Astronomy. — "*Report on the principal lines of research followed by me at the Union Observatory, Johannesburg, from* 1923 *November to* 1924 *October.*" By EJNAR HERTZSPRUNG [1]).

(Communicated at the meeting of November 29, 1924).

The practical astronomer is subject to many restrictions, which he will try to diminish as much as possible beforehand. The principal reasons for my stay at the Union Observatory, Johannesburg, are: firstly the excellent climate, and secondly our relatively limited knowledge of the Southern hemisphere. Additional attractions were the suitability of the Franklin Adams star camera to some of my researches, and the possibility of complete devotion to scientific research without being distracted by every day duties. I am greatly indebted to the director and staff of the Union Observatory for their readiness to help and effective assistance in many respects.

The Franklin Adams objective has an aperture of 254 mm and a focal length of 1123 mm, so that 1 mm on the plate equals 183".6. Plates 20 $\times$ 20 cm (the largest size for which Dr. SCHILT's microphotometer is adapted) thus represent an area of about 100 square degrees, and as the aperture nearly equals that of the „carte du ciel" refractors, half an hour's exposure will show stars of about the 14th photographic magnitude.

The scale of the plates being rather small, such faint stars will be closely packed in some regions of the Milky Way, but this circumstance will cause serious trouble in exceptional cases only.

Considering all possibilities the instrument seemed to be especially adapted to focal plates of faint variable stars. This being determined on, the question arose, whether it would be preferable to search for new variable stars in many different parts of the sky, or to investigate some selected regions only, taking a sufficiently large number of plates to determine the periods and light-curves for all the variable stars occurring on them. I have preferred the latter

[1]) In 1923 an agreement was drawn up between the observatories at Johannesburg and Leiden, which has been approved by the respective governments, and according to which astronomers attached to either institute have the right to use the resources of the other (cf. Report of the director of the observatory at Leiden for the year 1923. *B. A. N.* II, **46**, p. 31). As a result of this agreement Prof. HERTZSPRUNG left Leiden for Johannesburg on 1923 October 26.

course, the more so as in many cases the discovery of variable stars has not been followed up by a thorough investigation of the special stars. This abundancy of discoveries, which requires no special scientific training, is doubtlessly partly due to the sportive charm of this kind of work.

It may be expected, that the investigation of faint variable stars will give us many important clues about the structure of the galactic system. The more distant, and therefore ceteris paribus fainter, the star is, the more difficult it becomes to investigate its light spectroscopically, even only with respect to colour. Variability in brightness will remain within the range of our observational power for considerably fainter objects.

As regions of which a large number of plates will be taken, I have selected :

1. The great Magellanic cloud.

About one thousand variable stars in this cloud, which is completely covered by the 20 × 20 cm plates, have been listed at Harvard Observatory, which still await final discussion. Though in some parts of the cloud the stars are so crowded, that the scale of the Franklin Adams plates is too small, a sufficient number of variable stars remains, which may safely be measured with the microphotometer.

Up till now 56 plates of this region have been taken, the exposure time being half an hour in the mean.

These plates have not yet been definitively measured, but it can now already be stated, that the greater part of the variable stars occurring in the great Magellanic cloud are of the δ Cephei-type, a fact which has been noted previously at Harvard Observatory. No eclipsing variable stars have been found in this region up to the present time. On the contrary there are many variables of the RR Lyrae-type, but it is as yet uncertain whether these stars belong to the cloud, or are only accidentally projected on it.

II. The region about η Carinae.

This is one of the most interesting clouds of the Milky Way, and contains many relatively bright stars, whereas the faintest stars are not so abundant as to make the scale of the Franklin Adams plates too small for reliable measurement.

About a dozen Cepheid variables were already known in the region on a area of only 100 square degrees. I have added about double this number, principally by discovering many faint objects

of this type. This is important, as we must conclude that either the majority of these stars does not belong to a single cloud, or that the relation between period and luminosity, found by Miss LEAVITT for Cepheid variables in the small Magellanic cloud, does not hold in this region.

LUDENDORFF has pointed out, that the character of the light-curve of Cepheid variables depends systematically on the period. It is particularly striking that for periods of about 10 to 12 days the range of variation is small and the light-curve nearly symmetrical, whereas for shorter and longer periods the curves are very unsymmetrical. I have been able to confirm this remarkable result by means of several new Cepheids in the region about η Carinae having periods of about 10 to 12 days. Any theory of the nature of Cepheid variation should take this fact into account.

