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Geneva photometry of stars in the double cluster h and χ Persei

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Abstract. — We present the results of a campaign of photometric observations of stars in the double cluster h and χ Persei that spanned eight years. The long time scale of the data has allowed us to discover that at least half of the brighter stars in h and χ Persei are variable stars. It appears that most of these variables are Be stars or related objects. Accurate color-magnitude diagrams for the brightest stars of the double cluster show that (1) the reddening is not as uniform as was assumed so far, (2) the observed parameters of many stars are very much affected by the high rotational velocities, and thus cannot be easily interpreted in terms of physical quantities, and (3) the reported age and distance differences of both clusters are probably spurious. We caution that the large intrinsic scatter of the colors and magnitudes of the h and χ Persei stars casts doubt on the validity of photometric calibrations that rely heavily on observations of the double cluster.

Key words : clusters : open, and associations — photometry — stars : Be — stars : variable.

1. Introduction.

The double cluster h and χ Persei is one of the richest young open clusters accessible to northern-hemisphere observers, and so is well documented in the literature. An extensive photographic study was carried out by Oosterhoff (1937) ; MK spectral types for cluster members were determined by Bidelman (1943), Johnson and Morgan (1955), Schild (1965, 1966, 1967), and others ; optical photometry in various systems was carried out by Johnson and Morgan (1955), Wildey (1964), Schild (1965), Crawford *et al.* (1970), Moffat and Vogt (1974), and others ; infrared photometry was obtained by Mendoza (1967) and Tapia *et al.* (1984).

So far, relatively little attention has been paid to the detection of variable stars in h and χ Persei. The few small searches for short-period variability among early-type stars in h and χ Persei did not prove very successful. Percy (1972) essentially gives a list of non detections, and Cox (1983) did not find any convincing short-period variations for the six stars he monitored. On the other hand, it is remarkable that for the earliest measurements of h and χ Persei stars in the Geneva system (Rufener, 1981) an unusually high scatter was observed. A thorough search for variable stars in h and χ Persei might thus still prove worthwhile doing, the more so since the double cluster is of roughly the same age as the southern cluster NGC 3293, in which a remarkable number of β Cephei stars have been detected (Balona and Engelbrecht, 1983). Other clusters belonging to the same age group are NGC 4755, NGC 6871, and IC 2581 (Mermilliod, 1981). In the present paper, we discuss new photometric observations in the Geneva system of the brightest blue stars in h and χ Persei that we have been accumulating at Jungfraujoch in Switzerland since 1979.

The accumulation of data with optimal accuracy and homogeneity has always been one of the main objectives in the Geneva Photometric System (Golay, 1980 ; Rufener, 1985, 1986). We have chosen not to limit ourselves to differential photometry, as is usual for variable-star work, but prefered to accomplish absolute measurements following the standard procedures used in Geneva photometry. Indeed, precise photometry of h and χ Persei is an issue of some importance. There is no general agreement on the ages and the distance moduli of both clusters. Crawford *et al.* (1970) con-

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clude on the base of *uvby* β photometry that both clusters have nearly the same age and distance, the distance modulus being $(m - M)_0 = 11.4 \pm 0.4$; Balona and Shobbrook (1984) have thought it necessary to correct this value for evolutionary effects and adopt a distance modulus of 11.16 for both clusters. On the other hand, Tapia *et al.* (1984) find confirmation of a previous suggestion by Schild (1967) that h Per is younger and more nearby than χ Per, with distance moduli of 11.7 and 12.0, respectively. This suggestion by Schild was based on the presence of four (now five) B0.5 stars in h Per, while the turnoff point is at spectral type B1 in χ Per. The uncertainty on the distance moduli of h and χ Persei may thus well exceed 0.5 magnitude. The main error source, besides possible systematic errors in the calibration processes, is probably the limited accuracy of the cluster fitting method to h and χ Persei. The determination of the interstellar absorption toward the clusters does not cause a major problem : from the most recent discussions, it appears that interstellar reddening is fairly uniform, with $E(B - V) = 0.59 \pm 0.02$. Some stars present additional obscuration of circumstellar origin (Crawford *et al.*, 1970 ; Tapia *et al.*, 1984).

The importance of accurate data on the double cluster is clear when one realizes that calibrations of photometric colors in terms of absolute magnitude for the most luminous stars on the northern celestial hemisphere rely heavily on observations of h and χ Percei. In recent calibrations of the *uvby* β photometric system (Crawford, 1978 ; Balona and Shobbrook, 1984), h and χ Persei are the main or the only northern clusters containing B1 and B2 stars. The recent study by Manfroid and Sterken (1987) illustrates how careful one should be when comparing photometric observations taken with different instruments. "Precise" observations do not necessarily allow one to construct "accurate" calibrations. In the particular case considered here, one may ask whether the calibrations of photometric colors in terms of luminosity that rely heavily on southern clusters, apply at all for the measurements of northern early-B stars. Clearly, for an accurate estimator of the luminosities of the earliest-type stars, more numerous and more homogeneous data of northern clusters would be welcome, and especially so of stars in the double cluster h and χ Persei.

The plan of this paper is as follows. In the next section we describe the observational procedure that was followed. Next, the interstellar and circumstellar reddening and the color magnitude diagrams are discussed. It then appears that an essential point is the presence of numerous stars that are variable in color and magnitude. Finally, the implications of these findings on the problems outlined in this introduction are discussed.

2. Observations.

The observations were carried out with the Geneva photometer that is permanently attached to the 76cm-telescope of the Hochalpine Forschungsstation Jungfraujoch, Switzerland, since 1979. The observatory being situated at a latitude of 46°, the wheather conditions are not easily predictable. However, when the sky is clear at Jungfraujoch, the conditions at this high-altitude site (alt. 3578m) are often of remarkable quality. The average extinction during such nights is low (Rufener, 1986). For our observations, a mean extinction coefficient was adopted, and observations were carried out at nearly constant air mass, so that extinction variations could be compensated by applying a gliding-means fit to the observations of standard stars, that were measured at regular intervals. Typical precision for measurements carried out at Jungfraujoch is of the order of 0.008 mag (Rufener and Bartholdi, 1982).

The field of h and χ Persei being extremely crowded, observations of the fainter stars and of the stars in the nucleus were only carried out when seeing conditions were good, so that small diaphragms could be used. The main additional error source for the faint stars is connected with the determination of the sky background. Since h and χ Persei do not show prominent obscured regions or emission nebulae, in contrast with clusters of similar age, such as NGC 3293 and NGC 4755, the possible contamination by faint stars is the most important contribution to errors in the sky background determination. Therefore, only these stars were measured for which inspection of the deep maps by Oosterhoff (1937) allowed the choice of a nearby field devoid of stars. For stars with discordant measurements in different nights, the possible errors induced by sky measurements were checked during the reduction. Finally, the sky magnitudes for the measurements of the most often observed objects were considered : it appeared then that variation of the sky brightness with time was essentially due to the motion of the Moon, and not to careless observation.

The observational data are summarized in table I. We list for each star its number in the compilation by Oosterhoff (1937), the weighted number of observations and standard deviations for the color indices, the mean indices, the weighted number and standard deviations for the visual magnitudes, the mean visual magnitudes, and the spectral types from the literature. The last columns refers to some remarks.

3. Reddening.

An appropriate reddening-free formalism for early-type stars in the Geneva system has been developed by Cramer and Maeder (1979). The suitable observational HR-diagram is the *XY*-diagram. We list the *X*- and *Y*-parameters for the program stars in table II. Following Cramer (1982) we have estimated the dereddened indices $[U - B]_0$ and $[B - V]_0$ from X and Y, using a polynomial fit of degree 3, and so the color excess $E[U - B]$and $E[B - V]$. The dereddened indices and the color excesses are also listed in table II. The last but one column of the table lists the ratio $E[U - B] / E[B - V]$. This ratio is approximately equal to 0.64 for purely interstellar reddening (Goy, 1970 ; Cramer, 1982). The procedure obviously gives spurious results for the later-type stars in table II. These stars are marked by an asterisk in the last column, as are stars like Oo 2178 and Oo 2589, which have discrepant excess ratios and thus present anomalous reddening.

Fifty stars are common to Crawford *et al.*'s (1970) compilation and to ours. The color excesses $E[B-V]$ and $E[b-y]$ are compared in figure 1. The ratio $E[B-V]/E(b-y)$ averages 1.63 ± 0.07 (r.m.s.) A few objects deviate from the mean relation ; they are A supergiants and Be stars. For the former, some part of the discrepancy may be due to the uncertainties in the determination of intrinsic colors for the most luminous stars. The differences for the Be stars are probably due to the long-term variability of these stars and their circumstellar components (see Sect. 5).

It is clear from figure 1 that a rather important range in color excesses is observed. For some of the most obscured objects, a circumstellar absorption component is present in addition to the interstellar one : large excesses ($E[B-V] \geq 0.8$, while for the other stars the mean excess is 0.65 mag) are observed for the supergiants Oo 1057, Oo 1162, and Oo 2621, and the Be stars Oo 2138 and Oo 2284. In addition, the interstellar absorption shows some real variation over the cluster, which has not been accounted for in previous studies. The color excesses $E[B-V]$ are mapped on the plane of the sky for the nucleus of h Persei in figure 2. Absorption is systematically larger than average for the stars in the south-eastern part of the cluster. Inspection of this region on Oosterhoff's map clearly indicates a lower star density in this part, again pointing to additional obscuration.

When the south-eastern part of h Persei is excluded, it turns out that the reddening toward both cluster nuclei is not significantly different, i.e. $E[B-V] = 0.65 \pm 0.03$ for h Per (14 stars), and $E[B-V] = 0.65 \pm 0.07$ for χ Per (15 stars), which corresponds to $E(B-V) = 0.56$ in the UBV system. Part of the scatter must be of circumstellar origin, since both clusters are particularly rich in Be stars. The rather uniform interstellar component over the whole cluster region suggests that the main absorbing clouds must be rather nearby, in agreement with the findings by Golay *et al.* (1988). This point is substantiated by the color excess of the foreground star Oo 1015 — $E[B-V] = 0.445$ — which is situated at roughly half the distance to the clusters. We will see in the next Section that the highly reddened star Oo 1257, in the south-eastern part of h Per, with $E[B-V] = 0.878$, may also be a foreground object.

