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MEETING OF THE ROYAL ASTRONOMICAL SOCIETY.

Friday, 1935 January 11.

Professor F. J. M. STRATTON, M.A., D.S.O., President, in the Chair.

Secretaries: W. M. SMART, M.A., D.Sc. W. M. H. GREAVES, M.A.

The Minutes of the last Meeting were read and confirmed.

The election by the Council of sixteen Fellows was duly confirmed.

Sixty-eight presents were announced as having been received since the last meeting.

The President announced that the Gold Medal of the Society had been awarded to Professor E. A. Milne for his work on "Radiative Equilibrium and Theory of Stellar Atmospheres"; and that a Jackson-Gwilt Medal and gift had been awarded to Mr. W. F. Gale, of Waverley, N.S.W., for his discoveries of comets and his work for astronomy in New South Wales.

The President. I wrote to Mr. Prentice conveying the greetings and congratulations of the Fellows on his discovery of Nova Herculis. I will first call on Professor Sampson to describe some spectra of the nova taken at Edinburgh, and there are several other speakers to follow with their accounts of observations.

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Professor Sampson showed a selection of nine spectra taken with the 36-inch reflector and slit spectrograph of the Edinburgh Observatory, and he read Mr. Storey's notes on the spectra compiled when the original negatives were in the micrometer. The Edinburgh telescope had proved very suitable for getting the nova spectrum which extended on the plates from $H\alpha$ to beyond K. The comparison spectrum used was that of iron.

The first of the Edinburgh spectra was obtained about 24 hours after the discovery of the nova by Mr. Prentice and showed a composite emission band and absorption line spectrum; the continuous spectrum appeared rather weak on the films in comparison with its visual appearance as examined with a McLean star spectroscope.

The spectrum on December 20, when the visual magnitude of the nova was 2^m·15, showed the H and K lines and the continuous spectrum strong with many absorption lines. On December 21, when the nova was observed at its brightest (1^m·85) from Edinburgh, the D lines were present in absorption for the first time; the emission lines were sharp and of medium strength, but the absorption lines generally were less sharp.

A notable feature of the spectrum on December 31 was the great density of the $H\alpha$ line on its redward side. Prof. Sampson also showed a light curve of the nova derived from magnitude observations made at Edinburgh.

Dr. Lockyer described a series of spectra obtained between December 15 and January 7 with the 9-inch and 12-inch prismatic cameras at the Norman Lockyer Observatory. The spectrum taken on December 15 showed the hydrogen lines bright and very broad on the redward side, and the enhanced lines with bright components. The spectrum of December 20, when the visual magnitude of the nova was 2.5, showed a striking resemblance, line for line, to that of α Cygni. Succeeding spectra showed changes which were synchronous with the chief variations of the light curve of the nova.

Dr. Dobbie showed a composite slide made up from spectra, taken on Dec. 15, 16, 19, 20, 21, 27 and 31 with the 25-inch refractor at Cambridge, together with a Fe spark comparison spectrum and a spectrum of α Cygni. The slide showed very clearly the considerable changes that occurred between these dates and the close resemblance on about Dec. 21 to the spectrum of α Cygni. The plates

taken on Dec. 27 and 31 showed a bright band spectrum. An examination of other plates indicated that the second outburst of emission took place on about Dec. 25.

Dr. A. Beer showed some of the 30 spectra, taken at Cambridge with the Huggins 15-inch refractor, covering the region between $H\alpha$ and $H\beta$. Comparison spectra of neon, iron and titanium were used, and the plates were all standardized photometrically. He pointed out the resemblance of the spectrum of the nova to that of α Cygni. The identification of lines showed a number due to ionized iron and ionized silicon; one line of considerable strength has not been identified, but it apparently corresponds with the unidentified line of the solar chromosphere at λ 6155·4.

Doppler shifts of the emission lines on Dec. 18 indicated a mean receding velocity of 145 km./sec., whereas the H α absorption on the same spectrogram gave an approaching velocity of 310 km./sec., Si~II an approaching velocity of 75 km./sec., and Fe~II 140 km./sec. Compared with the velocities of H β , etc. on Dec. 15 and Dec. 16, the velocity of H α on Dec. 18 was decreasing, but between the H α plates of Dec. 21 and 27 a radical change has occurred. A plate taken by M. Beyer at Hamburg on Dec. 25 and sent to Cambridge shows that this change took place between Dec. 24 and Dec. 25.

