Electron Correlation in Space Plasmas

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ABSTRACT

Correlators have been used to measure the temporal characteristics of electrons in space. Implemented both in hardware and in software these auto-correlators take as their input detection pulses from particle instruments. These measurements have lead to significant results with rocket studies of the auroral beam - ionospheric plasma interaction, in active electron beam experiments on the Shuttle, and in an active wave experiment on Oedipus-C. Most recently the technique has been included within the DWP instruments on the four ESA Cluster II and on the Chinese DSP equator spacecraft. This paper describes CORES, a combined spectrograph and correlator for the OBSTANOVKA experiment on ISS.

CORRELATION WITH SPECTROMETERS

The particle correlation technique has directly identified wave-particle interactions generated over a wide range of space plasma scenarios: the natural auroral beam; natural waves; artificial beams; and artificial waves. Correlators have measured strong electron modulations ranging in frequency from 100Hz to 10MHz, directly identifying wave modes: upper hybrid; electron plasma and gyro-harmonics; and Čerenkov ion acoustic. The technique can also provide a measurement of the instantaneous spatial distribution, which promises to provide fresh insights into fundamental plasma processes such as turbulence. Previous particle correlator measurements of wave-particle interactions were limited by the necessity to use existing spectrometer designs for the source of electron detection events. However, as the primary task of these spectrometers was to measure complete electron velocity distributions, their energy band was continually stepped or swept over the full energy range, limiting the time for correlation studies any each energy level to a few mS at a time.

CORES SPECTROGRAPH FOR OBSTANOVKA ON ISS

The experience gained from all of these missions has lead to the design of a new compact spectrograph, CORES, see Fig.1. While the previous applications of electron correlation to spectrometers were limited to one or two channels time sequenced through energy and angle, CORES can simultaneously analyse 256 separate fixed electron and ion energy-angles in parallel, corresponding to 8 separate directions around a 360° plane, each direction in 16 pseudo-logarithmic energy bands covering the range from 10eV to 10keV. CORES is designed to contribute to the Russian/Ukranian "Obstanovka" Experiment Complex scheduled to fly on the Russian segment of the International Space Station, ISS, in 2006. "Obstanovka" includes a wide range instrument types to measure ionospheric plasma parameters as well as magnetic and electric fields from DC to the electron plasma frequency. The OBSTANOVKA experiment complex is designed to measure the effect of: ISS on the local ionospheric environment; the effect of the ionosphere on ISS; and monitor the effects of space weather at the location of most manned space activity. All CORES 256 energy-angle channels are continuously measured, with the 128 electron channels all simultaneously analysed by parallel correlators for wave modulations in the frequency range 0-10kHz, to include the lower hybrid frequency, and frequency range 0-10MHz, to cover local plasma, electron gyro, and upper hybrid frequencies in the ionosphere at ISS. CORES is fully self contained, including all HV supplies,etc, within a 10x10x15cm, 1kg, box.

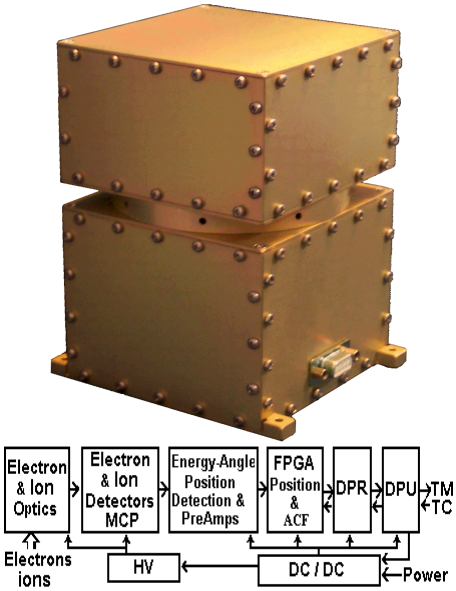

Fig.1. OBSTANOVKA / CORES for ISS with instrument functional block diagram.