
The discovery of the magnetic field

By M. Kruglanski

The existence of radiation belts is already supposed from the beginning of the 20th century, long before they are discovered by satellite measurements. Birkeland, a Norwegian interested in the origin of auroras, has firstly investigated the subject. In 1896, he shows that the poles of a magnetised sphere attract the electrons of a cathode beam. To understand these observations, Stoermer (also Norwegian) looks for mathematical solutions of the energetic particle trajectories in the vicinity of a bar magnet (i.e. a magnetic dipole). Stoermer's work does not explain the auroras, but is very useful for the study of radiation belts and cosmic rays. Stoermer shows that, for specific starting conditions, the charged particles are trapped by the bar magnet magnetic field. Since the Earth's magnetic field is analogous to a bar magnet field, it can also trap energetic particles.

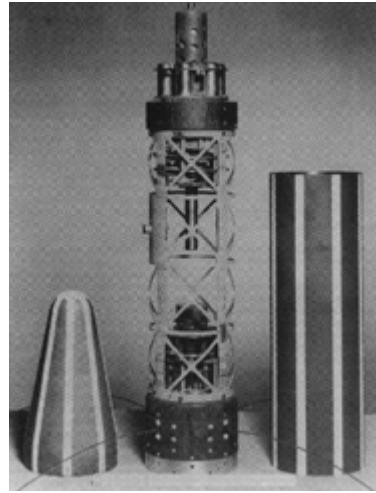
Stoermer is not the only one who conducts research on charged particle trajectories in a magnetic field. In 1896, Poincaré describes the bounce of charged particles when they reach a given field intensity (mirror point). In 1929, Gunn describes the slow drift around the Earth of trapped particles. In the fifties, the interest in controlled nuclear fusion results in several studies of the trajectory of charged particles in a magnetic field. Alfven for example, introduces the guiding center and the definition of the first invariant.

In 1957, just before the discovery of the radiation belts, Singer suggests the existence of an electric ring current around the Earth due to the movement of low energy particles trapped in the Earth's magnetic field. The ring current concept was already proposed before: by Stoermer to explain inaptnesses of his theory with regards to the auroras, by Schmidt to describe the main phase in magnetic storms, and, by Chapman when describing the interaction between the Solar Wind and the Earth's magnetic field.

In January 1958, the USA successfully launch their first satellite: Explorer 1. Contrary to the Russian satellites Spoutnik 1 and 2, which are already in orbit, Explorer 1 is placed in a very elliptic orbit, culminating at a height of about 2500 km. The satellite is designed by a team of the University of Iowa, lead by Van Allen, and contained among other things a Geiger counter to record the cosmic radiation intensity as function to the altitude.



The Van Allen team discovers the radiations belts by observing the counter signal which brutally falls to zero after a gradual strengthening: the satellite goes through a such radiative region that the Geiger counter is overflowed and saturated. The radiation belts are discovered. Shortly after, the Spoutnik 3-satellite confirms the discovery.



In August and September 1958, the US air force blows up, three atomic bombs at very high altitude in south Atlantic. The experiment is suggested by the Greek Christofilos in order to create artificial radiation belts. These nuclear explosions inject a huge amount of highly energetic electrons in the magnetosphere. Part of these electrons cause artificial auroras observed up to the Azores islands. An other part of the electrons creates effectively an artificial radiation belt which is probed by the Explorer 4 satellite during a period of several weeks.

In July 1962, the trial of an H-bomb above Hawaii, also injects energetic electrons in the radiation belts, a number of which are trapped for a period of several years.

After the discovery of the Van Allen belts, lots of satellites are equipped with instruments to investigate the structure and the dynamic of the radiation belts. At the same time theoretical studies were initiated to understand and model the observed phenomena.

In 1991, data from the American satellite CRRES reveal that the Van Allen belts have a more dynamical structure than firstly supposed. During a magnetic storm, new radiation belts can be formed in less than an hour and persist for months.

The CRRES satellite observations arouse once again the interest of the scientific community for the radiations belts. This topic is now being addressed within a new domain: the space meteorology.

