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News of Science

Scientists at Space Agency Seminar Compare Views on Composition and Origin of Van Allen Radiation Layer

On 26 and 27 March the Theoretical Division of the National Aeronautics and Space Administration held a conference on problems associated with the Van Allen radiation layer. The conference, one of a series of seminars on current theoretical problems in space exploration, was organized by NASA.

The discovery of an intense layer of radiation in the outer atmosphere first reported by Van Allen and his collaborators at the State University of Iowa, constitutes the most significant research achievement of the IGY satellite program. The discovery was reported by Van Allen on 1 May 1958, at a meeting of the National Academy of Sciences, and confirmed by Sputnik data released by the U.S.S.R. at the Moscow IGY conference in August 1958. The layer probably provides the explanation of the aurora borealis and other geophysical phenomena, and it will also influence the design of vehicles for manned space flight.

As yet, very little is known regarding the properties of the layer, and its origin and geophysical effects have been the subject of extensive speculation. At the beginning of the year it was clear that the time had arrived for an informal meeting on these problems. In accordance with its policy of stimulating and coordinating research in frontier areas of the space sciences, the National Aeronautics and Space Administration invited a group of physicists to Washington for a symposium on the theoretical problems associated with the existence of the Van Allen layer.

The conference included three formal papers, by T. Gold (Harvard), E. N. Parker (Chicago), and N. Christofilos (Lawrence Radiation Laboratory), which served as nuclei for the discussion. These were supplemented by contributions from S. F. Singer (Maryland), P. Kellogg (Minnesota), E. Ray (Iowa), C. McIlwain (Iowa), and many other participants. A series of vigorous debates generated high ambient temperatures, which testified to the success of the meeting.

Trapped in Orbits

A large amount of provisional material on the radiation layer has been published in the press and in the scientific literature. Some of the material is well enough established to stand the test of time, and this can be summarized very briefly. First, the layer is known to consist of charged particles because the intensity variations follow the configuration of the earth's magnetic field. The magnetic field acts on charged particles, but it does not act on neutral particles or on radiation. We know from a great deal of theoretical work, which goes back to papers published by the Norwegian physicist Stoermer 50 years ago, that these charged particles may be trapped in orbits in which they spiral about the lines of magnetic force in the manner of a helix, traveling back and forth between the north and south magnetic poles.

If the particle is produced on a line of magnetic force at an altitude which is well out of the atmosphere, where the air density is low, then it can live for a long time, going back and forth from one reflection point in the Northern Hemisphere to the conjugate point in the Southern Hemisphere. The estimates of the lifetime depend on altitude, and they range from seconds at a few hundred kilometers to years out at a thousand kilometers. Lifetime estimates have been made by Christofilos, Singer, and Kellogg; these were among the few theoretical results on which there was agreement at the conference.

Under the circumstance of extended lifetimes the particles can be fed into the layer at a very slow rate, but, because they stay there so long the population of particles will nonetheless build up to very substantial values. That is the key to the formation of the Van Allen layer.

Hard and Soft Components

The Pioneer III space rocket extended the radiation measurements out to a distance of 110,000 kilometers from the earth and showed that the layer actually contains two separate zones, with centers at 13,000 and 25,000 kilometers, respectively. The population of the inner zone may be divided into a soft component, with energies of the order of 100,000 volts, and a hard component, with energies of 6 million volts or more. The hard component is so named because it has sufficient energy to penetrate a 1-centimeter slab of aluminum in front of the shielded counters. It has always been assumed that the soft component consists of electrons, because electrons of the same energy and intensity had already been observed in rocket flights into the upper atmosphere. The penetrating particles of the hard component remained unidentified, but at the conference McIlwain and Ray reported for the Iowa group the result that these particles were definitely protons, with energies in the neighborhood of 100 million volts. The identification of the penetrating particles as protons rested on analysis of unexpected variations in the Explorer IV data, which indicated their specific ionization to be roughly 4 times minimum.

McIlwain and Ray also reported that the Pioneer data show the presence of a relatively penetrating component in the outer zone as well, with a range corresponding to electrons of 650,000 volts or more. The nature of the outer penetrating component is not known at the present time.

Solar Origin of Outer Zone

The probable origin of the layers was the subject of the liveliest debate at the conference. The origin of the belts may be either the beta decay of cosmic ray neutrons into electrons and protons or injection into the upper atmosphere by streams of particles coming from the sun. At the conference, Gold described a theory of solar origin in which gusts of plasma emitted from the sun established magnetic channels for the transit of energy-charged particles to the neighborhood of the earth. Parker has proposed, as an alternative theory of solar origin, that protons from the sun form a "solar wind," which may blow across the earth and inject particles in the Van Allen layer without prior establishment of a solar-terrestrial magnetic channel. Whatever the precise mechanism for transfer of particles to the layers, the solar origin of the outer zone appeared to be definitely established by preliminary Pioneer IV results presented at the conference. McIlwain and Ray reported that the radiation intensity in the outer zone was several times greater during the Pioneer IV flight than that observed in Pioneer III. They noted further that the Pioneer IV flight had followed directly on 5 days of continuous and unusually intense solar activity.

