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THE NEARER STARS.

By J. Jackson, M.A., D.Sc.

(Presidential Address 1935-1936.)

The structure of the universe is a subject to which astronomers rightly devote a large portion of their time. There are many methods of approach to the subject, direct and indirect. Before the first determination of a stellar distance, not quite a century ago, the scale had to be a purely arbitrary one. Halley's detection of the proper motion of a few stars in the early years of the eighteenth century was the first demonstration that the stars are not at an infinite distance, but it was not till more than half a century later that the general structure of the galactic system was first revealed by Herschel's star gauges, or counts of the number of stars visible in his telescope when pointed in different directions. By assuming that the stars in space had a general average of brightness, the same at all distances from the sun, and by taking as the unit of distance the rather indefinite average distance of the stars of the first magnitude, Herschel obtained a remarkably accurate picture of our stellar system.

Much work has been based on star counts since Herschel's time, especially by Seeliger and Kapteyn, but the securing of the observations is by no means as simple as it looks. The accurate determination of the apparent brightness of the stars turns out to be a problem of extreme difficulty. The brightness extends over a range of 20 magnitudes; or expressed in ordinary language, the faintest stars are 100 million times fainter than the brightest. An error of half a magnitude in the faintest stars compared with the brightest would correspond to an error of 60 per cent., and it is by no means easy to be sure that such an

Comet 1936*a* (Peltier) Union Observatory, Johannesburg, *7th August, 1936* error may not arise. The problem is complicated by variations of colour, whether the observations are visual or photographic. In the past distances have been calculated on the assumption that space is perfectly transparent, and only recently have the first attempts been made to allow for the absorption of light in calculating distances by comparison of the apparent and real brightness. It is not to be wondered at that all investigators have realised the importance of the direct determination of stellar distances and that Herschel himself led the way, even although he failed to find any measurable parallax.

The first reliable parallax was published in 1838, but prior to that astronomers had formed pretty accurate conjectures as to which stars were nearest. Newton had estimated that the sun would appear as a star of the first magnitude if it were 100,000 times more distant than Saturn, when the parallax would be $0''.2$ and the apparent diameter $''.002$. W. Struve's great work on double stars 'Mensurae Micrometricae,' published in 1837, has a remarkable chapter on the parallaxes of the fixed stars. After computing the parallax and diameter of Arcturus on the assumption that it is a replica of the sun he went on to show the connection between the parallax and mass of a binary system with the period and semi-major axis. For seven stars he computed with great accuracy the product of the parallax by the cube root of the mass. His results would give the mass if the parallax were known and a determination of the parallax if the mass were known. For 61 Cygni he deduced a parallax of $0''.254$ if the mass were equal to the sun's mass and stated that the parallax could only be as low as $0''.1$ if the system were 16.4 times as massive as ours. The modern value of the parallax of 61 Cygni is $0''.299 \pm .003$. Struve plainly described three methods for picking out the nearest stars. He wrote "From all these considerations we are able to indicate those stars, which before all others, offer the hope that their parallaxes may be detected :—

(1) Stars of the first and second magnitude.

(2) Stars with proper motion exceeding $1''$ annually—
η Cassiopeiae, μ Cassiopeiae, τ Ceti, δ Trianguli, ι Persei, 40 Eridani, Sirius, Procyon, θ Ursae Majoris, 61 Virginis, Arcturus, γ Serpentis, 72 Herculis, 70 Ophiuchi, σ Draconis, 61 Cygni, Argelander 540, 85 Pegasi.

(3) Double stars, which for their apparent separation show the most rapid orbital motion—

61 Cygni, 70 Ophiuchi, η Cassiopeiae, ξ Ursae Majoris, Castor, γ Virginis, ζ Herculis, δ Herculis.

We see that some stars are common to (1) and (2) and also to (2) and (3). To the third class 40 Eridani should be added for its association with a star of the 9th magnitude, 83" distant is a remarkable phenomenon. Amongst all the stars the following appear to be most worthy of being observed for parallax:—

> α Tauri, Capella, Sirius, Procyon, Arcturus, α Lyrae, α Aquilae, Castor, 61 Cygni, 40 Eridani, μ Cassiopeiae, Argelander 540, 70 Ophiuchi, ξ Ursae Majoris, γ Virginis, and ζ Herculis."

These three methods are those which we use to-day in selecting stars for observation in the hope that their parallaxes may be measurable. The order of reliability is the opposite of the numerical order given. The range of variation in the mass of stars is very small, only the cube root is involved, and the mass itself can be estimated with considerable accuracy from the spectral type and luminosity. Consequently the parallax of a binary star for which the orbital elements are available can be estimated with great accuracy. Unfortunately the number of double stars for which orbital elements are available is small. The estimation of the parallax of a star from its proper motion is affected by the considerable range in the linear velocities of the individual stars. If the proper motion were merely the refection of the solar motion the parallax would be obtained by dividing the annual proper motion by 4 times the sine of the angle from the star to the solar apex, but experience shows that when stars are selected because of large proper motion, the parallax is often less than one tenth of the proper motion and not infrequently less than one twentieth, say one fifth of that anticipated from the proper motion. Mere apparent brightness is a very unreliable guide to the distance of a star, as the real brightness may vary from one star to another by a factor of many thousands so that distance estimated merely from brightness may be wrong by a factor of a hundred. Modern researches into the physical condition of the stars enable us in many cases, from an examination of the spectrum, to estimate the intrinsic brightness and then from the apparent brightness to deduce the distance. In selecting stars for parallax determinations we rely on the three criteria stated so clearly by Struve before a single reliable parallax was determined.

The publication of Prof. Schlesinger's General Catalogue of Stellar parallaxes containing all the determinations available to him up till the beginning of 1935 enables us to realise the progress which has been made in determining the distances of the stars, particularly in the last 20 years. The following table gives the number of stars with parallaxes between certain limits. (In the case of double stars or pairs of stars the number counted corresponds to the number of entries in the catalogue, *e.g.*, the two stars forming α Centauri are counted as one, while the distant companion Proxima Centauri is counted separately.)

Parallax.	Number.	Total including Sun.	Computed.
Greater than ″.200	29	30	30
″.159 to ″.200	21	51	60
″.139 to ″.158	13	64	90
″.126 to ″.138	16	80	120
″.117 to ″.125	13	93	150
″.111 to ″.116	7	100	180
″.105 to ″.110	15	115	210
″.101 to ″.104	6	121	240
″.080 to ″.100	59	180	469
″.060 to ″.079	178	358	1111

Including the sun there are 30 stars known within a distance of 5 parsecs. If we take this as the star density we should have 240 stars with a parallax exceeding 0″.1 while the catalogue contains only half this number. The table shows how with increasing distance the star density appears to fall off. This is of course to be attributed to lack of observations for the more distant stars which appear fainter to us and have smaller apparent motions.

It is interesting to compare Struve's list of the nearer stars with their parallaxes as given in Schlesinger's catalogue. Struve's list contains by name 27 stars. Of these 15 have a parallax exceeding 0″.1 and for only two of the stars is the parallax less than 0″.05, viz., Aldebaran (″.046 $\pm$ .004) and δ Herculis (″.027 $\pm$ ″.006). The first of these is a giant K type star with a comparatively small proper motion and appears to have been listed merely on account of its apparent brightness. The other was considered by Struve as a binary star but now it appears that the two components are not physically connected, and what he took for orbital motion is only the difference of proper motion. Of the 29 stars in Schlesinger's Catalogue with proper motion exceeding 0″.2, 20 are fainter than the sixth magnitude. Of the remaining nine, six are on Struve's list, so that he missed only three naked eye stars nearer than 5 parsecs. These are the two far south stars α Centauri and ϵ Indi, together with ϵ Eridani, a single star 10° south of the equator with a proper motion just under a second a year. These figures suffice to show the wonderful accuracy with which Struve forecasted which stars are nearest.

Up till 1910 the progress in determining stellar distances was painfully slow although the work was carried on energetically by several of the most skilled observers. In his book on Stellar Movements and the Structure of the Universe, published in 1914, Eddington gives a list of 19 stars nearer than 5 parsecs, and an additional 27 for which reliable observations showed them to be within twice that distance. The 46 stars included four for which modern observations show the parallax to be less than $0''.1$, while Schlesinger's catalogue contains 120 stars with a parallax greater than this.

The parallax of a star is of the greatest importance. Once it is known we can calculate the real or absolute brightness from the apparent brightness, and the linear cross velocity in miles or kilometres per second from its proper motion in seconds of arc per century. If it is a double star we can calculate the mass of the system from the orbital elements. The spectral type enables us to calculate the amount of radiation from unit area and when the parallax is known we can utilise this for a determination of the superficial area and hence the radius of the star. In other words the parallax is the key by which the absolute dimensions are determined.

A study of the nearest stars gives us quite a different conception of the nature of the constituent bodies of our stellar system from what we would have from a study of the stars selected merely on account of their apparent brightness. The naked eye stars, for example, are far from representative of the stars as a whole. Many of them are enormous globes with a diameter ten or even a hundred times greater than that of our sun, so that they are visible to us at enormous distances while other smaller stars may exist in vast numbers but pass unnoticed on account of their faintness (real and apparent). We have mentioned as the least important criterion for estimating the distance of a star its apparent brightness. The well known case of Canopus, the second brightest star in the sky, may be cited. Its parallax is given in Schlesinger's catalogue as $''.005 \pm ''.006$ from observations made photographically at Johannesburg and visually with the heliometer at the Cape. If the parallax is $''.005$ then Canopus is 80 thousand times as bright as our sun. The Astronomer Royal has pointed out that such a star placed at the distance of α Centauri would shine with half the brilliance of the full moon. Our knowledge of the real brightness of Canopus is, however, very uncertain. It is hardly likely, however, that the parallax exceeds $''.02$ so that it cannot well be less than 5,000 times as bright as the sun. On the other hand its parallax, for all we know, may be ten times smaller than that adopted, which would entail a brilliance 8 million times that of the sun.

Let us now contrast with Canopus, Sirius, the brightest of the stars. There is no doubt about its parallax, ″.373 ± ″.002, and consequently about its real dimensions. It is 26 times as bright as the sun, and from its spectral type and computed surface brightness, its surface is rather less than four times and its radius twice that of the sun. Its proper motion of 1″.315 per annum corresponds to a linear speed of 16.7 km. per sec. Sirius is a binary star and from this fact additional and most unexpected facts have been derived. The mass of the system is 3.3 times that of the sun, distributed roughly in the ratio 3 to 1 between the bright and the faint components. There can be no doubt that the mass of the faint component is about three quarters that of the sun, and that its real brightness is only about one four-hundredth part that of the sun. Considering that the mass is not much less than that of the sun we would expect that the faintness would be due to low luminosity of the surface compared to the sun. But now the spectroscopist comes along and tells us that the surface brightness exceeds that of the sun and that the feebleness of the light must be attributed to small surface area. Calculations show that the radius of the companion of Sirius is about one-thirtieth that of the sun in spite of the fact that the mass is three quarters that of the sun. From these figures we deduce the density as 20,000 times that of the sun, or nearly thirty thousand times that of water.