Dr. Beer showed a slide giving a light curve of the nova since discovery, which had been derived by him from 191 magnitude observations, collected from various published and unpublished sources. He thought that there was no doubt that the major inflexions of the curve were real. In particular, the fresh outburst shown by the spectra between Dec. 24 and 25 was confirmed. maximum, about 1^m·3, seems to have occurred on Dec. 23 in the morning: a second maximum, 2^m·1, in the morning of Dec. 27, and a third one, 1m.7, in the morning of There can be seen three corresponding January 1. minima: Dec. 14 morning, 3^m·8: Dec. 26 evening, 3^m·4 and Dec. 29 evening 3^m·5, in addition to the minor fluctuations already mentioned.

The Rev. T. E. R. Phillips showed a slide of the light curve of the nova derived from observations made in Spain by Mr. P. M. Ryves. The rise to maximum on Dec. 22 was followed by one or two peaks; at the present time the nova appeared to be approximately stationary

in its light, or the oscillations were so small that there was perhaps some uncertainty about them. At Headley the nova had been observed on 15 nights; its magnitude the previous night (Jan. 10) was estimated to be 2.7.

Mr. Greaves said that at Greenwich they had, whenever practicable, photographed the spectrum of a comparison star on the same plate as that of the nova. The comparison star was selected so that at the time of observation it was at approximately the same altitude as the nova. The plates were calibrated for photometry in the usual way, and the presence of the comparison stars, whose colour temperatures were being measured in the ordinary way, made it possible to study the distribution of energy in the spectrum of the nova.

As far as the continuous spectrum of the nova was concerned, it approximated at discovery to a Planck curve, and the colour temperature subsequently fluctuated between fairly wide limits. At the end of December, appreciable variations from a Planck curve set in. If the measures at λ 4000 and λ 6000 were fitted to a Planck curve, then it was found that the intensity at λ 5000 fell below the curve. It would be interesting to see if this departure from the Planck formula developed still further. The Greenwich plates would also be available for measuring the total intensities of the lines.

Father Rowland showed a spectrum of Nova Herculis, extending from H β to H γ , taken at Stonyhurst on January 4.

The President said that at Cambridge spectra of the nova had been secured on 26 nights out of the last 29, and therefore a fairly complete record of the nova during the past month was available for study. The loss of emission from Dec. 14 to 21 and the moving in of the absorption lines from high to low displacement made him think that the first maximum was not before discovery, but on Dec. 21, when the absorption had grown at the expense of the emission.

With regard to the distance of the nova, a first estimate had been made at Cambridge from the strength of the interstellar calcium lines, which, together with the brighter maximum that the nova had reached since discovery, indicated a distance of 200 light years rather than one of 2,000 light years as had been suggested. One point to be noted was that for Nova Herculis the velocity

given by the displacement of $Fe\ II$ absorption lines increased with the wave-length, as Dr. Wright had found for Nova Geminorum 1912.

The President then closed the discussion on Nova Herculis, and asked Dr. Chandrasekhar to give an account of his recent investigation of Stellar Configurations.

Dr. Chandrasekhar read a paper describing the research which he has recently carried out, an account of which has already appeared in The Observatory, 57. 373, 1934, investigating the equilibrium of stellar configurations with degenerate cores. He takes the equation of state for degenerate matter in its exact form, that is to say, taking account of relativistic degeneracy. An important result of the work is that the life history of a star of small mass must be essentially different from that of a star of large mass. There exists a certain critical mass M. If the star's mass is greater than M the star cannot have a degenerate core, but if the star's mass is less then M it will tend, at the end of its life history, towards a completely collapsed state.

