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APPENDIX I—REPORT OF THE COMMITTEE ON THE SPECTRA OF VARIABLE STARS

(prepared by G. H. Herbig, Chairman)

The province of this committee is not entirely distinct from that of Commission 29 (Stellar Spectra) insofar as variable stars are concerned. In a rough way, it might be said that the committee is concerned with all spectroscopic work on variable stars that falls short of detailed astrophysical analysis. As a result, we tend to consider here (with certain exceptions) those spectroscopic results that are of a qualitative nature, or are intended mainly as an aid to the classification of variable stars.

In the latter regard, mention should be made of the extensive Sonneberg program for the spectral classification of variables with an objective prism, on the Bergedorf Spektral Durchmusterung system. Five lists by Götz and Wenzel (**1**) have appeared, giving types for 368 stars. Schaifers (**2**) has separately determined types for red variables. Many stars of emission, M, S, and C types have also been classified by Perraud (**3**) and by Nassau and Stephenson (**4**). Such information is most valuable, but it might be pointed out that at least another dimension can be added to spectral classification by the use of a slit spectrograph of modest dispersion on a relatively small reflector. The design and construction of such a spectrograph of high efficiency

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is a relatively elementary matter today, and is to be especially recommended in this area because the present trend with the very large telescopes is toward high-dispersion observations of brighter stars. As a result, a growing neglect of spectroscopic observations of variable stars fainter than, say, mag. 12 may be anticipated unless a rebirth of slit spectroscopy with smaller instruments can be encouraged.

Miras and Long-period Variables

Merrill, Deutsch, and Keenan (**5**) published an important paper on the absorption spectra of the M-type Mira variables. Although earlier workers, particularly Merrill and Joy, devoted much attention to the complexities of the emission spectra and to line displacements, a lesser amount of work has been done hitherto on the details of the absorption spectra at coudé dispersions. Merrill *et al.* examined several interesting aspects of these spectra, and in particular the question of *line weakening*. They confirmed that, as had been noted before, there is a systematic weakening of the entire absorption spectrum (with respect to normal M giants) in the shorter period ($P < 260^d$), early Me type, high-velocity Mira variables. Since large metal deficiencies are well known among hotter stars of this same population, it is plausible to ascribe this to a simple abundance effect. They pointed out, however, that the low velocity Miras of longer period and later type, in addition to a permanent line weakening of lesser degree, sporadically exhibit an additional weakening whose amount differs greatly from one cycle to another. They believe that the temperature dependence of the molecular band opacity may in part account for this effect in the appropriate spectral regions, but that a major part remains unexplained. The answer may involve the source of continuous opacity in these cool stars; certainly any interpretation in terms of low metal abundance will involve this question directly, as Deutsch (**6**) has emphasized. There has been speculation for many years on the importance of non-conventional sources of continuous opacity in late-type stars, such as polyatomic molecules, molecular continua, and solid particles. It is hardly reasonable to expect the elementary possibilities to be dominant: H^-, Rayleigh scattering by H and H_2, overlapping rotational lines of diatomic molecules, etc. At these temperatures, refractory solids can exist (see the recent speculations by Hoyle and Wickramasinghe (**7**) on graphite flakes in variable carbon stars) and if sufficiently small, will not behave as black bodies. Furthermore, in laboratory sources the familiar band systems of diatomic molecules are sometimes accompanied by continuous spectra of unknown origin, which might be present in the stars as well. In fact, the presence of such complications under these physical conditions would be less surprising than proof of their absence.

Merrill *et al.* pointed out that, in *o* Cet, the degree of line weakening in a given cycle tends to correlate with the height of that particular maximum, in the sense that the weakest lines and bands occur in the cycles having the faintest maxima. It is possible that the appearance of AlO *in emission* at abnormally low maxima is to be regarded as an exaggerated manifestation of this phenomenon. The second recorded case of AlO emission (the first was that of *o* Cet in 1924) was discovered by Iwanowska, Mitchell, and Keenan (**8**) in R Ser at the 1960 maximum. They observed a systematic weakening of the strongest TiO bands throughout the $\lambda\lambda$ 4300–8400 region, while the weaker bands seemed unaffected. The Ca I λ 4226 line developed a most peculiar structure, but the remainder of the absorption spectrum seemed to be normal. The most striking peculiarity was the appearance of the AlO band head sequences near λ 4648 and λ 4842 in emission. The description of R Ser by Iwanowska *et al.* is confirmed by several Lick coudé spectrograms obtained at about the same time. No physical explanation of this curious phenomenon has been offered, but more detailed observations of more such maxima are clearly called for. To this end, with the co-operation of the AAVSO, a program was begun by Herbig (**9**) in late 1961 for the prompt detection of abnormally low maxima among a selected list of 20 Mira variables. In its first two years of operation, this program has led to the observation of 5 stars whose maxima were reported by the visual observers as being lower than the mean, but in no case were unusual spectroscopic features present.

Merrill *et al.* (**5**) also discussed empirically the behavior of the bands of the metallic oxides (YO, ScO, TiO, ZrO, . . .) in the Mira variables; their discussion represents one of the most comprehensive observational studies of this question yet made. The aim of such considerations is ultimately to define the abundances of the molecular constituents. This is certainly not an elementary question, as the equilibria also involve more complex chemical species. The calculations of Stanger (**10**) suggest that the formation of dioxides complicates the picture so seriously that, for example, the total abundance of Ti cannot be safely inferred from Ti and TiO alone, but must include allowance for TiO_2. It is a problem for laboratory spectroscopists to discover whether such metallic dioxides or hydroxides have spectra that might conceivably be detectable in late-type stars.

Another important study of the Mira variables, by Feast (**11**), appeared. Although concerned mostly with the luminosities and kinematics of the group (not discussed here) as revealed by the radial velocities both old and new, the paper gives also new spectral types and luminosities for southern variables. An interesting new spectroscopic phenomenon is suggested by Feast's observation of rather rapid changes in both the emission and absorption-line velocities of S Ind about $0 \cdot 12P$ after maximum light, and lasting for about one month. The same effect has been detected by Feast in old Mt. Wilson observations of U Ori. Feast remarks that such a phenomenon would be difficult to establish by conventional observations of long-period variables which are usually made about once a lunar month. It seems to be a matter well worth following up by suitably planned high-dispersion observations of a few selected stars. Feast has discussed the data from the evolutionary point of view as well. He points out, for example, that the variation of systematic motion with period in the Me variables permits a tie-in of these variables with other kinds of stars whose age has been determined as a function of motion. On this basis, the Me variables of mean period 150^d to 457^d encompass the range between stellar populations characteristic of the galactic disk on the one extreme, and of the intermediate Population II on the other. There is some reason to suspect that this progression does not continue into the M stars of still shorter periods.

