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ASTRONOMICAL RESEARCH DURING 1929

(Retiring President's Annual Address, February 4, 1930.)

By W. E. HARPER

Before beginning my address may I have the privilege of expressing my appreciation of the generosity of the members of the Royal Astronomical Society of Canada in having elected me last year as their President for a second term, and this too in spite of the fact that some 3,000 miles separated me from the Headquarters of the Society, making it impossible for me to shoulder many details of office. In consequence, these were laid on others' shoulders and my best thanks are due to the Vice-President, Dr. R. K. Young, who has done most of the work, while I have been accorded the honour.

Popularizing Astronomy. I referred in my last address (see JOURNAL for March, 1929) to the need of making the Editor's task as light as possible by furnishing him with suitable material to pick and choose from. I think the JOURNAL at present is meeting the need for which it was intended, is exceedingly well got up, and reflects much credit on the Editor, Professor C. A. Chant. Realizing, however, that our Society should try and reach a wider audience than comes in touch with astronomical science through our meetings in various Centres or through the columns of our JOURNAL, or even the unseen listeners over the radio, your president was able to interest a syndicate of newspapers the past year to publish brief popular articles on astronomy. These, as many of you know, are prepared by some of our leading members and appear fortnightly in the Southam Newspapers in Hamilton, Ottawa, Winnipeg, Cal-

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gary, Edmonton and Vancouver. The Victoria *Colonist* and Halifax *Herald* have also purchased the rights to the series and are using the articles. Other papers, we trust, will follow suit. Two benefits accrue. Firstly, a wider circle of readers in Canada is becoming interested, as the articles are such as to attract the average person. Secondly, the treasury of our Society benefits financially for each article published more than a Life Membership costs. The hope is expressed that some of such monies might well establish a fund to provide some instruments for research upon a simple problem in which a number of our members from the Atlantic to the Pacific could have a share.

It seems to be the custom for the Retiring President to give in his address at this meeting a résumé of the progress achieved in the science during the year just closed. I wondered if I could not break away from the custom and choose something else, but I found that almost every subject upon which I might hope to say something had been touched upon recently in your gatherings. Rather reluctantly, therefore, I have fallen back upon the customary topic. The preparation of the material for such an address would be much easier if one could only postpone it for a month or so, for then the valuable summaries which are given in the *Monthly Notices* of the R.A.S. would be available. However, the digging out of the material at first hand and the necessary sifting and condensing of that which would be suitable to present on this occasion is an education in itself. Particularly is this true in my own case for in the rush of observational and computational work I find all too little time to even read, much less digest, what other similar workers are doing.

I shall follow roughly the plan I adopted last year and deal first with

1. The Solar System

Solar Activity. The average daily number of sun spots reached a maximum in 1928, the Zurich numbers rising from 5.8 in 1923 to a maximum of 77.8 in 1928. When the areas of the sun spots are made the basis, however, the curve of activity has two maxima, one in 1926 and one in 1928, with a slight depression for 1927. The

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maximum is thus somewhat of a rounded form, but 1928 would probably be a better date to assign than 1927 as stated in my address of a year ago.

Taffara at Catania, Italy, from a study of the curve of solar activity as given by all its forms,—such as spots, prominences, faculae, etc.—shows that there is a tendency for successive maxima to be alternately high and low. Now from the work of Hale and his associates at Mount Wilson we have learned of the alteration of the polarities of sun spot groups in succeeding cycles as if the true period were just double the 11½ year one generally accepted. Taffara's findings, that a high maximum alternates with a low, is therefore in harmony with the longer period hypothesis.

Stetson is reported as stating that a 15-month cycle is superimposed on the longer cycle. Investigations by him and Pickard seem to show that radio reception is poorest when sun spots are active and thus radio reception should improve during the next few months.

It has long been known that at the beginning of a sun spot cycle the spots appear in high latitudes and gradually move towards the equator, dying out as minimum approaches at a latitude of about 10°. Statistics are now being kept as to their distribution in longitude also, and it is learned that the activity is greater in one quadrant than in the others, but that a gradual shifting to other quadrants appears to be the rule.

While we are definitely on the downward slope of the curve nevertheless large spots have recently been seen and may naturally be expected at occasional intervals. In the year 1920, three years after the maximum had passed, the most extensive stream of sun spots that had been witnessed in fifty years was a feature of the solar surface.