4. Color-magnitude diagrams.

The dereddened visual magnitudes V_0 in table II were computed with a ratio of total-to-selective absorption $A_V/E[B-V]$ equal to 2.75 (Cramer, 1982) and with the individual color excesses of each star. For the mean visual magnitudes of the non-variable stars that are common to both samples, good agreement is found with the results by Crawford *et al.* (1970). For a few variables (see below) the discrepancy between both data sets is larger than 0.3 magnitudes. Also, differences between the dereddened data occur because we corrected with the reddening computed for each star separately, while Crawford *et al.* computed V_0 with a mean reddening. One unexplained discrepancy is that of the star Oo 991, which we found to be 0.6 mag fainter as did Crawford *et al.*

In figures 3 to 5 we display the color-magnitude diagrams V_0 *versus* $[U-B]_0$ for the nuclei of h and χ Persei separately and for all stars from table II. On all three figures, the scatter is high along both axes. A few stars are more than 0.1 magnitude bluer than the bulk of the other stars that have the same brightness. The brightest such star is the blue straggler Oo 2172 (HD 14434), which is situated on the continuation of the ZAMS of the cluster, well beyond the turnoff point (Mathys, 1987). The others are Oo 245, Oo 1261, Oo 2196, Oo 2262, and Oo 2284 ; except for Oo 245, all these stars have been classified as Be stars.

It is well known that the average rotational velocity for the brightest stars in h and χ Persei is high (Slettebak, 1968). High rotational velocities may lead to quasi-homogeneous evolution, which was proposed as an explanation for the blue-straggler phenomenon (Wheeler, 1979 ; Maeder, 1987). It also affects observational parameters such as colors, magnitudes, and spectral types (Collins, 1987). It is therefore reasonable to assume that at least part of the horizontal scatter in the color-magnitude diagrams of the double cluster reflects a range in rotation velocities and/or inclination angles. Strong support for this assumption comes from the fact that a majority of the most deviating stars are Be stars, which are well known to rotate more rapidly than the average B stars. Also, the scatter is consistently less for the color-magnitude-diagrams in the Geneva system for clusters of similar age, such as NGC 3293 and NGC 7160 (Rufener, 1988).

The high rotational velocities then also cause part of the observed scatter of the color-magnitude diagrams in the vertical sense. An additional source for vertical scatter is binarity. The most deviant main-sequence star — Oo 1257 — is situated about 1.5 magnitude above the main sequence, and thus probably is a foreground star. The high reddening of this star then confirms that the reddening is produced relatively near to us. Another foreground object may be Oo 2185 ; this star presents a reddening near the mean value of the clusters.

Following Schild (1967), it is sometimes assumed that h Persei is younger and more distant than χ Persei (e.g. Tapia *et al.*, 1984). This assumption is based on the occurrence of B0.5 stars in h Per, while the earliest stars in χ Per are of spectral type B1. These B0.5 stars are indicated as circles in figure 3. Obviously, the color-magnitude diagram does not confirm that these stars testify a hotter turnoff for h Per. In fact, when figures 3 to 5 are superposed, no systematic shift in color appears. We conclude therefore that no systematic mean age difference can be detected between the two clusters and also between the clusters and the fringe region, stressing the fact that in all parts a large intrinsic scatter exists, part of which is due to the effects of rapid rotation.

5. Variable stars.

Rufener and Bartholdi (1982) discussed the typical accuracy of measurements in the Geneva system by studying the histogram of the standard deviations on the visual magnitudes for the 14633 stars in Rufener's (1981) catalog. By studying the long tail of the distribution they also defined criteria for (micro) variability. Even after allowing for the peculiar observation conditions of a crowded cluster and accordingly relaxing the conditions, we find that an unusually high fraction of the cluster stars must be variable. The typical standard deviation found by Rufener and Bartholdi is $s'_V = 8.2$ mmag. Of the B stars in table I, 25% have $\sigma_V \leq s'_V$, 25% have $s'_V \leq \sigma_V \leq 2\, s'_V$, and 50% have $2\, s'_V \leq \sigma_V$.

A first class of variables found in the double cluster consists of supergiant stars. The four BIa-supergiants Oo 16, Oo 1057, Oo 1162, and Oo 2621 clearly are variable. The light variations we observed for Oo 16 and Oo 1057 in 1983 are displayed in figure 6. They are erratic in nature : no obvious time scale seems to be present in the variations of these early-B supergiants.

The largest-amplitude variability was observed for several objects that are known to be Be stars. In figure 7 we display the brightness variations of Oo 309, Oo 1702, Oo 1926, Oo 2138, and Oo 2165, i.e. five stars that were known to be Be stars before our survey began. The variability of some of these stars was already clear from the earlier measurements at Haute-Provence (Rufener, 1981). It is seen in figure 7 that long-term variations, with time scales of years and amplitudes of some tenths of a magnitude, dominate, but that shorter variations with smaller amplitudes occur within each observing season. These short-term vatiations still significantly exceed the observational scatter. This point may be evidenced by comparing the variation of Oo 309 with those of the other stars in figure 7 : it appears clearly that stars with smaller long-term variations also show smaller short-term variability. The associated color variations are also important : $[U-B]$ indices of these stars varied by up to 0.05 magnitude (the stars being bluest in $[U-B]$ and reddest in $[B-V]$ when brightest), i.e. by nearly one half of the color spread on the main sequence in figure 5.

Similar large-amplitude variations on various time scales and with important color variations were observed for a number of stars initially not known to be Be stars, such as Oo 49 and Oo 717 (Fig. 8) and Oo 864. We summarize the data about the most observed variable stars in table III.

Although most variable stars in the double cluster could not be monitored as intensively as the stars listed in table III, it appears that a general pattern emerges : for all stars the variations on a longer time scale, from weeks to years, clearly exceed in amplitude the nightly variations by an order of magnitude, and the amplitude of the color variations roughly scales with that of the brightness variations. We think therefore that most variable stars — i.e. at least half of the stars in table I — are Be stars or related stars. The known Be stars have the largest amplitudes ; the fact that they are detected spectroscopically and not the others may thus be due to the treshold of the spectroscopic surveys so far. This view is supported by more recent spectroscopic observations by Slettebak (1985), who found several new Be stars in the double cluster, among them Oo 49. It is also consistent with the large average rotation velocity and the important scatter of the main sequence in the color-magnitude diagrams.

The double cluster is of roughly the same age as the southern open cluster NGC 3293, which is particularly rich in β Cephei stars. One of the initial motivations of our project was then to search for β Cephei stars in the double cluster. We have therefore searched for short-period variations in some objects, such as Oo 30, Oo 146, Oo 260 and Oo 1586, which — according to their colors — fall in the β Cephei instability strip. The fact that seven-color measurements are rather time consuming and the unpredictability of the weather at Jungfraujoch prevented us from obtaining large data strings with good time coverage. Typically not more than five measurements were made each night, and observation during subsequent nights was not always possible ; in such conditions, determination of short periodicities is hazardous. We therefore later focussed mainly on the variability on a longer time scale. It is, in our opinion, nevertheless significant that no short-period oscillations were found in our survey. The stars investigated never showed rapid variations in excess of 0.02 mag. Although we can by no means claim that our search for β Cephei stars in h and χ Persei is complete, our null result contrasts with the large number of Be stars found and is consistent with the negative result of a broader search by Percy (1972). In his search for short-period variability among 39 stars in h and χ Persei, Percy could not detect any β Cephei variable ; from the seven stars for which Percy found some evidence for variability at the 0.03-mag level, only two could be short-term variables ; on the other hand, our study showed that many of the stars observed by Percy are long-term variables. For the sake of completeness, we also mention a negative result of a search for β Cephei stars in h and χ Persei by Cox (1983). It is a significant fact that all stars that were found by Cox to be constant on a short time scale turn out to be variable on longer time scales.

6. Discussion.

Although the large rotation velocities of stars in h and χ Persei and the large number of Be stars in the double cluster have been known since some time, the importance of these points has been underscored. They may explain the broadening of the main sequence in a natural way and render the claims for different ages of the clusters rather doubtful.

In the present study, we were mainly concerned with the brighter cluster members. More data on the fainter members are needed in order to tie the cluster sequence down to sequences of other clusters, so that a new estimate of the distance modulus can be made. But even if the distance modulus of h and χ Persei were accurately known, it may be questioned whether the observations of these clusters are useful for calibrating the absolute magnitudes of the earliest-type B stars in terms of photometric indices. Indeed, the influence of various effects of rotation on the colors is so huge that it seems hopeless to find a unique relation between absolute magnitude and colors for stars of h and χ Persei. This problem is very worrysome, since only a few other very young northern clusters are within reach. Indeed, existing calibrations depend critically on data for h and χ Persei. For constructing calibrations that are reliable for northern objects, it is therefore critical that observations be carried out in a photometric system that allows a homogeneous coverage of both celestial hemispheres. But even then it may be doubted that any photometric calibration which does not take into account the effects of rotation on the colors can enable one to estimate accurately the physical parameters of the hottest rapidly rotating stars.

The large numbers of Be stars in h and χ Persei has struck other investigators as well. Schild and Romanishin (1976) and Abt (1987) estimated the Be star frequency in χ Persei at about 25%, while for the average frequency of Be stars in clusters they quoted values near 10%. However, Abt (1987) stressed the fact that such comparisons could be biased by the various techniques involved in different studies.

We have suggested in the previous section that the 50% or so variable stars in our sample are Be stars or stars related to them. Of course, it is hazardous to term a star as a Be star without direct spectroscopic evidence. We feel, however, that the similarity of the photometric behavior of these stars suggests that they are all of a similar nature. Since the largest-amplitude variables consistently turn out to be Be stars, it is then also natural to conclude that the known Be stars constitute the "tip of the iceberg", i.e. those stars whose Be character can be demonstrated with the rather low spectroscopic resolution devoted to their study so far. As we have mentioned earlier, our photometric study started before we were aware of the new spectroscopic work by Slettebak (1985), and it is therefore highly significant that some of the largest-amplitude variables that were not known to be Be stars before, were confirmed as such by Slettebak. It is probable, in our opinion, that more frequent spectroscopic observations, with higher resolution, would reveal more Be stars in both h and χ Persei.

