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Scientific Worthies

XLVI.—THE RIGHT HON. LORD RUTHERFORD OF NELSON, O.M., F.R.S.

IT is often a matter of surprise to note the profound differences between the methods the human mind adopts towards the problems it is seeking to solve, and any narrow classification would necessarily be inexact because of the variety of possible temperaments. Among the scientific investigators who have devoted their lives to the study of physics, two main tendencies can, however, be noted. On one hand, there are those who are dominated by the abstract aspect. They are interested not so much in the facts as in the theories to which these facts lead. There is no lack of illustrious men to whom the intellectual aspect has appeared the more important, and quite recently striking successes have resulted from just such methods of investigation. Other scientific men, while not denying that the object of science is to correlate and to predict phenomena, and without confining themselves merely to the compilation of facts, yet feel that we are so far from being able to form a logical and clear idea of reality that we are scarcely beyond the point of realising the danger of too abstract generalisations. Such generalisations run the risk of describing more the mind of the man who puts them forward than Nature itself—which is the object of research and of experimental physics. As has often been remarked, facts serve to produce theories, leading in their turn to the discovery of new facts, which may in their turn destroy the theories by which they were discovered.

The scientific career of Lord Rutherford is a splendid example of this second method of physical investigation, and it will be sufficient to show that this point of view is not in any way inferior either in importance or in fertility to the other.

Lord Rutherford's earliest work was in a sphere quite apart from that to which he has since devoted his life, but it showed clearly enough his remarkable qualities as a physicist. He investigated the change in the magnetisation of a steel wire due to the passage of oscillatory currents, and he was able to show that Hertzian waves could, by producing oscillatory currents, cause a sudden diminution in the magnetisation of such a wire. This discovery was utilised later by other workers and developed to form a detector for wireless telegraphy.

The three years, 1895–98, which Lord Rutherford passed at Cambridge working under Sir J. J. Thomson determined the orientation of his future

interests by permitting him to study the newly discovered properties of ionised gases and the causes of this ionisation. He went to McGill University in Montreal imbued with the ideas and inspiration which had enabled Sir J. J. Thomson to make the Cavendish Laboratory a birthplace of famous physicists. It was not long before the young professor found in radioactivity the subject for which his peculiar genius was most suited. It was then 1898, two years after the discovery by Becquerel of the radioactivity of uranium; Pierre Curie and Mme. Curie had just added greatly to the range of the new phenomenon by discovering polonium and radium, and the list of the radioactive bodies already included thorium and the two alkali metals.

While, however, the far-reaching importance of these new discoveries was obvious to everyone, the interpretation of the facts in this new domain presented fundamental problems which remained unanswered. A most important research from this point of view was published in 1900 by Rutherford, from Montreal, when he was able to show that the thorium bodies gave out a type of radioactive emanation. He maintained the view that this was in effect a material gas constituting a new chemical species which should find a place in the family of inactive gases to which helium and argon belonged, and this was ultimately, in collaboration with Soddy, shown to be true. This bold hypothesis received a most striking confirmation when the more marked and more permanent phenomena shown by radium emanation were discovered in their turn.

Following up his researches on thorium, Rutherford was able to detect the presence of an induced radioactivity which he attributed to an active deposit, invisible and yet material, carried in the form of electric particles which could be concentrated on an electrode by means of an electrostatic field. This active deposit was an attribute of the emanation and was thus an example of the affinity which exists between the radioactive bodies. Later, while studying the radium emanation discovered by Dorn, Rutherford found many properties which emphasised its material properties, as, for example, that it could be condensed in suitably cooled tubes. He was also able to obtain a complete spectrum of this new chemical element, which Ramsay and Soddy had shown beyond doubt was a gas. It is very remarkable that Rutherford and Soddy suggested in 1902 that helium might be one of the products of disintegration of the radioactive bodies.