Interest in the finer details of late-type stars extended also to the carbon stars. Although most of the objects studied are variable in light, this fact is incidental to the studies of Fujita and his collaborators (**12**), Wyller (**13**), and Bouigue (**14**) so here we only mention these investigations. A substantial number of new C stars have been found in objective prism surveys by McCarthy (**15**) and by Dolidze (**16**), who has also published the positions of a number of new S and MS stars. Infra-red objective prism work at Sonneberg resulted in the discovery of many new late M-type stars, and Richter, Schaifers, and Wenzel (**17**) have now reported on new variables found among them. Schaifers (**18**) and Schaifers and Wenzel (**19**) have observed the M-type Mira variables X Cam and R UMa in the near infra-red with an objective prism, and have derived infra-red light curves ($6800 \text{Å} < \lambda < 8800 \text{Å}$) and spectral-type curves (from the TiO and VO bands) throughout the cycle.

It remains a most curious question that despite the fact that over 70 Mira variables have been observed spectroscopically at minimum light (**20**), still only *o* Cet and R Aqr, two of the brightest, are known to have *hot* companions. Since the separation of *o* Cet *AB* is about $0''.8$ at the present time, *B* can be observed separately when the primary is near minimum, and so there is hope that eventually the total mass of the system will be determinable. Fernie and Brooker (**21**) have made the most recent attempt to estimate the mass in this way. The total mass seems to be in the range 3–4 $\odot$ judging from the relative motion, but the mass of *A* depends upon the contribution to this total by B, which spectroscopically is a very peculiar object and whose mass is therefore largely a matter of opinion. If the rough resemblance of the spectrum of *o* Cet B to the primary of AE Aqr (Joy (**22**)) is pertinent, then a minimum mass of about 1 $\odot$ is

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indicated for the companion, corresponding to an upper limit of 2–3 ⊙ on Mira itself. A completely satisfactory solution to this problem may have to await the absolute astrometry of the system.

The shock-wave interpretation of the cyclic activity of a Mira variable was applied by Gorbatski (**23**) in an attempt to explain the bright hydrogen lines through the ionization of H behind the shock front, and by Odgers and Kushwaha (**24**) to explain the radial velocity variation of R Hya. An earlier, less quantitative effort in the same direction had been made by Deutsch and Merrill (**25**). It seems safe to say that an elaboration of these ideas offers the greatest promise at the present time of making physically intelligible the activity of the Mira variables.

RV Tauri and Semiregular Variables

A large spectroscopic and photo-electric survey of the RV Tau and yellow semiregular stars was published by Preston, Krzeminski, Smak, and Williams (**26**). Most of the spectroscopic work was carried out at low dispersion (400 Å/mm), but this had the advantage that a large number (48) stars could be observed, some of them quite faint. Preston *et al.* found it possible to distinguish 3 spectroscopic groups among the RV Tau variables: a G-K-type group that show TiO bands at minimum light; a peculiar F-type group with anomalously strong CH and CN bands at the minima; and an F-type group in which CH and CN are always weak or absent. The yellow semiregulars, on the other hand, show peculiar, weak-line spectra of type G or K, and strong H emission lines near maximum. The U, B, V data, which were obtained concurrently with the spectroscopic observations, were also discussed. The fragmentation of these objects into four groups suggests that such observations should be extended to a still larger sample of stars, so as to be certain of the generality of the classification.

The brightest member of the first sub-class of RV Tau stars is R Sct. A detailed study of this star has been made by Preston (**27**) on Lick coudé spectrograms of dispersion 2, 4, and 16 Å/mm. At high dispersion, the metallic absorption lines were double, with a splitting of about 30 km/sec; near a secondary maximum, weak emission lines appeared between the absorption components. There were complicated changes in the spectrum with time. A model involving an emitting layer within the stellar atmosphere together with two superimposed absorbing layers was postulated to explain the observations. Preston (unpublished) has under study similar high-dispersion material on U Mon, another member of the first sub-class. In another paper, Preston and Wallerstein (**28**) studied at 16 Å/mm the yellow semiregular SX Her and the peculiar small-amplitude variable TY Vir. Both stars are metal-poor with respect to the Sun by a factor of 50. This, together with the high space velocities and $U-B$ excesses, suggests their membership in a halo population similar to that of the cluster M3.

An interesting problem has arisen with regard to EP Lyr, a member of the F-type, strong CH and CN sub-class of RV Tau stars. It has been pointed out by Wenzel (**29**) (see also Götz and Wenzel (**30**)) that the light curve, as well as certain spectroscopic features visible on objective-prism spectrograms could be interpreted in terms of an eclipsing binary composed of A- and G or K-type super-giants. Curiously, this unconventional proposal for an RV Tau star cannot readily be refuted; some rather indirect arguments are given by Preston *et al.* (**26**). A spectrophotometric study of the continuous spectrum of AC Her, a very similar star, has been published by Alania (**171**).

Cepheids and W Virginis Stars

The most detailed spectroscopic study of a cepheid to appear in the triennium was the coarse analysis of κ Pav by Rodgers and Bell (**31**), on the basis of Mt. Stromlo coudé plates (2 to 7 Å/mm) obtained throughout the 9-day cycle. The abundance analysis led to a deficiency of *s*-process elements with respect to *e*-process by a factor of about 7. The curves of growth

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also yielded the variation in the density of a given mass element through the cycle; it varies by a factor of 10^4, showing a sharp peak just before maximum, superimposed on a more regular pulsation. A similar study of the cepheid β Dor by means of differential curves of growth is in press. In a third paper (in press), the same authors study the variation in line profiles of κ Pav through the cycle, and find a macroturbulent velocity that is a function of phase, with the maximum value occurring immediately prior to light maximum.