The large frequency of Be stars and the apparent absence of β Cephei stars in the double cluster stands in striking contrast with the small number of Be stars and the large number of β Cephei stars in the southern cluster NGC 3293, which is of similar age. In the two known Be stars of NGC 3293, the β Cephei phenomenon is not observed. These observations lend support to the old idea that large rotational velocities tend to be incompatible with the β Cephei phenomenon. This idea was questioned when some β Cephei stars with large $v \sin i$ were discovered, but it remains an observational fact that the pulsation amplitudes in such stars are lower than in the slowly rotating pulsators (Jakate, 1979). Also, no β Cephei stars are observed in the closest binaries, where tidal effects enforce rapid corotation (Waelkens and Rufener, 1983).

7. Concluding remarks.

In this study, we have found that an unusually large fraction of the brightest members of the double cluster h and χ Persei are Be stars. We suggest that this fact may allow for a large part of the spread in color on the upper-main-sequence of both clusters. It seems that the evidence for an age difference between both clusters and the surrounding stars is weakened. Also, we have warned against the use of photometric luminosity calibrations that depend too heavily on measurements of the brightest stars in h and χ Persei.

Comparisons of h and χ Persei with the cluster of similar age NGC 3293 reveals that striking differences in average rotation velocities play an important role. The age group of these clusters being a rich one (Mermilliod, 1981), it may be rewarding to extend the present study to the clusters NGC 4755, NGC 6871, and IC 2581.

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References

ABT H. A. : 1987, in "Physics of Be Stars", Proceedings of the 92nd Colloquium of the International Astronomical Union, A. Slettebak and T.P. Snow Eds. (Cambridge University Press) p. 470.

BALONA L. A., ENGELBRECHT C. E. : 1983, *Mon. Not. R. Astron. Soc.* **202**, 293.

BALONA L. A., SHOBBROOK R. R. : 1984, *Mon. Not. R. Astron. Soc.* **211**, 375.

BIDELMAN W. P. : 1943, *Astrophys. J.* **98**, 61.

COLLINS G. W. : 1987, in "Physics of Be Stars", Proceedings of the 92nd Colloquium of the International Astronomical Union, A. Slettebak and T.P. Snow Eds. (Cambridge University Press) p. 3.

COX A. N., in "Astrophysical Processes in Upper Main Sequence Stars", 13th Advanced Course of the Swiss Society of Astronomy and Astrophysics, edited by Geneva Observatory, p. 69.

CRAMER N. : 1982, *Astron. Astrophys.* **112**, 330.

CRAMER N., MAEDER A. : 1979, *Astron. Astrophys.* **78**, 305.

CRAWFORD D. L. : 1978, *Astron. J.* **83**, 48.

CRAWFORD D. L., GLASPEY J. W., PERRY C. L. : 1970, *Astron. J.* **75**, 822.

GOLAY M. : 1980, *Vistas Astron.* **24**, 141.

GOLAY M., RABATTU X., CRAMER N., HUGUENIN D. : 1988, *Astrophys. Space Sci.* **147**, 1.

GOY G. : 1970, Ph.D. Thesis, Université de Genève.

JAKATE S. M. : 1979, *Astron. J.* **84**, 552.

JOHNSON H. L., MORGAN W. W. : 1955, *Astrophys. J.* **122**, 429.

MAEDER A. : 1987, *Astron. Astrophys.* **178**, 159.

MANFROID J., STERKEN C. : 1987, *Astron. Astrophys. Suppl. Ser.* **71**, 539.

MATHYS G. : 1987, *Astron. Astrophys. Suppl. Ser.* **71**, 201.

MENDOZA E. E. : 1967, Bol. Obs. Tonantzintla y Tacubaya **4**, 149.

MERMILLIOD J. C. : 1981, *Astron. Astrophys. Suppl. Ser.* **44**, 467.

MOFFAT A. F. J., VOGT N. : 1974, Veröff. Astron. Inst. Ruhr Univ. Bochum nr. 2.

OOSTERHOFF P. T. : 1937, *Ann. Sterrewacht Leiden* **17**, 1.

PERCY J. R. : 1972, *Publ. Astron. Soc. Pacific* **84**, 420.

RUFENER F. : 1981, *Astron. Astrophys. Suppl. Ser.* **45**, 207.

RUFENER F. : 1985, in "Calibration of Fundamental Stellar Quantities", Proceedings of the 111nd "Symposium of the International Astronomical Union", D.S. Hayes, L.E. Passinetti and A.G. Davis Philip Eds. (Reidel, Dordrecht) p. 253.

RUFENER F. : 1986, *Astron. Astrophys.* **165**, 275.

RUFENER F. : 1988, Catalogue of stars measured in the Geneva Observatory photometric system (forth edition), Geneva Observatory Publication.

RUFENER F., BARTHOLDI P. : 1982, *Astron. Astrophys. Suppl. Ser.* **48**, 503.

SCHILD R. E. : 1965, *Astrophys. J.* **142**, 979.

SCHILD R. E. : 1966, *Astrophys. J.* **146**, 142.

SCHILD R. E. : 1967, *Astrophys. J.* **148**, 449.

SCHILD R. E., ROMANISHIN W. : 1976, *Astrophys. J.* **204**, 493.

SLETTEBAK A. : 1968, *Astrophys. J.* **154**, 933.

SLETTEBAK A. : 1985, *Astrophys. J. Suppl. Ser.* **59**, 769.

TAPIA M., ROTH M., COSTERO R., NAVARRO S. : 1984, Revista Mexicana de Astronomia y Astrofisica **9**, 65.

WAELKENS C., RUFENER F. : 1983, *Astron. Astrophys.* **121**, 45.

WHEELER J. C. : 1979, *Astrophys. J.* **234**, 569.

WILDEY R. L. : 1964, *Astrophys. J. Suppl. Ser.* **8**, 439.

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TABLE I. — *Observational data for the program stars. Listed are the Oosterhoff numbers, weighted number of color observations, mean standard deviation of the colors in millimag, the color indices, the weighted number of magnitude observations, the mean visual magnitudes, and the spectral types as recorded in the literature.*