Prof. Milne. I have had an opportunity of seeing Dr. Chandrasekhar's paper. We have both been working on the same problem. I had intended to present a paper, written around Mr. Fairclough's latest numerical results, to this Meeting of the Society, but it has been unavoidably delayed. In many ways the methods pursued and the results obtained are the same as Dr. Chandrasekhar's. I have pursued a cruder method of analysis, but I believe that my method gives more insight into the fundamental physical postulates underlying the work, takes account of our ignorance of the behaviour of degenerate matter, and gives a more rational picture. A result common to our theory and Dr. Chandrasekhar's is that the more massive a star, the smaller its radius when completely collapsed. This has a bearing on the Russell diagram.

The President. Fellows will wish to return their thanks to Dr. Chandrasekhar. I now invite Sir Arthur Eddington to speak on his paper "Relativistic Degeneracy".

Sir Arthur Eddington. Dr. Chandrasekhar has been referring to degeneracy. There are two expressions commonly used in this connection, "ordinary "degeneracy and "relativistic" degeneracy, and perhaps I had better begin by explaining the difference. They refer to formulæ expressing the electron pressure P in terms of the electron

density σ . For ordinary degeneracy $P_{\sigma}=K\sigma^{5/3}$. But it is generally supposed that this is only the limiting form at low densities of a more complicated relativistic formula, which shows P varying as something between $\sigma^{5/3}$ and $\sigma^{4/3}$, approximating to $\sigma^{4/3}$ at the highest densities. I do not know whether I shall escape from this meeting alive, but the point of my paper is that there is no such thing as relativistic degeneracy!

I would remark first that the relativistic formula has defeated the original intention of Prof. R. H. Fowler, who first applied the theory of degeneracy to astrophysics. When, in 1924, I suggested that owing to ionization we might have to deal with exceedingly dense matter in astronomy, I was troubled by a difficulty that there seemed to be no way in which a dense star could cool Apparently it had to go on radiating for ever, getting smaller and smaller. Soon afterwards Fermi-Dirac statistics were discovered, and Prof Fowler applied them to the problem and showed that they solved the difficulty; but now Dr. Chandrasekhar has revived it Fowler used the ordinary formula; Chandrasekhar, using the relativistic formula which has been accepted for the last five years, shows that a star of mass greater than a certain limit M remains a perfect gas and can The star has to go on radiating and never cool down. radiating and contracting and contracting until, I suppose, it gets down to a few km. radius, when gravity becomes strong enough to hold in the radiation, and the star can at last find peace.

Dr. Chandrasekhar had got this result before, but he has rubbed it in in his last paper; and, when discussing it with him, I felt driven to the conclusion that this was almost a reductio ad absurdum of the relativistic degeneracy formula. Various accidents may intervene to save the star, but I want more protection than that. I think there should be a law of Nature to prevent a star from behaving in this absurd way!

If one takes the mathematical derivation of the relativistic degeneracy formula as given in astronomical papers, no fault is to be found. One has to look deeper into its physical foundations, and these are not above suspicion. The formula is based on a combination of relativity mechanics and non-relativity quantum theory, and I do not regard the offspring of such a union as born in lawful

wedlock. I feel satisfied myself that the current formula is based on a partial relativity theory, and that if the theory is made complete the relativity corrections are compensated, so that we come back to the "ordinary" formula.

Suppose we are dealing with a cubic centimetre of material in the middle of a star. Ordinarily we analyse this into electrons, protons, etc., travelling about in all In wave mechanics, the electrons are repredirections. sented by waves. There are two kinds of waves, progressive and standing. In the ordinary analysis of matter into electrons one is dealing with progressive waves; but in the analysis which leads to the Exclusion Principle (used in deriving the degeneracy formula) the electron is represented by a standing wave. Now an electron represented by a standing wave is a quite different sort of entity from the electron represented by a progressive The former is constantly changing its identity. I might compare the progressive wave with Professor Stratton and the standing wave with the President of the Royal Astronomical Society; only, to make the analogy a good one, the Society would have to change its President gradually and continuously, instead of suddenly every two years. The formulæ which apply to such a President would be different from the formulæ which apply to an ordinary individual; and this point has a definite bearing on the question. The electron represented by a progressive wave can be brought to rest by a Lorentz transformation, and it then becomes a standing wave. This transformation introduces a factor into the equation, which is not needed if the waves referred to are standing waves originally. My main point is that the Exclusion Principle presupposes analysis into standing waves, and this has been wrongly combined with formulæ which refer to progressive waves.