It is not necessary to pursue the companion of Sirius further at present. It was at one time considered a rather freak object in the universe, but several similar objects have been discovered in connection with other double stars. In recent years a number of stars, intrinsically very faint, have been discovered. These may be similar to the companion of Sirius, but the mass and density could only be determined if they were components of binary systems.

Let us now examine generally the stars in Schlesinger's catalogue with large parallaxes. There are 357 stars with a parallax of ″.060 or greater. As the probable error is of the order of ″.010 it may be considered that the distances and absolute dimensions of these stars are fairly well known.

The simplest question to consider is the distribution of these stars over the sky. If we divide the sky into four equal areas as follows ; from the north pole to declination +30°, from declination +30° to the equator, and then southwards in two similar stages to the south pole we find the number of stars in the four areas to be 112, 87, 77 and 81. The fact that the numbers south of the equator are not much short of those north, indicates the activity of the parallax work at the southern observatories, especially Yale and the Cape. Good work is being done at the Bosscha

Observatory some 7° south of the equator in Java while some of the northern observatories have carried their work well south of the equator. The somewhat larger number for the region round the north pole is probably partly to be attributed to the exhaustive work done for this region at Greenwich.

Perhaps a more interesting way is to divide the sphere into four equal areas using galactic latitudes instead of declinations—*i.e.*, using the natural stellar system of coordinates instead of a terrestrial system. The figures for the four areas are 98, 85, 88, 86. The slightly larger number for the region round the north galactic pole may again be attributed to activity at Greenwich; but the outstanding feature of these figures is their approximation to equality. The stars in our immediate neighbourhood appear to be very uniformly distributed and to show no tendency to congregate towards or to avoid the galaxy. I was in fact prepared to find the stars apparently avoiding the galaxy, for with an actual uniform distribution the nearer stars might be more easily missed in that region. The result shows that this is not the case for the nearest stars.

The next simplest way to consider the stars is by apparent brightness. The number for different ranges is as follows:—

Brighter than 3.0	17	7.0—7.9	33
3.0—3.9	25	8.0—8.9	46
4.0—4.9	39	9.0—9.9	49
5.0—5.9	57	10.0—	49
6.0—6.9	42		

Only 138 or 40 per cent. of the total are naked eye stars. It is unlikely that many more naked eye stars with a parallax greater than 0″.06 will be found, for the Yale Observatory has made a special investigation of all naked eye stars likely to have a sensible parallax. (Stars of early spectral type and therefore presumably very bright and very distant have not been observed.) At most we may put down 150 naked eye stars as having a parallax as great as 0″.06. This is only about 3 per cent. of the 4,850 stars reckoned as brighter than magnitude 6.0. As the sun would appear as faint as magnitude 6.0 if moved to a distance where the parallax would be ″.06 it follows that all the naked eye stars beyond this distance must be brighter than the sun, and in fact many of those inside this distance are also brighter than the sun. Hence not more than one or two per cent. of the naked eye stars are intrinsically as faint as the sun.

We cannot, however, by any means conclude that the majority of the stars, considered as a whole, are brighter than the sun. The list of the nearer stars tells quite a different story. Of the stars considered above 177 or 50 per cent. have an apparent magnitude of 7.0 or fainter—the brightest of these if its parallax is as small as 0″.06 is of absolute magnitude 6.0, or about one magnitude fainter than the sun. A very considerable majority of the stars known within our limit of distance are fainter than the sun, and this is by no means the whole story. We have already stated that for the brightest stars the survey is fairly complete. For fainter stars it is far from complete and it becomes less and less complete as we consider stars of increasing faintness. A few figures will show this. Eddington's list, published in 1914, included 17 stars with a parallax now accepted as 0″.200 or over. Schlesinger's 1935 Catalogue contains 12 more with apparent magnitudes as follows: 6.6, 8.3, 8.6, 9.4, 9.5 (two), 9.7, 10.0, 10.2, 11, 12, 12.3. All except the first three are fainter than stars normally observed with meridian circles. All the large parallaxes are now found amongst faint stars with large proper motions, discovered by comparison of photographs separated by an interval of ten years or more. A majority of these stars are to be found in lists published by Wolf and Ross. Many of these stars are of extreme faintness and require rather long exposures with the large refractors generally used for parallax work. In this connection the work ot Van Maanen with the great reflectors at Mount Wilson should be mentioned. He has tackled stars of large proper motion as faint as photographic magnitude 17.7. Some of these stars have proved to have comparatively large parallaxes proving that they are very faint intrinsically. Well over 200 stars are now known with photographic absolute magnitudes fainter than 10, *i.e.*, if they were at a distance of 10 parsecs they would appear as stars fainter than magnitude 10. Van Maanen has given a list of 12 stars fainter than absolute magnitude 15. As all these stars are near, errors in the figures are more likely to arise from inaccurate apparent magnitudes than inaccurate parallaxes. The star of least luminosity in the list is Wolf 359—a star missing from Schlesinger's Catalogue, although α Centauri, Proxima Centauri, and Barnard's star are the only stars nearer to us. Its apparent photographic magnitude is 15.4 and its parallax 0″.413. From these figures we calculate the absolute magnitude of 18.5. The luminosity is .00002 that of the sun. A study of the stars of large parallax shows that many of them emit less than one-thousandth the light of the sun. In the course of time we shall doubtless discover many more, and still fainter ones. We must await for their relative nearness to be revealed by comparison of long exposure photographs before their distances will be measured.

The percentage of the different spectral types amongst the nearest stars is shown below. For fifty stars the spectral type is unknown and these have had to be excluded from this analysis. For comparison the percentage of the different types in the complate Draper catalogue of some 225,000 stars, essentially complete to magnitude 8.25, and including many fainter stars, is added.

	B	A	F	G	K	M
Near Stars	0	4½	17	26	39	13½
Draper Catalogue	11	22	19	14	31	3

The important features of this comparison is the entire absence of B type stars and the comparative scarcity of A type stars, and the relative abundance of M type stars amongst the nearer stars. The explanation, of course, is simple. The B type stars are the most brilliant and even when very remote are bright enough to be seen and catalogued out of proportion to their actual numbers in space. The same is true to a lesser extent of the A type stars. At the other end of the table we find M and to a lesser extent K type stars in relative abundance amongst the nearer stars. There are, however, K and M type stars at great distances and of great luminosity besides the intrinsically feeble stars of those types found amongst our neighbours in the sky. Many of the faint stars of large proper motion found amongst the nearer stars are of these spectral types. Of the twelve stars listed by Van Maanen of absolute magnitude fainter than 15, seven are known to be of spectral type M; the spectral type of the others is unknown.

Lastly we have to deal with the motions of the stars. In selecting stars for parallax observation the greatest consideration has been given to proper motion, and an attempt is being made to observe all stars with proper motion over half a second a year, and frequently to half this amount. In this way we select not only near stars but also more distant stars of excessive linear speed. The following table gives the number of stars between different limits of annual proper motion, amongst the nearer stars.

Up to 0″.2	22	1″.0—1″.5	54
0″.2—0″.4	68	1″.5—2″.0	25
0″.4—0″.6	77	2″.0—3″.0	14
0″.6—0″.8	47	3″.0—4″.0	6
0″.8—1″.0	32	Greater than 4″.0	10

For two the proper motion is not given in Schlesinger's Catalogue.

All the stars given by Russell, Dugan and Stewart as having an annual proper motion exceeding 3″.0 have parallaxes over 0″.1 and mostly above 0″.2 with the exception of the pair of stars known as Washington 5583 and 5584, for which the parallax is $+$ ″.040 $\pm$ ″.004 and the proper motion 3″.68. The transverse velocity of this pair of stars is therefore 440 kilometres per second, and the radial velocity is 300 kilometres per second. The linear velocities of many of the nearer stars when computed from the proper motion and parallax come out at over 100 kilometres a second, or six times the average speed of the stars as determined from radial velocities. The explanation appears to be that the stars have been specially selected for large proper motion and when a correspondingly large parallax is not found a large linear velocity necessarily follows. The dwarf late type stars are known to have on the whole larger velocities than the average for the stars.

The nearer stars afford reliable material for the determination of the way in which luminosity and the linear speed vary with spectral type. The closeness of the relation between type and luminosity may be derived from the following. In his discussion of the nineteen nearest stars Eddington found that the star O.A.N. 11677 did not fall into line with the others. Its luminosity was found to be only 0.004 of that of the sun, while from the spectral type, F, it was expected to be several times brighter than the sun. Eddington wrote, " This star was measured with the heliometer by Krüger as early as 1863 ; apparently the determination was an excellent one. It would perhaps be desirable to check this result by observations according to modern methods, but we are inclined to believe that the exception is real." The parallax has been checked and confirmed but the spectral type is now given as M*b* and so the star falls into line. It is, however, an excellent plan to keep our eyes open for outstanding results of this kind as they may turn out to be of great importance though unexpected.

The principal results which follow from a study of the stars of large parallax concern the star density in our neighbourhood and the distribution of the various spectral types and their luminosities. The B type stars forming one-ninth of the stars in the Draper Catalogue, are quite unrepresented. These must therefore be very bright stars scattered at great distances through space. Next come the A type stars. When stars are selected merely for apparent brightness nearly a quarter are stars of this type. Our examination of the nearer stars shows only one-fifth as many. Our list contains 14 stars. Several of these are amongst the brightest (apparent) stars in the sky. Ten of them are much more luminous than the sun, three are comparable to the sun in brightness, but one is a very faint star (Wolf 1056) with a luminosity less than one-hundredth that of the sun. The discovery of other faint stars of early type shows that this class of star is not uncommon in space. As we proceed to consider stars of later spectral types we find them more and more abundant in comparison with their representation in ordinary star catalogues, while the intrinsic luminosity becomes less and less. The likelihood is that, if only we could observe them, there are very large numbers of stars of late spectral type and low luminosity. The only way of discovering them is by comparison of long exposure photographs and even then many may escape because of their faintness and redness. Amongst the intrinsically brightest stars—say, as bright as our sun—the list may be considered complete. This degree of completeness will be gradually extended by the observation of stars too faint to be visible to the naked eye with a proper motion in excess of the average.

May I now turn from these direct results of observation to do a little speculation ? What chance is there that we may discover a star nearer than α Centauri, say, with a parallax of one second ? If such a star exists what would it look like and how would we set about finding it ? Let us turn to our three methods of estimating nearness. If it were a double star of the same mass as the sun it would have a period of one year for a separation of 1″, and only 12 years with a separation of 5″. If the star were bright enough, and the components not too near we would unearth it through the orbital motion. Its brightness would have revealed it long ago if it were a tenth as bright as the sun, and even with one-hundredth of the luminosity of the sun it would still be a naked eye star and could not escape detection much longer. But we know that there are many stars more than a thousand times less luminous than the sun, and such stars if single might escape attention for a long time if the proper motion were small, say, less than 0″.2 a year. Such a proper motion is much less than we would look for in a star with a parallax of 1″, and in fact it would indicate that the star was probably a companion of the sun moving with it through space. It would at least mean that its motion perpendicular to the line of sight was nearly equal in size and direction to that of the sun. We thus conclude from our criteria that a star nearer than α Centauri must be a star a hundred, probably a thousand times fainter than the sun, moving along a parallel course. If the sun had a companion accompanying it in the same way that Proxima Centauri accompanies α Centauri, could we find it ? Proxima Centauri appears to us about 2° 11′ distant from α Centauri, so that if their distances from the sun are equal their actual separation is only about 1/26th of that between the sun and them. Proxima Centauri as seen from α Centauri would have a parallax of 20″ and instead of appearing of magnitude 11 as it does to us, it would appear of magnitude 4. A star of this magnitude and so large a parallax could not long escape detection even with no proper motion. Observations of right ascension near midnight three days apart would show a displacement of 1″. A star with a parallax as great as 20″ would surely soon be discovered on photographic plates if as bright as magnitude 12—involving an absolute magnitude of 23.5 and therefore 100 times fainter than Wolf 359. We can therefore rule out a companion as near to us as Proxima Centauri is to α Centauri, unless much fainter intrinsically than any star so far known—although I must add that we have no evidence against such faint stars existing in large numbers. Wolf 359 appears to us as a star of magnitude 15.4 while its parallax is 0″.4. If brought to one-tenth of its present distance it would have a parallax of 4″ and an apparent magnitude of 10.4. Such a star might be difficult to find if it were moving as a companion to the sun. The only possibility of stars brighter than apparent magnitude 12 escaping us is the absence of proper motion; and with a parallax as great as 4″ they might be discovered by parallactive shift in a month.

