SCIENCE NEWS

Science Service, Washington, D. C.

PAPERS PRESENTED AT THE PASADENA MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE universal truth of one of the greatest laws of all physics, the second law of thermodynamics which requires a dying universe, was seriously questioned by Professor Richard Tolman, of the California Institute of Technology, in a paper read before the American Association for the Advancement of Science. This law, invulnerable since it was formulated by the great physicists of the last century, Clausius and Kelvin, leaves no escape from the conclusion that the universe must eventually cool down and all its motions slow up until a meaningless inactivity pervades everything. Professor Tolman by a detailed analysis has reached his conclusions by incorporating the principles of the relativity theory in classical thermodynamics. His theory is made all the more acceptable by the fact that his reasoning gives an explanation for one of the greatest of modern astronomical mysteries: The fact that the universe is apparently bursting apart at a tremendous rate. Professor Tolman begins by setting up a hypothetical simplified universe of his own, whose behavior he can study with some certainty. He finds that in it an observer provided with a rigid meter stick for making measurements would make certain deductions about that part of the phantom universe in which he found himself, but these would be quite wrong for the universe as a whole. Professor Tolman's universe is a very simple one, filled evenly with a mixture of gas and radiation—something very different from the universe as astronomers know it and yet useful for certain scientific purposes. The hypothetical observer would conclude that the "entropy" or mixed-upness of his universe was increasing and yet the entropy of the universe would actually be constant, taken as a whole. He would also find that matter in this region was being annihilated . . . that the energy and temperature of the region was dropping, and that radiation was flowing out of the region into surrounding space, which would thus appear to be at a lower temperature than the material in his own vicinity. It is from just these facts that pessimistic conclusions as to the fate of our world are drawn. However, from the standpoint of the relativistic thermodynamics invented by Professor Tolman, all the processes in such a hypothetical system would be taking place reversibly without increase in entropy, and no final dissipation of energy would occur within it. Such a universe would continuously expand by the transformation of matter into radiation. As a matter of fact our own universe appears to be doing just this. The distant nebulae are rushing away from us at tremendous speeds and the real universe is constantly expanding.

WHAT the universe actually consists of so far as the largest of telescopes can determine was told by Dr. Edwin Hubble, of Mount Wilson Observatory. He reported that the universe is much the same wherever his telescope is pointed. There is no evidence that the great systems of stars and star stuff known as nebulae become any fewer at the very limits of observable space, a distance so great that light traveling 186,000 miles per second requires two hundred and fifty million years to reach our telescopes. When we look at the starry night sky we see principally the stars of the nebula in which our sun is one of millions of stars. Dr. Hubble explained that there are thirty million nebulae within reach of the Mount Wilson 100-inch telescope, each about a million times as bright as the sun, scattered about at intervals of about a million five-hundred thousand light years. It is such immensities of space and matter that Professor Tolman's new view of the universe perpetuates forever.

THE production of X-rays as penetrating as cosmic rays, with voltages of eighteen million, was forecast in a report made by Drs. F. Lange and A. Brasch, of the University of Berlin, which was read by Dr. Alexander Goetz, of the California Institute of Technology. Working in a small valley between two mountain peaks in northern Italy, a place where thunderstorms occur frequently in summer and early autumn, Drs. Lange and Brasch emulated Benjamin Franklin by snatching electrical energy from the skies. With their gathering system, suspended from heavily insulated wires strung across the valley, they obtained discharges of electricity which sparked twenty-five feet and measured eighteen million volts. Assured by these experiments on Monte Generoso that nature would provide the high tension electrical discharges for their experiments, Drs. Lange and Brasch returned to their laboratories at the University of Berlin to construct a new type X-ray tube, which would withstand such powerful discharges. They succeeded in building a tube of alternate rings of rubber and metal which has been tested at three million volts, continuing for an interval of a millionth of a second. These three-million-volt X-rays are the most powerful yet produced, exceeding any so far produced in America. Electrons are so speeded in this tube that they drill holes an inch deep in a brass plate at the bottom of the tube, each electron boring its own hole. The new X-ray tube, made of rubber and metal instead of glass, is less than a dozen feet long, despite the high voltage it withstands. It is estimated that an ordinary X-ray tube to withstand such voltages would need to be half a mile long, and therefore could not be constructed. When a tube now building has impressed upon it the high potentials of the natural electrical discharges there will be produced gamma rays equivalent to a hundred thousand grams of radium, which is at least a thousand times as much radium as there is now available for medical or industrial use in the world. When this experiment is performed, the super-X-rays obtained will equal the cosmic

rays in penetration and the experiments projected should settle the question of the nature of the cosmic rays. X-rays produced with three million volts in the Berlin laboratories have already penetrated a tower of lead a yard thick.