A judgment on the relative merits of the Gold and Parker theories will have to wait on further space-vehicle experiments, and in particular on the simultaneous measurement of magnetic field strengths and particle intensities during a period of varying solar activity.

Difficulties Remain

The origin of the inner zone is less clear, but the currently available evidence favors the beta-decay theory originally advanced by Singer, Christofilos, and Vernov (Moscow). Argus results reported at the conference by Christofilos indicate a remarkable stability of the inner-zone population, with no evidence of diffusion or mixing between the two zones. This result would appear to eliminate external streams as the origin of the inner zone.

Some difficulties remain in the beta-decay hypothesis. Estimates by Singer indicate that the decay of fast neutrons will yield perhaps 100 times more energetic protons than are actually observed. On the other hand, calculations by Kellogg on the yield of soft electrons from the beta decay of thermal neutrons indicate an intensity 100 times less than the observed intensity of the soft radiation. It is possible that these discrepancies may be accounted for by uncertainties in the values announced for atmospheric density, and by the approximations made in the course of a complex calculation.

The presence of a gap between the two zones poses a more serious problem. On the hypothesis of beta decay for the inner zone and a solar origin for the outer zone, we would expect the inner zone to rise smoothly into the outer, and it is difficult to explain the finding of a minimum in radiation intensity between the two. In this connection an interesting suggestion was made at the conference by Dessler (Lockheed, Palo Alto), who pointed out that there is an irregularity in the magnetic field of the earth over South Africa, an irregularity which may be described as a hole in the magnetic field. He pointed out, further, that the lines of force passing through this irregularity are located at the position of the gap between the zones. When particles are trapped on these lines of force in the magnetic field they descend to lower altitudes than would be the case in a perfectly dipole field. At the lower altitudes they pass through a denser atmosphere and are rapidly removed from the radiation layer.

ROBERT JASTROW
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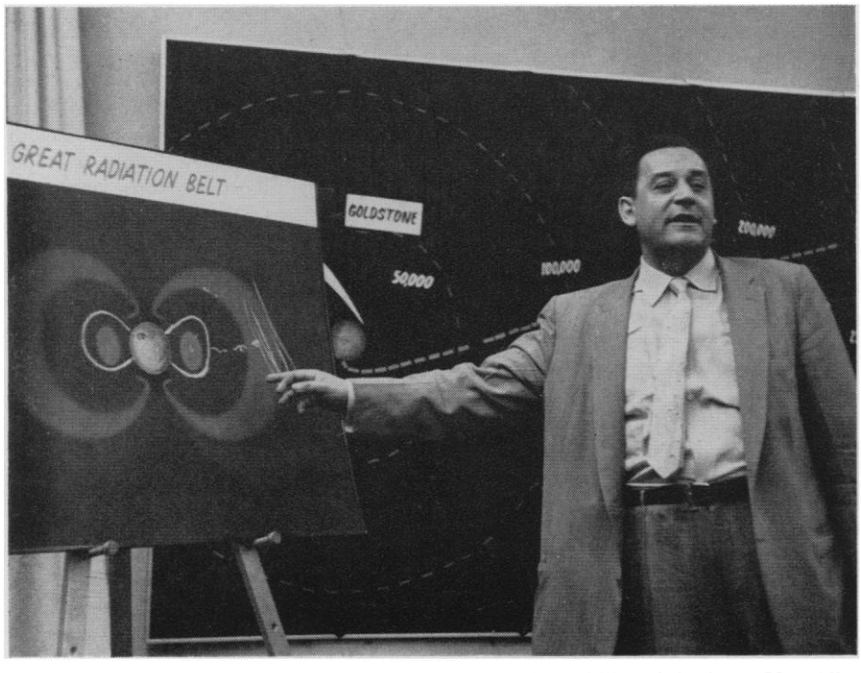

N. Christofilos describes the Argus results illustrating the stability of the inner Van Allen layer.

Nuclear Liability Problem Studied

The problem of nuclear liability is a growing one that is causing increasing concern. There is a risk that a catastrophic accident might occur in the operation of atomic power facilities and other nuclear installations. This could impose an overwhelming loss, both upon the public exposed to injury and also upon the enterprises operating or supplying the facilities. One of the groups that is studying this problem intensively is the International Atomic Energy Agency's Panel of Experts on Civil Liability and State Responsibility for Nuclear Hazards. This panel will hold a second series of meetings at IAEA headquarters in Vienna, beginning 11 May, as an outgrowth of a first series recently concluded.

IAEA Preliminary Findings

In the course of its first deliberations, the panel was provided with information on the safety evaluation of nuclear installations, the possibility of catastrophic accidents, the medical nature of injuries resulting from such accidents, the possible risks involved in the transportation and storage of nuclear fuels and radioactive materials, and emergency measures to be taken immediately after a nuclear incident. The panel agreed that, as a matter of first priority, it had to deal with the problem of civil liability for property damage and personal injuries from nuclear incidents. The experts also agreed that primary liability for such damage should not require proof of fault to be brought by the victim; that such