indirect spectroscopic methods had been devised. The study and classification of stellar spectra, in conjunction with the investigation of binary star systems, had led to the idea of giant and dwarf stars as outlined by Hertsprung and Russell. This developed into the Lane-Ritter theory of stellar evolution. A number of individual facts—such as the Mount Wilson determination of the diameter of Antares—appeared to lend strong support to the theory, and, as so often happens, we were probably inclined to overestimate the weight of the supporting evidence. Adam's investigations at Mount Wilson appeared to give us a reliable spectroscopic test for differentiating giants from dwarfs, and so of arriving at intrinsic luminosity from the spectral type. This theory gave a graph of two distinct branches when absolute brightness was plotted against spectral type, and the graph was accepted as indicating the course of stellar evolution. The discontinuity corresponding to the junction of the two branches was naturally supposed to indicate the attainment of a density at which the gas laws ceased to hold. During the past year, Eddington had shown that when absolute brightness is plotted against mass, a curve is obtained for a given temperature which is equally the locus for dwarfs and giants. Apparently, then, there was no such marked discontinuity in physical state, and stars could attain the dwarf state without the gas laws ceasing to apply. Eddington had advanced the reasonable hypothesis that the volume of the atoms was not important even in these dense stars because of the ionisation. The atom stripped of its outer electrons was greatly reduced in effective volume.

Professor Ross discussed the effects of the acceptance of Eddington's theory, and the address closed with a brief account of our present knowledge of the form and dimensions of our stellar or galactic universe.

Papers communicated to the Association.

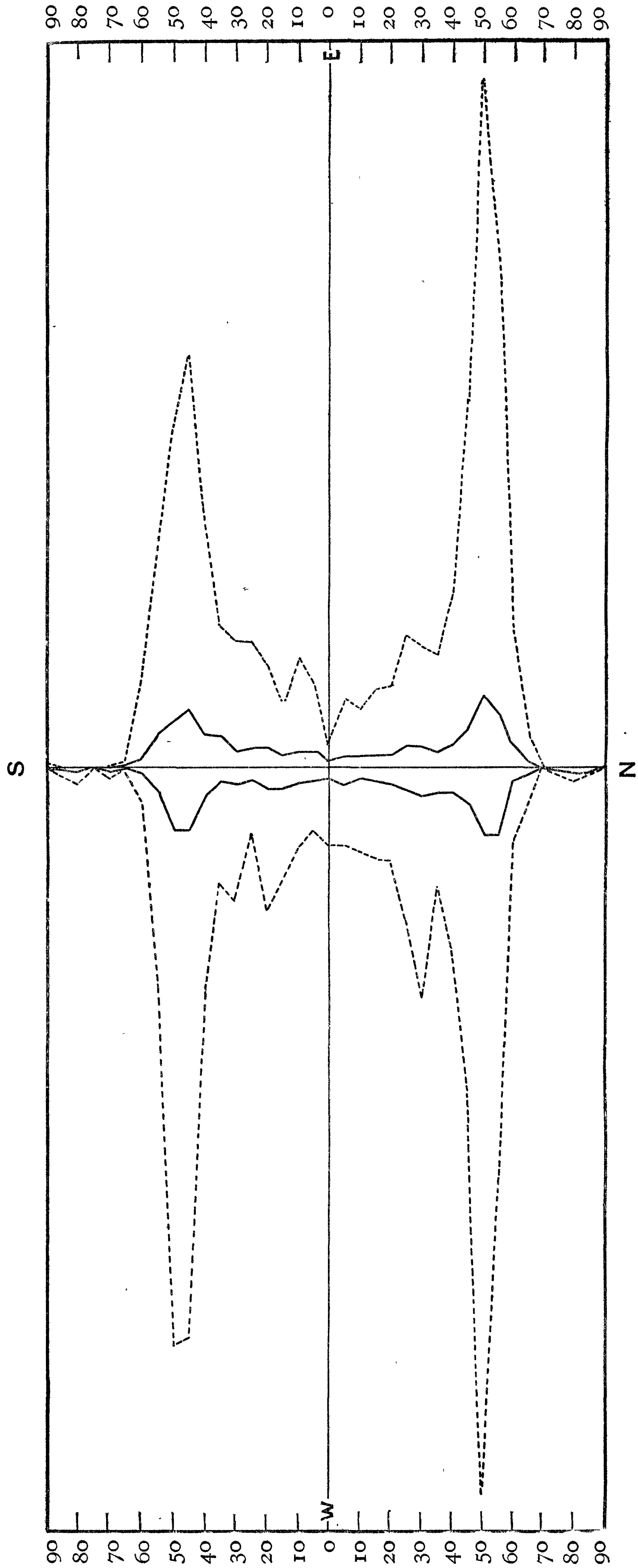
Results of Solar Prominence Observations, 1923.