AT two great electrical laboratories in America, the California Institute of Technology, Pasadena, and the General Electric Company, Schenectady, million-volt X-ray tubes will soon be available for therapeutic use. Dr. C. C. Lauritsen, of the California Institute of Technology, estimated that the 550,000-volt two-kilowatt X-ray tube now temporarily diverted from physical research to experimental treatment of cancer cases is equivalent to at least a hundred grams of radium, which if they could be obtained would be worth six million dollars. In a new radiation laboratory Dr. Lauritsen and his associates are now building an X-ray tube to operate at a million volts. This will produce hard, penetrating rays that all the radium in the world could not produce, and the physicians working with the physicists will be able to direct the output of this most powerful tube at a single case of cancer if research during the next few years shows that to be desirable.

TO the meeting Dr. W. D. Coolidge, of the General Electric Company, brought news of a new cascaded X-ray tube which will need 900,000 volts and will be used for cancer treatment at the Memorial Hospital in New York. Since the modern form of X-ray tube was invented by Dr. Coolidge and named after him, this is his latest and most advanced contribution to the production of high-energy electrical radiations.

SUCCESS in producing positive electrical particles that speed with million-volt velocities, although only forty thousand volts were used in generating them, was reported by Dr. E. O. Lawrence, of the University of California. He put the particles in a sort of merry-go-round electrical field in which they are given shoves periodically until they travel at enormous rates. Dr. Lawrence hopes to explore the nucleus with the high-speed particles.

DR. M. A. TUVE told how he and his associates of the Carnegie Institution of Washington had produced artificially by a combination of high-voltage Tesla coils and vacuum tubes beta and gamma rays of energies equivalent to those emitted by radium. He also described a method that promises to allow him to work with voltages of ten million and perhaps more in the future.

DIAGRAMS of the structure of the atomic nucleus were shown by Professor Wendell M. Latimer, of the University of California, to illustrate a new theory of the way in which the central portion of the atom is put together. This is the ultimate and final step in determining just what is the structure of the material things about us. Beneath the seemingly solid surfaces of metals and other substances with which we have daily contact, a multitude of regularly arranged crystals have been found—row on row of them, each made up of molecules, which in turn were shown to be definite arrangements of atoms. X-rays have aided greatly in this exploration of submicroscopic crystal worlds. The atom was shown to be fashioned as a very heavy nucleus surrounded by very light particles or waves known as electrons. Professor Latimer has assumed the task of discovering the architecture of that internal citadel of the atom. Previous investigators have pictured the nucleus of the atom in terms of the number of protons, or hearts of hydrogen atoms, and electrons that are present. In iron, for instance, the nucleus was known to consist of 56 of the protons, as the hydrogen nuclei are called, and 30 electrons or units of electricity. The radio-active disintegration of elements like radium gave a clue to how the protons and electrons were arranged in the nucleus. Disintegrating matter gives off both unattached electrons in pairs and bundles of four protons and two electrons known as alpha particles. These particular bundles known as alpha particles are known to be also the atomic hearts of helium, the inert gas that is used to inflate American airships. Other research has shown that these protons and electrons are spinning, and opposite spins play an important part in keeping the nucleus together. Professor Latimer first arranged alpha particles in a tetrahedral pattern, that is, at the corners of a triangular pyramid. Then he assumed that each of these alpha particles is itself a tiny tetrahedron of four protons with a pair of electrons spinning at its center. This Professor Latimer presented as the best picture that can now be drawn of the ultimate in the structure of matter.

PROFESSOR R. H. FOWLER, of the University of Cambridge, pointed out that exploration of the state of the atomic nucleus was progressing steadily and that the energy laws of the heart of the atom are being discovered to be very similar to those that Professor Niels Bohr found to apply to the atom as a whole. Just as the atoms have definite energy states in which they respond much as a violin string will vibrate to a definite sound vibration, so the nucleus has definite levels of energy within it that can be probed by physicists. Portions of the nucleus can not be knocked out in the same way that electrons can be removed from atoms by bombardment, but the physicists can watch alpha particles come out of their own accord during natural disintegration. These alpha particles are the hearts of helium atoms and with protons and electrons as somewhat trivial additions they form the nuclei of all atoms. The energy changes that occur when alpha particles and protons come out of the atom's nucleus are giving a number of investigators all over the world clearer pictures of the constitution of the nucleus.

