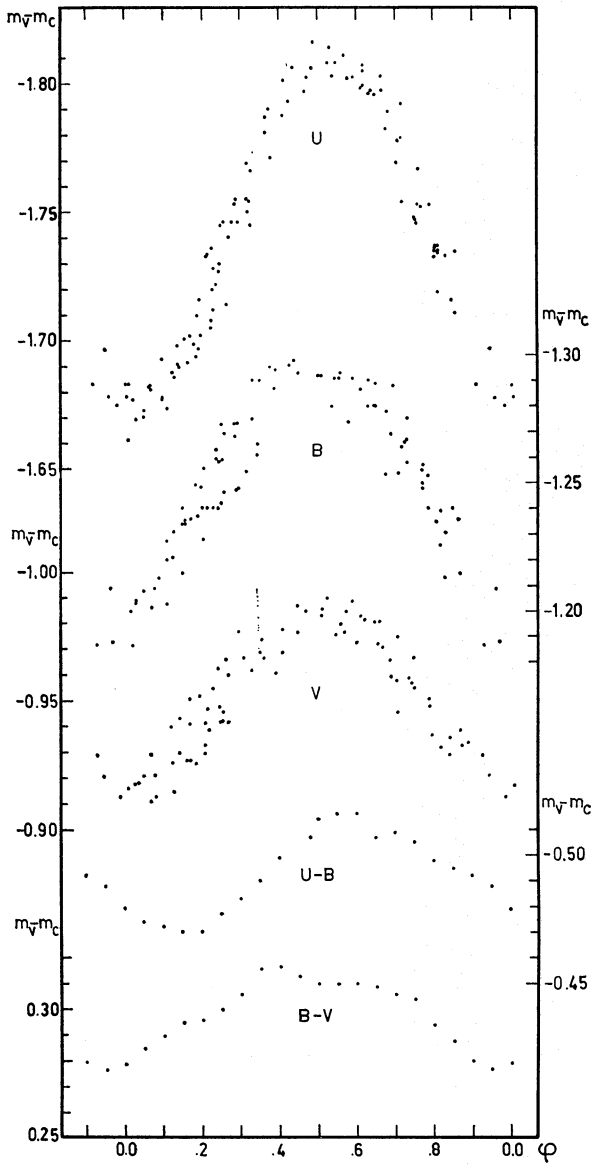

FIG. 1. Magnitude differences HD 124224−HD 121607 in our natural system U, B, V and color index curves all versus the phase calculated from the elements, Light Min. at J.D.⊙ = 2439995.4413 + 0^d.5206788E.

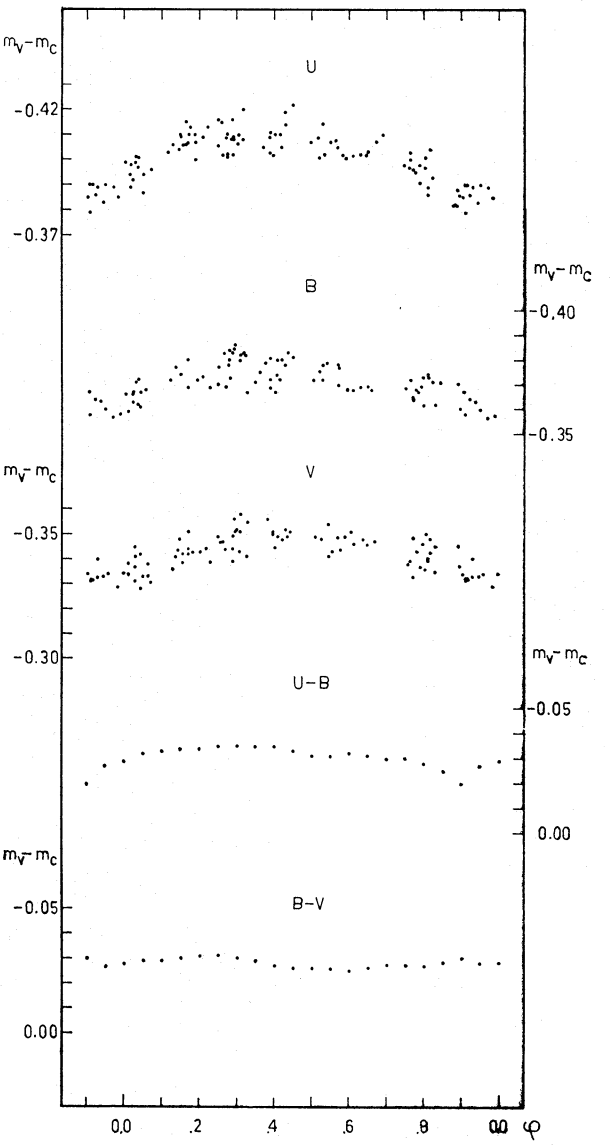

FIG. 2. Magnitude differences HD 140160−HD 141187 in our natural system U, B, V and color index curves all versus the phase calculated from the elements, Light Min. at J.D.⊙ = 2440329.7733 + 1^d.59584E.