The energy distribution in the cepheids δ Cep (**32**) and η Aql (**33**) were measured with a scanner by Oke, and interpreted via model atmospheres to give effective temperatures, whence radii and absolute magnitudes follow. The variation in the detailed structure of the Ca II lines through the period of η Aql was described by Jacobsen (**34**), using Mt. Wilson coudé plates. Thackeray (**35**) briefly discussed his spectroscopic observations of a W Vir variable in ω Cen. The question of companions to cepheids has risen again, following the 3-color work of Oosterhoff (**36**), which has been extended to 6-color photometry by Mianes (**37**). As a consequence, Preston (**36**) sought and found spectroscopic indication of the presence of an early type companion to AW Per, while more recent work by Miller and Preston (**38**) leads to the conclusion that probably RW Cam also has a hot companion, but V Lac (which had been suspected to be composite on the basis of its color) does not.

Rodgers has found on Mt. Stromlo plates that the Li I λ 6707 line occurs in the cepheid l Car in significant strength. Lithium was once believed to be present in detectable quantities only in a few very cool carbon stars, but among variable stars alone it has now been observed in S-type variables, in several M giants, in R CrB (**39**), in the T Tauri stars (see below), and now in a classical cepheid.

RR Lyrae Stars

A major advance in this subject resulted from the work of Preston (**40**), who found it possible to subdivide the RR Lyr stars on the basis of a rough metal-abundance index, ΔS, that could be assigned from inspection of low-dispersion spectrograms. This approach was later extended to a number of RR Lyr stars in globular clusters (**41**), and by Kinman (**42**) to some southern variables. The ΔS system was then placed on a quantitative basis by Preston's (**43**) coarse curve-of-growth analysis of 3 RR Lyr stars having small, intermediate, and large values of ΔS. These stars, DX Del, RR Lyr, and X Ari, were found to have metal-hydrogen ratios of 1, 1/20, and 1/500 the solar value, respectively. The first and last values are clearly indicative of membership in a disk and a halo population, but whether there is a continuous gradation in chemical composition between these extremes is not yet clear. A discussion of the full ramifications of these results would be beyond the scope of this report; the reader is referred to a review article by Preston (**44**).

A recent development was the study of the line structure in RR Lyr variables with both high dispersion and high time resolution. Transient emission structure and line doubling were observed in RR Lyr some years ago by Struve and by Sanford. Similar observations, but with a technique that gives finer time resolution, have now been made of nine additional RR Lyrae variables by Preston (**44, 45, 46**). He finds no H line emission during rising light in the Bailey type *b* or *c* stars, but it is detectable, with varying intensity, in five Bailey *a*'s. In the case of X Ari, which shows the phenomenon best, the emission persists for about 40 minutes as the star brightens. The structure of the lower Balmer lines is that of a shortward-displaced emission feature divided asymmetrically by overlying absorption, the whole superimposed on broad absorption wings having a shortward shift. At the dispersion with which this work was performed (16 Å/mm), the shift of the metallic lines appeared to change continuously, but 11 Å/mm spectrograms of RR Lyr itself showed an actual doubling that lasts for about 10 minutes during rising light. Hopefully, an explanation for these involved phenomena may in time be found in theoretical studies of compressional waves in pulsating stars; recent contributions to the subject are those of Iroshnikov (**47**) and of Whitney and Skalafuris (**48**).

As regards less extensive work, usually on individual RR Lyrae stars, reference is made to the photometric and spectroscopic investigation of TU UMa by Preston, Spinrad, and Varsavsky (**49**), and to radial velocity observations of two ultra-short period variables: VZ Cnc by McNamara and Rogers (**50**), and HD199757 by Churms and Evans (**51**).

We only mention here a major spectrophotometric study of RR Lyrae itself, using the photographic system of Chalonge, which has been performed by Fringant (**52**). The behavior of the gradients (visible and ultra-violet) and of the amount and position of the Balmer discontinuity were discussed as a function of phase in both the primary and secondary periods, and the radius obtained by a modification of Wesselink's method. Another spectrophotometric investigation of RR Lyr was made by Oke and Bonsack (**53**) with a photo-electric scanner, but here the observations were deliberately made over a short time interval in order to avoid complications due to higher periodicities. A similar study of SU Dra by Oke, Giver, and Searle (**54**) was discussed in the same general way, in which a comparison of the narrow-band light curves with the monochromatic fluxes from static model atmospheres give the *variation* in radius, while the radius at a selected phase is derived from the velocity curve, and the absolute magnitude obtained.

β Canis Majoris and δ Scuti Variables

There is growing evidence to the effect that the β CMa and δ Sct variables all have unusually low rotational velocities for their spectral types and luminosities. The data, as compiled by McNamara and his collaborators, are as follows:

Type	Number of variables	Average observed v_{rot} for variables (km/sec)	Average observed v_{rot} for non-variables (km/sec)
δ Sct	5	35	125
β CMa	11	22	164

Among the β CMa group, no member had a higher value of $v_{rot} \sin i$ than 40 km/sec (**55**). The upper limit on rotation in the δ Sct group is apparently not greatly different (**56**); one apparent exception, τ Cyg, has been disposed of by Abt (**57**). Another interesting fact is the tendency among the β CMa variables for those stars having the larger $v_{rot} \sin i$'s also to be those having variable velocity amplitudes and beat phenomena. This correlation has already received some theoretical attention (for example, by Chandrasekhar and Lebovitz (**58**) and by Böhm-Vitense (**59**)).

One lingering possibility that may deserve examination, however, is the following: McNamara and Hansen (**55**) have shown that if one examines the sample of bright northern stars between types B0·5 and B2, about 24% have $v_{rot} \sin i \leqslant 50$ km/sec, and of these about half are known β CMa variables; in luminosity classes III and IV alone, the percentage is about 65%. McNamara and Hansen point out that the remaining sharp-line, non-variable objects may be only rapidly rotating stars seen nearly pole-on. Consequently, they favor the hypothesis that β CMa-type variability is favored in those B giants having low rotational velocities. One would like to be very certain, however, that the search for β CMa variables has been unbiased with respect to rotation. It is clear that searches based on *radial velocity* observations must have favored stars with narrow lines, but whether the photo-electric searches were biased or not also deserves investigation. In other words: is it absolutely certain that there are no β CMa variables with large $v_{rot} \sin i$?

A differential curve-of-growth investigation at moderate dispersion of two δ Sct stars — δ Sct and δ Del — was published by M. Boyarchuk (**60**). No striking spectral anomalies were discovered, but a H/metal ratio lower by a factor of 2, and a C/metal ratio lower by a factor of 1·2 with respect to the comparison stars was reported.