By A. M. Newbegin, F.R.A.S.

The results of observations for prominences are a continuation of former years and the general scheme of recording the phenomena instituted in 1914 has been adhered to, so that, by including the year last mentioned, we have a more or less continuous record of prominences for 10 years.

At some future time it may be worth while to embody the whole of these observations into one paper, but for the moment we will confine ourselves to the year 1923.

1923.



FULL LINE = NUMBERS. BROKEN LINE = AREAS.

DISTRIBUTION OF PROMINENCES.

The results seem to indicate that the minimum period of activity occurred in September, the mean daily number and the mean area for that month being the smallest. June only yielded four observations, owing to cloudy conditions and the figures from such a small number are probably unreliable. But it is evident that a revival of activity set in during October and was maintained throughout the remaining three months of the year.

Metallic activity was observed on two occasions only, and displacements of the Hα line at the limb on eight days, six of which were to the violet. Dark absorption was present in one prominence. Taking the observations as a whole, the prominences were all of a small type and exhibiting but very few changes. The highest recorded was 125″ and occurred in October after the revival had set in.

The table gives the results for each month and the diagram indicates the positions of greatest and least activity throughout the year. It will be seen the poles are almost entirely neglected.

There was a slight preponderance of prominences in the Northern hemisphere, but the balance between East and West was practically equal.

MONTHLY STATISTICS.

Month.	Observations.	Prominences.	Mean Daily Number.	Mean Area.	Mean Height.
				sq. m.	″
January - - -	9	67	7·44	2·19	36·34
February - - -	8	56	7·00	2·04	35·44
March - - -	7	49	7·00	2·74	34·90
April - - -	9	56	6·22	2·19	37·76
May - - -	8	49	6·12	1·69	32·55
June - - -	4	22	5·50	2·02	35·22
July - - -	9	55	6·11	1·78	33·27
August - - -	7	43	6·14	1·50	31·30
September - -	11	63	5·72	1·68	32·30
October - - -	10	76	7·60	2·10	33·28
November - -	11	86	7·82	2·09	33·08
December - -	6	43	7·16	1·63	31·74
Totals - -	99	665	6·71	1·97	33·93

In conclusion, it may be mentioned that these observations for statistical purposes have now been discontinued. Prof. A. Fowler and others are of the opinion that this branch of the work is better left to the workers with the spectroheliograph. Attention will be given in future to individual prominences with a view to recording visually the rapid changes occurring in active outbursts. Small intruments of from 4 inches to 6 inches aperture are very suitable for this class of work, and one would like to see more amateurs giving their time to these very fascinating objects.

The Spiral Nebulæ.

By PETER DOIG, F.R.A.S.

The rapid progress of knowledge, and the changing state of speculative theories of the nature and origin of these objects, perhaps make the compilation of such a paper as the present one rather a risky procedure. Nevertheless the following notes are presented to members, not as containing all the information which could be collected, but as an attempt to sketch the main outlines of the subject in what it is hoped will prove a useful form. The physical data will first be dealt with and later the speculations current at the present time.

Number.

Until recently it was considered that practically all of the great numbers of non-galactic nebulæ are spirals. By means of photographs taken at Lick by the 36-inch Crossley reflector of over 400 regions of the sky, H. D. Curtis,[1] concluded that "at least 700,000 and very probably 1,000,000 small spirals are within reach of large reflecting telescopes." These small nebulæ were not, however, clearly distinguishable on the photographs as certainly spiral in shape, and lately more detailed study with the largest telescopes has shown that probably only a small fraction are spirals and that the shapes most frequently to be met with are spheroidal and spindle.[2] Probably the numbers quoted are too large, but in any case it is likely that those nebulæ with spiral arms do not comprise more than one or two per cent. of the total,[3] although the spiral formation is very possibly a late stage in the life-history of most of these spheroidal or spindle forms.

Distribution.