Solar Eclipse. Plans were made by several American, English and German astronomers to photograph the total solar eclipse of May 9 last, in Sumatra and other South Sea regions. Partially cloudy skies militated against the success of the English astronomers at Alor Star, Kedah, but some photographs of the corona were obtained. The results of the other expeditions have not been fully worked up yet. The form of the corona has been described

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by some as of the maximum type, by others as of an intermediate type. More than fifty years ago it was noted that there was a connection between the phase of the sun spot cycle and the form of the corona. Broadly speaking, at a maximum the surrounding corona is more uniformly distributed around the disk, whereas at minimum it is elongated in the equatorial regions and with short little brushes emanating from the poles. As data could only be accumulated at total solar eclipses, our information grew slowly, but using the photographs to date, Ludendorff and, later, Mitchell, have measured the eccentricity of what may be called the coronal boundary, one radius distant from the limb. At maximum, as just stated, it is zero; a year or so before minimum it is 0.30. Mitchell looks upon the coronal spectrum as predominantly solar, the radiation having its origin in the electron, the coronal light bearing the same relation to our sun as the nebulosities which are kindled into luminescence by high temperature stars associated with them.

Coronal Brightness. It has been generally accepted that the total brightness of the corona is one-millionth of that of the sun or about half that given by the full moon. According to an announcement card from Harvard, Stetson at the total solar eclipse of May 9 last measured the brightness as 1/33,000 of that of the sun, a figure considerably higher than previously accepted.

Elements in Sun. A by-product of the revision of the wave lengths of Rowland's Tables of Solar Wave Lengths has been an increase in the number of elements known to be present in the sun. The identification of solar lines with those of elements found upon the earth rests primarily upon comparison of wave lengths, but not wholly so. Recent progress in our knowledge of the ionization behaviour of many elements and series relations in spectra enable us to know what lines to look for once the principal lines have been identified. In such ways St. John and his collaborators at Mount Wilson have established the presence in the sun of 58 of the 92 possible elements. Freeman thought he had identified argon in the corona, but Russell and others refute the idea.

Age of Sun. Eddington's new conception that dwarf stars radiate energy as well as giants, by reason of their stripped and crowded atoms, gives virtually a longer life to the atom, and accord-

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ing to Jeffreys the age of the sun can the more readily be brought into accord with geological determinations.

Origin of Solar System. Theories of world building are always of interest and Jeffreys has recently modified the original suggestion of Buffon to account for the origin of the solar system. Of late the general conception has been that through the close approach of another star, tidal action has pulled the planetary matter out of the original sun. Jeffreys now considers that the observed facts will be better satisfied if an actual collision rather than a near approach had occurred in the long ago. On either theory rotation is imparted to the planets by the return to them of matter torn asunder by the tidal action of the sun at their perihelion passages. On the newer assumption the periods of rotation of the larger planets would be of the order of 8 hours, a value more in agreement with observation than values deduced from the near approach theory. Under the older hypothesis the possibility of such an encounter was exceedingly small; with the newer actual collision theory the chances are naturally very much smaller so that, if the collision theory be the correct one, solar systems like our own must be exceedingly rare in the universe.

Moonlight. Minor researches have been carried on upon the light of the Moon. Danjon, with an ingenious cat's-eye photometer, has compared the earth-shine with the light from the illuminated crescent and finds the former much bluer in quality. This earth-shine is sunlight which is reflected to the moon from our earth, principally from our atmosphere. Since it is bluer than ordinary moonlight it must have been less scattered; consequently our atmosphere is not so rough a reflector as the moon's surface, a finding of course quite to be expected. The earth's albedo is given as 0.29, a figure much less than previous values.

Millman and Keenan have investigated the light of the eclipsed moon taking advantage of the total lunar eclipse of Nov. 27, 1928. Keenan photographing through four colour filters from ultra-violet to infra-red finds light of all wave lengths diminished in intensity to about 1/10,000th of its normal value with the red and infra-red rays weakened slightly less than the others. Millman finds the red increased in intensity with respect to the blue as the moon comes out of the umbra.