How the formation of chemical compounds is being explained mathematically by the new theories of physics was the subject of a symposium in which Dr. W. Heitler, of the University of Göttingen; Dr. Linus Pauling, of the California Institute of Technology, and Dr. J. C. Slater, of the Massachusetts Institute of Technology, took part. Before the invention of the new quantum

theory, chemists had been unable to understand the formation of a great class of chemical compounds, those in which there is no direct electrical attraction. Ways have now been found of explaining these and many other chemical facts in strict mathematical terms. The new mathematical theory confirms completely the idea of Professor G. N. Lewis, of the University of California, that the non-polar type of linkage between atoms consist of two electrons paired. Only atoms in which there is an unmated electron can form compounds of this sort. Further, said Dr. Heitler, the quantum theory shows that the electron possesses quite a remarkable property, its spin. The electron has an axis which can not assume all directions in space. For two adjacent electrons the axes must either be parallel or antiparallel. If the spins, and therefore axes, are in opposite directions there is an attractive force between the molecules. This is the chemical force. Dr. Pauling was able to explain why some atoms combine and others not. The new theories will also explain the strength of chemical attractions, magnetic properties and the angles made by the atoms in compounds.

WAVES of electrons will soon make possible a clearer picture of the internal structure of crystals than ever before, according to Dr. C. J. Davisson, of the Bell Telephone Laboratories, New York, speaking before a joint meeting of the association and the American Physical Society. Very short wave-lengths are available in electron waves and this results in greater power to photograph the fine crystal structure of matter. Just as shortening the wave-length of light used in illuminating a microscope allows smaller objects to be seen, use of electrons made visible by their effects on photographic plates allows physicists to study more minute structure in crystalline matter. The electron waves are diffracted by crystals and give rise to diffraction patterns which are quite similar to those produced by X-rays. X-ray studies have given much information on matter's structure in the past decade. The scattering power of atoms is about a million times greater for electron waves than for X-rays. The electron waves will therefore give information chiefly regarding the structure of surfaces of crystals, whereas the X-rays give information about the structure of the bodies of crystals. He also expects that the electron waves will allow the study of layers of gas attached to the surfaces of metal crystals.

DR. P. W. BRIDGMAN, of Harvard University, discussed metal crystals and explained that much more is known about simple common salt crystals than about simple metal crystals.

DR. FRITZ ZWICKY, of the California Institute of Technology, described newly discovered secondary structure of crystals which physicists expect will aid them to a better understanding of how matter is put together.

ASTRONOMERS are not quite certain of the size of the planet Pluto which was discovered last year. Dr. E. C. Bower, of the University of California, reported a study of gravitational pulls between Pluto and the other members of the solar system which unfortunately does not give conclusive results. The most probable result is that Pluto has seven tenths of the mass of the earth. Dr. Bower explained that an observation of the planet's disc in the hundred-inch telescope at Mount Wilson probably offers the best chance of determining its size. Since with poor seeing conditions at Mount Wilson no disc could be seen, Dr. Bower believes the outermost planet of the sun's family can not be larger than eight tenths the size of the earth. If under the best conditions for astronomical observations Pluto does not appear to be more than a mere point of light it can not be heavier than a tenth of the earth's mass.

JUST a mere fifty miles above our heads the temperature is between a thousand and two thousand degrees Fahrenheit, according to a new theory of the earth's atmosphere presented by Professor B. Guthenberg, of the California Institute of Technology. According to this theory the atmosphere is practically the same in composition throughout and not exclusively helium in some high layers, as other physicists have concluded. Although the temperatures are high in the heights of the stratosphere, the air is very diffuse and thin. Only a rocket could actually penetrate the atmospheric heights to bring back evidence of what actually exists there.

THUNDERSTORMS that come suddenly in the night are about the most troublesome feature in western aviation, and the hardest to guard against, Vincent E. Jakl, meteorologist of the Omaha municipal airport, told the American Meteorological Society at its meeting at Pasadena. It is exceedingly difficult to predict the time or place of a thunderstorm, he said, and while aviators can usually see such storms in the daytime and fly around them, it is not always possible to see them at night in sufficient time to avoid them. Other weather changes are predicted with considerable success, from maps of the region prepared at three-hour intervals and from the larger maps prepared twice each day. Aviators flying over the region with which he is especially concerned, reaching from Chicago to Cheyenne, have fewer weather troubles in the western half of the area, because it is considerably drier than the eastern half. As a possible improvement in airway forecasting, he suggested that special stations be established on either side of the air lanes, in addition to the present chains that lie directly along the lines of flight.

FOUR active substances, probably hormones, have been isolated from the placenta, part of the female reproductive organs, Dr. J. B. Collip, of McGill University and one of the Toronto group that gave insulin to the world, reported also to the Association for the Study of Internal Secretion. These substances act as sexual stimulants in both males and females. One of them is valuable in treating disturbances of the reproductive cycle in females. It is the first preparation of this type which is effective when given by mouth.