Another question arises in connection with the possibility of very near stars: Could they be discovered by gravitational attraction? There appears to be no hope of such a discovery. A star comparable in mass with the sun would produce no perceptible perturbations in the solar system if near enough to have a parallax of 100″. But the sun and such a star would act as a binary and there would be orbital motion with all the planets accompanying the sun. The orbital motion in 100 years would, however, be only half a degree and would be completely indistinguishable from the solar motion. An absolutely dark star within a few thousand astronomical units of our system might escape detection indefinitely. Any hopes we have of finding a star nearer than α Centauri rest on the comparison of photographs when it will reveal itself either by proper motion or directly by parallax. Such a star must be intrinsically very faint—its mass may be anything.

At present astronomers are busy in both hemispheres determining the proper motions of fainter and fainter stars, and then observing those with largest proper motion for parallax. Since 1912 the photographic method has led to greatly increased accuracy and to a great increase in the number of determinations. In 1914 Eddington wrote, "The star Cordoba 32416, magnitude 8.5, having the enormous annual motion of 6″.11 seems to have been left alone entirely." Schlesinger's Catalogue gives for this star four determinations of parallax: Yale ″.222$\pm$8, Innes ″.268$\pm$20, Cape ″.221$\pm$13 and Voute ″.179$\pm$19. A star of one-tenth the proper motion and one-tenth the brightness would not remain long neglected nowadays.

I have chosen to speak to you on the Nearer Stars because of their importance in forming a true picture of the stellar system. The actual determination of the distances is very laborious and makes the greatest demands on the astronomer for accuracy, especially the avoidance of all possible sources of systematic error. Although theoretically we can determine the parallax (and proper motion) of a star from three observations, nearly all modern observers base parallax determinations on 20 or 30 photographs extending over a period of at least two years—and so covering three epochs of maximum displacement in one direction and two in the other. These observations require a telescope of considerable light grasp and of fairly long focal length. While therefore amateur astronomers can hardly be expected to take up this class of observation it is pleasant to relate how much South Africa has contributed to it. The first observations to give a reliable parallax were those of α Centauri made by Henderson at the Cape in 1832-33, although they were not reduced till later and not published till after Bessel's work on 61 Cygni. The observations by Gill and his collaborators with the heliometer were a most important contribution in the last two decades of the nineteenth century while I have already mentioned the work of the Yale station at Johannesburg—the most productive of parallax determinations in the world—and our own work at the Royal Observatory.

LIST OF NEAREST STARS

Stars with a Parallax of a tenth of a second or over (within a distance of 32.6 light years) as given in Schlesinger's Parallax Catalogue (1935 edition). The columns give for the stars (1) name, (2) right ascension for 1900, (3) declination for 1900, (4) visual magnitude or, with asterisk, photographic magnitude, (5) spectral type, (6) parallax, (7) proper motion.

Name.	R.A.	Dec.	Mag.	Spec.	Par.	P.M.
	h. m.	° ′			″	″
+43° 44	0 12.7	+43 27	8.1	Ma	.284	2.89
ζ Tucanae	0 14.9	−65 28	4.3	F8	.133	2.058
β Hydri	0 20.5	−77 49	2.9	G0	.143	2.243
+66° 34	0 26.3	+66 42	9.5	M3	.103	1.74
54 Piscium	0 34.2	+20 43	6.1	K0	.104	0.595
η Cass	0 43.0	+57 17	3.6	F8	.182	1.242
Boss 171	0 43.1	+ 4 46	5.8	G5	.148	1.367
Wolf 28	0 43.9	+ 4 55	12.3	F0	.243	2.98
−31° 325	0 48.1	−30 54	7.2	G5	.107	0.63
Ross 318	0 55.3	+71 9	9.2	...	.106	1.76
μ Cass	1 1.6	+54 26	5.3	G5	.130	3.761
Boss 377	1 36.0	−56 42	6.0	G5	.161	0.286
107 Piscium	1 37.1	+19 47	5.3	G5	.132	0.734
τ Ceti	1 39.4	−16 28	3.6	K0	.301	1.920
Boss 394	1 40.5	+63 22	5.7	K0	.111	0.635
Boss 588	2 30.6	+ 6 25	5.9	Ko	.144	2.320
−13° 544	2 47.7	−13 11	6.1	G5	.134	0.42

Name.	R.A.	Dec.	Mag.	Spec.	Par.	P.M.
	h. m.	° ′			″	″
κ Ceti	3 14.1	+ 3 0	5.0	G5	.106	0.283
ζ^1 Reticuli	3 15.6	−62 58	5.5	G0	.110	1.493
82 Eridani	3 15.9	−43 27	4.3	G5	.159	3.165
ζ^2 Reticuli	3 16.0	−62 53	5.2	G0	.100	1.488
ε Eridani	3 28.2	− 9 48	3.8	K0	.305	0.971
−48° 1011	3 31.9	−48 46	9.1	K5	.107	0.48
δ Eridani	3 38.5	−10 6	3.7	K0	.114	0.749
o^2 Eridani	4 10.7	− 7 49	4.5	G5	.202	4.082
Ross 33	4 37.0	+18 47	10	...	.107	1.27
1 Orionis	4 44.4	+ 6 47	3.3	F8	.128	0.474
−5° 1123	4 55.9	− 5 52	6.5	K0	.105	1.25
Kapteyn's star	5 7.7	−44 59	9.2	K2	.262	8.75
Ross 41	5 22.6	+ 9 35	13.4*	...	.108	0.89
−3° 1123	5 26.4	− 3 42	8.8	K2	.168	2.22
+53° 935	5 33.4	+53 27	9.8	K7	.117	0.47
Ross 47	5 36.4	+12 29	10	...	.156	2.53
γ Leporis	5 40.3	−22 29	3.8	F8	.122	0.462
χ Orionis	5 48.5	+20 15	4.6	F8	.104	0.207
−21° 1377	6 6.4	−21 49	8.7	K5	.183	0.68
α Mensae	6 13.2	−74 43	5.1	G5	.118	0.242
Wolf 287	6 31.5	+17 38	9.5	M1	.100	0.84
Sirius	6 40.7	−16 35	−1.6	A0	.373	1.315
Wolf 294	6 48.4	+33 24	10.5	...	.161	0.87
Procyon	7 34.1	+ 5 29	0.5	F5	.291	1.242
Pollux	7 39.2	+28 16	1.2	K0	.100	0.623
Lal 18115	9 7.6	+53 7	{ 8.1	K2	.162	1.683
			{ 8.1	K2		
−59° 1362	9 19.2	−59 51	9.6*	...	.120	0.84
....	9 34.5	+70 31	12.3*	...	.100	0.74
−45° 5378	9 40.8	−45 18	10	...	.103	0.78
+50° 1725	10 5.3	+49 58	6.8	K5p	.220	1.45
+20° 2465	10 14.2	+20 22	9.4	Mdp	.193	0.49
Ross 446	10 23.6	+ 1 21	9.4	...	.113	0.96
Wolf 358	10 45.8	+ 7 22	13.2*	...	.136	1.23
Lal 21185	10 57.9	+36 38	7.6	Mb	.388	4.779
Lal 21258	11 0.5	+44 2	8.6	Ma	.174	4.52

Name.	R.A.	Dec.	Mag.	Spec.	Par.	P.M.
	h. m.	° ′			″	″
ξ Urs. Maj.	11 12.9	+32 6	3.9	Go	.138	0.730
+66° 717	11 14.8	+66 23	9.3	Ma	.120	2.99
61 Urs. Maj.	11 35.8	+34 46	5.5	G5	.109	0.388
β Virginis	11 45.5	+ 2 20	3.8	F8	.101	0.793
Groomb 1830	11 47.2	+38 26	6.5	G5	.108	7.047
β Can. Ven.	12 29.0	+41 54	4.3	G0	.108	0.756
β Comae	13 7.2	+28 23	4.3	G0	.134	1.184
61 Virginis	13 13.2	−17 45	4.8	G5	.129	1.528
Ross 490	13 24.9	+10 55	9.1	...	.123	1.49
Wolf 489	13 31.8	+ 4 13	14	M0	.130	3.94
Lal 25372	13 40.7	+15 26	8.5	K2	.191	2.30
−58° 5467	14 12.0	−58 54	7.0	K0	.114	0.98
Prox. Cent.	14 22.8	−62 15	11	M	.762	3.85
α Centauri	14 32.8	−60 25	{0.3 1.7	G0 K5	.756	3.682
ξ Bootis	14 46.8	+19 31	4.6	G5	.147	0.170
Lal 27173	14 51.6	−20 58	5.8	K5	.172	1.977
Wolf 562	15 14.2	− 7 21	10.6	M5	.152	1.32
−40° 9712	15 25.7	−40 54	9.4	...	.166	1.54
....	16 21.1	+48 36	10.5	...	.132	1.22
−12° 4523	16 24.7	−12 25	9.5	M5	.255	1.24
ζ Herculis	16 37.5	+31 47	3.0	G0	.110	0.601
+33° 2777	16 41.4	+33 41	8.6	K5	.113	0.37
Wolf 629	16 50.0	− 8 8	11.7*	...	.138	1.26
Wolf 630	16 50.1	− 8 9	8.9	K5p	.151	1.23
−4° 4226	17 0.0	− 4 55	9.7	M3	.100	1.44
+45° 2505	17 9.2	+45 50	9.6	K5	.144	1.56
36 Ophiuchi	17 9.2	−26 27	4.6	K0	.182	1.228
Boss 4372	17 10.1	−26 24	6.7	K2	.176	1.224
Boss 4378	17 11.5	−46 32	5.6	K0	.132	0.970
Boss 4386	17 12.1	−34 53	5.9	K2	.147	1.194
+2° 3312	17 20.8	+ 2 14	7.9	K5	.124	1.32
−46° 11540	17 21.1	−46 47	9.4	...	.225	1.15
−44° 11909	17 29.8	−44 14	10.0	...	.208	1.14
....	17 33.4	+18 37	9.8	K5	.113	1.39
+68° 946	17 37.0	+68 26	9.2	Mb	.213	1.33

