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THE ENERGY CONTAINED IN COSMIC RAYS

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COSMIC rays, totally unknown a few decades ago, are now recognized to comprise the greater portion of the radiant energy of the universe, Dr. Robert A. Millikan, of the California Institute of Technology, told the National Academy of Sciences at its annual meeting in Washington.

As the result of new researches with sounding balloons and airplanes this past year, Dr. Millikan and his associates have determined with great accuracy the way in which cosmic rays vary downward from nearly the top of the earth's atmosphere. The recent experimental results, combined with the findings of Dr. Millikan and other experimenters in past years, allow Dr. Millikan to conclude that the total radiant energy in our galaxy in the form of cosmic rays is nearly the same as that in all the other forms of radiation, such as light and heat emitted by stars.

In the immense spaces between the galaxies of stars the starlight and heat must diminish to a small amount of that found in our own Milky Way galaxy, but the cosmic radiation coming to the earth from far beyond our neighbor stars, from the depths of the universe, must be even greater in intensity in intergalactic space. In this way Dr. Millikan concludes that cosmic radiation forms the greater part of the radiant energy of the universe.

One of the sounding balloons launched by Dr. Millikan and Dr. I. S. Bowen reached a height at which only a half of one per cent. of the atmosphere's weight remained above it, equivalent to about 20 miles altitude (16 millimeters of mercury pressure). The cosmic ray electroscope record obtained was reliable up to nearly that height, to within about 92 per cent. of the top of the atmosphere. One other balloon flight, carrying the remarkably light, automatic instruments to great heights in the stratosphere, agreed closely with the record flight and the two checked closely the results of a similar sounding balloon ascension made at the same time (last summer) by the German physicist, Regener.

With a cosmic ray electroscope, devised by Dr. H. Victor Neher, which records accurately and automatically under the strenuous conditions of rushing auto, railroad train or airplane, measurements of cosmic ray intensity have been made at altitudes up to 29,000 feet, nearly six miles. U. S. Army bombers and pursuit planes carried the instruments aloft first without screening and second screened by a shield of lead of 10 centimeters' thickness at several localities in the United States and at Panama, while commercial planes were used in experiments 17 degrees below the equator in Peru.

The results of these airplane tests bring to light the fact that cosmic rays grow rapidly softer or less penetrating as altitude increases. This softening is so marked that more than 75 per cent. of the rays existing at altitudes of 25,000 feet have insufficient energy to penetrate four inches of lead. As Dr. Carl D. Anderson in Dr. Millikan's laboratory has measured the loss of energy of cosmic rays passing through lead, Dr. Millikan can conclude that more than three fourths of the cosmic rays at 25,000-foot altitudes have energies of less than 350,000,000 volts. But particles of this voltage can not penetrate more than half of the depth of the atmosphere, and Dr. Millikan concludes that the experiments furnish convincing proof that the cosmic rays found at low altitudes are certainly secondaries which are formed in the earth's atmosphere by collision with air atoms. Photographs taken by Dr. Anderson have caught the cosmic rays, which are non-ionizing and can not be photographed themselves, in the act of smashing atomic hearts and letting loose positively and negatively charged particles.

Dr. Millikan concludes that his researches present strong evidence that all but a small fraction of the cosmic rays observed at sea-level by cosmic ray counters and other devices used by other investigators are secondary rays produced within the earth's atmosphere.

Most of the cosmic rays, then, according to his interpretation, enter the atmosphere as photons or radiation-like light, x-rays or radium's gamma-rays, not as charged particles, like electrons or positrons. The new airplane experiments also lend support to Dr. Millikan's theory that the total cosmic ray curve is to be explained by not less than three and probably four or five cosmic ray bands, corresponding to different colors of light in the visible spectrum. Those rays that reach only the upper part of the atmosphere are, he finds, with energies less than some 75,000,000 volts.

Dr. Millikan's experiments were supported by funds of the Carnegie Corporation administered by the Carnegie Institution of Washington. In the sounding balloon experiments he had the full and effective cooperation of the U. S. Weather Bureau, and in the airplane test the equally effective cooperation of the U. S. Army Air Force and the Royal Canadian Air Force.

RADIATION OF THE NIGHT SKY

THE night sky glows with a faint light that seems to come from nowhere. It certainly is not made of scattered starlight, for it is richest in wave-lengths of the red and infra-red regions of the spectrum, whereas scattered starlight is poorest in exactly these rays. This sky radiation has been called the "cosmic radiation" of the night sky by Dr. V. M. Slipher, of the Lowell Observatory, Flagstaff, Arizona, who reported on his long study of the subject at the meeting in Washington of the American Geophysical Union.

This designation, however, should not be confused with the cosmic radiation proper, which consists of extremely penetrating rays or particles studied by Hess and Kolhoerster in Germany, and by Millikan, Compton and Swann in this country. The cosmic radiation proper

almost certainly comes from outer space, whereas the sky rays studied by Dr. Slipher are almost as certainly the product of the earth's atmosphere, excited into faint luminescence by radiation from the sun.

