McIlwain's study of particles

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A physics professor at the University of California's San Diego campus is absorbed today in a Population study which seeks to help explain the mysterious behavior of some important citizens of outer space.

Instead of counting people, Dr. Carl McIlwain is mapping the energetic particles trapped high in the earth's magnetic field-- electrons and protons which compose the Van Allen radiation belts. His object is to obtain a description of this immense particle population which encircles the earth in a doughnut-shaped region located on the magnetic equator.

"Truly to understand the particle mechanisms," he says, "we first must know what's up there."

Discovery of the particles in 1958 by Dr. James Van Allen stimulated great scientific interest in their distribution and behavior. And while data received from both U. S. and Russian space flights has contributed significant insight into the processes responsible for the particles, there remain many important and unanswered questions. Among them are:

What is the origin of the particles? How do they accelerate from magnetic pole to magnetic pole? And, for the future, what danger do the particles pose to astronauts?

Analysis of particle flux data, based on theoretical predictions and actual space information, may enable the desired understanding of these problems physicists believe. Yet Dr. McIlwain says, as great as the interest in successfully mapping the particle intensities are difficulties involved in developing a satisfactory theory, or model, for doing so.

"The research is more than just a simple mapping, or counting, problem," he explains, "We're mapping in many dimensions, for there exists more than one particle type. Our models and theories must be designed not only to understand the distribution of particle intensities in space, but also the energy distribution and time behavior of the particles."

An Associate Professor of Physics at UCSD and a former associate of Van Allen's at the University of Iowa, Dr. McIlwain has experimented with a number of theories for describing the particles, but he has yet to discover a workable one.

"I discarded the latest of the theories as unworkable just recently," he explains, "There is no question that we are still in the preliminary stages of describing the particle population. We have done enough, though, to know the situation is very complex indeed."

Supported by recent National Aeronautics and Space Administration grants of $277,997 and $250,000, Dr. McIlwain and associates are involved in the design of a comprehensive program of particle mapping. It includes the development of particle detectors for flight on rockets, satellites, and other space probes, plus various experimental techniques.

Their most recent space contributions were particle detectors aboard the Relay I and Injun III satellites launched in December, 1962. Another set of particle detectors orbited in October on the Explorer XV satellite lofted to study the artificial radiation belt created by the United States high altitude nuclear explosion over the Pacific Ocean. This satellite afforded scientists an opportunity to study not only the artificial particles, but also those trapped in the natural radiation belts.

The origin of the particles, and their mechanisms for entering the magnetic field, are still mysteries, although many physicists believe that the great mass of particles originates in the sun. There is general agreement, however, that once inside the belt the particles are guided by the magnetic field and revolve in a corkscrew path around the earth. The particles remain trapped in the belts, held by the magnetic field, and reverse themselves continuously, while making millions of journeys from one magnetic pole to the other.

"Even at this point," says Dr. McIlwain, "we're at a loss to describe an explicit particle acceleration or loss mechanism. For instance, we know that the particles are accelerating in the magnetic field, but this acceleration is acting in a manner we don't understand.

"Nor can we as yet make blanket statements about any of the regions where the particles exist," he says, "It has been stated that the inner belt is characterized by very high-energy protons, but it is also possible that low-energy protons may dominate in the same region. We do know that observed particles have a wide range of energies, from a few electron volts to a billion electron volts."

In 1961, Dr. McIlwain devised a "magnetic coordinate system," which today provides the framework for analysis of data returned from space. Basically, the system enables physicists to organize measurements made at different geographic locations by transforming-- on paper-- the earth's magnetic field into an equivalent dipole field. This is necessary because of the irregular character of the earth's magnetic field.

"The system lets us distort the earth so that its magnetic field looks smooth," says Dr. McIlwain, "We can now take data from all around the field and plot it in a single plane. Previous systems had serious shortcomings so that particle mapping was pure chaos."