joint meeting with Section D (Zoology) will be to discuss the subject of "Species and Chromosomes." It will be opened by Prof. R. Ruggles Gates, and other speakers are Dr. H. Harrison, Prof. T. H. Morgan, of Columbia University, Mr. Julian Huxley, Miss K. Blackburn, and Mr. A. D. Peacock.

Prof. V. H. Blackman's presidential address to the Section will be entitled "Physiological Aspects of Parasitism." Of the numerous papers to be presented, it is impossible to mention more than a few. Contributions from the North American continent include papers on the "black dot" disease of potato, by Prof. B. T. Dickson; on the fluorescent pigments of the Cyanophyceæ, by Prof. F. E. Lloyd; on the distribution of potassium in plant tissues, by Miss E. S. Dowding; on the status of the biogenic law, by Prof. E. C. Jeffrey; on the growth of British Columbia trees, by Prof. A. H. Hutchinson; and on the behaviour of chloroplasts and other cell contents at low temperature, by Prof. F. J. Lewis. A number of papers will also be presented by British botanists.

SECTION L (EDUCATIONAL SCIENCE).

The Section is to open its session with a paper on the teaching of history and geography of the British Empire by Prof. G. M. Wrong, of the University of Toronto, followed by a paper on modern tendencies in the teaching of geography, by Mr. Ernest Young. The presentation of the Report of the special committee appointed last year to inquire into the educational training of boys and girls in secondary schools for life overseas will be followed by a discussion on the subject to be opened by Sir John Russell.

On the second day Principal Ernest Barker will deliver his presidential address, the subject being the "Nature and Conditions of Academic Freedom in Universities." Mr. A. E. Heath, of the University of Liverpool, will follow with a paper on "Modern Developments in the Method and Scope of Adult Education." A joint discussion with Section J (Psychology) on the subject of "Tests for Scholarships and Promotions" will occupy the third morning; the chief speakers will be Principal Barker, Prof. Cyril Burt, Prof. G. M. Whipple, Prof. B. R. Buckingham, and Prof. Sandiford. The latter in conjunction with Messrs. Brennan and Holmes will also contribute a paper on "The Use of Partial Coefficients of Correlation in Educational Research."

A discussion on "Modern Developments in Science Teaching" is to be opened by Mr. C. M. Stuart, late headmaster of St. Dunstan's School, Catford. Prof. J. L. Myres will read a paper on the place of classics in a secondary school system, to be followed by Mr. A. H. Hope, headmaster of Roan School, Greenwich, on the present position of classics in French secondary schools. The fourth morning will be devoted specially to subjects of Canadian interests. Sir Robert Falconer, president of the University of Toronto, will read a paper on "The Canadian University"; the Hon. Dr. H. J. Cody on the administration of education in Canada; Prof. G. M. Weir on an educational experiment in rural Saskatchewan; Dr. S. B. Sinclair on the selection of pupils for auxiliary classes; and Major J. B. Cowles on the working of the Adolescent Education Act in Ontario.

SECTION M (AGRICULTURE).

The meetings of Section M will be held under the presidency of Sir John Russell, the director of the Rothamsted Experiment Station, whose address on "Combination in tackling Farmers' Problems" will be given on Monday, August 10.

The proceedings on Thursday, August 7, will be opened by a short address by the Hon. J. S. Martin, Minister of Agriculture for the Province of Ontario. He will be followed by Dr. F. T. Shutt on "The Influence of Cropping on the Nitrogen and Organic Matter Content of Western Prairie Soils." Mr. H. J. Page, the head of the Chemical Department at Rothamsted, will read a paper on "Nitrogen Balance in the Soil"; and he will be followed by Dr. Scott Robertson on "The Fertilising Effect of Rock Phosphate." The next morning will be occupied by a joint discussion with Section D (Zoology) on "The Soil Population." This will be opened by Mr. D. Ward Cutler. In the afternoon, Mr. J. B. Reynolds, the principal of the Guelph Agricultural College, will speak on "Agricultural Colleges in Canada."

On Saturday, August 9, Mr. R. A. Fisher, of Rothamsted, will read a paper on "The Incidence of Rainfall in Relation to the Wheat Crop," and later in the morning Dr. McRostie will speak on "Forage Crops in Canada." The same day, Mr. Engledow will read a paper on "A Spacing Experiment with Wheat," which will terminate the day's proceedings.

On Monday, August 11, Mr. Godden will speak on the work which is being carried out at the Rowett Research Institute on the mineral requirements of farm animals, and Prof. Berry will follow with a paper on "The Chemistry of the Oat Crop." The afternoon will be occupied by a joint meeting with Section K (Botany) on "Forest Problems in Canada," to which Mr. Zavitz and Dr. Faull are contributing.