The year 1903 was one of the most decisive for the new science which was then growing up, for it saw in effect the discovery of the production of helium from radium emanation, the fundamental discovery by Curie and Laborde that preparations of radium gave out a continual supply of heat, and it also saw the birth of the theory of radioactive transformations put forward by Rutherford and Soddy to explain the facts shown by the thorium family. At first sight many of the phenomena shown by the radioactive bodies were very strange; the activity did not always seem to depend upon the bodies which constituted the source; it could be carried to a certain distance and could there produce the phenomenon called induced activity, all of which was very obscure. Neighbouring surfaces, without apparently suffering any modification, acquired a power of emitting radiations for which the rate of decrease with time appeared to be connected in a mysterious way with the growth of activity of the primary substance. To-day, when we have a theory of the atom, admittedly rough, but which yet explains in an admirable way a great number of diverse facts, the interpretation of these phenomena, so inexplicable in the early days, now seems simple enough. But if one looks back to the year 1900, when the ideas of the nuclear atom, and of Bohr orbits, were as yet unformulated, it will readily be appreciated what imagination and what sureness of intuition were necessary in order to disentangle so rapidly such a complication of strange and new facts.

Rutherford and Soddy put forward in 1903 a complete theory of these phenomena which permitted the prediction, both qualitatively and quantitatively, of the whole complicated consequence of events. This theory was based on a conception of the utmost simplicity which has since served, without any modification, to classify all the facts discovered in this new domain.

The fundamental idea of this theory is that among the great number of atoms of a body which possess the property of radioactivity, there is a definite probability that in a given time a certain number of these atoms will have changed into a new type by the ejection of a material particle owing to a type of instability. In other words, the number of atoms which change in unit time is always proportional to the total quantity of matter which is then present.

A detailed calculation then showed that such a substance will disappear according to an exponential law; if the new atoms are also unstable and are transformed much more rapidly than the first kind

(which is the case for uranium, radium, and thorium), there will result a type of equilibrium between the successive descendants of the same radioactive family, so that their relative proportions are perfectly defined in the minerals and in the preparations which contain them. The radiations which are emitted are a direct result of the transformations of the atoms and therefore provide an exact measure of its rate of disintegration.

Schweidler and later Kohlrausch showed that Rutherford's theory, which was at first presented as a kind of analogy with irreversible monomolecular reactions, could be viewed entirely from the point of view of chance and was therefore subject to the laws of the calculus of probability. This was perhaps one of the first examples of the intervention of statistical laws in fundamental atomic phenomena, an idea of which the more recent discoveries of physics have shown both the generality and the profound philosophic importance. In the light of present knowledge, one may well ask to-day whether such a law was not imposed *a priori* to the exclusion of all others.

The laws of radioactive disintegration thus stated formed a framework for the classification of all the new substances produced by the successive transformations of each family. Thus a new chapter in physics and in chemistry was begun, that of matter in a state of evolution, which has led in time to all that we know to-day about radioactivity.

But besides this, the study of the radiations, the investigation of their nature, of their properties, and of their effects, form a peculiarly interesting branch of this new science, and it is only necessary to compare the early works of Mme. Curie and of Rutherford with the latest volumes published by Kohlrausch and by Rutherford to understand the double aspect of the facts grouped under the name of radioactivity.

After 1905, Lord Rutherford directed his efforts mainly to the study of the radiations, and the success which he achieved in this field was not less than that which had greeted his earlier efforts. There are three kinds of rays, α , β , and γ , and Lord Rutherford's earliest work was concerned with distinguishing between them. Afterwards, commencing with the α -particles, he has contributed more than anyone else to establishing the fact that they consist of helium atoms carrying a double positive charge and projected with a velocity corresponding to an energy of several millions of volts. It has been possible not only to study the properties of a beam of α -rays, but also to detect the effect of single particles and to count them by

direct methods, which in course of time have been developed to a high degree of perfection. The detection of single particles has now rendered possible the detailed verification of the predictions of the law of probability about the distribution of the particles both in space and in time.

The expulsion of helium nuclei and of β -particles, that is, high speed electrons, from the radioactive nucleus, threw a new light on the whole problem of the constitution of atoms. This question had previously seemed so remote that no one had dared thus to think of it before the first ten years of the twentieth century. In fact, it remained so obscure that, at the first Solvay Conference, when it was asked what picture one could form of the emission of spectral rays, the eminent specialists there present were caused merely to reveal their own ignorance on the subject. No one was better placed than Lord Rutherford to make a decisive attack on this problem, by bringing to it a definite atomic model founded on experimental facts.