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As regards individual β CMa stars, the velocity curve of σ Sco was redetermined in 1960 by Struve, Sahade, and Zebergs (**61**). The velocity variation of α Lup, apparently a β CMa star that is not perceptibly variable in light, was studied by Rodgers and Bell (**62**) and by Milone (**63**). The spectral-type variation of β Cru during the light cycle was investigated by Milone (**64**). The results of the 1956 international campaign for the observation of DD Lac have been published by de Jager (**172**); they include radial velocity observations made by Sahade (at Mt. Wilson), Heard, and Miss Hack.

Symbiotic Variables and Related Objects

A general account of the present status of the spectra of symbiotic stars has been given by Sahade (**65**). A program for the detailed study of some of these objects at coudé dispersion has been initiated by Aller (**66**), while spectrophotometric measurements of the continuous energy distribution in several members of the class have been published by Arkhipova (**67**) and by Dolidze and Pugach (**68**). AG Peg has been the specific subject of spectrophotometric studies by Ivanova (**69**) and by Arkhipova and Dokuchayeva (**70**). Detailed spectroscopic observations of a number of individual symbiotic stars have appeared during the report period, as follows.

Z And. Z And underwent an outburst in 1959, rising to $m_{pg} = 10$, and again in May 1961 to $m_{pg} = 9{\cdot}2$; normal minimum is about $m_{pg} = 12$. The spectral changes accompanying this activity have been described by Bloch (**71**). The 1959 maximum resulted in a strengthening of the ordinary 'stellar' emission spectrum, a weakening of the high-excitation nebular lines, and the near-disappearance of the TiO bands. But the 1961 outbursts changed the spectrum profoundly: the H emission lines developed very complex structure, a strong continuous spectrum appeared in the photographic region, the character of the emission-line spectrum was modified significantly, and TiO (i.e., the gM absorption spectrum seen near minimum) disappeared entirely. These variations are reminiscent of those observed about 20 years ago by Swings and Struve at lower dispersion. In addition to the Haute-Provence observations, a number of Lick coudé spectrograms of Z And were obtained in 1960–61, and are being studied by A. Boyarchuk. Coudé observations have also been made at Mt. Wilson by Swings.

TX CVn. TX CVn became bright during the first half of 1961; the spectrum after the outbursts has been described by Bloch (**72**) and by Bertaud and Weber (**73**). P Cygni structure appeared at the lower Balmer lines, but otherwise emission was inconspicuous. A rich absorption spectrum composed of lines of the neutral and ionized metals was present. Lick coudé spectrograms obtained in 1962 showed a considerable variety in the line profiles throughout this spectrum, as well as a remarkably complex structure in the Balmer P Cygni-type absorptions.

AG Dra. AG Dra has now been the subject of an extensive photometric study by Sharov (**74**), which shows that the star brightened abruptly by 2 mag. in 1950, as had been noted earlier by Wenzel. It faded slowly, returning to normal minimum magnitude ($m_{pg} \sim 11{\cdot}0$) by 1956. During the outburst and decline, however, the star oscillated cyclically with a period very near one year, and a range of about 1 mag. Wenzel (**75**) points out that the brightening in 1950 must have been associated with the change in the spectrum between 1948 and 1952 described by Roman: in 1952, the K-type spectrum that had been present earlier was masked by a strong hot continuum, although there was no major change in the strength of the H, He I, and He II emission lines with respect to the continuous background. Lick spectrograms taken in 1952–56 show strikingly that the late-type absorption spectrum gradually reappeared as the variable declined and the overlying continuum faded. Spectrophotometric measurements of AG Dra in 1958–59 by Mirzoian and Bartaya (**76**) and in 1957–61 by Dolidze and Pugach (**68**), after the outburst had subsided, show a steep increase to shortward in the energy distribution below about λ 3900. The obvious interpretation is that this is only the remnant of the hot continuum of the star responsible for the outburst, but a more sophisticated explanation may be required.

AX Mon. AX Mon (= HD45910) has been observed at 10 Å/mm dispersion by Doazan (**77**). This complex, variable spectrum has previously been studied by many observers. Merrill dis-

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covered that the metallic lines of the M giant component, observable in the red, showed a cyclic variation in velocity with a period of 232 days. Still earlier, Plaskett had noted a periodic variation in the displacement of the Balmer emission and absorption lines with a period of about 235 days, but the phase relationship of Plaskett's curve with Merrill's is not clear. Doazan found, apparently by combining all published material, that a sub-period of 38·5 days represents the data well as single-line binary motion. An investigation by Mrs Cowley (**78**) on the other hand, substantiates the period of 232 days, from measurements of the late-type spectrum. She finds that maximum intensity of the shell absorption spectrum also occurs at a definite phase in this cycle; she ascribes the shell to material streaming between the two components of the binary system. A clarification of the question of the period length is in order.

RR Tel. RR Tel may be more closely related to the slow novae than to the symbiotic variables, but the fact that it was periodically variable ($P = 387$ days) before the outburst has given rise to the suspicion that another star besides the nova is present. The early Harvard objective-prism spectrograms of RR Tel in 1949–50 have now been studied by Pottasch and Varsavsky (**79**). No sign of a second star is present on these plates, but this is hardly surprising since the nova was very bright at the time; the F-type spectrum observed shortly before maximum was certainly that of a shell, not another star.

R Coronae Borealis Variables

A coarse curve-of-growth analysis of R CrB itself has been made by Searle (**80**), using Mt. Wilson and Palomar coudé material. An analysis of the similar object RY Sgr has been performed by Danziger (**81**), but the details are as yet unpublished. Searle's work has been supplemented by a study of the line identifications in the same star by Keenan and Greenstein (**39**). The high apparent abundance of carbon in R CrB is confirmed by Searle: the C/Fe ratio is about 25 times that in δ CMa, the comparison star. C is about 10 times as abundant (by number) as H, which corresponds to a reduction in the H abundance with respect to δ CMa by a factor of about 1300. The relative abundances of the metals and rare earths appear normal. As a result of the great abundance of carbon, the spectrum of C I is represented by over 200 lines in the region studied by Keenan and Greenstein, but a large number of lines still remain unidentified. Keenan and Greenstein also find the He I λ5875 line in surprising strength. These abundances suggest a relationship of R CrB to the hot helium-rich stars, such as HD160641 and BD + 10°2179, and is made particularly intriguing by the fact that one such object (MV Sgr) is known to be an irregular variable, perhaps of the R CrB type (**82**). The remarkable star V348 Sgr may also be of this type. It would seem very important to investigate the possibility that other He-rich stars are also variable in light.