On Tuesday, August 12, the whole morning will be devoted to a joint meeting with Section F (Economics), the subject for discussion being "Diminishing Returns in Agriculture." This discussion will be opened by Dr. C. R. Fay, and it is hoped that other speakers will include Sir John Russell, Lord Bledisloe, Sir Henry Rew, and Mr. Ashby.

The proceedings of the Section will conclude with a joint meeting on forestry with Section K, in which such subjects as forest protection in Canada, and the cultivation of Canadian trees in other parts of the world, will be brought forward.

After the conclusion of the meeting, several local excursions have been arranged, including a visit to the Agricultural College at Guelph.

Atoms and Ethereal Radiations.[1]

IN his first lecture the speaker, after outlining the steps by which he and his collaborators had succeeded in pushing the region of wave-lengths explored by mechanically ruled gratings down to 136 Ångströms, presented the results which had very recently been obtained by Mr. I. S. Bowen and himself, through the analysis, with the use of high resolution, of the fine structure of these extreme ultra-violet lines.

Photographs were shown in which such a close doublet as the B_{III} line at 677 Ångströms was not only clearly resolved, but had its components so well separated that their distance apart, which amounted to but 0·15 Ångströms, could be measured with certainty to 0·01 Ångströms or better, and in which the seven components of the 834·0 line of oxygen were

[1] Abstract, prepared by the author, of three lectures delivered on June 16, 17, and 18, at University College, London, by Robert A. Millikan, Director of the Norman Bridge Laboratory of Physics of the California Institute, Pasadena, entitled (1) "Filling in the Gap between X-rays and Light"; (2) "Electronic Orbits in Atoms"; (3) "The Penetrating Radiations of the Upper Air."

clearly obtained in orders as high as the seventh. This high resolution has made it possible for Mr. Bowen and the author to prove with certainty that in their "hot-sparks" in high vacua, they have succeeded in stripping all of the valence electrons from the series of atoms, lithium, beryllium, boron, carbon, nitrogen and sodium, magnesium, aluminium, silicon, phosphorus, sulphur, six electrons having been removed from the outer shell in the case of the atom of sulphur.

As an illustration of the way in which this can be proved, as well as of the way in which the recently discovered laws of atomic mechanics can be beautifully verified, the lecturer took the case of the stripped boron atom B_{III}, the spectrum of which had not before been known. Mr. Bowen and he first predicted that if they had B_{III} in their source they should have a line at 2077·4 Ångströms. They arrived at this figure by dividing the corresponding line of lithium ($3d$-$4f$) by nine. They then set their spectrograph for this wave-length and obtained the predicted line—quite a strong one—at the accurately measured wave-length of 2077·79 Ångströms. They next predicted a line ($4f$-$5f$) at 4500 Ångströms, and obtained it at 4499 Ångströms, or within one part in 5000 of the predicted wave-length. They next predicted two doublets ($2p$-$3d$) and ($2p$-$3s$), of the same frequency separation at 677 and 758 Ångströms, and found both of them in the positions predicted and with the same frequency separation precisely as their theory demanded, this separation agreeing, too, as it should, with that of the first line of the principal series of B_{III} ($2p$-$2s$) first accurately measured in this work. Photographs showing all these lines as doublets, with the correct separation, were shown.

The speaker concluded his first lecture with the presentation of the proof, furnished by his slides, that the Moseley law of progression of frequencies with atomic number, discovered through the study of X-ray spectra, holds also in the region of optical wave-lengths, such as he has been studying with the aid of his mechanically ruled gratings. In particular he showed that the L_I levels of sodium, magnesium, and aluminium obtained from his "hot sparks" fall, along with that of neon, very accurately upon a Moseley line; also that the strongest L line of the foregoing elements can be plotted upon the same straight line with the corresponding lines obtained by Siegbahn with the elements down to copper; and that a like type of progression was found in the L spectra of the elements from neon down to lithium.

Thus, though the wave-lengths between the lecturer's lower limit of 136 Ångströms reached by grating spectroscopy, and Siegbahn's upper limit of 18 Ångströms, reached by crystal spectroscopy, had not thus far been directly obtained, yet this small remaining gap has been bridged over by the establishment of a common law, with the aid of which it is now possible to compute with certainty some of the most outstanding characteristics of the radiations which must fall in the as yet unexplored region. To this extent then, the gap between X-rays and light has already been completely bridged.

In his second lecture the speaker presented, in a series of tables, work of Mr. Bowen and himself, as yet unpublished, in which two other X-ray laws, namely, the *regular*, or relativity-doublet law, and the *irregular* doublet law were definitely extended throughout the whole field of optics. This extension has become possible because the foregoing series of stripped atoms gives the first opportunity to compare, *in the field of optics*, a fairly long series of atoms possessing exactly the same electronic structure, but in which the nuclear charge progresses by unitary steps. It is in general such a series of identical electronic structures which is dealt with in comparing X-ray spectra. Hence the possibility of a very precise comparison of atomic behaviour in the optical and the X-ray regions.

