Reg. 17th June 1903.

UNIVERSITY EXTENSION LECTURES.

The University extension lectures will be inaugurated this evening by Professor W. H. Bragg, M.A., who will deal with "The electron and the radio-activity of radium, thorium, and other substances." In the precis which has been issued concerning the discourse it is explained that:—"Professor J. J. Thompson, of Cambridge, and other workers have shown that when an electric discharge takes place across a tube very nearly exhausted of air the current is borne by a stream of tiny carriers. These are called electrons. Each carrier has the same mass and the same charge—a negative charge—no matter what the tube is made of or what gas it contains. The mass is far smaller than that of any atom, being about a thousandth of the mass of the atom of hydrogen. One or more electrons can be torn off from each atom; indeed, it may be true that the atom consists of nothing but electrons, in which case we have in the electron the fundamental 'material' of all substances. In some circumstances, easily produced and shown, the electrons move with enormous speed, such as would take them once or twice round the earth in a second." As far as possible, the three lectures to be given on the subject will be illustrated by experiment." The University is not rich enough to possess a specimen of radium, since the laboratory funds are needed for the regular class work," adds Professor Bragg. "But it is intended that the radio-activity of thorium shall be shown, which differs from that of radium only in degree. Not even radium gives out a blaze of light, as might appear from some sensational accounts. The marvels of its existence and nature have nothing to do with its power to act as an illuminant—a power which indeed it only exercises feebly and indirectly. They are marvels because they are of transcendent importance in the advancement of scientific research." The following additional courses of lectures will be given:—Three lectures by Professor Henderson on "Leaders of the middle ages" (Richard I., King of England, Francis of Assisi, and Louis IX., King of France), on Tuesday evenings, July 7, 14, and 21; three lectures by Professor Stirling on "Colour in nature," on Tuesday evenings, July 28, August 4, and 11; six lectures by the Rev. John Reid, M.A., on "The romantic plays of Shakspeare," on Thursday evenings, August 6, 13, 20, 27, and September 3 and 10; three lectures by Professor Mitchell on "Materialism," on Tuesday evenings, September 15, 22, and 29.

Ad. 18th June. 1909

THE ELECTRON.

Professor W. H. Bragg, M.A., gave the first of a course of three lectures on "The Electron" at the University on Wednesday night.

In a pamphlet on the subject of the lectures, the electron is described as the "atom" of electricity. Researches into the nature and properties of this tiny thing are reducing to order the observations and theories of years. What the electron is, and what it means to the theories of electricity and astronomy, as well as to chemistry, is explained in the following words:—

Professor J. J. Thomson, of Cambridge, and other workers have shown that when an electric discharge takes place across a tube very nearly exhausted of air the current is borne by a stream of tiny carriers. These are called "electrons." Each carrier has the same mass and the same charge—a negative charge—no matter what the tube is made of or what gas it contains. The mass is far smaller than that of any atom, being about a thousandth of the mass of the atom of hydrogen. One or more electrons can be torn off from each atom; indeed, it may be true that the atom consists of nothing but electrons, in which case we have in the electron the fundamental "material" of all substances. Under some circumstances, easily produced and shown, the electrons move with enormous speed such as would take them once or twice round the earth in a second. The conception of the electron greatly simplifies and strengthens our knowledge of electric action. A current of electricity is a stream of electrons. The Röntgen rays are ethereal ripples, the splashes due to the violent impact of electrons on any obstacle which stops them. Our theories of magnetism, of the influence of heat upon electricity, and of electricity upon heat, and many other theories, are deeply affected by the new discovery. Light consists of ether waves started by the varying motion of the electrons. There is no other cause. Consequently we now know far more of the mysteries of the spectrum, of the influence of electricity and magnetism upon light, and vice versa, of phosphorescence, and fluorescence. We have a better explanation of the fact that substances generally absorb some colors and transmit others, and, indeed, of the general theory of color. The electron in the theory of astronomy is of importance not only because of the new interpretation which it gives of the spectroscopic observations of sun and stars, but because it gives us fresh ideas as to the phenomena of the sun's corona, of comets, and of the aurora, as to the limits of vision through space and other things.