Oo	P	σ	U-B	V-B	B1-B	B2-B	V1-B	G-B	Q	σ_v	m_v	ST
3	15	6	0.569	0.700	0.837	1.522	1.416	1.818	10	16	7.386	B2Ib
16	37	4	0.553	0.646	0.845	1.517	1.368	1.751	33	20	6.468	B1Iab
30	10	6	0.617	0.748	0.847	1.526	1.465	1.877	10	10	9.916	(B)
49	37	18	0.576	0.658	0.843	1.518	1.380	1.760	35	58	9.104	B1II
146	17	7	0.564	0.778	0.832	1.532	1.487	1.910	16	6	9.178	B1III
245	27	7	0.495	0.754	0.832	1.536	1.469	1.883	26	33	9.896	(B)
260	10	6	0.623	0.620	0.853	1.508	1.337	1.722	10	9	9.372	B1IIIa
309	32	14	0.502	0.563	0.864	1.499	1.291	1.640	30	39	9.483	B1IIIe
339	11	10	0.631	0.621	0.846	1.500	1.346	1.722	11	22	8.847	B1IV
551	3	6	0.814	0.603	0.869	1.479	1.320	1.705	2	16	10.415	
566	9	10	0.595	0.767	0.841	1.531	1.481	1.897	9	30	9.658	B1Vpe
572	2	5	0.734	0.640	0.863	1.508	1.345	1.739	1	4	10.567	
590	4	9	0.631	0.738	0.840	1.514	1.449	1.862	3	5	10.123	(B)
604	2	10	2.422	-0.713	1.424	1.068	0.091	0.184	2	5	9.108	
612	7	10	0.609	0.674	0.847	1.510	1.390	1.772	6	16	8.414	B1II
662	9	5	0.647	0.622	0.855	1.506	1.343	1.717	8	12	8.198	B1Ib
692	4	5	0.586	0.680	0.847	1.530	1.404	1.794	4	16	9.392	
717	59	8	0.670	0.630	0.859	1.503	1.351	1.733	57	57	9.287	B1V
748	3	6	1.412	0.725	0.894	1.476	1.443	1.852	2	14	10.305	(A)
782	5	7	0.697	0.665	0.852	1.512	1.383	1.773	4	10	9.468	(B)
803	2	3	0.695	0.595	0.858	1.489	1.303	1.688	2	5	10.511	(B)
839	3	3	0.702	0.549	0.867	1.491	1.272	1.631	3	8	9.375	(B)
843	12	7	0.717	0.639	0.861	1.503	1.360	1.745	12	10	9.344	B1.5V
847	8	6	0.744	0.538	0.869	1.491	1.265	1.624	6	15	9.135	B3III
864	21	8	0.765	0.616	0.866	1.491	1.333	1.720	20	32	9.946	B1V
867	2	12	1.355	0.212	1.057	1.329	0.972	1.268	2	15	10.553	B2V
899	4	12	3.957	-2.097	1.585	0.981	-1.211	-1.348	2	88	9.378	M3.5Ib
911	3	19	0.843	0.604	0.883	1.485	1.331	1.692	3	44	11.253	B2V
922	11	9	0.708	0.597	0.861	1.498	1.317	1.690	11	23	9.525	B0.5V
936	5	10	0.730	0.603	0.858	1.501	1.329	1.713	5	65	10.469	B1.5V
950	6	36	0.801	0.532	0.865	1.464	1.250	1.628	5	27	11.295	B2V
963	2	6	0.732	0.614	0.856	1.506	1.336	1.711	2	17	11.019	B2IV
978	8	11	0.766	0.574	0.875	1.488	1.288	1.661	8	53	10.659	B1.5V
991	1	7	0.892	0.554	0.899	1.491	1.284	1.657	1	6	11.356	B2V
1004	8	8	0.800	0.568	0.877	1.481	1.299	1.662	7	67	10.855	B2V
1015	4	7	1.243	0.640	0.888	1.459	1.353	1.744	3	6	10.591	B8V
1057	32	6	0.901	0.422	0.892	1.462	1.157	1.482	30	23	6.581	B3Ia
1067	2	5	0.756	0.644	0.864	1.494	1.355	1.743	2	7	10.512	(B)
1078	9	8	0.758	0.576	0.870	1.494	1.301	1.675	7	20	9.786	B1V
1085	1	0	0.762	0.572	0.865	1.490	1.259	1.662	1	0	10.391	B1.5V
1116	5	10	0.793	0.522	0.878	1.488	1.249	1.607	4	11	9.268	B0.5V
1132	4	7	0.784	0.521	0.892	1.497	1.242	1.595	4	14	8.457	B0.5V
1133	7	11	0.767	0.504	0.880	1.482	1.231	1.578	6	29	9.022	B0.5V
1141	3	6	0.765	0.596	0.869	1.497	1.318	1.691	3	8	9.851	(B)
1161	4	13	0.800	0.460	0.890	1.461	1.183	1.523	5	42	10.137	B1.5V
1162	12	6	0.789	0.376	0.888	1.458	1.112	1.428	8	30	6.663	B2Ia
1187	4	45	0.740	0.554	0.864	1.485	1.279	1.644	4	39	10.789	B2IV
1196	3	7	0.758	0.617	0.862	1.496	1.338	1.715	3	8	10.639	
1242	3	14	1.502	0.335	1.003	1.355	1.062	1.386	3	59	10.314	
1257	2	8	1.005	0.348	0.915	1.442	1.083	1.398	2	3	10.351	(B)
1261	5	7	0.691	0.400	0.894	1.468	1.140	1.455	5	16	9.561	
1268	10	8	0.743	0.533	0.878	1.493	1.258	1.619	10	12	9.383	B0.5V
1352	5	4	0.743	0.599	0.866	1.487	1.319	1.699	5	8	9.925	
1364	4	6	0.789	0.542	0.872	1.489	1.272	1.632	4	14	9.933	
1391	3	6	0.669	0.696	0.851	1.513	1.410	1.821	3	9	10.423	
1586	9	6	0.693	0.597	0.861	1.505	1.315	1.688	8	25	8.984	B1III
1655	3	59	3.714	-1.889	1.686	0.956	-1.012	-1.128	2	186	7.930	M3Iab
1702	38	17	0.594	0.528	0.868	1.489	1.256	1.603	36	88	9.569	B1.5IIIe
1781	8	8	0.715	0.642	0.866	1.502	1.356	1.750	6	31	9.227	B1IV
1818	7	47	3.824	-1.908	1.763	0.931	-1.020	-1.173	5	107	7.969	M1Iab
1870	2	7	0.734	0.573	0.866	1.494	1.291	1.663	2	6	9.479	
1899	7	10	0.724	0.610	0.863	1.500	1.328	1.712	5	25	8.518	B1.5II
1924	3	8	0.757	0.576	0.872	1.499	1.306	1.682	3	3	9.924	(B)
1926	35	14	0.621	0.426	0.883	1.475	1.163	1.482	34	64	9.895	B1IIIe
1932	2	5	1.298	0.306	1.010	1.341	1.031	1.364	2	2	10.452	(B)
2049	3	10	0.590	0.617	0.851	1.514	1.339	1.714	3	4	9.930	(B)
2079	3	9	1.946	-0.039	1.096	1.292	0.728	0.952	3	14	9.587	(B)
2088	13	13	0.646	0.623	0.854	1.506	1.340	1.724	14	75	9.479	B1.5V
2114	4	13	0.802	0.602	0.869	1.489	1.324	1.704	4	19	10.955	B2V
2138	23	16	0.674	0.474	0.876	1.484	1.205	1.545	22	66	9.208	B0IVpe
2139	12	30	0.737	0.656	0.865	1.503	1.373	1.770	11	43	11.378	B2V
2144	1	0	0.807	0.575	0.869	1.468	1.310	1.678	1	0	10.928	(B)
2165	26	22	0.563	0.506	0.864	1.491	1.237	1.574	24	102	9.932	B2Ve
2172	4	4	0.408	0.785	0.833	1.540	1.494	1.916	3	6	8.490	06
2178	3	6	1.573	0.311	0.913	1.431	1.061	1.340	0	0	6.387	A1Ia
2185	5	18	0.970	0.614	0.879	1.490	1.327	1.717	4	20	10.950	B3V
2196	5	56	0.698	0.657	0.851	1.510	1.367	1.754	5	48	11.550	B1.5V
2227	7	5	0.699	0.571	0.860	1.501	1.294	1.663	6	18	8.053	B2Ibp
2232	9	12	0.695	0.701	0.854	1.508	1.410	1.814	9	26	11.093	B2V
2235	6	7	0.711	0.601	0.859	1.506	1.319	1.698	6	13	9.357	B1V
2246	9	8	0.688	0.628	0.858	1.505	1.346	1.728	9	33	9.941	B2III
2251	5	14	0.948	0.578	0.892	1.475	1.283	1.671	5	31	11.561	B3V
2262	7	22	0.679	0.527	0.875	1.485	1.251	1.603	7	68	10.452	B2V
2284	8	9	0.615	0.521	0.870	1.489	1.253	1.601	8	15	9.688	B2III-IVe
2296	7	9	0.687	0.629	0.850	1.502	1.344	1.725	8	21	8.532	B1III
2299	3	4	0.669	0.632	0.854	1.503	1.348	1.735	3	7	9.076	B0.5IV
2311	4	11	0.714	0.639	0.861	1.511	1.356	1.744	4	18	9.385	B2III
2330	3	10	0.794	0.645	0.843	1.481	1.354	1.758	2	22	11.446	(B)
2361	4	4	0.729	0.535	0.874	1.493	1.260	1.614	4	8	8.765	B0.5III
2371	11	6	0.659	0.599	0.864	1.504	1.320	1.697	11	25	9.220	B2III
2377	6	9	0.797	0.562	0.873	1.479	1.281	1.638	6	14	11.070	(B)
2392	4	8	0.797	0.586	0.873	1.490	1.308	1.674	4	22	10.663	(B)
2402	3	7	0.882	0.326	0.913	1.447	1.072	1.369	3	9	9.589	B1III
2417	2	42	3.641	-1.791	1.479	1.036	-0.924	-0.992	1	300	8.509	M4Iab
2488	2	3	0.647	0.668	0.849	1.502	1.373	1.765	2	2	9.920	
2520	2	5	0.848	0.435	0.886	1.455	1.153	1.490	2	6	10.624	
2572	1	3	0.761	0.594	0.869	1.491	1.311	1.675	2	9	10.034	
2589	5	6	1.632	0.127	0.944	1.408	0.885	1.130	3	26	7.471	A2Iap
2605	2	3	0.626	0.668	0.845	1.512	1.374	1.778	2	11	9.716	
2621	8	4	1.232	0.246	0.925	1.429	0.991	1.271	5	18	7.006	B8Ia
2691	1	14	3.350	-1.796	1.683	0.952	-0.911	-1.065	1	7	8.168	M0Iab
2758	1	0	3.698	-1.918	1.711	0.910	-1.015	-1.217	1	0	8.511	M0Iab
2964	2	10	0.710	0.609	0.903	1.485	1.328	1.708	2	13	10.234	

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TABLE II. — *Dereddened data for the program stars. Listed are the Oosterhoff numbers, weighted number of color observations, mean standard deviation of the colors in millimag, the dereddened parameters X, Y, and Z, the color excesses E[U—B] and E[B—V], the ratios of the color excesses, and the dereddened visual magnitudes. Asterisks in the last column denote stars with peculiar reddening.*