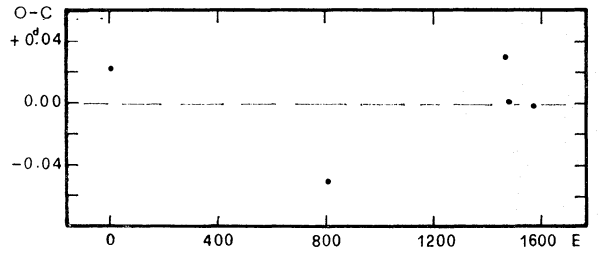

FIG. 3. $O-C$ values and elapsed E of HD 224801 computed by means of the formula, Light Max. at J.D.⊙ = 2437427.77 + 3^d.73975E.

by Hardie in B, the shape of the light curve has not changed since the time of Hardie's observations. From the color index curves it can be seen that HD 124224 is reddest at minimum light.

III. HD 140160

HD 140160 (χ Ser = HR 5843, A1p, 5^m.3) was observed spectroscopically by Deutsch (1952b) who found abnormally strong absorption lines of Sr II varying in intensity with a period of 1^d.59584. The same period satisfies Provin's (1953) photoelectric observations. HD 140160 was observed for 25 nights from April to July 1969 and 101 observations in U, 88 in B, and 90 in V light were obtained. The magnitude difference between the comparison stars HD 141458 and HD 141187 showed cyclical variations due to HD 141458. To calculate phases we used the epoch of the minimum of our V observations and the period given by Deutsch, viz.

$$\text{Light Min. at J.D.}\odot = 2440329.7733 + 1^d.59584E. \quad (2)$$

This ephemeris agrees quite well with that of Provin. The magnitude differences HD 140160 minus HD 141187 in U, B, and V light and color index curves are plotted versus phase in Fig. 2. From this figure it is evident that the maximum variation of brightness occurs in the U curve and that U minimum does not occur at zero phase, but at about 0^p.9, while the B light curve does not appear appreciably shifted. With respect to the $U-B$ variation it is seen that HD 140160 has a behavior similar to HD 124224, while the $B-V$ variation is very small.

TABLE II. Times of observed maximum V light of HD 224801 and their $O-C$ values, elapsed E, and references. The $O-C$ values and elapsed E are computed by means of the formula, J.D. ⊙ = 2437422.77 + 3^d.73975E.

J.D. ⊙ 24···	$O-C$	E	References
34222.77	+0.023		Provin (1953)
37240.686	−0.049	807	Rakos (1963)
39723.965	+0.028	1471	Stępién (1968)
39757.5977	+0.003	1480	Blanco and Catalano (this paper)
40101.6502	−0.003	1572	Blanco and Catalano (this paper)

IV. HD 224801

HD 224801 (CG And = HR 9080, A0pv, 6^m.3) was observed in 1967 and 1968 from August to December. We obtained 104 observations in U, 96 in B, and 97 in V light. The difference in magnitude between the comparison stars HD 224166 and HD 224720 did not show any significant variation. Starting from the photoelectric observations by Provin (1953), Rakos (1963), Stępién (1968), and ours, we determined a mean value 3^d.73975 of the period. Times of observed maximum V light, their $O-C$ values and the number of elapsed periods based on Provin's epoch, and the above-men-