For some time it was commonly believed that there is a concentration of spirals towards each galactic pole. The work of Hinks, Hardcastle and Reynolds has shown that galactic longitude is at least as important as latitude. From a study of nearly 400 spirals of 2′ diameter or larger, Reynolds[4] has found that there is a wide band of spirals in the Northern Galactic Hemisphere (N.G.H.) stretching from Ursa Major to Virgo through the north pole of the Galaxy, but with no particular concentration round that point. In the Southern Galactic Hemisphere (S.G.H.) there is no special polar concentration observed. It is of particular interest to note in passing that, "broadly speaking, spirals and globular clusters are mutually exclusive,"[5] the one class being numerous where the other is scarce.

Disposition in Space.

The same authority points out that the spirals seem to be more numerous on the North side of the Milky Way, and that the five largest are to be found on the South side of the galactic plane, these facts suggesting that the Galaxy is situated eccentrically with regard to the system of the spirals. He also finds that there are, however, more spheroidal nebulæ in the S.G.H., indicating perhaps that there is a later stage of development amongst the spirals of the N.G.H.[6] Brown and Reynolds further have shown[7] that the planes of the spirals as revealed by the ratios of their axes of figure seem to be more often inclined at small angles to the line of sight than would be expected if random arrangement prevailed. With random inclinations there should be equal numbers inclined at angles to the line of sight greater and less than 30°, whereas they come out as in the following table, which also gives the average angles of inclination for groups arranged by grades of size :—

Size.	No. under 30°.	No. over 30°.	Average Inclination.
10′ and over	19	8	21°·9
5′ to 10′	58	24	24·2
3′ to 5′	95	59	26·7

It may be remarked, however, that the relationships shown in this table have been attributed to a possible greater surface brightness in an object seen inclined at a small angle to the line of sight, whereby larger numbers of those at small inclinations would be visible.[8] Gregory has recently found evidence of an avoidance of parallelism with the plane of the Galaxy which is more marked in the case of the larger spirals.[9]

Spectra.

Various investigators [10] have found the spectra of the nuclei to resemble F—G type. In Professor Dingle's book "Modern Astrophysics," p. 325, the following useful summary is given : "There is a fair amount of variety. Fath finds an almost continuous sequence from spectra consisting chiefly of bright lines (including the characteristic nebular radiations at λλ 5007, 4959) to absorption spectra of K type. It does not appear that the spectra of the arms have been studied, but Seares has shown that, in spirals, whose nuclei show a spectrum approximately of solar type, the arms are decidedly bluer than the nuclei. This would point to an earlier type of spectrum for the arms. There is nothing in the spectra of spiral nebulæ, so far as we know, of a novel character." The studies of "effective wave-length" by Lundmark and Lindblad have also given results corresponding to spectra of from G to K types.[11] It is of interest to note that Fath has found that the integrated light of the Milky Way gives a G type spectrum. On the other hand, however, it has been shown by Seares[12] that the surface brightness of the Galaxy viewed from a distant point would probably be much fainter than that of the average spiral nebula.

Nature and Distribution of Luminosity.

Reynolds has repeatedly referred to the textureless appearance of the nebulosity in many spirals, rendering it difficult to consider their material to be other than gaseous or of dust clouds. They are of two main types, the condensed and uncondensed, the former having, especially in the outer regions, a considerable number of star-like points and condensations which may be of a stellar nature. Some spirals, especially of the uncondensed type, show a dark line or band in those seen "edge on." This band is probably due to the absorbing action of cooler matter at the edges of the spiral and is not seen in the case of the condensed type. The typical uncondensed spiral is M. 64 and the light curve, if shown for the brightness across the central region, would in such cases be an almost continuous curve from zero at the extremities to a high peak in the centre. Reynolds[13] states: "The heaping up of light in the nucleus in spirals of this type is usually very great, the light curve approximating in the case of the Andromeda nebula to the inverse square (x^2y = constant) and in the others to the curve xy = constant, while in the periphery illumination ceases altogether, and there appears a dark area of absorbing matter, which is often very conspicuous in photographs of spirals having their planes inclined at a small angle to the line of sight." M. 81 is a good example of a partly condensed spiral, while M. 33 is typical of the condensed variety.

Motions.