The electron in chemistry gives a new method of research; and has already made clear an entirely new set of chemical actions, and revealed the existence of substances hitherto unknown. It has been found that certain substances are always shooting out electrons and atoms into the space about them. Such are thorium, the new thorium X, and the thorium emanation; uranium and the new uranium X; and most strange of all radium, whose radio-activity is so great that the issuing particles possess measurable quantities of energy. In these cases and by these methods we have found, apparently, instances of subatomic change; constant breaking down of atoms to form fresh combinations; a phenomenon of the nature of that vainly sought by the alchemist centuries ago.

Professor Bragg dealt in his initial lecture with the elementary laws of electricity and magnetism, and showed how they were influenced by electrons. His remarks and experiments were followed with keen interest by a large audience.

Reg. 24th June 1903.

UNIVERSITY EXTENSION LECTURES.

THE ELECTRON.

Professor Bragg gave the second of his series of lectures on the electron at the University on Tuesday evening, when the lecture theatre was again crowded with an interested audience. Having sketched the general outlines of the facts leading to the theory of the electron in his initial lecture, the professor at once plunged more deeply into the discussion of the recent research which has demonstrated its existence, and further, its mass, charge, and its velocity of movement. By the elucidation of the various modern discoveries and experiments regarding the electron, he showed how its different properties had been enumerated and compared with those of ordinary atoms, with the result that its mass was put down as one-thousandth that of the standard hydrogen atom, and the speed with which it travelled about one-tenth that of light, or between 10 and 20 thousand miles a second. Intricate and beautiful experiments demonstrated the active properties of the electron. First, the professor gave an ordinary example of the Rontgen rays, and then by a remarkable experiment went to show how their passage acted upon a gas by splitting it up, and causing it to be a good conductor of electricity. To do this the bulb from which the rays generated was hung against the ceiling, above a pair of charged insulated uprights. When the rays were turned on, their influence in the air caused the charged uprights to dissipate their charge, and lose the repulsive power which the charge had be-

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fore given them. Another more intricate experiment, to demonstrate further this fact, was obtained by a mass of apparati ingeniously arranged so that when air thus disturbed by the passage of X rays was blown into a region across which a current of electricity was straining to pass, the passage at once took place. This was made visible to the whole of those present by a reflected ray of light, which moved along a scale at the back of the stage of the theatre on the passage of the current. Then a still more remarkable experiment showed how the electrons acted as means for the condensing of moisture in a bulb in which the air was suddenly rarified, and in losing heat gave up some of the liquid it was no longer able to hold. The passage of the electrons provided a means around which drops of the moisture could form into drops. By an original method the lecturer was able to make the fog caused by these small drops distinctly visible to the audience. He concluded with the discussion of radio-activity, and the rays given off by the spinning electron. During the lecture the audience repeatedly expressed appreciation of the clear and convincing manner in which the different points of the advanced subject were explained, and the wonderful, and at least so far as this state is concerned, unique experiments which the lecturer employed in the elucidation of his subject.

Next week Professor Bragg will conclude the series of lectures, when he will deal more specifically with the radio-activity of radium, thorium, and of other substances.

Reg. 1st July '03.

THE ELECTRON.

WHAT IS RADIUM?

THE LATEST MARVEL.