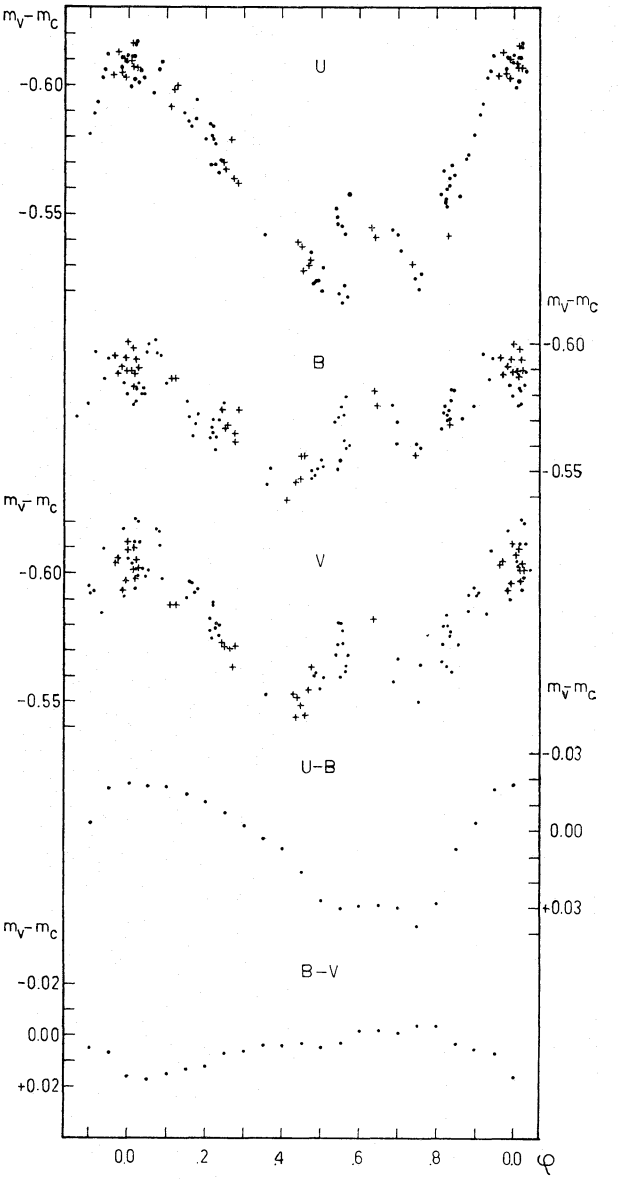

FIG. 4. Magnitude differences HD 224801 − HD 224720 in our natural system U, B, V and color index curves all versus the phase calculated from the elements, Light Max. at J.D.⊙ = 2440101.6502 + 3^d.73975E. *Dots* refer to the observations of 1967, *crosses* to those of 1968.

TABLE III. Periods of photometric and spectroscopic variations of HD 124224, HD 140160, and HD 224801. For HD 224801, the time the magnetic field reverses polarity is given in the last column.

Star	Photometric period	Spectroscopic period	Magnetic polarity reversing
HD 124224	$0^d.56$	$0^d.52$ (Deutsch 1952a)	
HD 140160	1.59	1.59 (Deutsch 1952b)	
HD 224801	3.73	1.25 (Hack and Tamburini 1958)	$\sim 1^d$ (Babcock 1958)
		4.88 (Rakos 1963)	
		3.7 (Preston 1971)	

tioned period are listed in Table II. These $O-C$ values versus elapsed E are plotted in Fig. 3. No period variation is found, the different value being only an improvement because of the greater number of elapsed periods. The magnitude differences HD 224801 minus HD224720 for the ultraviolet, blue, and visible 1967 and 1968 observations and the curves of color index, all versus the phase calculated by the ephemeris elements

$$V \text{ Light Max. at J.D.}\odot = 2440101.6502 + 3^d.73975E \quad (3)$$

are given in Fig. 4. From a comparison of the 1967 and 1968 observations it is evident that the light curve remained unchanged in shape and size. The amplitude of the light variations changes in the three light curves, being maximum in the U and minimum in the B, contrary to the other stars of this type where the minimum variation occurs in the V. The presence of a secondary maximum occurring at the same phase in all three light curves is evident from Fig. 4. The color index curves show that HD 224801 becomes bluer during the minimum of light.

V. CONCLUSION

The available values of the photometric and spectroscopic periods for HD 124224, HD 140160, and HD 224801 are listed in Table III. From this table it is seen that the photometric and spectroscopic periods agree for HD 124224 and HD 140160. In the case of HD 224801, different values of the spectroscopic period are available, but the spectrum variations based on Babcock's and Preston's spectrograms agree very well with the period 3.7 days derived from photometry (Preston 1971). Besides, in a period of 3.7 days, the reversal of polarity of the magnetic field should occur in about one day, just the reversal time observed by Babcock (1958). Therefore the oblique-rotator model for magnetic stars seems to be applicable to all these three stars.

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