For the average annual proper motion of 66 spirals Curtis has found 0″·033 and Lundmark has obtained a similar value. This proper motion was at one time thought to be spurious and due to accidental errors in the measurements, but is now believed to be of the right order of magnitude.[14] The radial velocities of about 40 spirals have been found to average 625 km./sec., which is much higher than the velocities of any other class of object. All of the velocities, except in the case of five, are recessive. Four of the five are for objects grouped together at about 30° South galactic latitude, including the Andromeda nebula and M. 33 Trianguli. The fifth is in the N.G.H., also at a comparatively low galactic latitude (39°) and the velocity concerned is very small, being only —30 km./sec. These velocities are much below the average, varying from —25 to —300 km./sec., and may therefore—particularly as the galactic latitude is low—be the component in the line of sight of movements really recessive from the galactic plane.

Internal Movements.

Recently van Maanen has measured unmistakeable movements in several of the larger spirals, M. 33, 51, 63, 81, 94, 101 and N.G.C. 2403, which are best interpreted as motion outwards along the arms.[15] Taken as rotations these movements indicate periods of the order of 10^5 years. Rotational line-of-sight velocities for points about 2 minutes of arc from the centres of the nuclei have been measured spectroscopically by Pease, Slipher and others, who have found an average value of about 170 km./sec. for three objects (M. 81, 31 and N.G.C. 4594).[16]

Novæ.

Over 30 nova-like objects have been observed in several of the larger spirals. Two of these have been much brighter than the others, reaching 7·0 m. at their brightest; one, Nova Andromeda, appearing in M. 31 in 1885 and the other, Nova Centauri, in N.G.C. 5253 during the year 1895. The magnitudes of the others averaged about 17·0 m. or 10,000 times fainter. Lundmark[17] has studied the light curves of the Andromeda and Centaurus objects and also of several of the fainter stars which have appeared in M. 31, and finds that the curves were similar to that of a typical galactic Nova. Unfortunately no spectroscopic observations of value were made of the 1885 and 1895 stars and the others are too faint for even the most powerful means, so that it is not definitely known whether they are similar in other respects than variation of light, to the ordinary temporary star.

Parallaxes.

Various methods have been used to estimate the parallaxes of spirals. No direct trigonometrical measurement is possible as the parallax due to the Earth's annual orbital movement is quite inappreciable at the distances which seem to be involved. From the mean proper motions and the radial velocities quoted above a mean parallax of 0″·00025 may be derived.[18] Some doubt has been cast on the validity of this method owing to the systematic nature of the radial velocities.[19] However, the average galactic latitude being high and the real general direction of movement being very probably on the average *from* the Milky Way, the mean radial velocity in the line of sight (625 km./sec.) is possibly greater than the average transverse component of movement to which the mean p.m. of 0″·033 corresponds. If we can take this to be the case, then the value of 0″·00025 is possibly in the nature of a *lower* limit for the mean parallax of the 66 spirals concerned. If the average of these spirals be representable by one situated at 60° galactic latitude, moving at right angles to the galactic plane, the radial velocity in the line of sight being 625 km./sec., then the transverse component would be 625 × cot 60° or 360 km./sec. and the parallax 0″·00043, instead of 0″·00025. In any case it would appear likely, assuming the substantial accuracy of the proper motion 0″·033, that the average parallax cannot be much smaller, as otherwise the velocities concerned, which are already very great, would have to be materially increased. Another method is based on the observed rotational velocities and periods (170 km./sec. and 10^5 years respectively) and from this a value closely in accordance with the foregoing result is obtained,[2] *i.e.*, 0″·00021. A third method is based on the assumption that the novæ in spirals are similar to those in our galactic system. In the first place we may take the two 7·0 m. stars of 1885 and 1895, and assuming them to have been of abs. mag. — 7 (a likely value for galactic novæ),[21] we obtain $\pi = 0''\cdot00016$, which is of the same order of size as the two values given above.[22] On the other hand, if the 17 mag. objects (a number of which have appeared in the Andromeda nebula) are assumed to be — 7 abs. mag., the parallax derived is one hundred times smaller, the absolute magnitude of the two bright objects then being — 17, which is a luminosity equal to the combined light of more than 600 million stars like our Sun! It appears very probable, therefore, that the ordinary nova-like object in spirals is not of the galactic nova order of brightness but very much fainter in reality, although the 1885 (Andromeda) and the 1895 (Centaurus) objects may have had the rank of a typical nova. Another method of estimating the parallaxes of spirals is derived from Jeans's theory of the development of these objects, which will be referred to later.