Oo	P	σ	X	Y	$(U-B)_0$	$(V-B)_0$	E(U-B)	E(V-B)	ρ	V_0	
3	15	6	0.167	0.053	0.195	-1.307	0.374	0.607	0.616	5.717	
16	37	4	0.090	0.054	0.129	-1.330	0.424	0.684	0.620	4.586	
30	10	6	0.259	0.027	0.270	-1.275	0.347	0.527	0.660	8.468	
49	37	18	0.129	0.068	0.169	-1.323	0.407	0.665	0.612	7.275	
146	17	7	0.224	0.040	0.241	-1.287	0.323	0.509	0.635	7.778	
245	27	7	0.106	0.042	0.138	-1.322	0.357	0.568	0.629	8.334	
260	10	6	0.165	0.046	0.191	-1.305	0.432	0.685	0.631	7.487	
309	32	14	-0.070	0.015	-0.025	-1.371	0.527	0.808	0.653	7.262	*
339	11	10	0.190	0.053	0.215	-1.300	0.416	0.679	0.613	6.979	
551	3	6	0.421	0.008	0.411	-1.232	0.403	0.629	0.641	8.685	
566	9	10	0.247	0.036	0.260	-1.280	0.335	0.513	0.653	8.247	
572	2	5	0.318	0.046	0.324	-1.264	0.410	0.624	0.657	8.850	
590	4	9	0.287	0.024	0.294	-1.267	0.337	0.529	0.638	8.668	
604	2	10	1.214	-0.989	1.257	-6.121	1.165	6.834	0.170	-9.686	*
612	7	10	0.185	0.045	0.208	-1.299	0.401	0.625	0.641	6.694	
662	9	5	0.192	0.054	0.217	-1.300	0.430	0.678	0.634	6.333	
692	4	5	0.153	0.071	0.191	-1.317	0.395	0.637	0.620	7.641	
717	59	8	0.233	0.034	0.248	-1.283	0.422	0.653	0.647	7.491	
748	3	6	1.321	0.069	1.176	-1.080	0.236	0.355	0.665	9.330	
782	5	7	0.300	0.060	0.313	-1.273	0.384	0.608	0.632	7.796	
803	2	3	0.250	0.024	0.261	-1.276	0.434	0.681	0.636	8.637	
839	3	3	0.204	0.049	0.226	-1.295	0.476	0.746	0.638	7.323	
843	12	7	0.304	0.038	0.310	-1.266	0.407	0.627	0.649	7.620	
847	8	6	0.255	0.060	0.274	-1.285	0.470	0.747	0.630	7.081	
864	21	8	0.358	0.021	0.355	-1.249	0.410	0.633	0.648	8.205	
867	2	12	0.749	-0.390	1.123	-1.517	0.232	1.305	0.178	6.964	*
899	4	12	2.113	-0.381	2.008	-0.437	1.949	2.534	0.769	2.409	*
911	3	19	0.426	0.022	0.414	-1.234	0.429	0.630	0.681	9.522	
922	11	9	0.256	0.051	0.272	-1.282	0.436	0.685	0.637	7.642	
936	5	10	0.305	0.056	0.316	-1.270	0.414	0.667	0.621	8.634	
950	6	36	0.367	0.010	0.363	-1.245	0.438	0.713	0.614	9.335	
963	2	6	0.304	0.080	0.325	-1.278	0.407	0.664	0.613	9.194	
978	8	11	0.308	0.024	0.312	-1.262	0.454	0.688	0.661	8.768	
991	1	7	0.447	0.017	0.432	-1.228	0.460	0.674	0.682	9.502	
1004	8	8	0.357	0.021	0.355	-1.249	0.445	0.681	0.654	8.982	
1015	4	7	1.033	0.039	0.935	-1.121	0.308	0.481	0.641	9.268	
1057	32	6	0.364	0.063	0.368	-1.258	0.533	0.836	0.637	4.282	
1067	2	5	0.361	0.021	0.358	-1.248	0.398	0.604	0.659	8.850	
1078	9	8	0.308	0.041	0.314	-1.266	0.444	0.690	0.644	7.889	
1085	1	0	0.318	0.027	0.321	-1.260	0.441	0.688	0.641	8.499	*
1116	5	10	0.302	0.055	0.312	-1.271	0.481	0.749	0.642	7.208	
1132	4	7	0.256	0.048	0.270	-1.281	0.514	0.760	0.676	6.367	
1133	7	11	0.247	0.046	0.262	-1.283	0.505	0.779	0.648	6.880	
1141	3	6	0.327	0.048	0.332	-1.263	0.433	0.667	0.650	8.017	
1161	4	13	0.259	0.008	0.269	-1.271	0.531	0.811	0.655	7.908	
1162	12	6	0.180	0.052	0.206	-1.303	0.583	0.927	0.629	4.114	
1187	4	45	0.275	0.046	0.286	-1.275	0.454	0.721	0.629	8.805	
1196	3	7	0.344	0.049	0.346	-1.259	0.412	0.642	0.641	8.873	
1242	3	14	1.081	-0.217	1.140	-1.096	0.362	0.761	0.476	8.221	*
1257	2	8	0.437	0.033	0.424	-1.234	0.581	0.886	0.656	7.916	
1261	5	7	0.047	0.021	0.081	-1.334	0.610	0.934	0.653	6.993	
1268	10	8	0.237	0.044	0.253	-1.285	0.490	0.752	0.651	7.316	
1352	5	4	0.315	0.017	0.318	-1.258	0.425	0.659	0.645	8.112	
1364	4	6	0.320	0.060	0.330	-1.268	0.459	0.726	0.633	7.937	
1391	3	6	0.298	0.024	0.303	-1.264	0.366	0.568	0.644	8.861	
1586	9	6	0.229	0.063	0.252	-1.293	0.441	0.696	0.633	7.071	
1655	3	59	1.832	-0.843	1.046	-2.966	2.668	4.855	0.550	-5.422	*
1702	38	17	0.035	0.026	0.071	-1.339	0.523	0.811	0.645	7.339	
1781	8	8	0.301	0.015	0.306	-1.261	0.409	0.619	0.661	7.524	
1818	7	47	1.874	-1.002	0.310	-4.756	3.514	6.664	0.527	-10.357	*
1870	2	7	0.271	0.048	0.284	-1.277	0.450	0.704	0.640	7.543	
1899	7	10	0.291	0.041	0.299	-1.270	0.425	0.660	0.644	6.703	
1924	3	8	0.305	0.044	0.312	-1.267	0.445	0.691	0.644	8.023	
1926	35	14	-0.022	0.029	0.020	-1.359	0.601	0.933	0.644	7.330	*
1932	2	5	0.790	-0.331	1.057	-1.356	0.241	1.050	0.229	7.564	*
2049	3	10	0.110	0.064	0.150	-1.328	0.440	0.711	0.619	7.976	
2079	3	9	1.318	-0.215	1.335	-0.998	0.611	1.037	0.589	6.736	*
2088	13	13	0.198	0.046	0.220	-1.296	0.426	0.673	0.633	7.628	
2114	4	13	0.395	0.032	0.387	-1.243	0.415	0.641	0.647	9.192	
2138	23	16	0.098	0.046	0.132	-1.325	0.542	0.851	0.636	6.867	
2139	12	30	0.346	0.018	0.345	-1.251	0.392	0.595	0.659	9.741	
2144	1	0	0.399	0.002	0.393	-1.236	0.414	0.661	0.627	9.111	
2165	26	22	-0.026	0.047	0.022	-1.366	0.541	0.860	0.628	7.566	
2172	4	4	0.005	0.004	0.043	-1.342	0.365	0.557	0.655	6.957	
2178	3	6	1.185	0.242	1.110	-1.116	0.463	0.805	0.575	4.173	*
2185	5	18	0.623	0.053	0.586	-1.200	0.384	0.586	0.656	9.339	
2196	5	56	0.291	0.067	0.308	-1.277	0.390	0.620	0.630	9.845	
2227	7	5	0.224	0.070	0.251	-1.296	0.448	0.725	0.618	6.060	
2232	9	12	0.329	0.021	0.330	-1.256	0.365	0.555	0.658	9.567	
2235	6	7	0.263	0.068	0.284	-1.285	0.427	0.684	0.624	7.477	
2246	9	8	0.254	0.048	0.269	-1.281	0.419	0.653	0.641	8.144	
2251	5	14	0.558	-0.002	0.532	-1.201	0.416	0.623	0.668	9.848	
2262	7	22	0.147	0.024	0.171	-1.304	0.508	0.777	0.654	8.315	
2284	8	9	0.060	0.028	0.094	-1.332	0.521	0.811	0.643	7.459	
2296	7	9	0.263	0.061	0.281	-1.283	0.406	0.654	0.621	6.734	
2299	3	4	0.240	0.041	0.255	-1.283	0.414	0.651	0.636	7.285	
2311	4	11	0.293	0.054	0.305	-1.273	0.409	0.634	0.646	7.642	
2330	3	10	0.463	0.035	0.447	-1.228	0.347	0.583	0.595	9.842	
2361	4	4	0.218	0.056	0.241	-1.293	0.488	0.758	0.644	6.680	
2371	11	6	0.186	0.037	0.207	-1.297	0.452	0.698	0.648	7.301	
2377	6	9	0.342	0.037	0.343	-1.256	0.454	0.694	0.654	9.160	
2392	4	8	0.359	0.044	0.359	-1.254	0.438	0.668	0.656	8.826	
2402	3	7	0.243	0.032	0.256	-1.280	0.626	0.954	0.656	6.965	
2417	2	42	2.017	-0.281	1.962	-0.537	1.679	2.328	0.721	2.107	*
2488	2	3	0.238	0.029	0.251	-1.281	0.396	0.613	0.646	8.235	
2520	2	5	0.312	0.032	0.316	-1.263	0.532	0.828	0.643	8.348	
2572	1	3	0.314	0.045	0.320	-1.265	0.441	0.671	0.657	8.188	
2589	5	6	1.098	0.232	1.045	-1.132	0.587	1.005	0.585	4.708	*
2605	2	3	0.217	0.041	0.235	-1.290	0.391	0.622	0.629	8.006	
2621	8	4	0.655	0.122	0.637	-1.209	0.595	0.963	0.618	4.359	
2691	1	14	1.376	-0.956	1.122	-5.286	2.228	7.082	0.315	-11.307	*
2758	1	0	1.744	-0.919	0.837	-3.998	2.861	5.916	0.484	-7.758	*
2964	2	10	0.233	-0.088	0.288	-1.274	0.422	0.665	0.635	8.406	

TABLE III. — *The largest-amplitude variable stars in h and χ Persei. Listed are the Oosterhoff numbers, number of observations, mean brightness, peak-to-peak amplitudes in [U−B], [B−V], and m_v, and the spectral types.*

Oo	N	$<m_V>$	Δ[U−B]	Δ[B−V]	Δm_V	S.T.
49	43	9.104	0.06	0.05	0.19	B1IIe
309	39	9.483	0.10	0.06	0.18	B1IIIe
717	69	9.287	0.06	0.04	0.32	B1V
864	28	9.946	0.05	0.03	0.12	B1V
1702	47	9.569	0.07	0.07	0.28	B1.5IIIe
1926	40	9.895	0.05	0.05	0.25	B1IIIe
2088	14	9.479	0.04	0.05	0.24	B1IIIe
2138	26	9.208	0.07	0.06	0.22	B0IVpe
2165	33	9.932	0.06	0.08	0.28	B2Ve

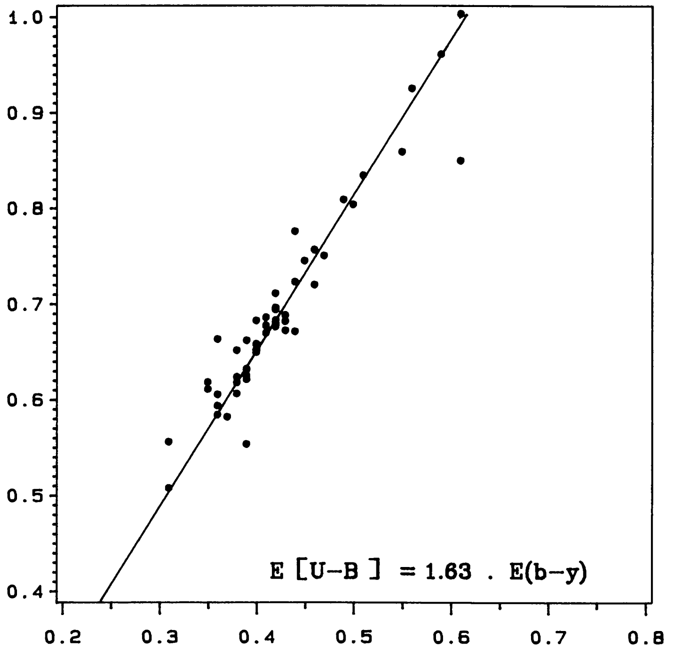


FIGURE 1. — The color excess $E[B-V]$ plotted as a function of the color excess $E(b-y)$ for the stars that are common to Crawford *et al.*'s (1970) and the present study.

