

Applications of the RENATE beam emission spectroscopy simulator

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Besides monitoring beam attenuation, Beam Emission Spectroscopy (BES) can be used to measure the density profile, turbulence characteristics and plasma waves. The desire for an accurate and comprehensive simulation of BES diagnostics, which could be used both in the evaluation of BES measurement results and the development of new BES systems led to the birth of the RENATE (Rate Equations for Neutral Alkali-Beam Technique) simulation code. As its name suggests, it was originally developed for modeling alkali beams (lithium and sodium), but support for the more common H and D beams was also added. RENATE can calculate beam evolution in plasmas with mixed isotope content and impurity composition using either a simple quasi-stationary model corrected with finite atomic level life-time, or by calculating the evolution of several atomic levels by solving the time-dependent rate equations.

Having calculated beam emissivity, RENATE has the capacity to take all the subtle geometrical effects into account. Complex beams having 3D structure can be composed from a large number of beamlets. Evolution of each beamlet in the 3D model of the tokamak geometry is calculated independently, and contributions to the observation channels is then summed up by the optical modules. Two levels of optical modules exist: the simpler module models a pinhole optics while the more sophisticated one uses ray tracing through the Zemax model of the optical system. Final result is the expected absolute photon current on the surface of each detector. RENATE also has a set of tools aimed at simulating and designing fluctuation measurements: visualization of the spatial resolution and calculation of the fluctuation response matrix.

RENAME has been benchmarked and tested against other codes and results were compared to real BES measurements. This paper presents these studies along with some applications for the feasibility study of KSTAR and ITER fluctuation BES systems.