Dimensions and Masses.

The diameters corresponding to parallaxes as derived above are of the order of 10^5 to 10^7 times the diameter of the Earth's orbit or, say, several scores or hundreds of light years. Van Maanen[23] has shown that the period of rotation of M. 101 derived by him (85000 years) and a parallax of the order of $0''\cdot0002$ would correspond to a mass of several hundred million times the Sun.

Nature and Origin.

There may be said to be two theories of the nature of the spiral nebulæ. One is that they are Island Universes so remote that the separate stars of which they are composed are not discernible, the nebulous appearance being thus explained. The other theory is that they are composed of dust and gas clouds shining by light reflected from stars contained in them, or possibly from the general stellar illumination of the Milky Way.[24] The convergence of ascertained facts seems to the writer to be distinctly toward the second of these two theories, some of the points in favour and against either being set out below.

From their distribution, disposition in space, and radial motions, it appears that spirals are systematically related to the Galaxy in a manner most unlikely for separate stellar systems of a nature similar to our own. Their absence from low galactic latitudes has been explained as due to obscuring cosmic clouds, but as the very distant globular clusters are found at even lower latitudes, this explanation does not seem to be convincing. Their spectra are perhaps more easily explained by the Island Universe theory, but the presence of bright lines is then a difficulty. The integrated spectrum of our Milky Way does not contain bright lines, but nevertheless is similar to that of the average spiral. As already pointed out, however, the surface brightness of our Galaxy is much less than that of a typical spiral. The distribution of luminosity suggests reflection from a source near the nuclei, especially in the uncondensed type, which (together with the occasional presence of bright lines) is perhaps against the idea that the luminosity is reflected light from our Galaxy, but is also adverse to the separate Universe hypothesis. Their internal movements as measured spectroscopically by radial velocities, and by rotations or radial motions shown in displacements on photographic plates, appear to correspond to dimensions much smaller than those attributed to our Galaxy. Indeed if the spirals are of galactic dimensions their observed internal movements would seem to entail peripheral velocities of the order of the speed of light itself. On the theory of unresolved clusters of galactic dimensions the Novæ observed in spirals seem to be of impossibly high luminosity in the case of the brightest. On the other hypothesis this is not the case, although the fainter novæ are then certainly not similar to galactic temporary stars. By the theory of Jeans[25] the spirals are assumed to have been rotating and contracting masses of gas or dust which have assumed lenticular shape and then later developed spiral arms as the result of tidal disturbance by surrounding stars. These spiral arms break into separate masses (supposed by Jeans to be stars in the making) the average distance between which depends only on the physical and chemical nature of the material.[26] Reasonable assumptions being made, a comparison between the calculated distance of separation of the condensations on the arms and the angular separation observed, gives values of parallax of the order of 0″·001 or less, which correspond fairly well with those found by other methods. The high radial velocities have been thought to support strongly the Island Universe idea, since the relative speeds of separate systems would not be necessarily similar to the speeds found for stars or nebulæ belonging to the Galaxy. An explanation of at least equal plausibility is to be found, however, in the effect of light pressure on dust clouds composed of particles of very small size. This explanation is also attractive from the fact that the motions would be expected to be predominantly away from the Galaxy, and of very great magnitude. As Professor Lindemann points out, "the light pressure upon a particle of appropriate size may rise to eight times the gravitational attraction in the case of the Sun . . . . velocities of recession eight times the maximum gravitational galactic velocities could be accounted for, and this is the order of velocities observed.[27] The redder central parts and the bluer outer regions of spirals are very difficult to reconcile, on the Universe theory, with the concentration towards the centre of our Galaxy of the slow-moving massive bluer stars, and the greater dispersion of the redder stars of higher velocity. It appears probable that our Galaxy, seen from the outside, would have a bluer centre and redder surroundings. Professor Lindemann suggests that in a dust cloud the larger particles would be in the centre and that the difference in colour in spirals is what might then be expected, the smaller outer particles being less capable of reflecting the red light waves.

Perhaps an attitude of suspended judgment on this question is still the truly philosophic one: the writer confesses, however, that he finds this difficult in view of the results of the survey he has attempted.

References and Notes.