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Moon's Atmosphere Negligible. Following out his general colour survey of the brighter planets and the moon, Wright has photographed the latter object in ultra-violet and extreme red light. One recalls that in the case of Mars, which has a considerable atmosphere, the details of its surface which were brought out on plates sensitive to the infra-red were completely obliterated on the ultra-violet photographs. While such a difference is not to be expected for the moon, due to its well-known lack of an atmosphere, yet it was thought possible that there might be a diffusion of light of short wave length which would tend to soften the intense blackness of the shadows so characteristic of the moon's surface. The conclusion reached was that there seemed to be no difference between the photographs; the blackness of the shadows was as great in ultra-violet light as that of the extreme red. Thus we have confirmatory evidence of the complete absence of any atmosphere surrounding the moon.

Earth's Rotation Period Variable. Irregularities in the moon's motion have of late years been connected with a variable rate of rotation of the earth upon its axis. Confirmatory evidence seems to be forthcoming from similar, though much smaller, residuals in the sun's longitude as tabulated from Greenwich observations of the past 150 years. The new reduction leads to a much closer resemblance between the curves of solar and lunar residuals than has previously been obtained, and thus strengthens the hypothesis that the cause of these fluctuations lies in the earth's rotation, not in the bodies themselves.

Markings on Jupiter. Marked changes of late have been occurring in the surface markings of Jupiter. Last year a long series of small, dark spots occurred in the south equatorial belt with a rotation period of 9h 59m. As the average rotation period of the planet is four minutes less, these were moving *eastward*. The last few months have witnessed a revival of activity in the north temperate zone, a belt of spots extending over half the circumference, and having a rotation period of 9h 49 m showing that they had a general *westward* motion on the surface. They appear similar to the great train of spots which appeared in 1880 and which in a month's time came together to form a new belt.

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It has been suggested that a huge, cold atmosphere of hydrogen, and perhaps helium too, overlies the surface of Jupiter, as it has been shown by the radio-metric measurements at Flagstaff and Mt. Wilson to have a surface temperature 150 degrees below zero Centigrade. Perhaps a study of the newly formed belts may help to throw some light on the constitution of this planet's atmosphere.

Minor Planets. About 100 new minor planets are being discovered yearly so that the total number at the end of 1929 is of the order of 1,300. On September 26 one was discovered with a rapid motion, which later was found to have a period of 4.375 years, and which at perihelion passage comes within the orbit of Mars. Using the 36-inch telescope of the Lick Observatory and the one-prism spectrograph, Bobrovnikoff finds the light of the asteroids is wholly reflected sunlight. There seems to be evidence that the composition of the asteroids differs among themselves as judged by the colour of their reflected light.

Meteors. Luyten has examined the Great South African find of iron and pronounced it to be a genuine meteorite. Its mass is of the order of 50 tons and thus it is the largest known. Olivier is quoted as saying that most of the meteors observed are moving in hyperbolic orbits and thus originate, not in the solar system, but somewhere in space.

New Comets. Four new comets were discovered during 1929, (a) by Schwassman and Wachmann in the course of photographing minor planets at Bergedorf; (b) by Neujmin at Simeis, August 2; (c) by Forbes at Cape Town, August 1; and (d) by Wilk at Cracow, December 21. The second has a period of 10.79 years while the third is 6.44 years. A good list of all the periodic comets having periods less than 170 years is given in *l'Astronomie* for May last.

Origin of Comets. Bobrovnikoff has discussed the statistics of 94 comets and has found a relation between the period and the brightness. Long period comets are the brightest, as if frequent returns to the sun caused the dissipation of the light-giving possibilities of the comet. The indicated rate of loss of light leads to the conclusion that comets are not original members of the solar system but have become attached to our system at some time in the immed-

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iate past. He suggests a million years ago as the time of capture when our solar system was passing through the nebulous regions of Orion. One possibly ought to accept the conclusions with reserve but the connection between period and brightness is very interesting.

Heights of Aurorae. Störmer obtained good photographs of aurorae for height at three stations on March 15 last. The highest rays extended up to 700 km., where they were in full sunshine. Their lowest points were found to be on the boundary between sunlit and dark atmosphere. Lower rays were also observed. Some commenced in sunlight, became invisible near the boundary and deeper down in the shadow again became visible apparently where the density of the air is great enough to excite luminosity.

