

A compact, broad-beam, low-energy, LED-based, UV photoelectron source for the calibration of plasma analysers.

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Electrostatic electron analyser instruments are used to make in-situ measurements of space plasmas and are typically designed to detect electrons with energies from a few eV to a few tens of keV. To make optimal use of such instruments, a complete calibration is performed in a laboratory vacuum chamber before flight. An electron source and a moveable stage are used so that the instrument response can be characterised at every relevant electron energy and beam direction. For an ideal calibration, the source should be a uniform, collimated electron beam of controllable energy and flux, which is sufficiently broad in diameter to cover the entrance aperture of the electron analyser instrument being tested.

Various sources are used for such purposes, including radioactive beta-emitters and thermionic emission guns — although the former have fixed flux and are broad-band in energy, and the latter are expensive and produce only a narrow beam with limited energy ranges and limited dynamical control. To produce a broad, uniform, highly-controllable, long-lifetime, monoenergetic beam, UV photoelectron sources are generally preferable. These consist of a UV light source which illuminates a photocathode causing it to release photoelectrons. These electrons, which are released with negligible kinetic energy, are accelerated toward a high transmission grid by an electric field. The source can thus be as wide as the grid and the photocathode, as spatially uniform as the light that falls on the photocathode, and as collimated and monoenergetic as the photocathode and grid are flat and parallel (and thus the E field uniform). The electron flux can be adjusted by adjusting the UV lamp intensity, and the electron energy can be varied by adjusting the strength of the grid-photocathode E-field.

Traditionally the UV photons are created using gas discharge lamps (e.g. mercury, xenon, deuterium), however these typically have poor dynamical control, can create large amounts of background light and are bulky and inefficient. In recent years however, advances in solid-state technologies have enabled increasingly powerful, efficient and affordable LEDs of various UV wavelengths. Accordingly this has enabled compact, low-power, UV-stimulated electron sources that can have intensities that vary between 10 to 10^{-9} electrons $\text{cm}^{-2} \text{s}^{-1}$.

To meet the requirements for calibrating the electron analysers for the SCOPE (cross Scale COupling in Plasma universE) mission, a 9cm beam diameter, UV photoelectron source of this nature has been built and is being tested. Weighing approximately 1.5kg (excluding power supplies) and consisting of rugged, low cost components it can be mounted inside the vacuum chamber with great flexibility, including on a motorised translation stage.

The SCOPE mission requires several FESA (Fast Electron energy Spectrum Analyser) instruments for 10eV to 30keV electrons and several EISA (Electron Ion Spectrum Analyser) instruments for 10eV to 20keV electrons and ions. The first duty of the new electron source is the testing of prototype developments for the EISA instrument: namely measuring the electron transmission properties of carbon foil and assessing the secondary electron emission performance of candidate dynode materials

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