Name.	R.A.	Dec.	Mag.	Spec.	Par.	P.M.
	h. m.	° ′			″	″
....	17 38.2	−57 14	11*	...	.158	1.77
+43° 2796	17 40.9	+43 26	10.3	M3	.102	0.59
μ Herculis	17 42.5	+27 47	3.5	G5	.109	0.817
Barnard's star	17 52.9	+ 4 25	9.7	Mb	.545	10.296
70 Ophiuchi	18 0.4	+ 2 31	4.1	K0	.196	1.131
χ Draconis	18 22.9	+72 41	3.7	F8	.119	0.641
Vega	18 33.6	+38 41	0.1	A0	.121	0.348
+59° 1915	18 41.7	+59 29	8.8	K5	.282	2.31
17 Lyrae C	19 3.6	+32 21	11.0	Ma	.123	1.66
Wolf 1062	19 7.0	+ 2 44	11.2	...	.105	1.88
Wolf 1055	19 12.1	+ 5 3	9.5	Ma	.170	1.47
σ Draconis	19 32.6	+69 29	4.8	Ko	.181	1.839
Ross 165	19 41.7	+26 55	13.8*	...	.116	1.34
α Aquilae	19 45.9	+ 8 36	0.9	A5	.208	0.659
δ Pavonis	19 58.9	−66 26	3.6	G5	.174	1.626
Boss 5166	20 4.6	−36 21	5.3	K5p	.177	1.624
−45° 13677	20 6.7	−45 28	7.5	K5	.145	0.77
Boss 5180	20 9.1	−27 20	5.7	K0	.110	1.258
....	20 29.0	+65 6	11.5*	...	.156	0.53
+61° 2068	20 51.3	+61 48	8.6	K2	.138	0.77
61 Cygni	21 2.4	+38 15	5.6	K5	.299	5.202
Lac 8760	21 11.4	−39 15	6.6	Map	.257	3.53
γ Pavonis	21 18.2	−65 49	4.3	F8	.124	0.814
−49° 13515	21 26.9	−49 26	8.6	Ma	.207	0.78
ϵ Indi	21 55.7	−57 12	4.7	K5	.288	4.695
Krüger 60	22 24.4	+57 12	9.3	Mb	.258	0.87
+43° 4305	22 42.5	+43 49	10.2	M5e	.207	0.84
− 15° 6290	22 47.9	−14 47	9.5	...	.231	1.12
−32° 17321	22 50.8	−32 6	6.5	K5	.121	0.37
Ross 671	22 51.8	+16 2	8.6	Ma	.161	1.09
Fomalhaut	22 52.1	−30 9	1.3	A3	.135	0.367
Lal 44964	22 55.0	−23 4	7.6	Ma	.125	0.90
Lac 9352	22 59.4	−36 26	7.4	Map	.278	6.90
Boss 5976	23 8.5	+56 37	5.6	K2	.146	2.102
−73° 2299	23 33.7	−37 15	6.7	K0	.135	0.76
Ross 248	23 37.0	+43 40	12	M6	.314	1.82
Lal 46650	23 44.0	+ 1 52	8.7	M2	.167	1.39
Cordoba 32416	23 59.5	−37 51	8.3	K5	.222	6.11

REPLY TO PROF. MILNE'S REVIEW OF MY PRESIDENTIAL ADDRESS.

By J. K. E. HALM, Ph.D., F.R.A.S.

In Volume 46, No. 10, of the Journal of the British Astronomical Association a review by Prof. Milne on my address to this Society has been published. Prof. Milne, while criticising a certain equation employed in the theoretical part of the address, is obviously under the impression that my thesis of an expanding Earth depends on the acceptability of this equation as an "equation of evolution," a property which he declines to accept. He comes to the conclusion that "whilst Dr. Halm's theoretical basis seems not to be well-founded, the hypothesis itself is extremely stimulating and suggestive."

I shall give reasons in the course of these remarks why I disagree with Prof. Milne's opinion on the criticised equation. But the first and most important objection against his final verdict is the fact that the theoretical basis of my theory does not depend on this equation at all. Let me briefly recapitulate the reasoning adopted in my address for showing that the Earth whilst cooling is expanding. This reasoning is based on a comparison between our planet and a star in the stage of a White Dwarf. *Apparently* there seems very little similarity between these two bodies which differ so widely in size, mass, density and temperature. But there is one important property common to both. In both bodies matter appears to be so far compressed that the bodies may be looked upon as "rigid" or, what comes to the same thing, that the atoms are packed as closely as possible, the distance between two neighbouring atoms being equal to the "diameter" of the atom. In such a state the density ρ is *solely* determined by the *atomic diameter* σ and the atomic weight m, the relation being

$$\frac{\rho\sigma^3}{m\sqrt{2}} = 1 \tag{1}$$

Now in the case of our planet $\rho = 5.6$, in the case of the two white dwarfs Sirius B and o^2 Eridani of the order 60000. To account for this enormous disparity the above formula admits of two possible explanations: Either the diameters of the atoms are the same in both bodies, and consequently the atomic weight of matter in the White Dwarf must be 10000 times that of matter in our planet, which is clearly an inadmissible assumption, or, the atomic weights are of the same order of magnitude in both bodies and consequently the "diameter" of an atom in the White Dwarf would be only about 1/20th of that of an atom in our planet.

In my address I have shewn evidence of a sensible diminution of σ with increasing temperature even within the narrow range of laboratory experiments. The observations are based on the behaviour of the coefficient of viscosity. According to these experiments the diameter is probably proportional to $T^{-\frac{1}{4}}$, T representing the absolute temperature. As an example take $T=10^7$ (which is of the order of the mean temperature inside a star like our Sun). Compared with the diameter σ at ordinary temperature 273°, the diameter inside the star would only be 1/14th of that observed at ordinary temperature.

This dependence of the diameter σ, and consequently of the *density* ρ on the temperature in a *rigid* star forms the sole basis of my hypothesis. The only assumptions on which the theory of an expanding Earth is based are:

(1) During at least the geological period our planet has been in a state of rigidity, *i.e.*, the atoms have been packed together as closely as possible.

(2) The internal temperature has been higher in the past than at present and consequently the "diameters" of the atoms have been smaller. As a necessary result, according to the above quoted relation between ρ and σ under conditions of rigidity, the density has been greater in the past than at present.

If these two assumptions are accepted, the theory of a slowly cooling and expanding Earth becomes self-evident.

To arrive at this result, the criticised equation is obviously not required. The equation, however, has been introduced in order to find a physical and mathematical relation between the density and the temperature. For, obviously, although the above assumptions (1) and (2) are sufficient to establish the theory of a cooling and expanding Earth *qualitatively*, they supply no information as to the *quantitative* relationship between temperature and density. On perfectly general thermodynamical grounds I have derived an equation of the form

$$\log T_s - a \log \rho_m = C \tag{2}$$

where T_s is the temperature at the surface of the planet and ρ_m its mean density. In this equation the term C involves the mass M of the planet, the total mass M_s of its atmosphere and a certain quantity S which depends on the thermal conditions at the surface.

Taking as an example our own planet, M and M_s may reasonably be assumed to remain constant during subsequent epochs. As regards S thermodynamics teaches us that it remains unaltered if the amount of irreversible heat energy absorbed within the surface layer is equal to the amount of heat energy radiated and conducted from it. Increased absorption means increased temperature within the layer and this in turn involves increased emission, and it is reasonable to assume that at all times there will be a tendency towards a balance between the in- and outgoing heat. In this case S, like M and M_s, is independent of the time. Consequently, all the terms entering into C are unaltered in course of time, and C is therefore constant at all epochs.

Prof. Milne admits that " under certain circumstances C might be constant at different epochs in the history of the *same* mass," but he emphatically denies that it can have the *same* value for *different* masses. Here, however, he ignores the essential condition on which my theory is based, viz., the *rigidity* of the bodies, *i.e.*, the close packing of the atoms. Their condition may be likened to that, for instance, prevailing in a bag of mealies. Now compare the conditions in the bag with those in a truck load of mealies of the same size. Obviously, while the masses in bag and truck are very different, the weight of the mealies contained in unit volume, *i.e.*, the density, is the same in both cases. Applying this conclusion to our problem, let us assume two rigid bodies, *e.g.*, the Earth and a star of the mass of a White Dwarf, whose temperatures T_s and atomic diameters σ are the same. Since rigidity implies that the densities ρ_m are the same, it follows directly from the above equation that C must have the same value for both stars *notwithstanding the enormous difference in their masses.* The equation

$$T_s \,/\, \rho_m{}^{0 \cdot 38} = 146 \qquad (3)$$

which I quoted in my address, and whose validity I demonstrated throughout the whole range White Dwarfs—Planets, is therefore applicable to bodies of different masses provided that the condition of rigidity is satisfied. I think that I am justified in considering this as a valid proof of the remarkable relation between T_s and ρ_m shewn in the above formula. We are here in the presence of a property of celestial matter which cannot be simply dismissed as a " curious empirical fact." Apart from these differences of outlook on the theoretical side of the problem, I am glad to have Prof. Milne's approval of my application of the theory to some of the outstanding features in the historical development of the Earth's crust and I hope that his advice to geologists and oceanographers for critical examination will not pass unnoticed.

ADDENDUM TO THE REMARKS IN MY ADDRESS ON THE QUESTION OF THE ORIGIN OF ICE AGES AND MOUNTAIN BUILDING.

By J.K.E. HALM, Ph.D., F.R.A.S.

In my address I have been dealing among other problems with the question of the climatic changes on our planet during the geological past. After the publication I reflected a little more on this side of the problem, and in the present note I intend to shew how readily these climatic changes find an explanation on the supposition of an expanding Earth.

The problem for which we have to account is seemingly of a bewildering and somewhat paradoxical complexion. On the one hand there is undoubted evidence that a *tropical* maritime fauna once flourished in the *arctic* regions, thus pointing to the conclusion that the temperature of the seas must have been considerably higher than at present. The theory of an expanding planet as developed in the address supports this conclusion. But, on the other hand, geologists tell us and shew evidence to the effect that even in the earliest geological epochs considerable portions of the continents even in the tropics must have been shrouded in vast sheets of ice and snow. Ice Ages seem to have existed at various epochs since the very beginning of the history which geological science has revealed to us. Let us try to see how the theory of expansion can account for observed facts which seem so glaringly to contradict one another.

If the Earth were completely covered by sea enveloped in a gaseous atmosphere its surface, on expansion, would always assume the curvature demanded by the action of the gravitational force. As I have pointed out in my address, however, the solid crust of the continents may for some time resist the tensile forces which tend to reduce the excessive curvature to the normal.

In Fig. 1 I shew the surface of the globe at two epochs, the sea level and the superincumbent atmosphere being indicated by concentric circles and the sections through two adjacent continents being indicated by the thickened segments. It is readily seen that the compact displacement of the inner segments to the outer sphere would mean an intrusion of the interior of the continents into higher strata of the atmosphere. Supposing that one of the segments has the width of equatorial Africa (about 60°) and that the radius of the globe has increased by 100 kms., we find that the elevation of the point C in the centre of the segment above the coastal point A is about 15 kms., *i.e.*, $1\frac{2}{3}$ the height of Mount Everest.

