CONSTRUCTION OF A PHOTOELECTRON BEAM FOR CALIBRATION OF SPACE PLASMA ELECTROSTATIC ANALYZERS

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1. Introduction

Space plasmas differ in many aspects from plasmas created in laboratories. Typical spatial lengths are obviously much larger, background pressures, plasma densities and beam fluxes are much lower than in typical plasma reactors. For this reason electrostatic energy analyzers in space operate with channel electron multiplier detectors (channeltrons) in counting mode, giving the number of electrons (or ions) per detection period instead of measuring an electrical current. The entrance aperture dimensions of these analyzers are also designed according to the fluxes to be measured and can be up to 1-2 cm^2 in area. The electron energies involved are typically from 0.1 eV to 50 keV.

The calibration of these analyzers therefore requires their exposure to an electron beam of very low intensity with diameters sufficiently large to illuminate the whole entrance area. This can be achieved using a cathode made of a thin gold film deposited over a fused silica substrate that is illuminated from the back with ultra-violet radiation. The UV photon energies are sufficient to produce photoelectrons in a large area of the thin film which are then accelerated to the desired energy.

In this work an electron beam system constructed for the calibration of a cylindrical electrostatic energy analyzer (project ELISA) to be launched in a scientific satellite (EQUARS mission) will be described.

2. Experimental

The electron beam was constructed with a photocathode comprised of a 21cm diameter gold thin film in a fused silica disk. Several UV radiation sources were tested and the HG2 Cathodeon mercury vapor lamp was selected. For controlling the radiation intensity, and consequently the beam intensity, thin metallic film filters, a radiation diffusing scheme and a third control grid were tested and will be described. The beam intensity is measured with a special picoampmeter set up, since the photocathode is kept in negative high voltages, and stray currents must be avoided.

The beam profile is measured using a channeltron detector scanned through its cross sectional area, and the measurements are integrated to be compared to the total current measured by the picoampmeter.

A two axis rotation structure (gimbal) supports the ELISA analyzer to vary the incidence angles between the beam and the entrance aperture axis. The detector´s response (number of counts) is measured for varying incidence angles and beam energies and is stored together with all parameters in a computer controlled data acquisition system.

3. Results

The beam intensity can be controlled by the three methods mentioned, but the diffusing system is not reproducible and the control grid presents difficulties in the picoampmeter electronic circuit. So thin metallic filters will be used.

The beam profile characterization was made using the gimbal system and a linear actuator system for radial displacement of the channeltron detector. The electrostatic analyzer was also used to certify that the electrons detected are the ones accelerated to the beam´s nominal energy and not secondary or reflected electrons that can be produced at the beam´s operating energy range.

The geometric factor (GF) of the electrostatic analyzer, determined by dividing the counting rates measured by the incident electron flux, will be presented. Counting rates are integrated over all angles of incidence and energies for each one of the 16 energy bands (from 1 to 27 keV) of the analyzer. Although the GF should depend only on the geometry of the device, the efficiency of the channeltron detector depends on energy.

The results are compared with numerical simulations made in an earlier work [1].

4. References

[1] P. D. G. de Melo, I. H. Tan, J. J. Barroso and R.S. Dallaqua, IEEE Trans. Plasma Sci. **44**(6), 1009-1017 (2016)

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