Cockcroft Institute Colloquium

Electron Acceleration in the Radiation-Belts of Earth, Jupiter and Saturn

Professor Richard Horne
British Antarctic Survey, Cambridge

Wednesday 26th January 2011, 14:00
Walton Rooms A & B, The Cockcroft Institute

Abstract

The Earth's radiation belts were the first major discovery of the satellite era. They consist of energetic electrons and ions trapped inside the Earth's magnetic field in a region extending out beyond geostationary orbit. The flux of relativistic (~ MeV) electrons in the outer belt can vary by several orders of magnitude during geomagnetic storms posing a risk to spacecraft on orbit and can affect the chemistry and temperature of the atmosphere from the top down. The major scientific problem is to understand how electrons can be accelerated up to energies of several MeV and what controls the variability of the radiation belts. Recent satellite data show that the generally accepted theory of how the electrons are accelerated, which has lasted 40 years or more, is inadequate, and that there must be another electron acceleration mechanism operating inside geostationary orbit. Here we show that cyclotron resonant wave-particle interactions with whistler mode waves can accelerate electrons up to MeV energies. We present satellite data to show, on a global scale, where the waves are observed, and use quasi-linear diffusion theory to show the conditions under which electron acceleration is most efficient. By solving the Fokker-Planck equation we present global modeling simulations to show that cyclotron resonant electron acceleration is very effective throughout the outer radiation belt and can reproduce relativistic electron flux variations during storms. We show that cyclotron resonant acceleration is also important for Jupiter's radiation belts, and suggest that it plays an important role in the production of synchrotron radiation from Jupiter. We also discuss whether cyclotron resonant acceleration could be important for Saturn and could be a universal process operating at all the magnetised planets.

Lancaster University, Lancaster, 26 January 2011

The University of Manchester

Northwest Regional Development Agency

Science & Technology Facilities Council

University of Liverpool

Lancaster University

ASTeC