Keenan and Greenstein measured the radial velocity of R CrB on 10 coudé spectrograms, and confirmed the variation suggested in 1935 by Berman; their range was about 7 km/sec. Further light on this question is shed by a series of some 60 Lick 3-prism spectrograms (dispersion 11 Å/mm) obtained in 1950 and 1951. These plates clearly demonstrate a velocity variation of about 12 km/sec, which tends to occur in waves of length 50 to 100 days. The length of this cycle can be used as an argument for the high-luminosity character of R CrB, which is supported anew by Searle's determination from the spectrum of a low surface gravity (this is, of course, only a qualitative manifestation of the spectroscopic luminosity classification as a I*b* super-giant).

An important study of the spectroscopic changes of R CrB during the 1960 minimum has been published by Payne-Gaposchkin (**83**), together with a general review of the properties of the group. The emission spectrum which appears as R CrB fades is most complex; it consists of a rich, sharp-lined display of lines of the ionized metals, and of broad lines of Ca II, Na I, and He I λ3889. The sharp-lined spectrum is ascribed by Payne-Gaposchkin to a rising chromosphere-like region whose brightness fades slowly after ejection from the star, while the broad lines are produced by the interaction of high-velocity material with circumstellar gas that

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perhaps was ejected on previous occasions. The general character of the changes described by Payne-Gaposchkin is confirmed by Lick spectrograms of the 1960 minimum as well as of the 1963 fading, obtained with the 120-inch telescope. It may be that further progress in this field will depend, not on further conventional observations of the type star, but on more information on the behavior of other members of the class.

Considering their high luminosity and distinctive photometric behavior, it would appear that the list of known R CrB variables must be remarkably complete for the solar neighborhood as compared to many types of variable. Nevertheless, new, fairly bright members of the class must still await discovery; the latest has been found by Cragg (**84**). Probably the richest region remaining for such discoveries is in the galactic bulge.

Miscellaneous Irregular Variables Not of Late Type

Two detailed investigations of the remarkable variable ρ Cas have appeared, by Beardsley (**85**) for the years 1939–50 in particular, and by Sargent (**86**) for 1955–60. This very high-luminosity star ($M_v \sim -8{\cdot}5$) underwent an abrupt drop in brightness of about $\Delta m_v = 1{\cdot}5$ in 1946–47, although this may have been foreshadowed by spectral changes as early as 1939. The spectral variations were very complex, and are not completely explained, but the 1946–47 minimum was probably due to the ejection of a dense shell. The expanding envelope was still observable in 1955–60, but yearly fluctuations in its rate of replenishment were apparent. Other high-luminosity stars also show minor spectroscopic changes that may have some physical relationship to the activity of ρ Cas. Comper (**87**) has studied the time variations in the Hα profile of α Cyg, while Underhill (**88**) has investigated the same phenomenon, as well as the radial velocity changes, in the super-giants 67 Oph, 55 Cyg, and χ^2 Ori. A weak set of shell lines due to Ni II has been found in the high luminosity star P Cyg by Herbig (**89**). Spectrophotometric data on a number of P Cygni stars have been given by Arkhipova (**67**).

XX Oph is a remarkable irregular variable that not only has no precise spectroscopic counterpart elsewhere in the sky, but cannot be satisfactorily fitted into any classification scheme for variable stars. Its emission spectrum has been measured at coudé dispersion by Merrill (**90**), in the last of his series of papers on the spectrum. The energy distribution in the continuous spectrum has now been measured spectrophotometrically, by Dolidze and Alaniya (**91**). Although a forbidding amount of detailed information is now available on the star, a clarifying physical interpretation is lacking.

Flare and Flash Variables

A summary of the present status of knowledge of the spectra of these objects has been published by Joy (**92**), who has certainly been the major contributor to the subject over the years. As regards new spectroscopic work in the past triennium, no major contributions have appeared. Wilson (**93**) examined the spectrum of the bright dMe flare star EV Lac (= BD +43°4305) on a coudé spectrogram of dispersion 9 Å/mm. Rough measures suggest (from the progression of width with atomic mass) that the emission lines are thermally broadened; there is no convincing evidence of a difference between the emission and absorption line velocities, or of any dependence of velocity on excitation in the emission spectrum. Another question that Wilson investigated was whether there was a detectable amount of He^3 present, since a small amount might be expected to be produced in stars burning on the *p-p* cycle. Although the isotope shifts of some of the He I emission lines are relatively large at 9 Å/mm, no evidence for the presence of He^3 was found.

A very curious observation of the dG5 star HD117043 was reported by Barbier and Morguleff (**94**): on a single Haute-Provence spectrogram, the resonance doublet of K I at $\lambda\lambda$7665, 7699 appeared in emission with great strength, without any other bright lines. The

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lines were not present the following night. The observations is quite without precedent, although permanent K I emission has been observed in peculiar stars. It would be comforting if the possibility of terrestrial origin could somehow be eliminated.

Variations in the spectrum of the dM2·5 star HD119850 were described by Kandel (**95**) and may have some connection with flare activity. Spectral types for some flash stars in the Orion Nebula were given by Herbig (**96**). It might be mentioned that the peculiar object described by Luyten (**97**) and believed to be a nebulous red dwarf is actually a Herbig-Haro Object.

T Tauri Stars and Related Objects

Joy (**92**) has published a review of the spectra of dwarf variable stars which contains much data on T Tauri-type objects. Wenzel (**98**) has, in a valuable contribution devoted mainly to the photometric properties of the 'RW Aurigae stars', considered what is known of their spectra as well. Herbig (**99**) has surveyed the subject of T Tauri stars and related objects, with emphasis on spectroscopic results and the evolutionary point of view. The latter paper contains a considerable amount of data not published elsewhere.

More specific contributions of the past several years can be grouped under the following headings.

Surveys for emission-Hα stars: recent work in this area will be found in tabular form in the report of the Committee (of Commission 27) on Variable Stars in Clusters.