The definite extension by Mr. Bowen and the lecturer of the X-ray laws into the field of optics means unquestionably, to take a simple specific case, that in the second quantum state the so-called $2s$ terms in optics correspond exactly to the L_I terms in X-rays, the $2p_2$ terms in optics to the L_{II} terms in X-rays, and the $2p_1$ terms in optics to the L_{III} terms in X-rays. Stated otherwise, if the L_{II} and L_{III} levels in X-rays represent a relativity doublet, as they have hitherto been supposed to do, and correspond therefore to two differently shaped electronic orbits, one a circle [2_2], and one an ellipse [2_1], then p_2 and p_1 in optics also represent a relativity doublet, and correspond to these same two orbits.

While from an experimental point of view this definite unification of optics and X-rays under a common set of laws (Moseley law, relativity-doublet law, irregular doublet law) must be regarded as a distinct step in advance, since it tends toward a simplification, for the purposes of prediction, of the whole subject, it nevertheless introduces a very serious difficulty into the present status of atomic theory. For it appears to force us to choose between two positions, either of which presents apparently insuperable obstacles.

If we retain the physical interpretation of the relativity-doublet formula—a formula which is derived without the introduction of any arbitrary constant whatever from the theory of the change in mass with speed, and has had *quantitative* successes in interpreting the whole fine structure of the lines of atomic hydrogen and ionised helium—we must discard very largely the interpenetrating-orbit ideas with the aid of which Bohr and other workers have recently interpreted so successfully both optical and chemical phenomena. Specifically the difference between the energies of the so-called s and the p terms in optics can no longer be interpreted as due to the difference in the shapes of the $2s$ and the $2p$ orbits, the $2s$ corresponding to an ellipse, and the $2p_2$ and $2p_1$ to two circles. For if the relativity doublet interpretation is applied to the levels $2p_2$ and $2p_1$, one of these levels, namely $2p_2$, must correspond to an ellipse, while the other, $2p_1$, corresponds to a circle. *This requires that $2s$ and $2p_2$ be orbits of the same shape, namely, 2_1 orbits, despite their large difference in energy.*

If, on the other hand, we retain the assignment of azimuthal and inner quantum numbers which has been universally made in recent years in the field of optics, and hence make the $2p_2$ and $2p_1$ levels correspond to two circles which differ slightly in energy because of a difference in orientation (inner quantum numbers), we are forced by the results herewith presented to treat L_{II} and L_{III} in the same way. This requires us to find some other cause than change of mass with speed to account for their observed difference in energy, which is, however, quantitatively accounted for by this so-called relativity-doublet theory.

Before the accumulation of the present data it was not so difficult as it is now to discard the relativity-doublet interpretation, but in this data the relativity-doublet formula has had new successes, for it fits satisfactorily with the behaviour of a whole group of atoms which pass over in successive stages toward the structure of atomic hydrogen and ionised helium. Thus there now seems to be no place to stop in discarding the relativity-doublet explanation short of abandoning *in toto* the idea of change of mass with speed in electronic orbits, and assuming that it was mere chance which caused this conception to lead to a formula which has had amazing successes, not

only in predicting exactly the fine structure of the hydrogen and helium lines, but also in explaining very beautifully the complexities of the Stark effect in these gases.

Such an assumption of accidental agreement where the relations are so beautifully quantitative and so numerous as they are here is one which the theoretical physicist will be very loath to make. The lecturer felt that further experimental data must be accumulated before a choice could with certainty be made between his alternatives. The present experimental situation, so far as the work of Mr. Bowen and himself are concerned, will be presented fully in forthcoming articles in the *Physical Review*.

In his lecture on the "Penetrating Radiation of the Upper Air," the results of the experiments made by Mr. Bowen and the lecturer at Kelly Field, Texas, were described. They sent up sounding balloons carrying recording electroscopes, thermometers, and barometers to a height nearly twice as great (about 16 km.) as that reached in preceding studies of the penetrating radiation. The total weight of the whole apparatus sent up, exclusive of the balloons, was but 180 grams. The electroscope chamber consisted of an hermetically sealed, steel-walled vessel of about 200 cc. capacity, containing air at varying pressures ranging from 1 up to 11 atmospheres. Four such instruments had been sent up and three recovered, two of which had reached altitudes between 15 and 16 km., and both agreed in giving the integrated ionisation not more than 25 per cent. of that obtained by extrapolation from Kolhörster's curves or computed from his 1914 absorption coefficient $\mu/D = 5{\cdot}77 \times 10^{-3}$ cm.^{2}/gm. These results showed quite definitely that no external source of radiation having the postulated characteristics existed. At the same time, they showed that the balloons in their ascent passed through regions in which the penetrating radiation was greater than its value at the earth's surface, since the integrated leak could not otherwise be greater than its value at the surface.