Dr. Slipher's sky rays range through the entire gamut of wave-lengths from ultra-violet to infra-red, though some of the colors are stronger than others. He spoke of a prominent yellow line that appears in his spectrographic photographs, and of a green line due to glowing nitrogen that can be caught just before dawn and just after evening twilight but not at midnight. This line seems to be identical with the most prominent band of wave-lengths in the light of the aurora.

Dr. Slipher made his studies with a specially built instrument that enabled him to obtain spectrum photographs of five parts of the sky at the same time: the four points of the compass and directly overhead. Comparing these simultaneous photographs, he discovered that the sky near the horizon gives off radiations rich in red and infra-red rays, while at the zenith these are relatively feebler, though the violet rays in the visible spectrum are as strong there as elsewhere in the sky. This effect Dr. Slipher attributed to the greater density of the atmosphere near the earth's surface, which selects out the rays of longer wave-length and partially blocks the violet and ultra-violet rays.

Dr. Slipher was called to England to receive a medal of the Royal Society just before his paper was to be read, so that the actual presentation of his paper was made by a colleague.

EFFECTS OF EARTHQUAKES ON WATERS OF THE EARTH

STRANGE tricks that earthquakes play with rivers, lakes and subterranean waters of the earth were described to the American Geophysical Union by Captain N. H. Heck, of the U. S. Coast and Geodetic Survey.

Earthquakes often cause fountains of water or liquid mud to spurt from the ground. They sometimes change the course of subterranean streams, or the quantity of water flowing in them. In the earthquake that occurred in New York State in 1929, the Attica reservoir filled, although there had been no rain, while in a region not far distant the wells went dry.

Earthquakes often cause strange behavior by rivers and other bodies of surface water. The famous New Madrid quake in the lower Mississippi Valley over a century ago caused the great stream to flow backwards for a time, and the disturbance was followed by the formation of several entirely new lakes that are still in existence. Earthquakes may dam up streams to form lakes, or they may break down natural dams and release floods or mud flows. Some of the most disastrous effects of recent earthquakes in interior China were due to the jarring loose of masses of watersoaked fine earth, causing terrific landslides.

Water, in its turn, has effects on earthquakes. Some of the strangest, and to scientists the most puzzling, of earthquake phenomena are the so-called gravity waves of earthquakes, waves that travel visibly along the surface at express-train speeds, though they are very much slower at that than the waves that are felt but are too swift to be seen. These gravity waves are much affected in their intensity and velocity by the amount of water held by the soil through which they move. Captain Heck recommended a thorough study of the rate of wave travel through water-soaked earth as a problem promising both theoretical and practical results in the science of earthquakes.

THE EARTH'S CORONA

THE earth, like the sun, has a corona—a luminous gaseous envelope extending far out into space. Its existence has been demonstrated by studies of the aurora borealis, or northern lights, Professor Lars Vegard, of the University of Oslo, Norway, told the American Meteorological Society at its meeting in Washington.

The earth's corona, however, shows some marked differences from the sun's. The sun's corona, so far as we know, is generated by the sun's own power; the earth's is a product of the action of the sun on gases in the earth's outer atmosphere. Furthermore, the earth's corona is decidedly eccentric, being far more extensive on the side of the earth nearest the sun than it is anywhere else.

Auroral displays have been measured at heights of from 70 to 700 or 800 kilometers (43 to 490 or 550 miles) above the surface of the earth. Spectroscopic studies of their light indicate that the glow is due mostly to electrically excited nitrogen gas, which apparently exists at considerable density even at those great heights.

"To explain this fact," the speaker continued, "we assume that in the auroral region the atmospheric matter is brought to high altitudes through the effect of electrical forces, which result from the photoelectric action of the sun's rays of short wave-length."

Singularly enough, there are no spectrographic lines indicating the presence of the light gases, helium and hydrogen, at these elevations; or at most they are exceedingly faint and feeble. This runs quite counter to the assumption often made that layers of these "balloon gases" float on the top of the earth's atmosphere. On the contrary, all the gases in the atmosphere seem to be thoroughly mixed.

Auroral light comes from rather chilly sources, though they are not so intensely cold as we are sometimes prone to think everything must be in the upper air. By comparing their spectra with those of laboratory light sources at known temperatures, Professor Vegard reached the conclusion that auroral light centers are active at temperatures about 30 degrees below zero Centigrade, or 22 degrees below zero Fahrenheit.

HEAVY WATER

A BATTERY of electrolytic cells for the production of heavy water and hydrogen of mass 2 was announced to the American Philosophical Society by Professor Hugh S. Taylor and Henry Eyring, of Princeton University.