[1] *Lick Observatory Publications*, **13**, 13–17.
[2] See *Journal B.A.A.*, **35**, 84.
[3] Reynolds states (*Observatory*, **46**, 306) "The number of actually known *spiral* nebulæ in the sky is certainly under 2,000."
[4] *M.N.R.A.S.*, **83**, 147; *Observatory*, **46**, 306.
[5] Reynolds, *M.N.R.A.S.*, **83**, 152; also **84**, 76.
[6] *M.N.R.A.S.*, **83**, 152.
[7] *M.N.R.A.S.*, **82**, 510.
[8] Opik, *Observatory*, **46**, 51, 165.
[9] *M.N.R.A.S.*, **84**, 456.
[10] Scheiner, Huggins, Wolf, Fath, Slipher.
[11] Lundmark, "The Relations of the Globular Clusters and Spiral Nebulæ to the Stellar System." Stockholm, 1919.
[12] *Mount Wilson Contributions*, No. 191.
[13] *M.N.R.A.S.*, **83**, 384. See also *Mt. Wilson Annual Report*, 1923, pp. 194–5.
[14] Van Maanen, *M.W.C.*, No. 243; Lundmark, *Popular Astronomy*, **30** 623.
[15] *M.W.C.*, No. 260 and others,
[16] Lundmark, "The Relations, etc.," p. 51.
[17] Lundmark, *loc. cit.*, 55. Possibly, however, N.G.C. 5253 is not a spiral; see *P.A.S.P.*, **34**, 293.
[18] From the formula: $\pi m = \frac{4 \cdot 74\, \mu_m}{V_m}$, where 4·74 is the distance between the Sun and Earth in kilometres divided by the number of seconds in a year, μ_m is mean annual p.m., and V_m mean velocity km./sec.
[19] *See* Dingle "Modern Astrophysics," p. 327.
[20] From the formula: $\pi m = \frac{29 \cdot 8a}{V_r P}$, where 29·8 is the circumference of Earth's orbit in km. divided by the number of seconds in a year, a is angular distance in seconds from centre of a point having a rotational velocity of V_r km./sec., and P is period of rotation in years.
[21] *B.A.A. Journal*, **33**, 42.
[22] From $\log \pi = \frac{M - m - 5}{5}$.
[23] *M.W.C.*, No. 118.
[24] Lindemann, *M.N.R.A.S.*, **83**, 354.
[25] *B.A.A. Journal*, **33**, 257.
[26] In this connection, however, see *B.A.A. Journal*, **34**, 365. It does not seem likely that these masses are normal stars.
[27] Lindemann, *loc. cit.*, 356.

The Interferometer.

By Lawrence Richardson.

It does not seem to be widely known that the working of this method can be beautifully illustrated with a comparatively small telescope for the measurement both of double stars and of disks. Apart from a little trouble in arranging the slits, the observation is a very easy one, though usually requiring a high power.

Using a $4\frac{1}{2}$-inch refractor with two slits over the object-glass, each $\frac{3}{8}$ inch wide and about 1 inch separation (centre to centre), a bright star appears as a row of five dots or short dashes (together with much fainter images strung out on a long line of faint light on either side). As the separation of the slits is increased, the bright dots are crowded closer together and also increase in number, so that it becomes very difficult to count them.

If now a double star like Castor is looked at, with the slits set not quite at right-angles to the line joining the pair, two rows of bright dots will be seen, parallel and close together, one a little in advance of the other, thus—

By varying the separation of the slits, the distance between the dots in each row may be varied, while the amount by which one row is in advance of the other remains constant, depending on the separation of the two stars. In this way the bright dots of one row may be brought exactly alongside the dark spaces of the other. Then by setting the slits exactly at right angles to the line joining the pair, the two rows coalesce and the dark spaces or "fringes" disappear. In the case of Castor, one star being brighter than the other, they do not wholly disappear, but become confused and indistinct. The first disappearance was found to occur with slits just under $\frac{5}{8}$ inch separation (narrower slits were used in this case); confusion was also noticed at $1\frac{1}{2}$ inch and again at about $2\frac{1}{2}$ inch (*i.e.*, roughly in proportions of 1, 3, 5), but the dark spaces were very plain at the intermediate positions of 2 inch and 1 inch.

A friend has given me the following formula:—

$$\text{Angular distance (in circular measure)} = \frac{1}{2} \times \frac{\text{Wave-length of light.}}{\text{Distance between slits.}}$$

Taking the wave-length of light as ·00058 mm., and the distance between the slits for the first disappearance as 15 mm., the result is 4″·0, tolerably near, considering the roughness of the measures, to the actual figure of 4″·4.