2. The Stellar Universe

Velocities of A-type Stars. In the latter part of the year there were issued the Yerkes results for the radial velocities of 500 stars of A- type, brighter than the sixth magnitude. Many of these have been under observation for some years and nearly one out of every three is known or suspected to be binary in character. Eight spectrum plates on the average were made of each star. Some three dozen observers or measurers have co-operated in the programme which was started about 1901. There are 265 stars in the list for which the Lick Observatory have also published results and the Yerkes are on the average 2.3 km. more positive than the Lick. Considering only 56 stars with many good lines this discordance decreases to 0.8 km. so that Frost and his co-authors believe their results are systematically 1 km. too positive.

In this connection brief mention may be made of the writer's own work on the A-type stars which deals with those within reach and brighter than 6.5 magnitude. While primarily intended for absolute magnitudes, nearly all have been measured for radial velocity. Including those obtained on the first Boss programme, between 1100 and 1200 are now available.

San Luis Catalogue. A catalogue of 15,333 stars has been published by the Carnegie Institution of Washington, giving the positions and magnitudes of these stars observed by Tucker and

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his associates at San Luis in 1911, as part of the Albany programme under Boss.

Parallaxes. Several lists of parallaxes have been issued during the year. Mention may be made of Alden's list of 50, being some of the first fruits of the Yale Southern Observatory. His redetermination of Alpha Centauri by modern methods gives a parallax of 0".757, almost identical with earlier results.

A list of dynamical parallaxes has been issued by Russell and Miss Moore. Owing to the recently established relation connecting mass with absolute luminosity, the masses of binary stars can be more closely estimated than formerly was the case, and as the parallax varies only as the cube root of the mass, such parallaxes are now considered the equal of the spectroscopic. Fairly good values can be obtained even when only a portion of the visual orbit has been completed.

Scutum Cloud. A study of the distances of galactic clouds is always of interest as affording a comparison with the condensations in the spiral nebulae. Many determinations have been made of the distance of the Scutum Cloud, in the brightest region of the Milky Way. The results varied between 1,500 and 7,000 parsecs and the need for a more rigid determination has long been felt. By determining spectral types both directly and by colour indices, and also obtaining the photographic magnitudes down to the limit of 18 mag., Krieger, at the Lick Observatory, has made a new determination on the usual assumption that the range of absolute magnitude within each spectral subdivision is small. As 1950 stars were used in his discussion his resulting value of 2,800 parsecs for the distance ought to be entitled to considerable weight.

Southern Milky Way. Pannekoek has issued from Lembang, Java, an extensive dissertation on the southern portion of the Milky Way. Numerous drawings are reproduced showing the brighter stars and the background of faint ones, and estimates of the brightness at various regions are given.

Distribution of A, K and B Stars. The same author, in a Memoir from the University of Amsterdam, his own University, deals with the space distribution of the A, K and B stars. As the basis of his work he uses the Henry Draper Catalogue from which

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counts of stars of the A and K divisions were made between magnitudes 4.25 and 8.25. Assuming the average absolute magnitudes of the A-types as 0.9 and of the K0-type, 0.7, after the dwarfs were eliminated, he deduced the corresponding distances of the various groups into which he had divided them. The B-type stars having a greater dispersion, had to be treated individually, using mean absolute magnitudes for each subdivision as given by Adams and Joy at Mount Wilson. His general aim is to determine the density distribution. He finds many well-known groups of B-type stars and every such group is at the same time a condensation of A stars. On the other hand there are many A-type condensations from which the B's are entirely absent and in these latter groups K-type stars are found to be very abundant.

Variable Stars. Considerable work has been done upon variable stars not only upon their light curves, but theoretical work which seems to indicate that the difference between the short-period variables, the Cepheids and long-period variables is only one of degree. Observational results and light curves are given by Jordan for 16 eclipsing variables.

Period-spectrum Relation. Adams and Joy, using 64 Cepheids and 44 long-period variables, with a number also of the cluster type, showed that, barring minor discrepancies, there was a linear relation connecting length of period with the type of spectrum involved. The cluster type variables with periods averaging half a day, are of fairly early type, the Cepheids with periods of a week or so, are of solar type, whilst long period variables of one or two hundred days are reddish m-type stars.