With this battery of 270 units each holding 200 cubic centimeters of potassium hydroxide solution it has been found possible in somewhat over seven days to concentrate by electrolysis the heavy hydrogen present in

twenty-five gallons of old alkali solutions which have been used for a period of years as a source of electrolytic hydrogen and oxygen. In this way the heavy hydrogen has been concentrated to yield about three quarters of a glassful of water containing 7 per cent. of the heavy hydrogen. A weekly production on this scale can now be maintained at Princeton.

The further enrichment of this water to yield the 100 per cent. pure heavy isotope of hydrogen of mass 2, or water of mass 1.1, is being effected by a combination of further electrolysis coupled with a new process of fractionation of the hydrogen isotopes from gas absorbed on gas-mask charcoal at the temperature of liquid air. It has recently been shown by Taylor, Gould and Bleakney that this method can secure a several fold enrichment of the hydrogen in a single operation.

The hydrogen of mass 2 produced at Princeton will be employed to trace the differences in speeds of reaction of the light and heavy isotopes at surfaces and with various gases. In this way fundamental advances in our knowledge of the speed of chemical processes are expected.

The water already attained represents a two thousandfold enrichment of the heavy water and it is calculated that 150 gallons of ordinary water must be decomposed to yield the residual ¾ glassful of water exhibited at Philadelphia.

CANCER HOUSE DISPROVED STATISTICALLY

Do "cancer houses" exist? "No!" is the emphatic answer of two French statisticians who have recently reported their investigations to the French Academy of Medicine. Their names are Auguste Lumière and Paul Vigne, and the town whose cancer death-rate they have investigated house by house is Lyon.

Here, in the course of 20 years, there were 6,703 deaths from cancer exclusive of those occurring in hospitals and nursing homes. The number of houses in Lyon was 23,258. Were the 6,703 deaths evenly distributed throughout these houses, or was their distribution so uneven that chance alone could not explain the frequency of cancer deaths in certain houses?

It was ascertained that there were as many as 18,231 houses in which there had been no death from cancer in the 20-year period. There were 3,869 in each of which there had been one cancer death, and 953 with two cancer deaths each. At the extreme end of this list were two houses in each of which there had been as many as 7 deaths, and one in which there had been 8 deaths.

Were these latter houses really cancer houses, possessing certain sinister properties responsible for these deaths? Or was the accumulation of cancer deaths just an accident? Finding a correct answer to these questions was not only of considerable academic and scientific interest, but also of some financial importance to the owners and tenants of the suspected houses.

As the number of persons living in each house was not available for statistical study, the answer to this question had to be sought indirectly by the following means: A study was made of the numbers of births, marriages and deaths from all causes in the same period and town. All three were found to be distributed throughout the houses of Lyon in the same apparently irregular manner as were the deaths from cancer.

Now, no one has yet had the Gilbertian fantasy to suggest the existence of birth or marriage houses endowed with peculiar properties which add to the fertility of nations or their matrimonial rates. And so long as cancer deaths are distributed throughout the houses of a community with the impartial irrelevance observed in the behavior of babies and brides and bridegrooms, no one need dread renting a house because it has a reputation for being a cancer house.

ITEMS

THE rate at which cosmic rays ionize, or electrically charge, molecules of three atmospheric gases has been determined by Dr. W. F. G. Swann, of the Bartol Research Foundation. Dr. Swann reported on his researches before the meeting of the American Philosophical Society. Dr. Swann arranged two cylinders, which could be filled with gas at a pressure of seven atmospheres, or 105 pounds per square inch. Electrical connections were arranged so that the "kick" of each molecule as it received a charge from a cosmic ray would be registered. Per centimeter (0.39 inch), the rays charged 145 molecules of oxygen, 150 of nitrogen and 200 of argon.

LIQUID helium and superconducting lead were produced at the new cryogenic laboratory of the California Institute of Technology just six months after the beginning of construction and a year after the project was started. Professor A. Goetz found that a thirty-foot coil of fine lead wire suddenly lost all trace of electrical resistance because of its immersion in liquid helium. It remained in this superconducting state for twenty minutes while he and Dr. Alfred B. Focke, research fellow, congratulated each other that the apparatus functioned perfectly as designed and needs no modification. Last December liquid hydrogen was produced as the new laboratory's first step toward liquid helium. Helium liquefies at 450 degrees Fahrenheit below zero.

SENDING up balloons and airplanes with observers and instruments to ask why the stratosphere over the equator lets out less of the earth's heat than escapes through the atmospheric envelope in the polar regions was advocated at the meeting of the American Geophysical Union in Washington, by W. J. Humphreys, of the U. S. Weather Bureau. He called attention to the anomaly that the earth loses less heat to outer space over the tropics than it does over the polar areas; less also from rainy areas than from those of prevailingly fair weather. Why this should be the case nobody knows as yet, and this gap in our scientific knowledge Professor Humphreys presented as a challenge to researchers in meteorology. He also proposed barometric measurements from high mountain tops to determine whether the temperature of the atmosphere as a whole varies with differences in solar radiation. An increase by as much as three degrees Centigrade, he said, would cause a 2.5-millimeter increase in the barometer reading.