Professor Bragg gave the last of his series of extension lectures on the electron to a record attendance at the University on Tuesday evening. Continuing his explanation of the means of studying the electron, he dealt with the effect which ultra-violet light has upon the air through which an electric charge is straining to pass. By the means of the rays thrown off by a burning magnesium wire he showed how a charge was permitted by their influence to pass between a piece of gauze and a zinc plate, both insulated, when before the rays were active the charge could not overcome the resistance of the intervening air. These ultra-violet rays were shown to possess the strange power of fluorescence, which was in another form of their power to split up a medium into atoms. These experiments concluded his theoretical demonstration of the properties of the electron, but he went on to show that the electron had practical properties in the concrete. The discovery of uranium in 1896, and soon afterwards thorium and pitch-blende, and again from the latter radium, polonium, and actinium, had provided the practical source of the electron, and put its study on a sound basis. The professor started with the fundamental experiment that thorium was able to influence the surrounding gas and split it up into electrons, as the Rontgen rays had done in previous experiments. This was done by inserting thorium powder in the neighbourhood of two insulated metals, between which an electric charge was vainly trying to pass. The thorium split up the air and overcame its resistance to the transference as the other experiments had done, showing that it had in itself the property of giving off electrons. He then explained that these rays of electrons were of three kinds. The first, or alpha rays, could only exist for a very little distance from the body; they were practically impervious to the influence of a magnet; they were undeviating and non-penetrating. The second, or beta rays, were both deviating and penetrating, and traversed the air to a much greater distance, having almost the same properties as the original kathode rays. The third rays, which penetrated to a much greater distance, were as yet but little examined. He remarked that the reason the beta rays could traverse the greater distance was that they were much less in mass than the alpha, which, being larger, encountered more resistance, and were unable to advance so far. He explained in detail the difference and relation between these rays and the properties which the latest scientific research had discovered. Then, taking thorium as a ground upon which to base his experiments, he showed its influence by a number of interesting experiments. A precipitate of thorium and ammonia gave another substance with properties other than those of thorium, while this thorium X gave rise in its turn to emanation and that to radio-activity. Thorium was sprinkled in a tube and air forced over it, along tubes through excessive heat and excessive cold, and through strong sulphuric acid and cotton wool, but by what scientists termed "emanation" its influence was unimpaired and had the same effect upon a strained medium as the substance itself.

—Radium.—

The much-discussed radium had the same qualities as thorium, only to nearly a million times as great an extent. It gave out electrons with many times greater power, and made examination of their properties considerably easier to the scientist. M. Curie and his wife had obtained it from examination of pitch-blende, and they claimed for it the property of eternal heat. That might be so, but neither heat nor light was in the substance itself. It shot out countless numbers of electrons, which, striking upon the neighbouring bodies, or even back again upon itself, caused heat and light. The property of radium was in the electrons which it cast off, and the property of the electron was in its influence upon the surrounding medium. The sun shot off electrons, and as they streamed into the atmosphere their excitement in the ether caused the formation of the wonderful aurora. The same electrons, meeting those emanating from a comet in proximity to the sun, caused them to stream out into a tail.

—Matter.—

The electron, however, led to the most important study of all things—Matter. As the electron moved through space it possessed energy, both by means of its charge and its movement. Take away the latter property, which might be common to all, and matter might be measured by its charge alone. The electron, considered only in relation to its charge, was an entity by the external influence it exerted. Electricity always existed on the outside, and if that electricity was the measure of the electron, of what did the centre of the electron consist? This was discussing the theory of matter. If everything was measured only by the external influence of its charge, and matter became an empty expression, it might be crossed out of the three fundamentals of our comprehension, and leave only ether and electricity.

Reg. 1st July 1903.

—The Experiments.—

Those who have attended the series of lectures given by the professor have been afforded a treat never before presented to a South Australian audience. The lecturer has elucidated the confused theories as to the position and substance of the electron with such skill and force that even those who have had practically no previous scientific training have been able to follow and understand his steps, and go away with a clear conception of what the electron is and means. This has been greatly augmented by a number of remarkable experiments, many of which, it is believed, have never been shown publicly in Australia, and some original ones in the world. A large amount of apparatus was employed in these experiments; yet not a single one failed at the appointed hour. For some of them, what seemed to the unscientific eye a tangled network of little copper wires, were suspended above the stage, each of which played its individual part in the manipulation of the different experiments. In order that no time should be wasted, a special keyboard, designed by Professor Bragg, and executed by Mr. Rogers, was used. By this means, although the different apparatus appeared hopelessly mixed up, each experiment could be performed by the manipulation of little runners, and the corresponding alteration in the currents. Passages of charges were shown to the whole room by the use of a powerful lantern, which, sending a beam of light on to a quadrant electrometer, caused a spot of light to move up and down on a scale at the back of the room.