New bright T Tauri stars: Emission-Hα stars as faint as $m_{pg} = 20$ are now within the reach of existing equipment; consequently, very faint T Tauri stars could be found in large numbers if there were any point in doing so. But it is more worthwhile to identify additional *bright* members of the group, for only in such cases is detailed study possible. It is perhaps surprising that, considering the depth of the surveys, bright T Tauri stars continue to be found. The most noteworthy recent discoveries are as follows:

Recent discoveries of Bright T Tauri Stars

Star	α (1900) h m	δ ° ′	Mag.	Ref.
González-González 405	6 34·2	+ 9 05	13 pg	**99, 100**
LHα 332–20	10 56·5	−76 30	11·3 vis	**101, 102**
CPD −76° 652	11 04·5	−77 06	10·6 vis	**101, 102**
LHα 332–21	11 09·3	−76 12	10·9 vis var?	**101, 102**
AS205	16 05·8	−18 23	12 pg var	**103**
AS209	16 43·6	−14 13	12·5 pg	**99, 104**
Iriarte-Chavira 34	19 15·6	+10 50	14 pg	**105**
LkHα 120	20 57·9	+49 58	12·9 pg	**99, 111**

Lithium in T Tauri stars: Following the recognition by Hunger that the λ6707 resonance line of Li I was abnormally strong in T and RY Tau, the work of Bonsack and Greenstein (**106**) and of Bonsack (**107**) placed the matter on a quantitative footing. Their analysis of 5 stars indicated a range in the Li/Ca ratio from about 50 to 400 times the solar value; 7 other T Tauri stars observed at lower dispersion showed the Li I line in similar strength. There can be no doubt that a large lithium excess is a group characteristic of the T Tauri family, and much work is now underway on the evolutionary implications of these results (see, for example, (**108**)) in normal stars and in the interstellar medium. Whether other abundance anomalies occur in the T Tauri stars is unknown, but deserves investigation.

Ultra-violet excesses are well established in the T Tauri stars, both photometrically and spectroscopically. The phenomenon however seems only to be part of the larger question of *continuous emission* in these objects, which appears to manifest itself in three forms:

(*a*) In the ordinary photographic region (λλ4000–5000), the absorption spectra of some T Tauri stars are either heavily veiled, or replaced altogether by a featureless continuum on which the usual bright-line spectrum is superimposed.

(*b*) In many stars having strong H emission lines and a slow Balmer decrement, there is unmistakable continuous emission extending shortward of the Balmer limit. Joy (**92**) has published spectrograms of stars that show this effect well. In AS 209, which has been studied by Kuhi at coudé dispersion, the high Balmer lines run smoothly into the continuum at the head of the series.

(*c*) In some stars, however, the Balmer lines fade out long before the limit is reached, yet the absorption spectrum of the underlying G- or K-type star is obliterated, at least as far as λ3300, by a smooth continuous spectrum that cannot be the Balmer continuum. In the case of RW Aurigae (the best example) this continuum extends in the opposite direction without change in character, to the limit of the plates near λ5000. It is possible that *c* is only an extension of *a*. It is apparently *b* and *c*, together with line emission, which contribute sufficient energy in the *U* pass-band to account for the large $U-B$ excesses observed in many T Tauri stars.

No observations of continuous emission in T Tauri stars in the yellow-red region have been made as yet. It would be of interest to discover whether the degree of veiling is the same as at shorter wavelengths.

The physical nature of the continuous emission (of types *a* and *c*) remains quite unknown. Spectroscopic observations of a number of stars which show these effects have been described by Walker (**109**); he has suggested (**110**) that the presence of continuous emission may have some connection with the occurrence of longward-displaced absorption components (see below), possibly through the effect of infalling material on the stars. However, continuous emission appears to be a far more widespread phenomenon among the T Tauri stars than are the longward components.

Mass ejection is indicated in the T Tauri stars by the presence of absorption components at the H and Ca II emission lines, whose displacement is generally shortward (except in certain stars observed by Walker: see below). Whether this material actually leaves the star has not been proven. The facts (*a*) that there is no spectroscopic evidence of its return, (*b*) that a few T Tauri stars are closely surrounded by directly-photographable nebulae of possibly ejected material, and (*c*) that almost all T Tauri stars have low-density emission regions in their immediate vicinity (as evidenced by the presence of [O I] and [S II] lines in the integrated light) have been used as arguments for actual loss of this material by the star. Kuhi (**111**) has recently studied the problem in six bright T Tauri stars on the basis of Lick coudé material. He finds that the line profiles can be represented by amounts of rising material corresponding to mass losses by the star of from $0{\cdot}3$ to $6 \times 10^{-7} \odot$ per year. These values can be integrated over the total period of activity if assumptions are made regarding the intensity of activity throughout the contraction period of a typical star. Kuhi used the statistics of T Tauri stars as a function of ejection rate for this purpose: for a typical star of $1{\cdot}0 \odot$, he estimates that the total mass lost during contraction on a Hayashi-type time scale is about 40%.

Longward absorption components that had been observed in T Tauri stars were in the past regarded either as transient (**112**), or although sometimes lying longward of the emission-line centers, as still representing negative displacements with respect to the *stellar* velocity (**113**, p. 262). Walker has recently reported (**109, 110**) observations of a number of faint T Tauri stars in the Orion Nebula and NGC2264 which persistently show absorption fringes displaced +150 to +300 km/sec from the H and Ca II emission lines. Although these components sometimes disappear, no shortward fringes apparently are found in these particular objects. The obvious interpretation is that infall of material is responsible. The implications of this interpretation are such, however, that alternate explanations should be examined carefully.

Line broadening in T Tauri stars should be clearly distinguished from the line weakening due to continuous emission; at low dispersion, the two effects might be confused. At coudé dispersion, it is obvious that in many T Tauri stars the absorption lines have intrinsic width. The rough curve-of-growth analyses of Bonsack and Greenstein (**106**) show that the microturbulent velocities are not unusually large, hence the broadening is presumably due to large-scale motion. Hunger (**114**) recently called this interpretation into question. He believes that the absorption lines of the T Tauri stars are actually sharp, and only appear broad on account of extensive blending. It is not clear in this picture why ordinary late-type stars observed at the same resolution should not show equally diffuse lines. Since Hunger's detailed results have not been confirmed on other coudé spectrograms of T Tauri stars, his conclusions should be regarded with reserve for the present. A careful high-dispersion investigation of the absorption spectra of a few stars of this class is long overdue.

The Spectra of stars in the Orion Nebula are under investigation by several observers. Spectral types for several stars were determined by Lallemand *et al.* (**115**). An extensive investigation by Rosino is as yet unpublished. A radial-velocity study of the brighter stars near the Trapezium is being prosecuted by Hugh Johnson (**116**). Blanco (**117**) has discovered a number of faint late-type stars in young clusters, notably the Orion Nebula, on objective-prism spectrograms; his results have important evolutionary implications. Herbig (**118**) has obtained low-dispersion infra-red spectrograms of a number of faint members of the Trapezium cluster, in an effort to clarify the nature of these highly intriguing objects. As a by-product, the spectra of a number of standard T Tauri stars were observed with the same equipment. The most notable result was that the infra-red Ca II triplet is distinctively strong in emission in the T Tauri stars, although it is very weak in dMe stars of comparable H,K emission intensity. An examination of this effect is being made by Pesch (**119**) on objective-prism plates.