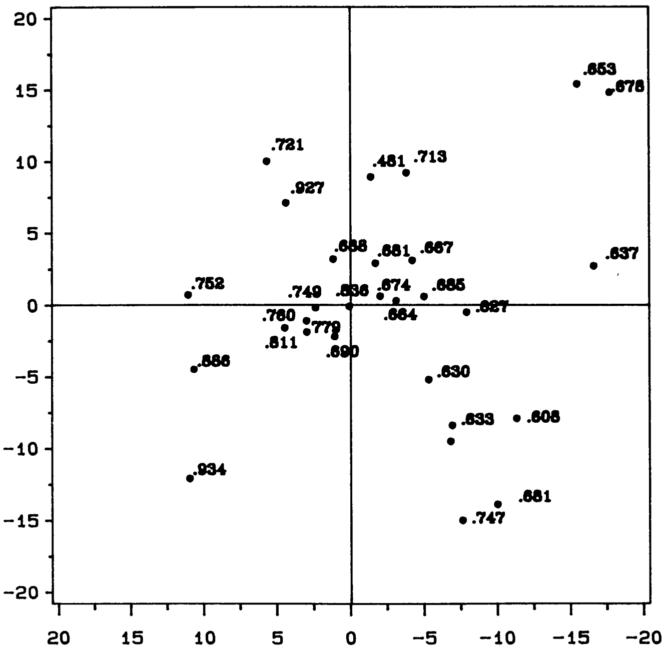


FIGURE 2. — The spatial distributions of the color excesses $E[B-V]$ for the stars of the nucleus of h Per. The relative positions with respect to Oo 1057 are expressed in arcminutes.

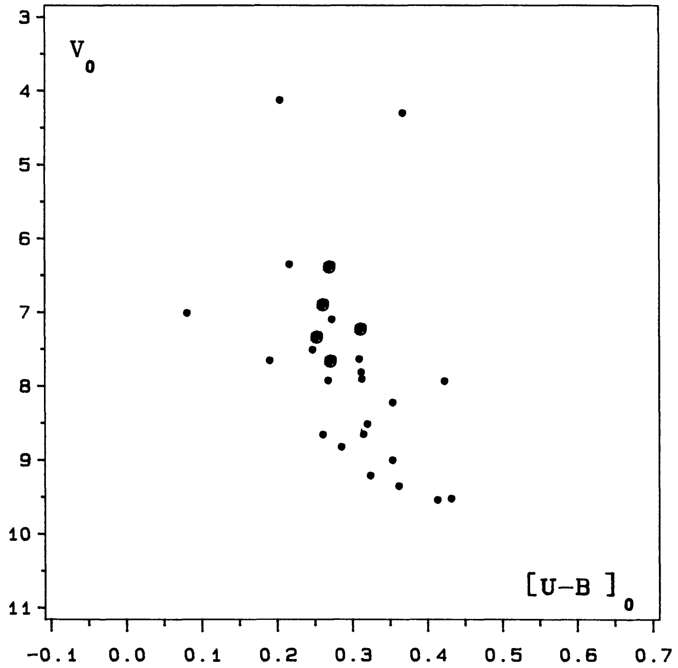


FIGURE 3. — Dereddened color-magnitude diagram for stars in the nucleus of h Per. The five B0.5 stars are encircled.

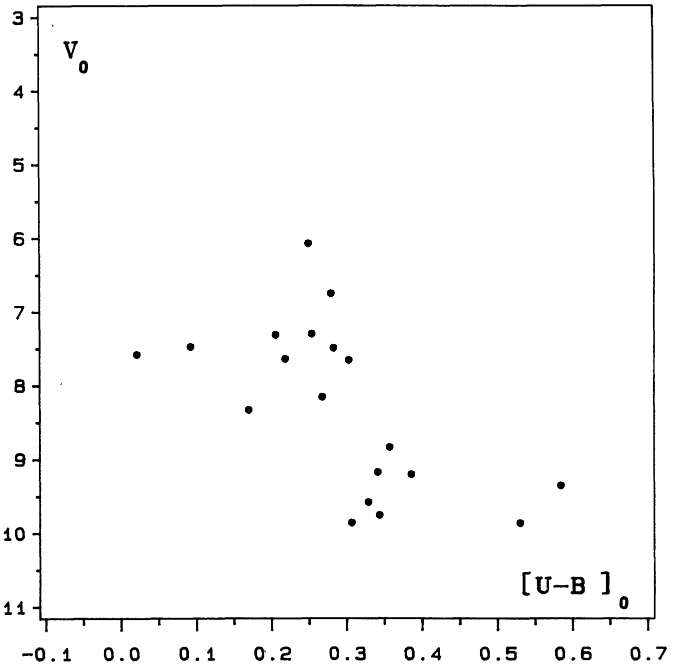


FIGURE 4. — Dereddened color-magnitude diagram for stars in the nucleus of χ Per.

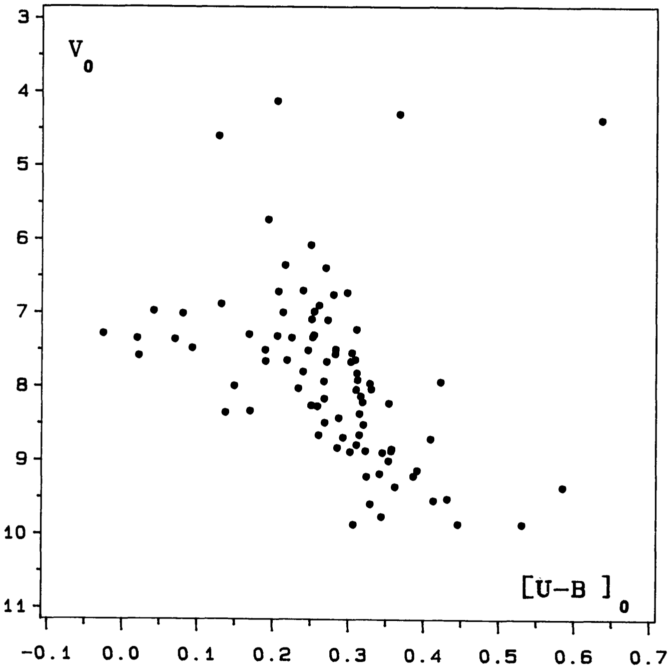
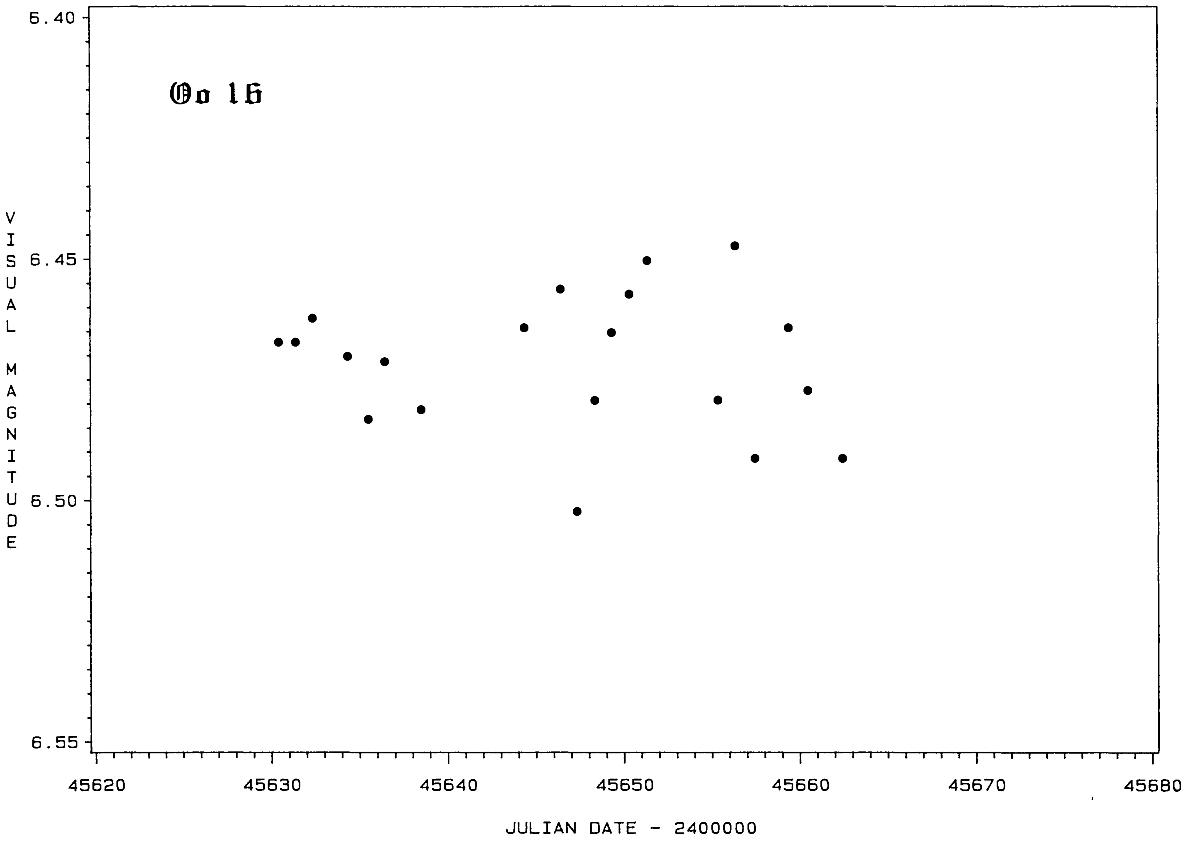


FIGURE 5. — Dereddened color-magnitude diagram for all program stars in the double cluster. As explained in the text, the stars that are to the left of the main sequence are mostly Be stars.