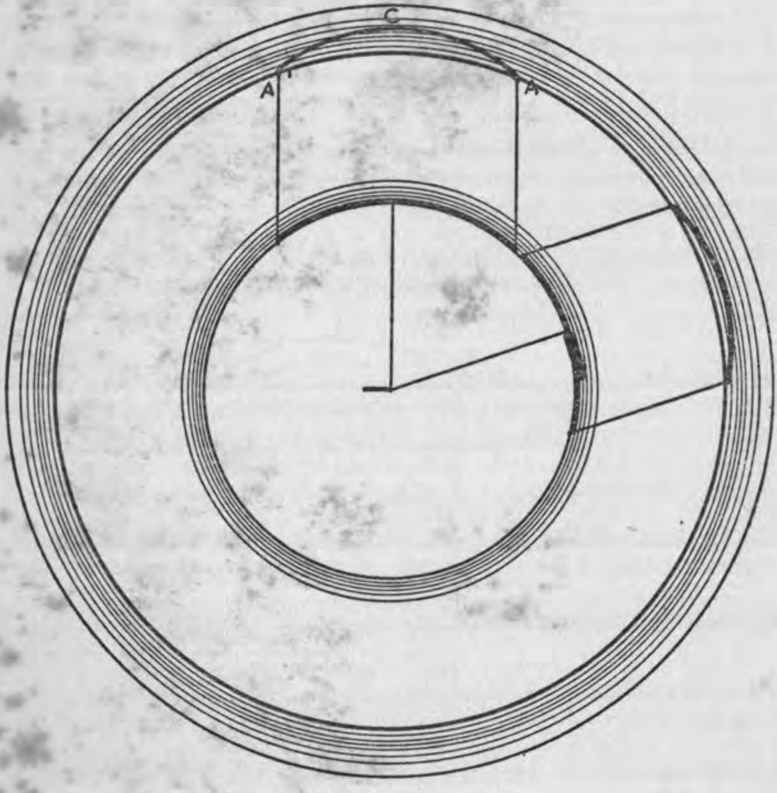

Fig 1.

Now we know that the temperature of the atmosphere decreases very considerably with height (at present between 5 and 6 degrees Centigrade for every kilometre, but probably considerably more in the past). Consequently, in our example, the difference in temperature between A and C would be at least 82° Centigrade (148° Farenheit). Hence, even assuming a temperature at sea level considerably higher than at present, a large portion of the inner continent would be covered with a cap of ice of probably tremendous extent and thickness. We are in the presence of an Ice Age for the continent under consideration at a time when the temperature of the Oceans may have been sufficiently high to permit the development of a tropical marine fauna in the Arctics.

The baffling paradox of palaeo-meteorology, viz., tropical climate near the pole and arctic conditions near the equator finds an explanation almost absurdly simple and self-evident.

Naturally, however, the preservation of excessive curvature and consequent thickening of the ice cap cannot go on for ever. A moment must come when the crust has to yield to the weight and the vault collapses. This has already been explained in my address, but I have not there considered the important role played in this process by the pressure of the accumulated ice. That this ice pressure is a very decisive factor is clearly borne out by the following reasoning supported by observation. In Fig. 2 I represent a section in the North-South direction through a continent such as Eurasia or Northern America. It is evident that the growth of the ice cap is much more favoured on the arctic than on the equatorial side, with the obvious result that lateral compression giving

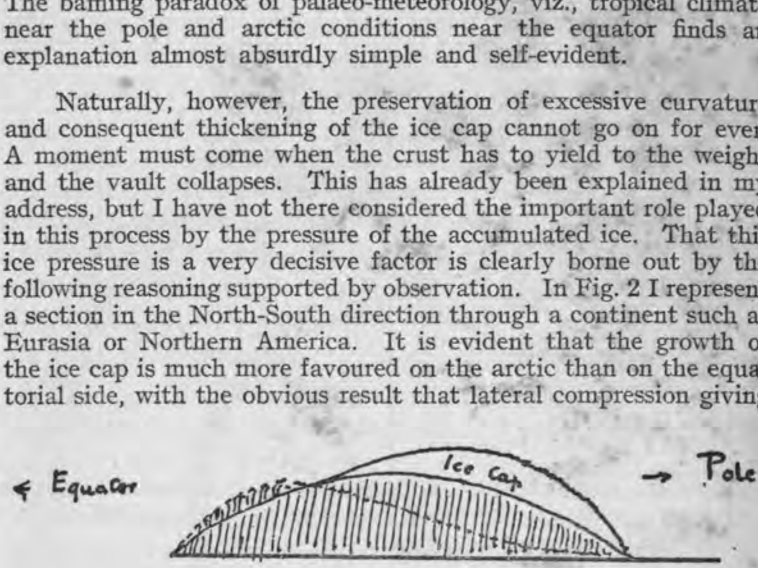

Fig. 2

rise to the formation of mountains is in the direction from pole to equator. Hence the formidable chain of mountains along the southern coast line of the Eurasian continent and the low land character of the arctic regions.

Fig. 3 is meant to convey a general idea of the process of mountain building. In (*a*) we have the surface of the solid crust transferred by expansion from a sphere of lesser to one of larger radius at which it arrives with an excessive curvature. As mentioned before the result is an extension into the higher and colder strata of the atmosphere and the formation of an icecap. Naturally, with continued expansion, a moment must come when the more and more unstable structure must collapse. The pressure being greatest in the centre, there will be a lateral compression (indicated by the arrows) towards the circumference and a chain of mountains along the coast will result (Fig 3(*b*)). This represents the first violent attempt of the crust to adjust itself to the normal curvature demanded by the gravitational forces. As time goes on, this process of "levelling," aided by denudation, continues ; the mountains are flattened out until a state is reached such as is represented in Fig. 3(*c*). But it must be borne in mind that, since expansion goes on continually, the state in (*c*) cannot represent a definite and permanent settlement. Once more the curvature becomes excessive and the stages (*a*), (*b*) and (*c*) repeat themselves.

Thus we are in the presence of a quasi periodic sequence of events ranging between the extremes (*a*) and (*c*).

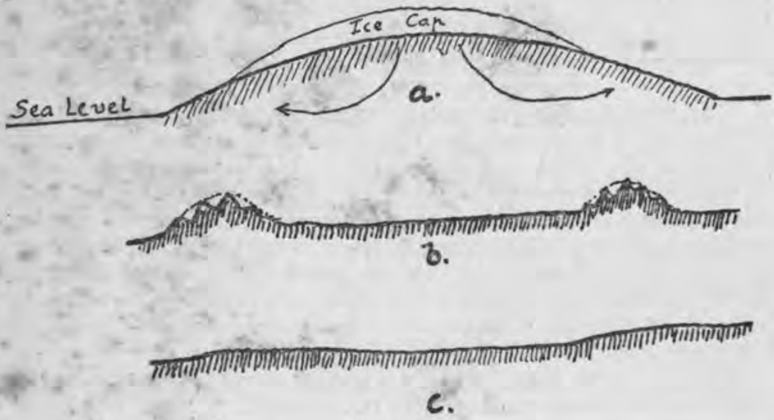

Fig. 3.

It is of interest to note that a phenomenon known to geologists as the principle of " accordance " finds a satisfactory explanation on the basis of the theory described above. This principle of accordance may be stated as follows : If we imagine a surface which shall everywhere touch the summits of the mountain peaks, it will be found to form a gently arching dome with major axis coinciding with the general trend of the mountains and highest in the interior of the range. This agrees exactly with the configuration represented in Fig 3(*b*) where the dotted line represents the section through the dome.

A few additional remarks may be of interest regarding the effect of the tensile tearing of disruptive forces to which the crust is constantly exposed in an expanding globe. Some of the major effects, the separation of continents (Wegener's theory), the tearing away of islands from the mainland (Japan, Zew Zealand), the formation of peninsulas (Scandinavia, Arabia) have been dealt with in my address. But I am inclined to attribute also the initial formation of the beds of rivers and inland lakes to feebler manifestation of the same cause, *i.e.*, to cracks, furrows and rifts due to the tensile forces of expansion. The Great African Rift is the most obvious example of the generation of lakes and rivers through this cause. There is in my opinion only a difference in *degree* between the forces which led to the vast basin of the Atlantic and the shallow furrow which directs the present course of the Rhine. And the same forces manifest themselves in a lesser degree even now in the tectonic earthquakes which remind us, in a subdued murmur, of the gigantic upheavals caused by the disruptive forces in the distant past.

REVIEWS.

"The Realm of Nebulae," by Edwin Hubble of the Mount Wilson Observatory. Oxford: University Press. 12s. 6d.

In recent years theoretical astronomers, especially those working on the astronomical implications ot the theory of relativity. have devoted a great deal of attention to the extent and nature of the physical universe. The greater the distance at which objects can be observed, the better the basis for the discrimination between different theories. The extra galactic nebulae are the most distant objects we can observe, and on the whole the more distant they are the fainter they appear. For their investigation the 100-inch reflector of the Mount Wilson Observatory is the most significant and in the hands of Dr. Hubble it has yielded results of the greatest importance. His discovery of Cepheid variables in the great spirals led the way to a reliable determination of the distances, sizes and intrinsic luminosities, first of the nearer objects and then of the more distant ones. The actual observations and the deductions that can be made from them form a most important and fascinating piece of astronomical research and astronomers are greatly indebted to Dr. Hubble for writing a comprehensive and up to date account of his own work and that of other workers in this field.

The book is intended for the educated layman as well as the professional astronomer. Mathematical formulae are few and refer mostly to the relationship between distance, real brightness and apparent brightness thus involving the logarithmic function. Light years have generally been preferred to the more natural unit of the parsec and speeds have been frequently converted from kilometers per second to miles per second.

The book is developed from the observer's point of view; the exclusion of mathematics has largely eliminated references to theories concerning evolution. The nebulae are treated first from their appearance, and divided into elliptical nebulae, normal spirals, barred spirals and irregular nebulae. These divisions are further sub-divided, the elliptical nebulae with regard to the degree of ellipticity, the spirals with regard to degree of resolution. The numerical data with regard to the various classes seem to fit together remarkably well. The apparent distribution and real distribution of the nebulae are next dealt with. In this special prominence is given to the effect of absorbing matter, especially inside our own system. Then follow important chapters dealing with the determination of the distances of the nebulae and on the relation between distance and velocity of recession. The final chapters deal with the local group (viz., the galactic system, the Magellanic Clouds and a few of the nearer spirals and irregular nebulae), the more distant nebulae definitely indentifiable as such, and finally objects of apparent magnitude as faint as 21.5 at the limit of long exposures with the 100-inch reflector. A specially attractive feature of the book is the illustrations. They are well chosen and magnificently reproduced. Each has a useful description to which we would have liked to see the exposure time added.

The difficulties and uncertainties of the subject are explained. In a book of this type it is justifiable to be as definite as possible, but the conservative reader may consider the claims for accuracy to be sometimes overstated. Thus we read on page 154 "Light from the sun reaches the earth in about 8 minutes ; from the most distant cluster that has been measured the journey requires 240 million years. The multiplication factor is about 1.5×10^{13} yet the distance of the cluster is known with an uncertainty that is probably not more than 15 per cent." This quotation has been given to show the kind of book this is. It is on the whole fairly easy to read, but occasionally, especially in the opening pages, the meaning is difficult to grasp, *e.g.*, on page 6 "Much of the source material may be of interest to the general reader. It presents a case history of scientific research in a rather simple form." Is this English ?