Novae During the Outburst

Spectroscopic studies of novae at minimum light are discussed later, while the spectra of super-novae are in the province of Commission 28. We discuss here the spectra of older novae in their declining stages, and spectroscopic observations of new novae discovered in the past triennium.

RS Oph (1898, 1933, 1958) was still under observation. A survey of the spectroscopic features of this star immediately following the 1958 maximum was made by Folkart *et al.* (**120**). The energy distribution in the continuous spectrum has been measured spectrophotometrically on several occasions in 1958 and 1959 by Dolidze and Alaniya (**91**). The spectrum to 89 days past maximum as observed at low dispersion was described by Joy (**121**), who gives many interesting details regarding the emission lines, together with a comparison with the spectrum at the 1933 outburst; the differences were minor. By 1960–62, the rich emission spectrum had, according to Wallerstein (**122**), been reduced to the stronger H, He I, Fe II, and [Fe II] lines superimposed on a shell absorption spectrum very similar to that observed by Sanford in 1947. There was no sign of the spectrum of a normal star.

η Car still remains a fascinating object for spectroscopists because of the exotic nature of its emission spectrum. Thackeray (**123**) has reobserved the infra-red spectrum to about λ 9100 with coudé dispersion. Most of the new lines measured are not unexpected, but about 28 defy identification.

Spectroscopic observations were reported for the following new novae during the triennium.

Nova Sco 1949. Henize, Haro (**124**): only Hα emission was observed.

Nova UMi 1956. In February 1963, seven years after maximum, Zwicky (**125**) found in the photographic region broad [O III] and He mission lines on a hot continuum. A spectrogram of the yellow-red region in June 1963 by Herbig shows only a wide Hα emission line and a weak continuum.

Nova (*V*446) *Her* 1960. This nova was observed extensively; a bibliography of the earlier spectroscopic work is given by Bertaud (**126**), while later reports are by Florsch (**127**), and by Rosino and Chincarini (**128**). Spectrophotometric investigations are described by Mustel *et al.* (**129**), Ivanova *et al.* (**130**), Prokofyeva and Belyakina (**131**), and Meinel (**132**). The latest spectroscopic observation reported was by Herbig in August 1963: the star was then near minimum, and showed rather weak [O III], Hβ, and λ4686 emission lines on a strong continuous spectrum. The star has several close companions that were not resolved from the nova on the slit, and they probably contributed to the observed continuum.

Nova Ser 1960. This nova was discovered by Nassau and Stephenson (**133**) long after maximum. Only an objective-prism observation of emission lines of [O III], H, and possibly N III was reported.

Nova Sct 1960. Objective-prism spectrograms were obtained by the (independent) discoverers, Nassau and Stephenson (**133**) and Saveljeva (**134**). The star was apparently observed only for a short time about 6 mag. below maximum.

Nova Oph 1961. The star was found on an objective-prism plate by Apriamashvili (**135**); emission lines of H, [O I], [N II], and [O III] were observed. A Lick spectrogram of the photographic region taken on 1961 June 11 by Herbig showed [O III], H, [Ne III], He II, and N III lines on a weak continuum; [O III] λ4363 was very strong.

Nova Sgr 1961. The only spectroscopic observations reported are those of the discoverer, Blanco (**136**), on objective-prism spectrograms. Emission Hα was present, and a few other lines suspected.

Nova (*VY*) *Aqr* 1907, 1962. The only known spectroscopic observation of this recurrent nova at its second maximum is a single Lick low-dispersion plate of the yellow-red region taken by Herbig on 1963 August 20 when the magnitude was about 16; it shows only a broad Hα emission line on an otherwise featureless continuous spectrum.

Nova Her 1963. An observation of the preoutburst spectrum was reported by Stephenson and Herr (**137**). Many spectroscopic observations of this bright nova were made. Brief notes by many observers appeared shortly following the discovery in *IAU Circ.*, *Harv. Ann. Cards*, and *Astr. Cirk. U.S.S.R.* More details have been given in preliminary reports by McLaughlin (**138**) and by Batten *et al.* (**139**).

Nova Sgr 1963. Blanco, the discoverer, reports (**140**) moderate Hα emission and a faint continuum on an objective-prism plate.

Hot Subluminous Variables

Under this heading we consider novae near minimum light, U Geminorum variables, and other faint hot stars that have received a great deal of attention in recent years. Their numbers may be quite substantial; it has been suggested by Haro and Chavira (**141**) and by Haro and Luyten (**142**) on the basis of their samplings in high galactic latitudes that very large numbers of faint blue (possibly eruptive) variables exist in the galactic halo. The four-fold division of the group employed here is certainly not a fundamental one, but largely reflects the type of observational information available at the moment. A general review of much of this field has been given recently by Kraft (**143**).

(*i*). *Novae near minimum light as eclipsing and spectroscopic binaries.* The historically minded will probably credit Struve (**144**) with the first serious speculation to the effect that all novae might be close binary stars, following Walker's discovery of the eclipsing binary nature of DQ Her. Since that time, largely due to the spectroscopic work of Kraft and the photometric observations of Walker and Krzeminski, seven old novae are known to be close binaries. The essential data are as follows, which we give without further comment, because it is certain that further advances in this subject will be forthcoming; the references are usually to the spectroscopic work.

Star	Outburst date	Spectral type	Period (days)	Reference
V603 Aql	1918	e	—	**143, 145**
T Aur	1891	—	0·204	**146**
T CrB	1866, 1946	e + gM3	227·6	**147**
DQ Her	1934	e	0·194	**148**
GK Per	1901	sdBe + K	—	**143, 145**
WZ Sge	1913, 1946	e + DA	0·057	**149**
V1017 Sgr	1901, 1919	comp.	—	**145**

(*ii*). *Short-period eclipsing systems with additional activity superimposed.* For obvious reasons, there may not be a true physical distinction between these stars and the old novae.

Star	Period (days)	Reference
VV Pup	0·070	**150**
V Sge*	0·514	**151**
RW Tri	0·232	**152**
UX UMa	0·197	**153**

*Double-line spectroscopic binary.