The obliteration of the "fringes" in the case of a disk may be studied on Mars, but owing to the large size of the disk (8″ or 9″ at present, though less in one direction owing to phase) the slits must be very close. With a separation of 10 mm., Mars appears as three short strokes in tandem with black intervals between; at 15 mm. the strokes are nearer together and the intervals are no longer black, though not fully illuminated; at 18 mm. the intervals have disappeared. This is due to the overlapping of the images of the disk and a wider separation of the slits would, therefore, not bring the fringes back. A low power is sufficient to show the effect with Mars and, knowing what to look for, I have seen it with a $1\frac{1}{2}$-inch telescope.

Further experiment has shown great advantage in using a number of equidistant slits, which give an increase of light and a much better definition.

Lunar Eclipses: the Variation of Illumination and Colour.

By ANTHONY JOHNSON.

Mrs. Maunder's instructive and interesting article, "The Meteor and Aurora Sections and the Upper Atmosphere," in the *B.A.A. Journal*, October 31, 1923, shows very clearly the useful work that could be done by the Members of the two Sections mentioned above.

Although aurora is more of a meteorological than an astronomical phenomenon, yet it might be called the connecting link between these two sciences, and observers in this Section co-operating with those in the Lunar Section possibly could, in addition to the work set forth by Mrs. Maunder, do still further useful work in the interest of the "mother of all the sciences," Astronomy. Observers in both these Sections, co-operating probably, might find out the cause of the strange variation in colour, and illumination, in lunar eclipses.

The cause of the illumination was not known until Kepler showed that it was due to refraction of the sunlight by the Earth's atmosphere; but refraction only partly accounts for the illumination, it does not account for the variation of colour and light intensity.

Published observations of lunar eclipses are all of interest, and they show that (if I may misquote) "One differeth from another in glory."

H. P. Hollis, F.R.A.S., writing in the *English Mechanic*, 1920 April 30, gives the dates and colour of a number of lunar eclipses. The eclipse of 1884 is described as a dark eclipse; total absence of any copper or red colour. 1888 January 28–29: "A brand new penny." 1895 March 11: "Bright colour. A penny after a few months' circulation." 1898 December 27–28: "Dull orange red, but a narrow segment in the N.W. was of a fairly bright orange colour, much yellower and more luminous than the rest of the disc" (Whitmell). 1906 February 9: "Glowing coppery hue. Light eclipse" (Whitmell). 1909 June 3–4: "Dark eclipse, though the whole of the disc was by no means blotted out" (Eddie). 1910 November 16–17: "Light copper, colour more red than yellow." 1917 January 8: "Earth's shadow unusually uniform in tint. Of a dull red" (Ellison). Dark eclipses also occurred in 1601, 1642, 1761, 1816. A. Danjon considers the eclipse of 1921 October 16–17 was an unusually bright one. Dr. Moye reports that the eclipse 1924 August 14 was also an unusually bright one. The prophet Joel (ii. 31) foretold that "The Sun shall be turned into darkness and *the Moon into blood*."

Explanations why one eclipse differeth from another include: refraction; amount of dust, and cloud, suspended in the Earth's atmosphere along the sunset–sunrise line; Zodiacal light, &c. P. H. Hepburn, F.R.A.S. (*B.A.A. Journal*, January, 1911) attributes much to the Sun's corona. But observers agree that an explanation of all the variations has not been arrived at yet. There is, however, another phenomenon which should be considered, and taken into account, in dealing with this very interesting feature of the eclipsed Moon, *i.e.*, the illumination of the Earth's atmosphere by the Aurora Borealis and Aurora Australis. It is known that, on rare occasions, these illuminations stretch from the Arctic and Antarctic regions to within a few degrees of the equator (Angot's "Aurora Borealis") and that in some instances the light intensity is equal to that of the full moon (*Encyclo. Britt.*: "Aurora").

The effect of the Earth's illuminated atmosphere on the eclipsed Moon could probably be found out by observers in the Aurora and Zodiacal Light Section co-operating with those in the Lunar Section. It would not be necessary to wait for a lunar eclipse, but observations could be made at the beginning of each lunation, and photometric measures taken of the intensity of the Earthshine on the Moon, and compared with measures taken of the brightness of the light of Aurora on the same date.

