

PHYSICS

# Earth Used As Instrument To Study Cosmic Rays

## Observations Made in India Near Magnetic Equator And Compared With Other Studies Farther North

USING the earth itself as a scientific instrument to analyze the mysterious cosmic rays, new evidence has been found that they originate between the stars when atoms of common elements are annihilated and turned into pairs of electrons.

This achievement was announced by Dr. Robert A. Millikan, head of the California Institute of Technology, in an address before the National Academy of Sciences. His researches were performed in collaboration with Dr. H. Victor Neher and Dr. William H. Pickering.

Cosmic rays entering the earth's atmosphere from outer space are made up to the extent of more than 60 per cent "of electronic bullets, each of energy between 2 billion electron volts and 15 billion electron volts," said Dr. Millikan. The action of these on the nuclei of atoms in the atmosphere produces other particles, mesotrons, which carry the energy farther than all the electrons themselves could penetrate.

To explain the origin of the incoming high-energy electrons, Dr. Millikan has adopted the hypothesis that they result from the total conversion of atoms of helium, carbon, nitrogen, oxygen and silicon. In support of this he cited the discovery, in the Institute's Kellogg Radiation Laboratory, by Dr. C. C. Lauritsen and Dr. William A. Fowler that a part at least of the energy which an atom has at rest is capable of transforming itself into a pair of electrons, one with a positive charge, the other negative. He also cited two discoveries by another of his colleagues, Dr. I. S. Bowen, "first, that atoms, when out in interstellar space, are able to undergo atomic transformations forbidden to them within the stars, and, second, that in ring-nebulæ, trillions of miles away from the exciting star and therefore presumably reflecting conditions in interstellar space, there are five of the atoms, namely helium, carbon, nitrogen, oxygen and silicon, each of which is more than ten times more abundant than any other atom save hydrogen." The latter, he stated, has such a small

rest-mass energy that it must be excluded from producing cosmic ray effects.

"The hypothesis made in view of these discoveries," he declared, "is that, while the evolution of energy by the stars is maintained, as Bethe has recently shown, by the partial transformation, within the stars of the rest-mass energy of hydrogen into radiant energy through the building of helium, carbon and other atoms out of hydrogen, and the release through this process of the so-called 'packing-fraction' energy, the energy of cosmic rays, on the other hand, is maintained, by the occasional complete transformation in interstellar space of the rest-mass energy of the atoms of helium, carbon, nitrogen, oxygen, and silicon (and even heavier aggregates), into cosmic rays, each such event presumably creating an electron pair, though an occasional photon pair, or neutron pair, or even proton pair for sufficiently high energies, need not necessarily be excluded."

Each of the five kinds of atoms should produce rays with definite amounts of energy. Those from the transformation of helium atoms would possess 1.9 billion electron volts (abbreviated b. e. v.), those from carbon 5.6 b. e. v., from nitrogen 6.6 b. e. v., from oxygen 7.5 b. e. v. and from silicon 13.2 b. e. v.

The magnetic field which surrounds the earth shields certain regions from these rays. Near the magnetic equator they have to travel across the lines of magnetic force, and only those of highest energy can penetrate. It has been estimated that a ray coming in vertically at the magnetic equator would have to have an energy of at least 18 b. e. v. Farther north, or south, they can spiral inwards along the lines of force, and less energy is required to bring them to the ground.

Thus, near the magnetic equator, only a very few vertical rays, due perhaps to elements other than the five mentioned, can come in. But north of latitude 20 degrees (measured from the magnetic equator and not the geographical one) the silicon rays may penetrate. Hence, as one travels northwards with detecting instruments, there should be a sudden increase

in the rays at 20 degrees latitude. No further increase should come until far enough north to encounter rays from oxygen, nitrogen and carbon, whose energies are roughly the same. Then there should be another "plateau," the next increase coming when the low-energy helium rays are reached. From this position, that of Bismarck, N. D., there would be no more increase to the pole.

To test this, observations were made in India, near the magnetic equator, with the cooperation of the British Indian Meteorological Service, and supported by the Carnegie Corporation of New York and the Carnegie Institution of Washington. These were compared with other studies made farther north. Evidence designated by Dr. Millikan as "excellent" was found for the existence of the different bands of energy in the cosmic rays. He also found good evidence for the four plateaus of constant cosmic ray intensity in the different latitudes. More experiments, in the United States and Mexico, are planned for the coming summer, he announced.

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METEOROLOGY

## Stratosphere Conditions Duplicated in Laboratory

STRATOSPHERE conditions of low atmospheric pressure and great cold are duplicated in a three-foot-square cabinet known as a "flight similitude chamber," developed by a University of Chicago meteorologist, Dr. Michael Ference, Jr.

The apparatus will be used in training weather observers for service in military and civil aviation, as well as in calibrating the radiosonde instruments carried up into the stratosphere by small balloons to record conditions there and report them back to earth by means of robot radio sets.

In the laboratory, the radiosonde instruments are placed in the flight similitude chamber. A vacuum pump partially exhausts the air, while a combination of dry ice and alcohol evaporation reduces the temperature. The radiosonde faithfully reports the changing conditions to the listening students, while an instructor checks accuracy of their interpretations.

Conditions duplicating those of 20 miles above the earth's surface, with atmospheric pressure reduced to one per cent of normal and temperature at 100 degrees below zero Fahrenheit, have been produced in the laboratory with the new apparatus.

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