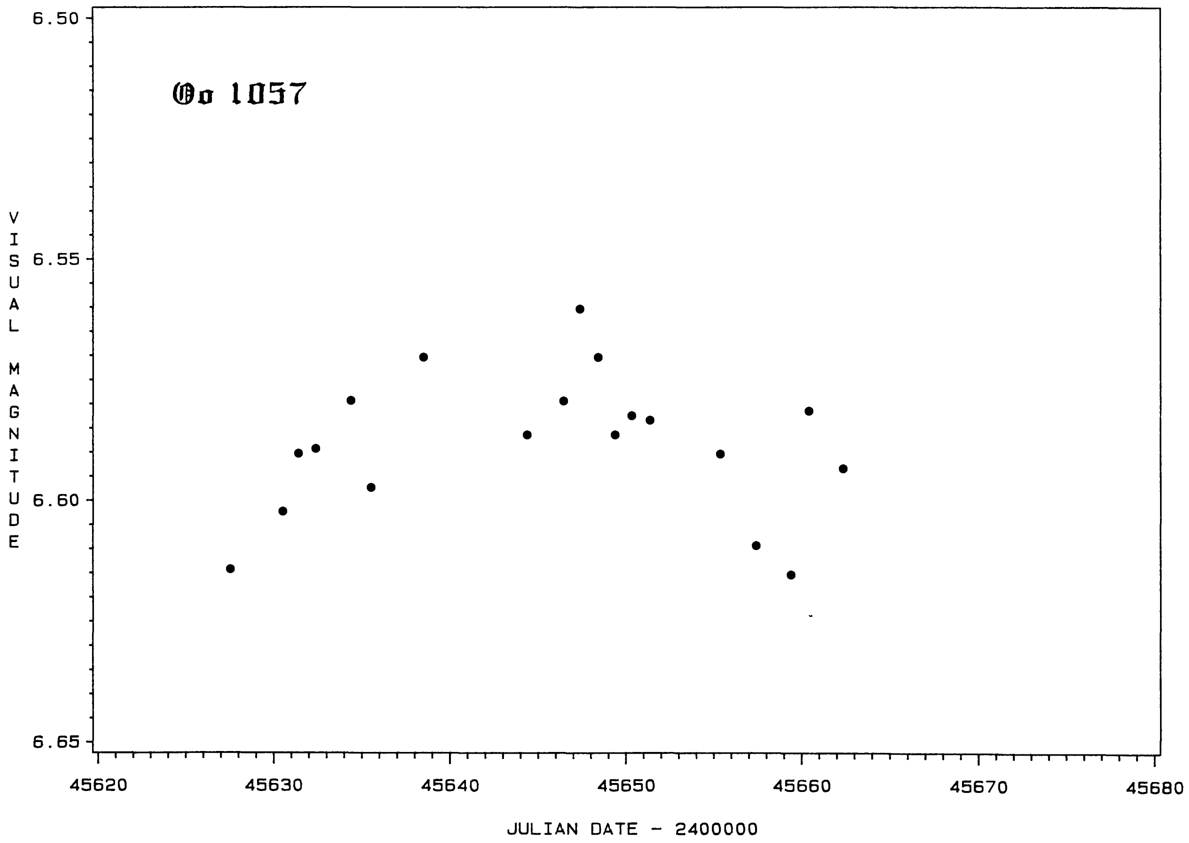
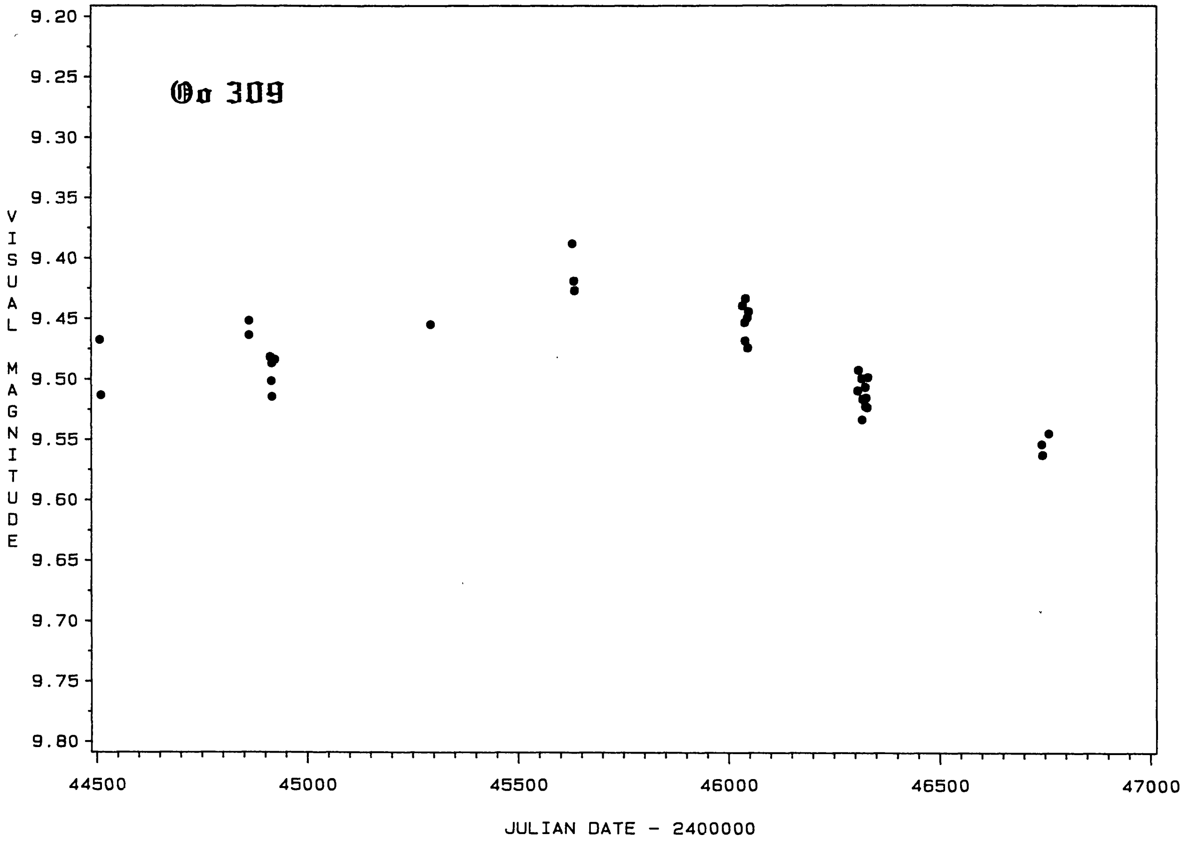


FIGURE 6. — Visual brightness variations of the early-B supergiants Oo 16 and Oo 1057 in 1983.



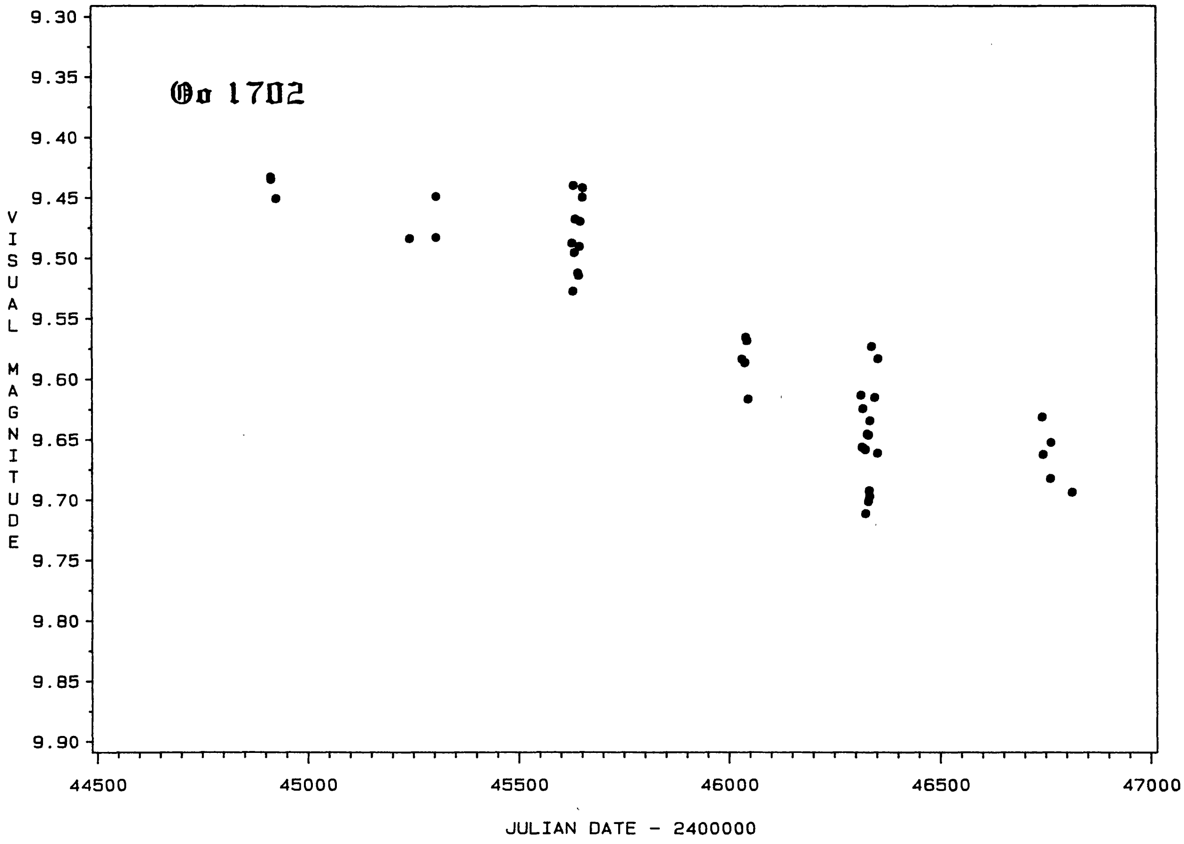


FIGURE 7. — Visual brightness variations of some known Be stars in h and χ Persei. The year-to-year variation dominate, but the stars are also variable on shorter time scales.