The book is one which no student of the universe can afford to miss.

"Worlds Without End," by H. Spencer Jones, F.R.S., Astronomer Royal, London. The English Universities Press. 5s. 0d.

In these days when a large number of books of a popular nature are written to meet the demands of a large number of readers whose interest in astronomy has been stimulated by articles in the press, lectures, etc., it is pleasant to come across a book so readable and so sound as "Worlds Without End." The Astronomer Royal's book "General Astronomy" requires a certain amount of mathematical knowledge. This latest book is intended primarily for the general reader. It is written in simple language, the use of technical terms has been avoided, but still the scientific spirit pervades it. It is a book which the beginner can take up for it begins at the beginning. Starting with our own earth the study of the celestial bodies proceeds from the nearer to the more and more distant, the chain of argument being continuous throughout. An unusual feature is a chapter "Life in other Worlds." There the limitations of our knowledge are definitely stated, but at the same time the little we do know concerning the composition and temperatures of the atmospheres of the other planets is expounded.

The final chapter " What was—what is to be " gives a short resume of various hypotheses as to the origin of nebulae, stars and planets, with speculations as to the future course of events. The author wisely refrains from hard and fast conclusions. Apart from this chapter the book largely deals with direct deductions from observation.

The book is well produced in large clear type with reproductions of a few typical astronomical photographs and a few diagrams. General ignorance of astronomy may be traced to lack of knowledge on the part of school teachers. This book can be recommended to them.

OBITUARIES.

Major George C. Fox.

The Astronomical Society regrets to have to record the death of one of its Members, Major George C. Fox, who passed out of space and time on the 9th October, 1935. He was born in 1864 at Bournemouth in England of South English yeoman stock. Both his grandfathers fought in the battle of Waterloo and both died in England at the advanced ages of 93 and 98 respectively.

Young Fox after leaving school went to sea, and spent two years battling round the world in wind-jammers, after which he was apprenticed and indentured, according to the custom of the times, with a firm of engineers in London. After qualifying himself as an engineer he came to South Africa in 1880, settled his family (for he had married early in his apprenticeship) at Durban and busied himself in the early mining endeavours of Zululand, Swaziland and Barberton. Later, the discovery of the auriferous conglomerates of the Witwatersrand drew him, like many other adventurous spirits, to settle in the South Transvaal where be began a very successful career as mining engineer, first in the service of Messrs. Goertz & Co. (now the Union Corporation) and later with Messrs. Lewis and Marks, whose consulting engineer he was during the greater part of the spectacular rise of that firm to importance in the world of mining finance. The late Mr. Samuel Marks for many years relied largely on Fox's acumen and advice in regard to new mining ventures submitted to him for approval or condemnation.

After the close of the Great War Major Fox decided to retire from mining and settled in Cape Town. In the native wars and Transvaal war which followed close on his arrival at Durban Fox had seen some military service, and in the events leading up to the Jamieson Raid and the Boer War, a few years later, he had also played a part in accordance with his English up-bringing and mental inheritance. During the Boer War he served as a commissioned officer in the Royal Engineers, along with his life-long friend the Scottish poet-engineer Charles Murray, under Col. Swinton (" Ole Lukoie ") who was later to become the inventor of the military tank, and is to-day Professor of Military History in Oxford University. Fox issued from the Boer War with the rank of Captain, and retained the warm friendship of Professor Swinton to the end of his life. At the outbreak of the Great War in 1914 Fox offered his services as soldier and engineer to General Botha, saw active service in German South-West with the temporary rank of Colonel, and emerged with the permanent rank of Major.

After his arrival in Cape Town he joined the Astronomical Society, and having purchased from the estate of the late Mr. C. J. Taylor the 10¼ in. reflector which in Mr. Taylor's competent hands had done so much for astronomy at the Cape, proceeded to erect in his garden at Sea Point a small observatory with the expert aid of the late Mr. James Hudson. Fox now applied himself vigorously to the study of astronomy, and under the inspiration and guidance of Dr. Spencer Jones, the Astronomer Royal, became one of the most active workers in the team which studied intensively the planet Mars during the opposition of 1923-4. Some account of his work appeared in the " English Mechanic," and a perusal of the drawings of Mars by Dr. James Moir in Vol. 1, No. 6, pages 200-203 of the Journal of the Astronomical Society of South Africa shows that of the sixty drawings there published no fewer than eighteen were the work of Major Fox, and the high quality of Fox's observations is duly recorded by Dr. Moir, the Director of the team.

In all matters Fox was a man of stern unswerving devotion to duty, keeping his mind firmly fixed on observable facts. Brilliant theorisings whether in astronomy or geology, though interesting him keenly, were little liable to sweep him off his feet. He did not suffer fools gladly, and was at times capable of action of a short-tempered nature. He hated high-placed incompetence and pretentious folly with an utter loathing which at times found very forcible and picturesque expression. His great friend Charles Murray has recorded as a remarkable fact that he and Fox for three years of the Boer War shared the prolonged intimacy of a bell tent without ever having heard from each other a harsh word or seen an unkindly look. Fox admitted few to his complete confidence, but the present writer, who knew and understood him well, and in fact during the last six years of his life (Charles Murray having retired to Scotland) succeeded to the privilege of being his most intimate male friend, has the duty and pleasure of putting on record Fox's unconscious honesty and scorn of all meanness, his keen intellectual alertness and mental activity combined with unusual dexterity of hand and eye, and the lovable nature of his stately personality patent to all who were admitted to his confidence and friendship. In accordance with his last directions, all that was mortal of him was cremated and the ashes, carried out to sea, were scattered on the saline wastes he had learned to love in his boyish sailor days.

ANDREW YOUNG.

Hugh Churchill Mason, 1873-1936.

The late Hugh Churchill Mason joined the Cape Centre of the Society in 1922 and from the first was an active and stimulating member. He early became a member of the Cape Centre Committee and was Chairman of the Centre for the 1929-1930 Session. He also served on the Council of the Society and on the Journal Committee.

Mr. Mason, the son of a Wesleyan Missionary, was born in Truro, England, while his father was enjoying a temporary transfer overseas. The family returned to South Africa in 1876, and for a while young Mason was educated in Natal, and later at Gill College, Somerset East. A protracted breakdown in health however cut short what promised to be a distinguished scholastic career.

Some years on a farm and a visit to England followed. In 1897 he returned to South Africa and joined the staff of the Natal Observatory at Durban.

Outside its routine work, this Observatory, associated as it was with the name of Neisen, specialised in lunar research. In after years, when his career as a professional astronomer was long over, Mr. Mason's interest in lunar problems remained. A full account of his theory of the origin of the lunar craters was printed in the Society's Journal, Vol. II., No. 3, page 101. This account was amplified in a paper he read to the British Association on its visit to South Africa in 1929 (Journal, S.A.A.S., Vol. II., No. 4). In the following year he linked up his theory of the origin of lunar craters with a theory that meteorites are of lunar origin (S.A. Journal of Science, Vol. XXVII., page 139 *et seq*).

Mr. Mason's theories deserve more attention than they have received. He wrote with considerable literary charm, but perhaps an unfortunate didactic mode of expression has discouraged expert criticism. To say, without qualification, that the active source of meteorites "is obviously not the sun itself" (S.A. Journal of Science, Vol. XXVII., page 139), is in such direct conflict with the researches of Olivier and others that it is hardly likely to predispose astronomers to a theory of the lunar origin of meteorites.

Mr. Mason's writing was not limited to scientific papers. He was the author of "The Golden Mean," a book embodying his philosophical and religious ideas; "The Inner Court," a series of meditative essays, and a novel, "The Devil's Christmas Box," a book in which much science is pleasantly blended with imagination and romance.

Besides astronomy, Mr. Mason was interested in a wide variety of subjects. He wrote, as has been said, on philosophy and religion. He was keenly interested in every branch of physics. His interest in modern social problems took him to Russia shortly after his retirement from the Cape Town City Engineer's Department in 1933. While planning a second visit to that country, he was struck down by the disease from which he died early in February, 1936.

A quiet yet forceful and courteous debater, his presence is much missed at meetings of the Cape Town Centre, where he would talk with equal facility about Du Toit's conception of "Gondwanaland" or Science in the Soviet.

ASTRONOMICAL SOCIETY OF SOUTH AFRICA.
Session 1935-1936.

Annual Report of the Council.

The roll of the Society now includes 111 members and associates, 5 honorary members and 2 members emeriti.

The Council has met three times during the year, those members who are eligible under Article VI. (iii.) of the Constitution being represented by alternates.

The Council regrets to record the loss through death of two Cape members, Major G. C. Fox and Mr. H. C. Mason.

During the year Vol. IV. No. 1 of the Society's Journal has been published. This number was printed on a better quality paper of slightly larger dimensions than its predecessors.

The work of the observing sections has been steadily continued throughout the year. The Council expresses its appreciation of the painstaking labour that directors and members of observing sections are devoting to the fulfilment of one of the objects of the Society, and would urge all who can to become members of observing sections.

The Council notes with pleasure the purchase of a telescope by the Cape Centre, for the use of its members who may wish to make astronomical observations.

In addition to the observations detailed in the Observing Section reports, the following observations of occultations were made by members of the Cape Centre:

Mr. D. C. Burrell	...	12	Observations.
Mr. A. W. Long	...	10	,,
Mr. R. Watson ...	...	4	,,
		—	
Total	...	26	,,

The Council has to report with regret, that the meetings of the Johannesburg Centre have been discontinued.

STATEMENT OF INCOME AND EXPENDITURE FOR YEAR ENDED 30th JUNE, 1936.

Income.	£	s.	d.	*Expenditure.*	£	s.	d.
To Balance 30/6/35 ...	8	6	6	By Printing Journal:			
,, Contributions:				Vol. 4, No. 1 ...	51	1	3
Cape Centre ...	34	5	2	,, Printg & Stationery	0	2	0
Durban	4	4	0	,, Postages	2	9	5
,, Donation—Cape				,, Sundries (Advertisg.	1	14	0
Centre	10	0	0	,, Rent	0	15	0
,, Sale of Journals ...	2	6	1	,, Refund *ex* Sundial			
,, Sale of Sundial ...	1	6	3	Account	0	13	1
				,, Commission on			
				Cheques	0	0	8
				,, Balance carried forward	3	12	7
	£60	8	0		£60	8	0

Examined and found correct.

E. J. STEER,
Hon. Auditor.

W. H. SMITH,
Hon. Treasurer.

21st July, 1936.

REPORTS OF SECTIONS.

For the Year ended 30th June, 1936.

COMET SECTION.

There are no comet discoveries to report from South Africa this Session. A regular search for new comets has been made month by month by members of the Section and we do not think we are missing them. The Section is looking forward, now that the Cape Centre of the Society has got a telescope of its own, to receiving much assistance from other members in the observation of comets.

There are only two cometary discoveries to report for the period. They are as follows :—

Comet 1935*d* (van Biesbroeck). This comet was discovered by Prof. G. van Biesbroeck at Yerkes Observatory by photography. It was magnitude 15.