Distinct gaps occur between some stars, which are somewhat bridged over by Gerasimovic in his discussion of eleven stars of the RV Tauri type of varaible.

Shapley, with extensive new data at Harvard, discusses the period-spectrum relation anew and concludes that the pulsation hypothesis can be logically extended to the long-period variable as well, on the basis of the observed similarity with Cepheids in bolometric absolute magnitude, radiation variations, spectral peculiarities and galactic distribution.

Gerasimovic discusses 76 M-type variable stars, showing emis-

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sion for which proper motions and radial velocities are known. Using these to deduce absolute magnitudes, he finds that the absolute luminosity diminishes as the period increases. Periods less than 250 days give an average absolute magnitude –2.3, whilst those greater than 340 days yield +0.3. Such would seem to disprove their similarity to Cepheids or if the Cepheid period-luminosity relation were considered to hold for them, they would seem to be on the descending branch after a maximum had been reached. Probably the data are too uncertain and meagre to consider the results dependable and, as Gerasimovic points out, the absorption bands play an unknown part.

While not strictly an investigation of the past year, McLaughlin's finding is of interest that the time of maximum light of a variable coincides with the time of maximum velocity of approach more closely as the five-day period is reached. The departures from coincidences in the times increase as we go each way from the five-day periods, the average one for true Cepheids.

The Star 12 *Can. Ven.* Miss Anger at Dearborn Observatory, by means of tracings with the Moll recording microphotometer, has studied the changes in intensities of the lines of the bright star 12 Can. Ven. In addition to the lines of the rare earth elements europium and terbium previously known to vary, she has found that the calcium 3933, the magnesium 4481, and the silicon pair 4128, 4131, also vary.

Belopolsky remarks on changes that have occurred in the spectrum during 1927 and 1928 in the coming in of emission bands and bright borders to absorption lines. It would seem that the star partakes somewhat of the character of a Cepheid.

Stellar Radiation. Measurements of stellar radiation by means of sensitive thermo-couples have improved much the past year or so. Thermo-couples weighing only 1/1,000 of a drop of water are in use with the 100-inch telescope at Mount Wilson, by which it is possible to measure variations of a millionth of a degree in a star's radiation. Betelgeuse, which sends us the most radiation of any star, deflects the spot of light from the recording galvanometer fully 18 inches, yet such deflection means an increase in the temperature of the thermo-couple of only 0.015 Centigrade.

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Andromeda Nebula Studies. Hubble has continued his study of the Andromeda nebula and has given us detailed results based upon 350 photographs with the 60 and 100 inch reflectors at Mount Wilson. No indication of resolution into stars has been found for the nuclear regions, but the intermediate and outer regions are partially resolved. Forty Cepheids with periods from 10 to 48 days conform to the period-luminosity law and yield a distance of 275,000 parsecs, practically 900,000 light-years. By this survey the number of photographically observed novae was increased from 22 to 87. Our galactic system is larger than the Andromeda spiral, but the ratio is not greater than between it and other extra-galactic ones.

Lindemann had previously made the suggestion that the brightness of the spiral was due simply to reflected light from the galaxy. Markov finds this cannot be so as its surface brightness is 76 times that of our galaxy so that while our own is large in size it is of low luminosity.

Luminosity of Planetary Nebulae. From trigonometric measures Van Maanen had deduced absolute magnitudes for the planetary nebulae of +8.1. Gerasimovic attempts to show that these parallaxes are too large and that the planetaries should be about three magnitudes brighter. One method is based upon proper motions and radical velocities, another on how they fit in on the assumption of galactic rotation, while the third depends upon their departure from the plane of the Milky Way. It is hard to decide where the error exists and one must await new data.

Similar discordances arise in the distances of dark nebulae determined by Gyllenberg and Lundmark by star counts. The former finds the dark nebula near S Monocerotis at 250 light-years distance; the latter puts it thirteen times as great.

Shapley and Miss Ames, exploring the rich nebular region near the pole of the galaxy, find the main assemblage of spirals at ten million light-years. Three other adjacent "clouds of galaxies" are fainter, smaller, and therefore, more remote. The correlation between magnitude and angular diameter suggests that space is perfectly transparent.