Up to the present time very few eclipsing variables were known in this region. By means of the "Blinkmicroscope" I have added 44 new ones to their number, not counting some older variables, which were found to be of this type. The most remarkable fact with respect to this new group of eclipsing binaries is perhaps, that statistically they do not differ very much from those already known in the whole heavens, unless in apparent magnitude. The relative frequencies of the periods are similar. Another striking fact is, that the fraction of the period during which eclipse takes place, shows only small dispersion about a mean value of about $^1/_{10}$.

Of course stars with shorter duration of eclipse will more easily escape detection, but my impression is, that this circumstance is insufficient to explain the scarcity of eclipsing binaries of this kind. I am inclined to see in this fact a confirmation of the theory of fission, according to which the components of double stars, which have originated by fission, will not greatly increase their separation in the course of their further evolution. According to this hypothesis the period of an eclipsing variable will give an indication of the density at the moment of fission.

With increasing ability in the use of the Blinkmicroscope I have detected more and more variable stars with small range of variation. This is very welcome. As to the eclipsing binaries: two spherical stars of equal diameter and surface brightness cannot loose more than $0^m{\cdot}75$ in the combined magnitude by an eclipse. The sensitiveness of the common methods of discovery of variable stars being only about half a magnitude, it is evident, that a strong preference for the discovery of eclipsing binaries of large variation exists, e.g. systems consisting of a bright star of relatively small diameter and

a large relatively dark star. This observational selection of the material at our disposition up to the present time makes it difficult to use of for statistical applications.

Among the new eclipsing binaries found in the region near η Carinae one having the very short period of 0·3052 days and showing double eclipse deserves special mention (*B.A.N.* **56, 113**). Only one case of this kind with still shorter period (^{d}·237) is known. Of another (*B.A.N.* **54** *d*) the range is unusually large, perhaps the largest known. Though no accurate determination of the range has as yet been made, I estimate it to be about 4^{m}. Further it is worthy of mention, that the eclipsing binary *B.A.N.* **52** *d* shows an extraordinarily long phase of constant brightness during minimum, namely about $^{1}/_{20}$ of the period, which is 14^{d}·**4**. Such stars are of special interest, because it will be possible, as soon as our instruments have become sufficiently powerful, to determine the ratio of the masses of the components by measuring the change of the radial velocity of the fainter star during the total eclipse of the brighter.

In the latest catalogue of ephemerides of variable stars, published by the Bamberg Observatory (*V.J.S.* **58**, 210; 1923) periods are given for 177 eclipsing binaries. These are distributed over **4** equal zones of the sky as follows

declination	+ 90°	+ 30°	0°	— 30°	— 90°
number of eclipsing binaries	78	41	31	27	

It is evident from these numbers, how unequally the amount of work has been divided between the two hemispheres up till now. By the discovery of new variable stars in the region of η Carinae only I have added **36** to the last number for the most Southern zone.

The number of δ Cephei-variables with known periods, taken over the whole sky, is about half that of the known eclipsing binaries. In the region of η Carinae I have found nearly the same proportion.

As the two plates which have been compared in the Blink microscope were always so selected, that the difference of the epoch amounted to a few days only, the variable stars found show nearly exclusively rapid variation. They belong with few exceptions to the eclipsing, δ Cephei or RR Lyrae types. Of the last named type only a small number have been found. This is in good agreement with the fact that the known variable stars of this kind do not show galactic concentration, notwithstanding their low apparent brightness. This is important with respect to their large peculiar velocities. They may belong to the group of stars with large, with respect to the Galaxy possibly hyperbolical, velocities pointed out by OORT.

Further investigation of the distribution of variable stars of this type in different parts of the sky may be well worth while.

Among the few stars showing rapid variation, which do not belong to the three types mentioned above, one is of exceptional importance. This star (*B.A.N.* **52**, 87) is faint or invisible on nearly all the plates. Only on the last three plates of five, which have been taken in succession on the same night, each with half an hour exposure time, the star is respectively about $1^m.8$, $1^m.1$ and $0^m.75$ brighter than normal. This seems to be a Nova of exceptionally short duration. It may very well be, that Novae of this kind are not too scarce, notwithstanding the fact, that such phenomena have not been observed with certainty before. For it is evident, that they may easily escape detection. Only in the case that such a Nova of short duration is visible on several plates taken in the same night, there will be no doubt as to the reality of the phenomenon.

Up till now I have taken 408 plates of the region about η Carinae more or less fit for use, within a period of seven months. Attention has been paid to observe in different hour angles, in order to secure material fit for the determination of periods of variable stars. But there are cases, in which additional observations secured at observatories in different geographic longitudes will be desirable.

In addition to the two regions mentioned above I have begun to take series of plates of some other regions. But the time has not yet come to report on these more in detail.