Comet 1936*a* (Peltier). A new comet was discovered by Mr. L. Peltier of Ohio on May 16th. It was magnitude 9.5 at discovery. It was discovered near the North Pole and is at present coming South. We hope to be able to see it well as it is expected to reach magnitude 4.3 on August 4th.

Since the date of the above report Comet Peltier came South and was an object of much interest to members.

We received the following report from Messrs. Houghton and Ensor :—

"The comet was picked up by Messrs. H. E. Houghton and G. E. Ensor at Pretoria with the naked eye on the night of the 31st July, 1936, in bright moonlight.

"The best view was afforded by inverting binoculars X 6; the 6½ in. reflector showed the nucleus very clearly, but gave poor contrast in the coma and tail.

"A very good view was obtained on August 7th and 8th before the moon rose. The accompanying photograph is reproduced from one taken at the Union Observatory, Johannesburg, on the night of the 7th August by Mr. E. L. Johnson, exposure 35 minutes. The comet is shown about 1° north of ϵ Microscopii, the bright star which appears near the edge of the plate.

"The magnitude was estimated to be about 3.5 at this stage, and the binoculars showed the broad, diffuse tail very clearly; the length of the tail appeared to be about 3° to 4°.

"On August 9th the magnitude was estimated about 4th, and on August 12th, 5th, on August 13th the comet was about magnitude 5.5 and hard to see with the naked eye.

"On August 17th the magnitude was about 6th and on August 21st about 7th and was difficult to see in binoculars.

"After the full moon the comet was picked up again on September 4th near ξ Pavonis, when its magnitude was about 9th. It was followed on most nights until the 19th September when its magnitude was about 11.

"It appeared to follow the predicted path very closely."

Mr. A. W. Long reports :—

"August 1st. Seen with naked eye to be obviously a comet with short tail. (First clear night since it came into our sky).

"August 2nd. Less distinct.

"August 7th. In 4½ in. refractor, very large coma, very bright and clear cut nucleus, faint tail for 5 or more degrees.

"August 15th. Seen with naked eye. Did not expect to see it again but, August 17th can still see it with naked eye.

"Later, the weather was cloudy."

Mr. H. C. Davies reports :—

"In 4½ in. refractor: Nucleus of comet appears as if it was a star of about magnitude 6, very solid and clear; surrounded by diffuse matter as if illuminated by nucleus."

The writer who observed it on 13 nights, notes the following :—

"It appeared at its brightest on the 5th. It was a magnificent object in an 8 in. reflector. The nucleus was very small, sharp and bright with around it a narrow border of light which appeared to be caused by the light of the nucleus lighting up the misty coma immediately adjoining. The head appeared to be quite round and was of an almost uniform degree of mistiness though at times one seemed to get a slight suggestion of lamination on the side next the Sun. The head was larger than the neck, and near the neck the tail was sharp on one side and much softened on the other. Could trace the tail to about 6 degrees.

"August 15th. Visible to naked eye but nearly at extreme limit of vision.

August 17th, 18th. Could see it easily with naked eye.

"August 19th. Could see it with naked eye, rather difficult.

"August 21st. Could only glimpse it with naked eye occasionally after finding its position with binoculars."

Mr. R. Watson, Somerset West, reports :—

"August 18th. Bright nucleus but not quite stellar.

"September 6th. Tail 20′ long and possibly 40′.

"September 10th. Tail 17′ long.

"September 19th. Tail 5′ long by half as broad. Magnitude 10 or 11."

A. F. I. Forbes,

Director.

VARIABLE STAR SECTION.

The total number of observations recorded during the year was 3,887, contributed as follows :—

R. P. de Kock	...	1,248	observations of	57	variables.
G. E. Ensor...	...	545	,,	96	,,
H. E. Houghton	...	2,094	,,	90	,,

Health and weather conditions adversely affected the output, and an increased membership of the Section would help to maintain a more level and regular return of observations from year to year.

The typing in a loose-leaf ledger of the Section's observations since its inception, which was begun by Mr. Ensor when he was Director, is progressing, and thanks are due to him for carrying out most of this work.

Notes.

Nova Pictoris continues to remain at about 9th magnitude, with some slight and irregular variations.

RS Ophiuchi and *T Pyxidis*, which are apparently new stars which have passed through that phase on more than one occasion, are kept under observation, the former being now about magnitude 11.4, its normal minimum, and latter invisible throughout the year (fainter than 13th magnitude).

S Apodis and *RY Sagittarii*, our two irregular variables, have been at about their maximum magnitudes of 10 and 6.8 respectively through the year.

Y. Pavonis. This star is shown in catalogues as variable (5.7—8.5 photographic) but no period has been recorded. Observations by the Director have been made regularly since 1928. Its spectral class is N and, like other N Stars, the brightness is difficult to estimate owing to the star's red colour, and the visual range is much less than the photographic range. No definite period has been shown, but it may be 73 days or probably a multiple of that number, as N class stars are amongst those with the longest periods; an average for 26 such stars being 380 days. The visual range of this star is about 5.2 to 6.7 though its magnitude does not always reach those limits.

H. E. HOUGHTON,

Director.

ZODIACAL LIGHT SECTION.

A preliminary report was issued last year but this is the first report of work done by the Section. It is for the above mentioned period but, as much work was done in South Africa by members before the Section was established, we have included that work also and therefore this review covers a period of about 3½ years.

During this period, observations have been sent to your Director from the following stations :—

No.	*Station.*	*Latitude.*	*Longitude.*	*Observer.*
1.	George ...	... −34° 58′	−22° 24′	C. L. O'B. Dutton.
2.	Eshowe ...	... −28 54	−31 29	Rev. S. Solberg.
3.	Claremont	... −33 59	−18 28	R. de Kock.
4.	Somerset West	... −34 5	−18 51	R. Watson.
5.	Salisbury	... −17 48	−31 3	Major J. F. Villar.
6.	Hermanus	... −34 25	−19 14	A. F. I. Forbes.

The charts that were mentioned in our last report have now been in use for one Session but they have not been made full use of. What has been done has shown that they will be a very useful medium in conveniently recording the observations and revealing accordances amongst the different observers and their observations. So we are encouraged to hope that in the coming years members will manage to snatch some time from the crowded events of life and use it for the observation of the Zodiacal Light.

The charts and the tabulated records received to date are submitted with this report. They may be examined by members.

We have studied and compared the records received and we would like to traverse the field of work and point out outstanding features that appear to be of interest and importance.

Also we would like to discuss in a general way the object we are aiming at, and the means we are taking to approach the subject in order to get the most useful results from our efforts.

This very magnificent, mysterious and changeful display in the morning and evening skies is an extremely interesting subject. It is so very faint and elusive, yet so definitely there that description often fails to convey what is meant and it calls for much keen observation in order to describe in an intelligible way what we see taking place.

The Zodiacal Light appears to consist of three portions :—

1. A Base widening out towards the horizon.
2. The main Zodiacal Light of the well known lenticular or cone shape.
3. The Band that extends from the apex of the cone and is sometimes seen across the whole sky.

Hereinafter we will simply describe them as "the Base," "the Light," "the Band."

The whole display is characterised by changefulness but generally the Base and the Light are seen as having convex edges. The Band appears generally as a true band, or ribbon of light of more or less equal width. In all descriptions of the Light the lenticular or cone shape seems to be its most constant and definite feature. It would be interesting and instructive to compare our efforts and see if, amidst all its changefulness, the Light has not some constancy in shape and size. We have compared the elongation of the apex from the Sun in the records sent by members during the period.

Dutton's records give the elongation of the apex as varying from 75° to 84° with a mean of 81°.

Solberg's records vary from 77° to 145°. (In some of his records he says "I suspect it may be the Band"). His mean may probably be about 83°.

Watson's records vary from 67° to 107° and give a mean of 90°.

De Kock gives a mean of 82°. The writer's records vary from 44° to 90° giving a mean from 22 observations of 63°. This shows a considerable variation but the position of the apex is sometimes very difficult to decide and in 1936 has been much more difficult than in 1934 and 1935. Sometimes the Band in its extension beyond the apex ends in a point and its superposition on the Light makes it appear as if it was all one long, tapering light. This may account for the differences in our records.

The records of the width of the light appear to be more in agreement and we think we shall get even better agreement in the future.

It is difficult to compare observations of the width of the light because some measure at the base near the horizon and some, like the writer, who cannot always see the base at horizon level, have to measure the width higher up. This is a point where the charts should be of very much assistance to us. We are inclined to believe that the width of the light does not vary much if we measure it at about 35° from the Sun.

This is generally the part where the Light carries the curve of its form best. In tracing the position of the edges the writer finds that the observer can say " This star is just in the light and that star just misses it " and so he can place the position of the edge within an error of about one degree at the most. There is certainly scattered light beyond this but the main body of the Light can be located with a fair degree of accuracy.

The diagrams submitted by the writer give the width of the Light as varying from a minimum of 8° to a maximum of 17°, but leaving out these two extremes, because they seem to be isolated instances, the variation in width is only from 11° to 13° with a mean in 21 observations of 11°.7.

In judging the width of the Light we have suspected that it sometimes bears a " big moon " appearance near the horizon, making it look broader than it really measures.

As to the position of the Light relative to the Ecliptic, Dutton's positions give the light as almost directly on the Ecliptic. Solberg's many tabulated records do not mention this but his two chart diagrams show the Light almost on the Ecliptic. Watson's six diagrams show the Light to be about three degrees South of the Ecliptic in all instances except one. De Kock shows one to the South and two to the North each about two degrees. In the writer's diagrams the general trend is South. There are four records giving 1° to the North ; three records directly on the Ecliptic and 17 records varying from 0°.5 to 2° South of the Ecliptic with a mean of 1°.23 South. This is leaving out one record which shows 4° South.

The charts do not show any tilt of the axis of the Light ; that is, if there are any records South of the Ecliptic in the morning and any records North of the Ecliptic in the evening or *vice versa*. The charts are yet too few for any indication like that appearing. We will need many more observations continued over a long period before we may look for results such as that.

The Band has often been observed by members. Mr. Solberg mentions seeing it on many occasions and on one occasion could trace it to 154 degrees from the Sun. The writer has seen the band on three occasions to 128 degrees and has suspected glimpsing it one morning to 188° to where it was lost in the Galaxy.

The Band appeared to be from 4° to 5° wide and as far as the writer could judge, exactly on the Ecliptic.

The Band has generally shown up best when the Light itself was not too high. Such a modest, retiring object as the Band is, at once disappears before the least infusion of a stronger light.

The variability of the intensity of the light is evident in all the reports, but in the absence of some delicate measure we do not seem to be able to get very far with that.

On several occasions during 1935-36 when one expected to see the Light, and the sky was apparently quite clear, there was no indication of it at all.

The records show there was a distinct fading of the light on the North side on the 28th/29th May and the 1st June at a zone marked X in the chart dated 1st June, 1933. This fading showed the same on all three mornings. The general tendency seems to be for the Light to be weak in parts on the North side. This we think gives the tendency for the Light to appear as if rising in a curve towards the North. It is suggested members should take particular notice of this point because it is suspected that when the light appears as if rising in a slight curve it is caused by a weakness of the light on the inner side.