Dimensions of Universe. The dimensions of the universe,

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using the term in the larger sense, has been a theme upon which there has not been unanimity of opinion. It was early noted from the Flagstaff radial velocities of spirals that they were large and predominantly velocities of recession. On De Sitter's cosmogony, distant objects would show a recession increasing with remoteness. This is ascribed to a slowing down of atomic vibrations and to a general tendency of material particles to scatter. Reference was made in the last summary to a velocity of N.G.C. 7619 by Humason of +3779 km. per second. On De Sitter's theory, this would yield a distance of 25 million light-years. It was planned at Mount Wilson to secure velocities of more of these faint spirals and three have now been obtained of faint spirals near the pole of the galaxy, two of which have velocities of recession about double the one just alluded to. The corresponding distance of the group is 50 million light-years. The third velocity is not in as good an accordance, and the spiral may not belong to the group.

Silberstein's Views. Silberstein takes direct issue with Hubble, considering as absurd a value for the curvature of space of 140 million light-years as deduced by the latter. From a discussion of 35 O-type stars, 29 Cepheids and 246 distant stars from Young and Harper's list, Silberstein early in the year concluded that space is finite and with a radius of 5 million light-years. A few months later he used in addition 460 more of our stars and obtained 5.74 million light-years. The greatest possible distance apart of two objects would then be nine million light-years. Thus there is marked disagreement and the writer does not feel competent to express an opinion on the discordance.

Belopolsky thought such an effect should be traceable in stellar velocities and while he found positive velocities to increase markedly with distance this has a more rational explanation in the rotation of the galaxy.

Rotation of the Galaxy. Mention was made in the summary of a year ago of evidence tending to substantiate the idea of our galactic universe being in rotation. The programme of the radial velocities of B-type stars, upon which Dr. Plaskett and Mr. Pearce have been engaged since 1924, has recently been completed at Victoria. The results for 500 stars, many of them exceedingly remote,

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and therefore correspondingly suitable, were thus available for putting the hypothesis to a rigid test. While all the stars showed the desired trend to the residual velocities, yet it is most plainly seen in those more than 2,000 light-years away, and when the 250 odd stars in this category were subdivided into groups on the basis of distance and longitude in the galactic plan, there was no doubt of a definite trend to the residuals. At mean longitude 10° they have a positive maximum of +24 km./sec; at 55° they pass through zero and reach a negative maximum of –28 km./sec at 100° longitude; again they go through zero at 145° and approach a second maximum at 190°. The observed velocities follow so closely those that would be expected from a rotation that there seems no reasonable doubt that such is the true explanation.

Moreover, similar confirmatory evidence is furnished from the velocities obtained from the interstellar clouds of calcium that permeate all space. On the assumption that the most distant stars will show the strongest interstellar absorption lines, the stars can be grouped on the basis of distance, and again, it has been found by Struve, Oort, and more definitely by Plaskett and Pearce, that this interstellar medium shares the rotation of the stellar universe. That such interstellar material is uniformly distributed throughout space is inferred from the fact that the rotational term is approximately half that of the corresponding stars, corresponding to the centre of gravity of the material between the star and ourselves.

Hub of Universe. The assumption of galactic rotation presupposes a massive nucleus about which rotation takes place, and reference was made in my last summary to the work at Harvard of hunting for the hub of the universe. Photographs of the region in Sagittarius where the nucleus is supposed to exist, reveal sufficient dark matter to obscure a mass sufficient to account for the observed rotation. At its edges, however, according to Shapley, our galaxy is completely transparent, permitting the observation not only of the most distant stars of our own system, but also the outside galaxies, probably millions of years beyond the farthest edge of our galaxy.

The K-term. Another by-product of the Victoria velocities of the faint B-type stars is the vanishing of the so-called K-term for

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stars fainter than 5.5 magnitude. It still persists in the case of the brighter B-type stars, about 390 in number, and has the approximate value +5.3, slightly higher than the value of Campbell, who first drew attention to it. The early explanations of this term as due to errors of measurement or of wave length, Einstein shift, and other causes, must be abandoned, for such should be operative in faint as well as in bright stars. A more rational explanation is that it represents a systematic drift of the near by helium stars, most pronounced in certain southern groups.