—End of a Popular Series.—

There is a French proverb which says that appetite comes with eating. Certainly Professor Bragg's audiences can appreciate this adage. Each lecture has deepened their interest in this remarkable study, until the University theatre has proved altogether too small for the crowd which has endeavoured to hear the lectures. Among the audience have been practically all residents of Adelaide who are interested in scientific research, either as amateurs or professionals; and the furore of applause which greeted the lecturer on the conclusion of his series on Tuesday evening was an loquent answer to the enquiry whether they have been satisfied with what they have heard and seen.

Reg. 15th June 1904.

"THE ELECTRON AND THE ATOM."

UNIVERSITY EXTENSION LECTURE.

Professor Bragg, M.A., lectured at the Prince of Wales Buildings, University of Adelaide, on Tuesday evening, on "The electron and the atom." This was the first of three addresses in continuation of the series delivered in 1903 on "The electron." His Excellency the Governor (Sir George Le Hunte) and the Vice-Chancellor of the University (Dr. Barlow) were present. Professor Bragg, in introducing his subject, said that it was just 100 years ago since Dalton communicated his atomic theory to Professor Thomas Thomson, of Glasgow. The professor at once utilized the conception in his lectures, and in 1807 he published a text book in which the theory was given to the world. The atomic theory had during the century been fully established, and all the growth of science had but served to give it a stronger hold. The atomic theory supposed that matter was composed of an aggregation of atoms, the hydrogen atoms being, for instance, all alike, but different from the atoms of another substance—oxygen, for example. With the idea of atoms came necessarily the conception that they were always in motion. That was exemplified by the diffusion of gases into one another, and even of metals into one another. Robert Austen pressed a piece of lead on a piece of gold, the faces of contact being carefully prepared, and he found after a lapse of four years that the surface layers of lead had been penetrated by so much gold that on assay they gave over 1 oz. to the ton. Heat was a mode of motion, and as a body became hotter its atoms moved about more quickly. All chemical and physical actions depended on the affinities of atoms for atoms. The chemist and physicist assumed the existence of those affinities, and on them built their work. But it was possible to enquire how the atom was built up and what were the natures of the affinities of atom for atom. That was what he proposed to do in the course of the three lectures. It had long been supposed that the atom was indivisible, as its very name implied, but the discovery of radio-activity, together with the revelations of the spectroscope, had made it clear that the atom was a complicated structure. A few main principles respecting the external characteristics of atoms must be stated before the main subject could be proceeded with. In the gaseous state matter consisted of atoms moving about with great speed, colliding against one another, but otherwise free from one another's influence. In a cubic centimetre of gas (about a thimbleful) the number of molecules at ordinary pressures and temperatures was 40,000,000,000,000,000,000. Each one on the average moved about 4-millionths of an inch before it hit another, but its diameter was 100 or 200-millionths of an inch. As to its weight, an ounce would contain, of hydrogen atoms, a number expressed by the figure 1 and 25 cyphers. The average speed of a molecule in air was about one-third of a mile in a second. The spectroscope method of getting at the nature of an atom consisted in an examination of the vibrations of the electric charges which it contained. That gave waves of light. The problem might have its analogue in the case of sound. If any one heard an instrument and tried to gather from the nature of its sound what the instrument was like, then the problem would be somewhat similar, except that one must be supposed whilst making the investigation to be quite ignorant of what a musical instrument was like. The lecturer explained that the charges in the atoms were set in vibration by extremely rapid collisions between one another, whose speed was in all probability largely due to electric attraction. He showed various spectra upon a screen, and compared the revelations there made with the effects given by musical instruments, using the organ and zither to illustrate some of the points. He told his audience how the complicated systems of lines in a spectrum had been analysed into series of lines which were related to one another somewhat as were the overtones of a musical string. He described how the spectrum changed with temperature, how that could be further illustrated by the spectra of the stars, and how in that way the stars might be arranged in order of their temperature. Thus it was apparent that the sun was one of the cooler stars, Sirius a much hotter one, and Gamma Argus still much hotter. Other stars were given much cooler than the sun. All the statements he made served to point out that an atom contained systems of electric charges, named electrons, in rapid motion within the boundaries of the atom. At the conclusion Professor Bragg promised to show at his next lecture what was to be gathered from the recently discovered phenomena of radio-activity.