We would like to get more observations and hope we will be able to get simultaneous observations in order to compare our records. Any suggestion for co-operation will be welcomed by the Director.

We hope that what we have been able to accomplish will encourage our further efforts in tbe study of this remarkable object, the largest in the sky.

A. F. I. FORBES,

Director.

A NEW TELESCOPE AND A NEW OBSERVING SECTION.

Since the publication of the last journal the Cape Centre of the Society has purchased and mounted a 4½ Refractor Telescope. And since this purchase the Council has formed a Jupiter Observing Section. How effectively these actions link up is well shown in the following leading article, which we quote, with acknowledgments, from the *Cape Times* of 1936, July 29th :—

AN ASTRONOMICAL OPPORTUNITY.

The Astronomical Society of South Africa has taken a very practical step forward. It has installed, within a few minutes' walk of Mowbray station, a four-and-a-half-inch astronomical telescope suitably housed and mounted. This has been made possible by the initiative of the member on whose property the Society's new observatory has been established, backed by financial assistance from other members. The new instrument—optically most excellent—is at the disposal of all members of the Society. This means that it is virtually at the disposal of the general public—for membership of the Society is open to "all persons interested in astronomy."

The Society's new instrument has been erected at a most opportune moment. Astronomy depends upon amateur observers for the bulk of its observations of planetary detail. The observation of the surface markings on Jupiter, for instance, has been undertaken for years past by a band of devoted amateurs in the Northern Hemisphere—particularly in England. Jupiter is now coming South. Writing to a South African correspondent, the Rev. Theodore E. R. Phillips—himself unsurpassed as a planetary observer—says :—

> Now that Jupiter is practically out of reach for some few years—at any rate as regards the finer details—for Northern observers, it is greatly to be hoped that those who have the opportunity in the Southern hemisphere will do their utmost to carry on the work of recording observations. . . . In fact we are *absolutely dependent on Southern observers* for the following-up of the specially interesting features shown by the surface currents, etc., which the British Astronomical Association's work (in the Northern hemisphere) has brought to light.

This additional work cannot be undertaken by the professional observatories of the Southern Hemisphere; they have already full programmes and an insufficiency of time, instruments, men and money. It devolves upon the amateurs. The Astronomical Society offers them the opportunity. Will they use it? And will new members rally to the Society to assist them?

Will members interested communicate with the Secretary, P.O. Box 2061, Cape Town, or with the Director of the Jupiter Section, Mr. C. E. Peers, "Cheshunt," Annerley Road, Rosebank, C.P.

CAPE CENTRE.

Twenty-Second Annual Report, 1935-1936.

Membership.

Eight additions to the roll of membership have been made during the year. Two members have been lost through death, while six members have resigned. The total membership is now 99, consisting of 88 members, 2 members emeriti, and 9 associates.

Meetings.

There have been eight ordinary meetings during the session, held in the Mountain Club Room at 38 Strand Street.

Addresses and Papers

The following addresses and papers were presented at the meetings:—

"Sunspots," Mr. R. Watson.

"An Evening with a 3-inch Telescope," Mr. Arthur W. Long, F.R.A.S.

"Telescope-making for the Amateur," Mr. H. C. Davies.

"Stellar Parallax," Miss C. Orpen, B.Sc., F.R.A.S.

"Reflecting Telescopes," Dr. J. Jackson, F.R.A.S.

"Saturn's Rings," Mr. H. E. Houghton, F.R.A.S.

"Star Observing with the Theodolite," Mr. W. Whittingdale.

"Cosmic Rays," Dr. B. F. J. Schönland.

"Nebulae," Dr. R. H. Stoy

Articles in the Press.

Articles detailing astronomical phenomena, together with charts and diagrams of the sky, have been published monthly in the "Cape Times." Astronomical notes have also appeared in "Grocott's Daily Mail," Grahamstown, and articles in Afrikaans in "Die Burger." All these were contributed by members of the Centre and were greatly appreciated by members and the public

Telescope Fund.

During the year under review the Centre has acquired a 4½-inch Refractor, for the use of its members. It was mainly through the efforts of Mr. A. W. Long, that this desirable purchase was made.

The instrument is housed in Mr. Long's observatory at "Carnalea," Malleson Road, Mowbray, and is open to all members every Wednesday (excluding Wednesdays on which meetings of the Centre are held) while those who wish to carry out an observing programme may purchase a key to the observatory to enable them to use the telescope on any night of the week.

It is hoped that all members will avail themselves of the observing facilities now provided.

The position of the Telescope Fund is at present as follows :—
Donations received to date, January 18th, 1937:

In hand, June 6th, 1935 (acknowledged in last journal)	£8	11	6
Mr. H. E. Houghton	0	10	6
Mr. R. Watson	0	10	6
Mr. W. Andrews	2	2	0
Mr. W. Whittingdale	1	0	0
Mr. H. E. Houghton	5	0	0
Mr. A. W. Long	5	0	0
Dr. R. H. Stoy	3	3	0
Rev. P. Macpherson	1	0	0
Mr. R. P. de. Kock	0	10	6
Miss C. B. Orpen	1	1	0
Mr. B. F. Jearey	10	0	0
Mr. G. Orpen	0	5	0
Mr. R. Watson	5	0	0
Capt. D. Cameron-Swan	3	3	0
Mr. A. F. I. Forbes	2	0	0

Mr. H. C. Davies	2	10	0
Mr. A. W. Robinson	3	3	0
Mr. E. J. Steer	1	1	0
Mr. V. J. Landers	1	1	0
Mr. D. G. McIntyre	5	0	0
Mr. A. Pilling	1	0	0
Mr. J. Simenhoff	0	10	6
Mr. J. B. G. Turner	1	0	0
Cape Centre	7	0	0
Interest	0	11	3
Mr. G. Cowen	0	10	6
Mr. C. E. Peers	1	1	0
Mr. W. H. Smith	0	10	0
Capt. D. Cameron-Swan	0	10	0
Dr. J. Jackson	5	0	0
Mr. A. F. I. Forbes	0	10	6
Mrs. L. E. Forbes	0	10	6
Mr. H. K. Greenwood	0	10	6
Mrs. C. E. Shepherd	0	10	6
Mr. R. T. Miller	0	10	0
	£81	17	3

An amount of about £20 is required to clear the expense incurred in erecting a dome on the observatory. It is to be hoped that this will be liquidated during the present session.

Committee of Cape Centre.

Chairman: Dr. R. H. Stoy.

Vice-Chairman: Capt. D. Cameron-Swan.

Hon. Secretary: Mr. A. Menzies.

Hon. Treasurer: Mr. J. B. G. Turner.

Librarian: Mr. W. Andrews.

Auditor: Mr. E. J. Steer.

Members of Committee: Dr. J. Jackson, Messrs. C. E. Peers, A. W. Long, and Miss C. Orpen.

A. Menzies,

Hon. Secretary.

FINANCIAL STATEMENT FOR THE YEAR ENDED 30th JUNE 1936.

Receipts.	£ s. d.	*Payments.*	£ s. d.
Balance at 30/6/35 ...	6 6 0	Typewriting and Stationery	4 11 6
Subscriptions :		Contributions under Article XIII. of Constitution	34 5 2
Arrears £23 13 6		Donation to Astronomical Society of S.A.	10 0 0
Current Year 42 6 6		Subscription to Astronomical Society of the Pacific	1 1 11
Advance	2 12 6	"Cape Times" and Postage to Country Members	3 9 9
	68 12 6	Rent of P.O. Box ...	1 5 0
Refund from Astronomical Society of S.A. (rent of room for Annual Meeting) ...	0 15 0	Rent of Meeting Room	7 10 0
		Donation to Telescope Fund	7 0 0
		Secretary's Expenses	1 17 0
		Treasurer's Expenses	0 16 0
		Bank Charges	1 11 9
		Balance	2 5 5
	£75 13 6		£75 13 6

Audited and found correct.

E. J. STEER.
Hon. Auditor.

J. B. G. TURNER,
Hon. Treasurer.

14th July, 1936.

NATAL CENTRE.

Annual Report, 1935-1936.

The Fourteenth Session of this Centre has not been the best we have known by any means but we absolutely refuse to be daunted and we intend to do what we can to foster an interest in Durban in the most sublime of all the Sciences.

Visitors in larger numbers than ever have been in attendance at the Observatory and they are always welcomed. Scouts, Rovers, Guides and Guiders have been to us and we have had the privilege of sending Lecturers to some of these bodies and also of conducting examinations for them.

It is disappointing that we have to record in our accounts so heavy a charge for the electric lighting. We cannot get any consideration from the City Council either in the way of a concession in charges or a grant-in-aid, but fortunately we have had a few donations from well-wishers which have augmented our very slender Members' Subscription List.

The attendance at our meetings has not been good and when we have brought outside friends in to give Lectures it has been most disappointing to offer them so poor a welcome from the point of view of numbers.

The following have been the Lectures during the period under review :—

"The Phenomenon of Globular Clusters," Mr. H. J. S. Bell.

"New Stars," Mr. H. E. Houghton.

"Great Astronomers," Mr. J. Bennett Mumford.

"A Far-off Cosmic Event," Rev. C. E. Wilkinson, M.Sc.

"The Solar System," Mr. H. J. S. Bell.

"The Expanding Universe," Mr. J. Willis.

"Jupiter," Mr. H. J. Roadknight.

"The Star of Bethlehem," Mr. F. T. Fox.

"Ancient and Modern Astronomy," Mr. J. Bennett Mumford.

We have to thank the authorities of the Natal Technical College and Mr. E. C. Chubb of the Durban Museum for kindly granting us the use of rooms for our meetings and we hope that under the new arrangements we shall have better attendances. At any rate we are going to continue the struggle.

REVENUE AND EXPENDITURE ACCOUNT FOR TWELVE MONTHS ENDED 31st MAY, 1936.

Receipts.	£	s.	d.	*Expenditure.*	£	s.	d.
1st June, 1935 :				31st May, 1936 :			
To Balance	8	8	8	By Stamps & Stationery	1	1	0
31st May, 1936 :				,, Sweeping	1	10	0
To Subscriptions ...	13	7	0	,, Advertising	5	13	6
,, Donations	2	2	0	,, Electric Lighting ...	5	10	8
,, Collections	1	10	0	,, Central Fund ...	4	4	0
				,, Bank Charges ...	0	10	8
				,, Balance	6	17	10
	£25	7	8		£25	7	8

J. BENNETT MUMFORD,

Hon. Secretary and *Treasurer.*

ASTRONOMICAL SOCIETY OF SOUTH AFRICA.

Officers and Council, 1935-36.

The Society acknowledges the receipt of publications, etc., from the following:—

University Observatory, Babelsberg, Berlin; Harvard College Observatory; Lick Observatory; University Observatory, Kasan; Union Observatory, Johannesburg; British Astronomical Association, Glasgow Branch of the British Astronomical Association, Sydney Branch of the British Astronomical Association; New Zealand Astronomical Society; Argentine Astronomical Society; Argentine Association of Friends of Astronomy; Antwerp Astronomical Society; Dr. L. J. Comrie; Yale Observatory; University Observatory, Bonn; Vereinigung von Freunden der Astronomie und Kosmischen Physik; Radcliffe Observatory; Astronomical Society of Tasmania; Royal Observatory, Cape of Good Hope.