The President. The arguments of this paper will need to be very carefully weighed before we can discuss it. I ask you to return thanks to Sir Arthur Eddington.

There is a paper by Dr. Woolley on "Oscillator Strengths", and I ask him to describe it to us.

Dr. Woolley. The continuous absorption coefficient of a stellar atmosphere is usually calculated from Kramers' theory, but the oscillator strengths of the atomic transitions in the continuous spectra at the head of series of lines offer an alternative method. The only completely

calculable case is hydrogen, where the oscillator strengths yield a result agreeing with Kramers' theory. When we come to the alkalis, Na and K, Kramers' theory, as used by Biermann, requires oscillator strengths that seem to disagree with experiments by Korff and Heard on the laboratory widths of the lines. If we assume that the solar absorption coefficient is approximately constant, we can calculate a mean oscillator strength for the continuous spectra of metals. The result is 2×10^{-6} . A sharp discontinuity is not to be expected at a series head, and there exists a mechanism, namely fluorescence, which tends to wash out large variations in the absorption The competition between fluorescence and coefficient. absorption is illustrated by the ultra-violet spectra in B type stars, some of which have a depression beyond the Balmer limit and some an "ultra-violet appendage". Since the abnormally yellow B stars show strong ultraviolet appendages, it is tempting to speculate whether the yellow colour is not due to a fluorescent appendage on the Paschen series. A plate showing the spectrum beyond the head of the series on an abnormally yellow B star would clear up this suggestion.

The President. I will ask Fellows to return their thanks to Dr. Woolley for this paper. We have now a paper from Dr. Smart.

Dr. Smart. It is usually recognised that, in general, stellar parallax is one of the least accurate quantities measured to-day, and for many purposes, especially in the case of faint stars, we are dependent on statistical methods based on stellar motions. The present investigation is the result of reading a recent paper by F. K. Edmondson *, in which he derives the following formula (which has the merit of extreme simplicity in its numerical application):

$$p=3.02\mu_0/R_0$$
, (1)

where p is the mean parallax of a group of stars and μ_0 , R_0 are the mean observed proper motion and radial velocity respectively, in each case taken without regard to sign. It is easily proved that in an assembly of stars moving in a haphazard manner,

$$p=3.02\mu/R$$
, (2)

where μ is the mean proper motion due to the transverse

* A. J. 42. 22 (1932).

peculiar linear velocity and R is the mean peculiar radial velocity, again in each case taken without regard to sign. When the solar motion is taken into account, Edmondson identifies (I) with (2); the substance of his proof is that $R_0 = f_1 R$, $\mu_0 = f_2 \mu$ and that $f_1 = f_2 = 1$, and that accordingly the true formula (2) leads to (1). It is not difficult to see that these arguments are erroneous. In deriving a formula of the type of (1), it is necessary to take into consideration the preferential motions of the stars, and in the paper I establish several theorems on the basis of the two-streams theory which appeared to afford advantages in the mathematical analysis over the ellipsoidal theory. In particular, I obtain functional expressions for f_1 and f_2 of very different mathematical form, but which can be proved to be identical. with the usual stream-constants $f_1 = f_2 = 1\frac{1}{2}$ approximately. The result is that the very convenient formula (1) is true —it is not often that one sees such a cancellation of correcting factors.

The thanks of the Fellows were returned to Dr. Smart, and the Meeting was then adjourned until March 8.

MEETING OF THE BRITISH ASTRONOMICAL ASSOCIATION.

1935 January 2.

Dr. H. Spencer Jones, *President*, in the Chair.

The President said that since the last meeting an important discovery had been made by a member of the Association, namely, the discovery on the morning of December 13 of Nova Herculis by Mr. Prentice. No other report of an independent discovery of this nova had been received, so that Mr. Prentice was the sole discoverer. He invited Mr. Prentice to tell members about his discovery.

Mr. Prentice said that he had come to hear about the behaviour of the new star rather than to speak of it, yet, perhaps, a plain and unvarnished account of its discovery might be a novelty after the sensational accounts in the Press.

On the nights of Dec. 11, 12 and 13 the maximum of the