Reg. 22nd June 1904.

ELECTRON AND ATOM.

PROFESSOR BRAGG'S SECOND LECTURE.

The second of the three lectures by Professor Bragg on "The electron and the atom," delivered at the University of Adelaide in connection with the extension series was given in the Prince of Wales Buildings on Tuesday evening. Every seat in the auditorium was occupied, and the professor was accorded a cordial reception. The professor said, in opening, that they proposed to discover what might be learned as to the nature of the atom from the phenomena of radio-activity. Some years ago Professor J. J. Thomson said that it was possible to detach from any atom a very small portion called an electron. That was a negative charge. The remainder of the atom was therefore left positive. Various agencies could break up the atom in that way. Such change centres were called ions, and a gas containing them was said to be ionized. The attraction of the electric charges was generally sufficient to cause neutral molecules to cluster around them so that the ions in a gas became molecule clusters. Electricity could pass through such a gas, because the negative ions moved one way and the positive ions moved the other. From whatever source it was derived, the electron was always the same in charge and mass. Electrons being so light were very easily moved, and in even moderate electro-motive forces acquired enormous speeds—tens of thousands of miles per second. Electrons moving with such speed were to be found in the ordinary vacuum tube. When an electron was suddenly stopped the shock caused ether waves to ripple away from the point of impact. Those were known as Rontgen rays. Radium gave out three totally distinct kinds of radiation. Two of them were radiations of matter; the third was of short pulses in the ether. Of the two former one was a radiation of matter of the size of atoms, the other of electrons. There were many substances which gave off small amounts of phosphorescent light when struck by rapidly moving electric charges. Radium was one of those, and therefore actually gave out a small amount of light under the impacts of its own projected particles. The radiations of matter from radium formed the new and deeply interesting phenomena which were so much studied at present. In the first place they had remarkable powers of penetration through substances; in the second place they moved with enormous speed. Since the electron could pierce a yard of air without being bent aside it followed that, being very light, it encountered nothing on the way. Yet it had gone through many millions of molecules. They were therefore driven to the conclusion that a molecule or atom was largely empty space, only a small portion of the region it claimed as its own being actually occupied by anything capable of resisting the impact of an electron. If, as was now supposed, the principal portions of an atom were its electrons—if, as seemed probable, they and they alone constituted what they called the mass of the atom—then it seemed certain that an atom contained a quantity of electrons in rapid motion around some centre and with wide spaces in between, to be compared with the motions of the planets around the sun and the great distances which lay between them. The alpha rays of radium consisted of matter of the size of atoms, and it appeared that they also could pierce other atoms without being stopped or suffering any marked deflection. So that it would almost appear as if when a certain speed had been exceeded atoms no longer rebounded from each other on meeting, but passed through each other. Similarly, electrons might pass through atoms. That critical speed was about 6,000 miles per second. It was that speed which was reached by certain rays in vacuum tubes, and by the particles projected from radium. Professor Bragg used some of the radium which he recently received from England in conducting his experiments, with which he illustrated and assisted his lecture. He promised that in the third address he would consider the nature of the processes involved in the extraordinary breaking up of the radium atom. At the conclusion of the lecture the professor courteously permitted persons in the audience, who were curious regarding the appearance of radium, to inspect his valuable samples, and he had the room darkened so that they might see through a screen the peculiar glow which emanates from the substance.