The undernoted observations show the nature of the work that could be done by the combined efforts of these two Sections:—

Our ex-President and Director of the Lunar Section, W. Goodacre, F.R.A.S., writing in the *English Mechanic*, April 16, 1920, says: "On the evening of March 22 the Earthshine on the Moon was very pronounced, and the 18-inch showed a large amount of detail on the unilluminated portion of the disc."

Another correspondent, William Henry, Brooklyn, New York, writing in the same paper of the same date an article entitled, "Great Aurora, March 22, 1920, as seen in Brooklyn": "Probably the most brilliant display of Aurora Borealis ever seen around New York was witnessed by thousands here on the night of March 22."

It does not follow that the brilliant display of Aurora as seen around New York was the cause of the very pronounced brightness of the Earthshine as observed by Mr. Goodacre; but it does show that the Earth's atmosphere was in a very luminous state on this particular night, and that probably accounts for the brightness of the Earthshine on that date. Probably the Earth's albedo is increased on these occasions.

Similar observations, combined with photometric measures, carried out systematically, would do much to prove what effect the Earth's atmosphere, when illuminated, has on the brightness of the eclipsed Moon. But observations taken during lunar eclipses would be of much greater value, as it is obvious that when the conditions are such that the Earth's atmosphere becomes very luminous it will have a marked effect on its shadow.

Magnetic storms and Auroræ are closely associated with certain disturbed areas of the Sun's surface; therefore if the variation in the illumination and colour of lunar eclipses be due to illumination of the Earth's atmosphere by Auroræ, then there should be a relation between the illumination of the Earth's shadow and the solar sunspot cycle.

A. Danjon* has already derived a relation between the brightness of the eclipsed Moon and solar activity. I consider this is not a direct effect due to sunspots, but an indirect effect due to radiations discharged from the sunspot areas striking the Earth, causing magnetic storms and illumination of the Earth's atmosphere by Auroræ, which thus illuminates the Earth's shadow.

Reviews.

Optical Measuring Instruments, by L. C. Martin, F.R.A.S. D.Sc., A.R.C.S., D.I.C., Lecturer in the Optical Engineering Department, Imperial College of Science and Technology, South Kensington. Large demy 8vo. x + 270 pp., with 172 figures. London. Blackie and Son, 1924. Price 17*s*. 6*d*. net.

This work, which is one of the publishers' "Applied Physics Series," is primarily a laboratory text-book, and is, so far as we know, the most complete of its kind in our language. It deals with a great variety of optical instruments used for measurements of precision, and aims at describing the principles underlying their design and adjustment rather than the details of procedure to be observed in their practical application by the regular worker. But the latter, be he physicist, chemist, metallurgist, biologist, surveyor, or astronomer, will find it none the less valuable on this account, for, as the author writes in his Preface, "no user of a tool can study it too thoroughly" and anything which tends to the closer coordination of theory and practice must be to the advantage of both.

The working astronomer who takes a proper interest in the theory of his instruments and in the errors to which they are liable will find some useful information in this book; though, as already hinted, he must not expect to be provided with exhaustive notes on the practice of observing. The standpoint of the author is that of the optical bench rather than the observatory, and the information given supplements rather than replaces that to be found in text-books of practical astronomy.

Among the chapters which may be said to have a direct bearing on astronomical work are those which deal respectively with the divided circle, the parallel wire micrometer, the principles of photometry, focometry, and the errors and accuracy of observation; and these should certainly be read by all practical astronomers interested in precision work. Those whose interest extends to surveying and "the art of navigation" will find also some useful notes on the theodolite, the level, and the sextant. But, in our opinion, those who should most of all derive benefit from the book are the actual designers and constructors of instruments, whether amateurs or professionals. Workers in special and restricted fields of research are far too apt to confine their knowledge and attention to the one particular instrument which they regularly use, and manufacturers are liable to a similar tendency, which shows itself by a marked conservatism in the matter of design. Now, if there is one fact which this book brings out more clearly than any other, it is that the same principles are, with modifications, employed in the construction of instruments of otherwise widely different types. Optical design would appear to admit of no system of watertight compartments, and here lies the value of a comparative study of a large variety of instruments. Such

* A. Danjon, *C.R.*, 171, pp. 1127–1129; pp. 1207–1210, 1920; *C.R.*, 178, pp. 1266–1267, 1924.