Wolf-Rayet Stars. Beals, at our own observatory at Victoria, has added to our knowledge of Wolf-Rayet stars. He has secured spectra of all within reach, namely 28, some of them as faint as eleventh magnitude. The width of the emission bands he finds proportional to the wave length and he interprets this as a Doppler effect. In brief, the emission bands are due to the continuous ejections of atoms from the high temperature star. While millions of tons of matter are thus lost yearly, so great are the masses that millions of years would elapse before a variation in the light could be detected.

3. Physical Theories

Stability of Stars. Jeans finds that gaseous stars are unstable, so the very existence of stars implies substantial deviations from gas laws. This is rather disconcerting, but Gerasimovic believes that Jeans failed to take ionization into account, and if this is done, then, with a few exceptions among the massive stars, which may be partially in the liquid state, the dwarfs, giants, and even supergiants, are stable in the gaeseous state. Pannekoek, who was with us at the Victoria observatory for six months the past year, thinks Gerasimovic in turn has omitted something in his formula.

Contours of Stellar Lines. The first 25 years of this century may be said to have concerned itself primarily with the positions of the lines in stellar spectra. From such measures of position have come an extensive knowledge of the radial velocities of stars, and through these in turn, we know of the larger movements of the parts of the universe relative to the whole. Succeeding years will

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undoubtedly see greater attention given to the character of the lines themselves, their widths, their intensities, and the relation between the two. Theory states that a stellar line should decrease in darkness from the centre outward, fading into the continuous spectrum gradually. Studying the curves which show how the intensity falls off in these wings at different distances from the centre of the lines, it is possible to calculate the number of atoms which are at work in producing the line. By such studies on the lines in the solar spectrum, Unsöld, a young German physicist who visited Victoria the past summer, has given us some ideas concerning the abundance of the elements in the solar atmosphere. Calcium vapour makes up possibly five per cent. of the sun's atmosphere. In general the intensity of the lines will be proportional to the abundance of the absorbing atoms.

Stark Effect. Of other causes operative to produce the widening of stellar lines, what is known as the Stark effect, has received considerable attention the past year. In 1906, Stark suggested that electric fields surrounding a radiating atom might be expected to produce perturbations, and seven years later, observation showed that under the influence of an electric field spectral lines actually broke up into components. Under strong fields the components are numerous, and blend into one broad line. As the effect is most pronounced for elements of low atomic weight, it has been thought that the great widths of the Balmer lines in A-type stars, or the helium lines in B-type stars, might be due to such an effect. Struve has examined a number of spectra of suitable stars, and finds the Stark effect a contributory, but not sufficient, cause of the broadening. The Stark effect is absent in highly luminous stars where the pressures are very low; it is only in the compact dwarfs that the electric fields are strong enough to produce broadening. Thus broad, fuzzy line stars are dwarfs; sharp, intense lines represent giants in agreement with the Mount Wilson discovery.

Similar work is in progress at Harvard College Observatory, where Miss Williams, studying the contours of A-type stars, finds the lines growing progressively wider for their depth as we pass to the less luminous stars.

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4. New Equipment

I discussed rather at length last year the matter of new equipment. Considerable progress has been made this year in connection with the proposed 200-inch telescope in the making of test disks of quartz of increasing aperture. One of 22 inches diameter has now been successfully cast, and it is expected that no insuperable difficulty will be met with on that score. For those who desire more details the November, 1929, number of *Harper's Magazine* will give them.

Two 24-inch refractors, one visual and one photographic, mounted on one tube, have been installed at Lembang, Java.

The 36-inch reflector for the Royal Observatory, Edinburgh, has been completed and installed. It is patterned after our Victoria instrument, and is to be used to study the intensities and positions of spectral lines.

I stated in my summary of last year that the 41-inch refractor had been installed in Russia. A visiting astronomer was emphatic as regards its completion, but from correspondence with Grubb, Stokely assures me it is not finished. I wish to make this correction.

The foregoing summary is necessarily incomplete, and none better than the writer recognizes its rather scrappy character. It is hoped, however, that in some way it will supplement the one given last year, and between the two, attention will be drawn to some of the advances in the science of the past couple of years.

Dominion Astrophysical Observatory,

Victoria, B.C.,
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