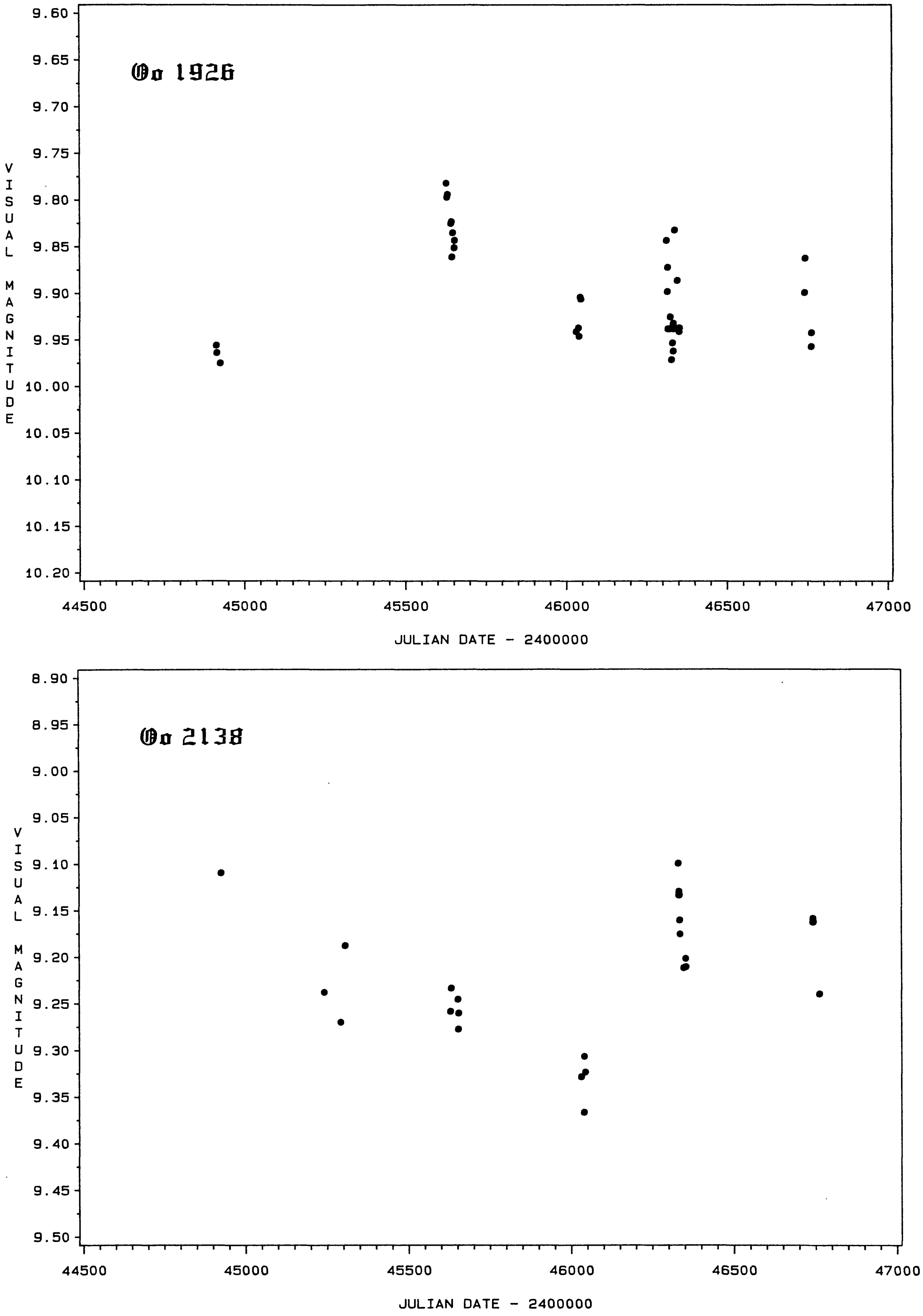


FIGURE 7 *(continued)*

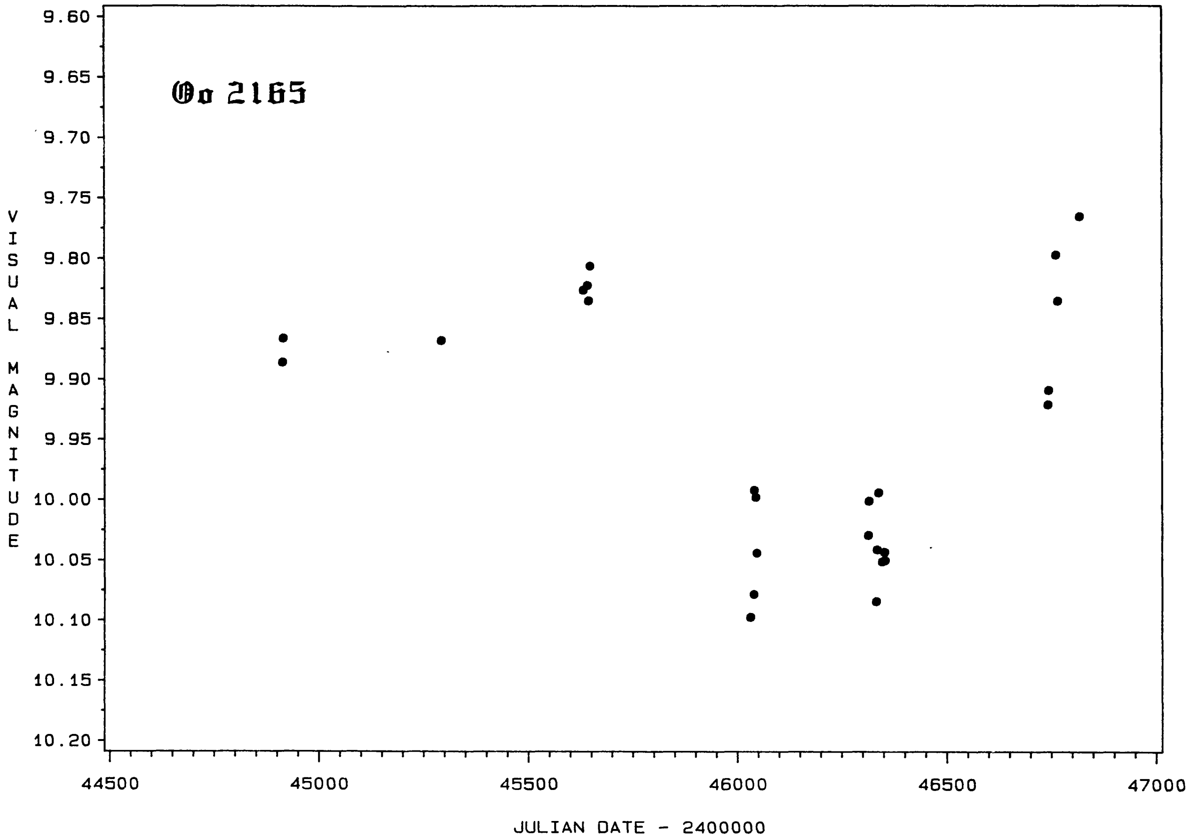


FIGURE 7 *(continued)*

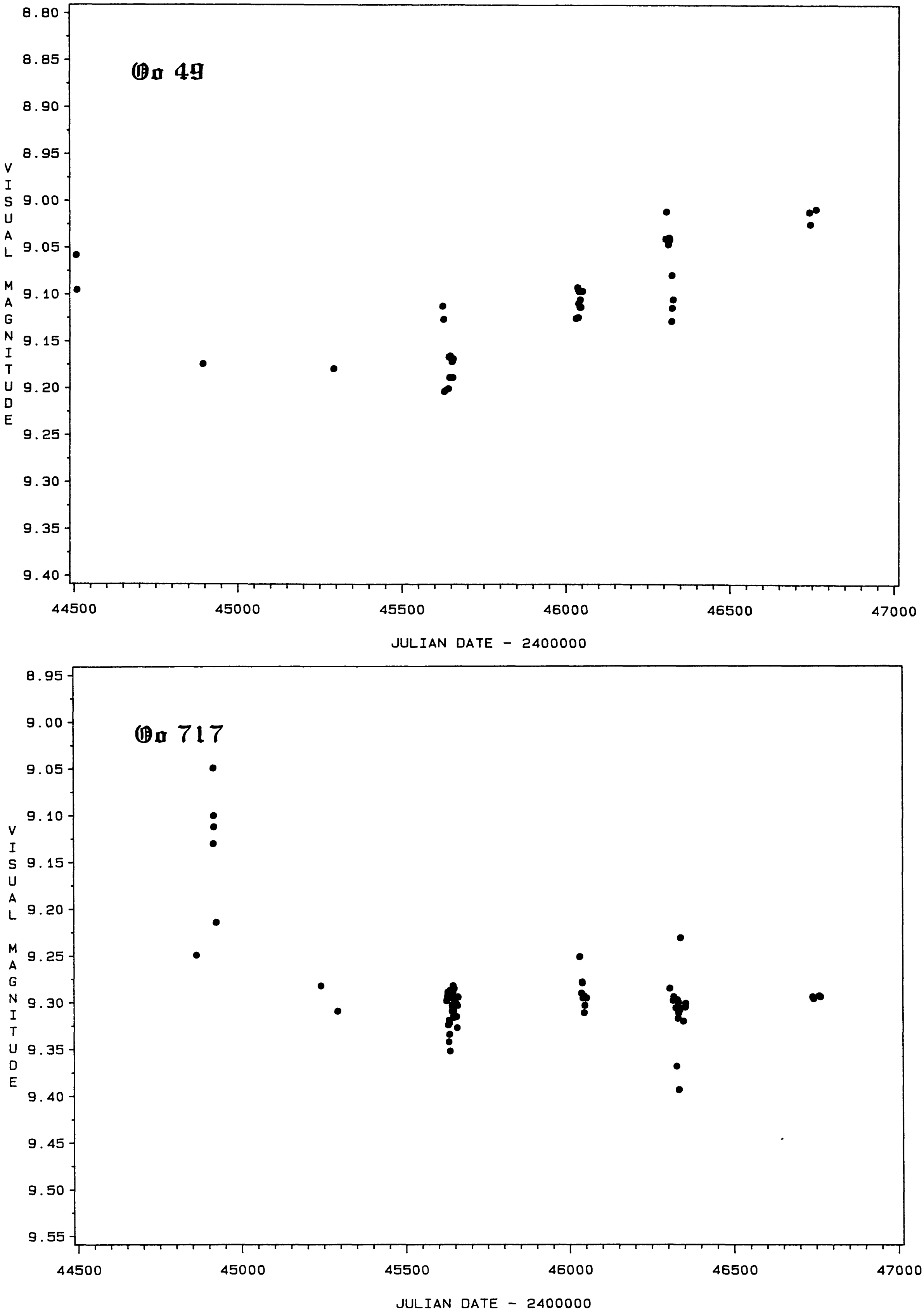


FIGURE 8. — Visual brightness variations of two stars that were not known to be Be stars when our survey began. On the base of the similarity with figure 7, we propose in the text that these and other stars are also Be stars. This proposition has been confirmed for Oo 49 by recent spectroscopic data.