Various experiments carried out under his direction on the scattering of rapid particles in their passage through matter led to the formulation of an approximate law describing the deviations, and this Lord Rutherford saw could only arise if there was some kind of condensed nucleus forming the central part of the atom. This theory, put forward in 1911, was greatly expanded and developed in 1914, after the splendid theoretical work of Bohr and the notable experiments of Moseley, which were both carried out in Lord Rutherford's laboratory. From this resulted the atomic model universally accepted to-day and known under the name of the Rutherford-Bohr atom. In this model, as is so well known, the atom is supposed to be formed by a central nucleus carrying a positive charge and surrounded by a cloud of satellite electrons, the number of which is equal to the number of the net positive charges on the nucleus. This whole number, called the atomic number, plays an essential rôle in the theory of spectra, in the classification of elements, and in all problems connected with atomic physics. It shows the position of an element in the natural order of the elements, characterises the chemical type, and, in conjunction with the number of protons in the nucleus, constitutes even to-day the data of which we are most sure in relation to the ultimate particles of matter.

The β -rays and the γ -rays also occupied the attention of Lord Rutherford and his school, and in 1914 he was able to obtain for the first time a spectrum of the γ -rays by diffraction from a crystal of rock

salt. The experimental method was extremely ingenious and was specially adapted to work with the necessarily small angles of reflection. In this way he was able to show that the γ -rays were analogous to the X-rays, but of shorter wave-length.

The electrons of different speeds which constitute the β -radiation can be separated out by a magnetic field, and a detailed analysis of this emission, and also the study of the high speed secondary electrons which are produced, formed an important chapter in the researches undertaken at about this time. The γ -rays emitted by radioactive bodies form a line spectrum, and while the greater portion of the β -rays form a type of continuous spectrum the origin of which is yet obscure, there is also a series of groups of electrons of definite speed which, when analysed by a magnetic field, form a type of corpuscular spectrum. The question as to whether there should be a connexion between these two spectra by means of the photo-electric effect was considered by Lord Rutherford, and later, in the hands of his co-workers, experiments on this subject threw great light on the complexity of the emission of the β -rays. In this way it was possible to study the spectrum of the γ -rays, although their wave-lengths were so short as to render the normal method of crystalline diffraction inapplicable.

Finally, there is a third phase of Lord Rutherford's work, marked by discoveries no less important than those preceding, and concerned with the artificial disintegration of the lighter elements by bombardment with the α -particles emitted by radioactive bodies. According to present ideas, which are in great part due to the researches which have just been referred to, the chemical properties of an element depend entirely on the value of the nuclear charge. Some of the electrons which surround the nucleus can be removed, or even the nucleus may be stripped bare, when the atom would in the first case be partly, and in the latter case completely, ionised; yet still, from the point of view of the chemical nature of the element, it would be the same as at the commencement of the process, and the atom would regain all its former properties as soon as it had recaptured its full number of electrons. In order to effect a change in the atomic species, it is essential to change the positive nucleus. It may be said, indeed, that the nucleus determines the structure of that portion of space which constitutes the atom. This central fort is guarded by strong defences. There is an intense electric field which opposes the progress of a projectile which approaches it, and will in fact

prevent its arrival unless it be endowed with very great energy. It occurred to Lord Rutherford that the α -particles did in fact constitute precisely the most powerful type of projectile at our disposal for attacking the nucleus, and he proceeded to use this weapon.

It was therefore in 1919 that for the first time an actual case of chemical transmutation of an element was proved scientifically. It was found that the hydrogen nuclei, which are to-day called protons, could be detached from the nuclei of nitrogen and other bodies by bombardment with α -particles. In the case of aluminium, the explosion sets free a certain quantity of intra-atomic energy, which gives the proton greater energy than that of the incident projectile.

This was the beginning of a new branch of physics and chemistry, that of artificial radioactivity. At first progress was somewhat slow, due to inherent difficulties in the early experimental methods, but now the science is making great strides. There is little doubt that it will quickly lead to important results and throw light on the intimate details of this new world of nuclei which the work of Lord Rutherford has opened up for the physicists of the future.

As professor of physics at Manchester—where he obtained in a few years so many striking results that it has been possible to form a museum of historic apparatus—and then at Cambridge, a successor to the great line of illustrious physicists of which the last, Sir J. J. Thomson, had just retired after influencing the whole subject of physics in a way which becomes more apparent every day, Lord Rutherford has continuously affected all those who surround him by his personal influence. He has maintained and even increased the great traditions of the Cavendish Laboratory, from which have come so many admirable researches and so many notable men of science. The list of the physicists who have worked under his direction is a long sequence of names of which the greater number have attained fame, and in no small measure is the brilliance and certainty of the results due to the continual co-ordination of a series of researches directed towards one end. The number of distinguished physicists who have co-operated in this advance is so large that it would be impossible to mention all and invidious to choose a few, but reference to any work on radioactivity will show how many have worked under Lord Rutherford and collaborated in his researches.