Dr. Russel Otis, of the California Institute at Pasadena, then checked these results by observations made in a number of aeroplane flights up to altitudes of 17,000 ft. In these flights he calibrated his electroscope at each particular level, thus rendering his results quite independent of any possible effects of temperature and pressure. He found, in agreement with Kolhörster, Hess, and others, that the penetrating radiation decreases slightly up to altitudes of six or eight thousand feet and then begins to increase. The actual values at 17,000 ft. (5·18 km.) were, however, but half those reported by Kolhörster at this altitude. Observations which Dr. Otis then made on Mt. Whitney at altitudes up to 13,000 ft. checked quite well with those made in aeroplanes, thus indicating that the phenomenon is one due to altitude rather than to locality.

The most conclusive evidence as to the source of the radiation has come from a continuous series of night and day observations, inside and outside 5 cm. thick lead screens, which the lecturer and Dr. Otis carried out last September on the top of Pikes Peak (14,100 ft.) in Colorado. During these observations, as a result of a snowstorm, the ionisation inside the closed observing chamber dropped suddenly about 10 per cent., but when the test was made inside the chamber *when it was completely shielded by its 5 cm. of lead*, the percentage fall in the ionisation was about the same as in the unshielded chamber, thus indicating that *local causes* modified the ionisation which got through 5 cm. of lead as much as they modified that which did not have to go through such a screen. If a very penetrating radiation of cosmical origin existed, this should have been completely unmodified by local changes, so that the percentage change inside the shielded vessel should have been very much less than that observed when the shields were removed. This observation was, then, an indication that the whole of the radiation measured in the closed vessel was of local origin.

This indication was confirmed as follows: assuming, following Kolhörster's 1923 conclusions, a penetrating radiation of cosmic origin which produces 2 ions/cc./sec. at sea-level, and has an absorption coefficient per cm. in water of $\alpha = 2{\cdot}5 \times 10^{-3}$, we find that this radiation would produce 6 ions/cc./sec. on top of Pikes Peak and 5·2 inside our lead shield. We found that the ionisation in our chamber contributed by the walls and the lead shields was at least 7 ions, so that if there were no local radiation at all on Pikes Peak capable of getting through our screens, a condition contrary to fact, the lowest obtainable value of the ionisation inside our vessel should have been $7 + 5{\cdot}2 = 12{\cdot}2$ ions. *We observed directly* 11 *ions*. We conclude, therefore, that there can exist no such penetrating radiation as we have assumed.

Our observations, therefore, seem to us to show that the whole of the penetrating radiation on top of Pikes Peak is of local origin. We have computed its absorption coefficient and find it but a little harder than that of the ordinary radioactive materials. How such quantities of radioactive material get into the upper atmosphere is as yet unknown.

University and Educational Intelligence.

BELFAST.—At the meeting of Senate of the Queen's University held on July 16, a letter was read from the trustees of the late J. C. White intimating that they intended to hand over to the University a sum of 60,000*l*. Of this amount (1) a sum of 45,000*l*. is to be used in founding a professorship of biochemistry with a salary of 800*l*. per annum and equipping the department. (2) The remaining 15,000*l*. is to be used in founding a lectureship in bacteriology with a salary of 450*l*. and equipping the department. The title of the professorship is to be the "J. C. White Professorship of Bio-chemistry," and the title of the lectureship the "J. C. White Lectureship in Bacteriology."

On July 17 the cheque for 60,000*l*. was handed to the honorary treasurer of the University.

CAMBRIDGE.—The Local Lectures summer meeting will be held on August 1-21, and an attractive programme has been issued. The chief subject of study will be Egypt, its ancient, medieval, and modern aspects, and among the lecturers who have been secured are Sir Flinders Petrie, Prof. A. S. Hunt, Dr. A. H. Gardiner, Dr. A. M. Blackman, Dr. W. F. Hume, and Sir William Willcocks. The group of lecturers on science include many of the leading scientific workers in the University, with the addition of Dr. Leonard Hill, director of the Department of Applied Physiology, Medical Research Committee, Prof. H. H. Turner of Oxford, and Dr. A. E. H. Tutton. The inaugural address to the meeting will be delivered by Viscount Haldane. Further information can be obtained by application to Dr. Cranage, Syndicate Buildings, Cambridge; letters should be endorsed "Summer Meeting."

EDINBURGH.—The following doctorates were conferred at the Graduation Ceremony on July 17, the subject of the thesis in each case following the name:—*D.Sc.*: Mr. T. M. Finlay, "The Old Red Sandstone of Shetland"; Dr. R. K. S. Lim, "Gastric