Simulation-Based Quantification of Alkali-Metal Evaporation Rate and Systematic Errors From Current-Voltage Characteristics of Langmuir-Taylor Detectors

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Abstract:

This article presents an analysis for deducing the total emission rate of cesium from Langmuir-Taylor detectors embedded on the cesium ovens for a large negative-ion (NI) source. The angular distribution of the Cs emission is simulated to obtain the flux intercepted by the detector and its intensity along its length. The space-charge-limited emission of surface-ionized Cs positive ions is also studied with particle-in-cell methods, to include the geometric features of the Cs emission nozzles. Combining the two methods reproduces with good agreement the full current-voltage characteristics measured by the detector. The proposed approach can be effectively applied to obtain the total emission rate, as it was verified in the absence of impurities. The measurement uncertainties in terms of shape and alignment of the detector filament are investigated and their influence is quantified. Measuring and controlling the Cs emission rate is essential for the success and repeatability of cesium operations in the prototype NI beam source for the ITER neutral beam.