Taking Lord Rutherford's work as a whole, one finds that underlying it there is always a concrete

picture of the problems based on direct experiments, and then, avoiding all mathematical complications, these experimental facts are connected up by means of a theory which gives a direct visual picture of the phenomena. Recent theoretical views suggest that such a mechanistic view of Nature cannot be pushed beyond a certain point, and that the fundamental laws can only be expressed in abstract terms, defying all attempt at an intelligible description. The philosophy of science has always swung between these two points of view. The work of the great physicist to whom these lines are dedicated shows, however, to what brilliant discoveries the method followed by Lord Rutherford can lead.

M. DE BROGLIE.

New Guinea Sorcerers

Sorcerers of Dobu: the Social Anthropology of the Dobu Islanders of the Western Pacific. By Dr. R. F. Fortune. Pp. xxviii+318+8 plates. (London: George Routledge and Sons, Ltd., 1932.) 15s. net.

DR. FORTUNE has given us a remarkably interesting and valuable account of the natives of the islands of Tewara, Dobu, and of the village of Basema, all in the D'Entrecasteaux group, which lies off the south-east end of New Guinea. Previously we had only the general observations of government officials in the Annual Reports of Papua, the useful little book "The Northern D'Entrecasteaux", by Jenness and Ballantyne (Oxford, 1920), and a few notes by various travellers. The great merit of this book is that it describes the functioning of society and of social activities: it is thus a dynamic survey and not merely an account of social structure, as has usually been the case in previous ethnological studies—and, indeed, it is a good illustration of the modern method of field-work.

The social unit of the Dobuans is the *susu*, or matrilineal group, of which a variable number constitute a village. Every husband must come from another village, and he has but a precarious position in his wife's village, as there is a strong solidarity between the wife, her brothers, and all other members of that *susu*, and, in addition, divorces are frequent. Every alternate year the family lives in the wife's and in the husband's village. When a man dies, he is buried in the domicile of his own *susu*, and thereafter his children may never enter that village. The marital group, or simple family, is necessarily weak as compared with the *susu*, and each village contains a hetero-

geneous collection of men from different villages, who distrust one another. A man cannot alienate from his sister's children, in favour of his own, his village land, his personal name, his skull, his status, or his fruit trees; but he can, and often does, teach his son his magical formulæ, and he is obliged to teach these to his sister's son. Teaching both parties is really a subversive action, as magic gives power, status, and a small income, and when put in the hands of individuals who are very apt to be antagonistic they may use it one against the other. A father will never give his magic to more than one son; the others are left magicless, with the result that blood brothers are usually very jealous of one another. Practically all property descends in the *susu*, but a father may give some garden land that lies away from the village to his son, as well as to his sister's son; but no child can eat of any fruit or crop grown on land that was his or her father's, though such food can be exchanged for food from someone else's dead father's land.

All activities such as gardening, the lashing of canoes, the love between man and woman, and even disease, death, wind, and rain, are supernaturally created by the ritual of incantation with the help of the appropriate technological processes, gifts, and the like. Technology and mundane measures are not to be despised, but the incantation is the really important factor. Incantations are directed to supernatural beings, many of whom originally were human beings but are now immortal; their names are never pronounced except in inaudible undertone in actual ritual. It was they who originated the formulæ and gave them to the first ancestors of man, but nothing happens if the possessor of the formulæ does not use it. For example, in the ritual addressed to seed yams, the man is not muttering a form of words to yams merely, he is addressing a Personal Being, for yams are such in a metamorphosed form. The section on social organisation in gardening and the ritual of the garden are of particular interest.

Sorcery permeates the whole life of the Dobuans and is an integral part of their supernatural system; it "is practised by everyone, and believed in firmly by everyone. Like most supernatural systems it enlists its believers, not by tricks, deceits, and stratagems, but by a more dignified faith in the reality of Unseen Forces, and in the reality of the power of human speech to affect these Unseen Forces, that were 'born with the sun and the moon and the earth'." In an appendix, Dr. Fortune criticises the action of the administration towards sorcery.