(*iii*). *U Geminorum and Z Camelopardalis variables as eclipsing and spectroscopic binaries.* The following 10 stars have been announced as belonging to this category:

Star	Spectral type	Period (days)	Reference
RX And	sdBe	0·212	**154**
AE Aqr*	sdBe + dK0	0·701	**22**
SS Aur	sdBe	0·15?	**154**
Z Cam†	e + G-K	0·288	**155**
SS Cyg*	sdBe + dG5	0·276	**156**
EY Cyg	sdBe + K0V	—	**154**
U Gem†	sdBe	0·174	**154**
EX Hya	e	0·069	**157**
RU Peg*	sdBe + G8 IVn	0·371	**154**
SU UMa	e	—	**157**

*No eclipses have been found despite specific search.
†Eclipse detected.

A number of other variables of the U Gem type, or believed to be so, have also been observed spectroscopically in the last few years. The interesting star 2·1937 Cet = HV8002 has near minimum an emission spectrum like many U Gem stars (**158**), but an attempt to detect radial velocity variation was inconclusive. YZ Cnc was found to be a U Gem variable by Vorobyeva and Kukarkin (**159**): Lick spectra at both maximum and minimum confirm the assignment. On the other hand, SU CVn and S5423 Gem have normal absorption spectra and no sign of emission lines at minimum light; possibly the photometric evidence for their assignment to the U Gem class should be re-examined. A very extensive study of SS Cyg was published by Lortet-Zuckermann (**160**). We refer here only to her conclusions that spectroscopic differences between different maxima are connected with the rapidity of rise, and not with the duration of the outburst.

(*iv*). *Hot, presumably subluminous variables with slow, apparently irregular fluctuations* There is little systematic information available on these stars. The brightest is BD + 14°341, studied photometrically by Huth (**161**), and photometrically and spectroscopically by Herbig and Smak. V751 Cyg (**162**) is superimposed on an obscured region near the North America Nebula, but it is not clear whether the star is a foreground object or not. Wenzel's suspicion (**163**) that the variable is really of later type has been dispelled by a recent Lick observation at higher dispersion than hitherto available: the star is clearly a very hot object, with a nearly continuous spectrum. Haro-Luyten no. 4 (**164**) has a R CrB-like light curve, but spectroscopically shows a hot continuum with strong H, He I emission lines. The two objects of this type first recognized were, of course, *o* Cet B and R Aqr B.

Nuclei of Planetary Nebulae

It seems generally accepted that the shells of planetary nebulae are ephemeral structures, with average lifetimes of the order of several 10^4 years, and that they are the result of ejection of matter by the central star. Since there are about 10^3 observable planetary nebulae in the galaxy, it follows that, on the average, one nebula must be 'replaced' on the average every few decades. Since the events accompanying the ejection of a shell may constitute a rather conspicuous phenomenon, it can be asked if there is any evidence whether such an event has ever been observed. A somewhat less general question is whether variability has ever been established in a planetary nucleus. There are four cases where such variability has been announced:

Star	Reference
V567 Sgr	**165**
S5337 = Haro 6−29	**166**
Zwicky's variable = Minkowski III, 18 = Velghe 61	**167**
Nucleus of NGC 7662	**168**

The difficulties of conventional photometry of such objects are so great that special attention should be given to techniques designed to minimize the contribution of the nebulosity.

Two other known variables occur very near the positions of planetary nebulae: AS Sgr lies very near IC4670, but it cannot be settled from published information whether the two are coincident. RU CrA has been mentioned as 'in' the planetary nebula IC1297, but it appears (Herbig, unpublished) that the variable actually lies outside the nebula; the spectrum of this star is not peculiar.

Certainly the best case for an ejection process under way at this time is the extraordinary variable 377·1943 Sge (**169**). The star, which has a remarkable photometric history, is centered in what appears to be a rather faint planetary nebula. The spectroscopic activity of the star has been described at low dispersion by several observers (**170**), and is currently being studied on 120-inch coudé material by Herbig and Boyarchuk.

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APPENDIX 2—REPORT OF COMMITTEE ON VARIABLE STARS IN CLUSTERS

PRÉSIDENT: Mrs Dr H. B. Sawyer Hogg, David Dunlap Observatory, Richmond Hill, Ontario, Canada.

MEMBRES: Arp, Rosino and Wesselink.

Introduction

This report will follow the outline adopted in the report of Sub-Commission 27*b* for the 1961 IAU meeting. Researches now in progress or published since the preparation of that report, and the meeting of the Sub-Commission will be considered under the following sections. 1. Variables in globular clusters. 2. Variables in galactic clusters and associations. 3. Variables in star clusters of external galaxies. There is less information in this report on current researches and unpublished material than the writer expected because members of the Commission did not send in material as fully as could be wished.

1. *Variables in Globular Clusters*

(*a*) *Discovery of new variables and derivation of periods.*

There are now 119 clusters catalogued as globular. In these 1688 variables have been published, with 85 clusters examined; five of these clusters have no variables, and three have only unpublished variables, which now total 23 for all clusters.

Table 1 lists those clusters, with references, in which data on new variables and their positions, and new or revised periods, have actually been published. Information on clusters under investigation, in which data are not yet available for periods or positions of new variables will be found in § 1(*e*).

(*b*) *Discussions of the RR Lyrae stars*

(1) *New variables and periods.* L. Rosino has been very active in the discovery of new variables in clusters, as shown in Table 1. In NGC5824 (**5**) he has found 27 new variables and nine periods. The median magnitudes of the RR Lyrae stars are concentrated toward a mean value of 17·65 and the period frequency distribution has a double maximum. In NGC6229 P. Mayer (**12**) has provisional periods for 10 of the 20 RR Lyrae stars discovered by Baade. The mean period of two *c*-type variables is 0·298, that of eight *a*-type is 0·518. Miss M. Harwood (**16**) in her comprehensive investigation of the Scutum Cloud has found new variables and determined several periods in NGC6712.

P. N. Kholopov (**3**) has discovered 18 new variable stars in the central region of M3. B. V. Kukarkin (**9**) has studied 19 variables in NGC6171. The mean period of 11 RR*a* type variables is $0^{d}535$, and that of 7 RR*c* type $0^{d}287$. Mannino (**10**) simultaneously determined periods of 10 variables in the same cluster, several of which differed from those determined by Kukarkin.

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