Overview of the RENATE beam emission spectroscopy simulation package

Association EURATOM/HAS

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Introduction, motivation

Beam Emission Spectroscopy (BES) is a diagnostic method used for density and density fluctuation measurements in fusion plasmas [1].

Association EURATOM-HAS has been building a large number of BES measurements around Europe.

The desire for an accurate and comprehensive simulation of the BES diagnostic, which could be used in the evaluation of BES measurement results [2] and the developmet of new BES systems [3], led to the development of RENATE (Rate Equation for Neutral Alkali-beam Technique).

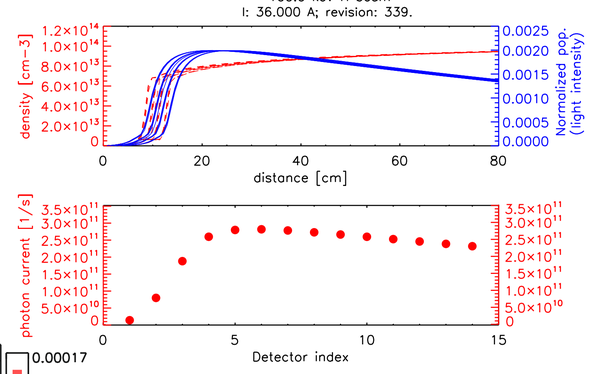
RENATE features

RENATE is a 3D code that incorporates different levels of simulation of the BES diagnostic system: from the calculation of rate coefficients of atomic processes, the modeling of 3D beam evolution to the modeling of the observation system.

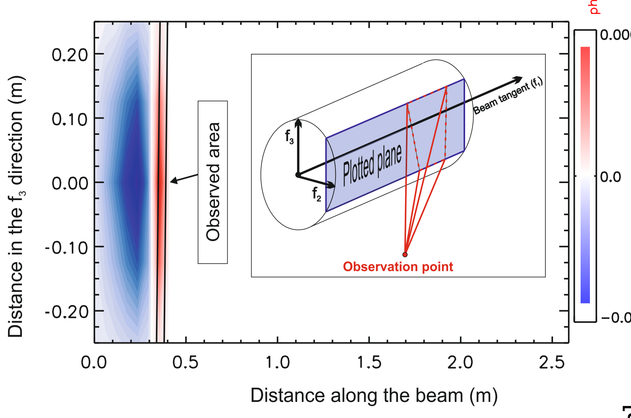
RENATE takes all the relevant atomic processes into account:

- collisional excitation/deexcitation
- collisional ionization
- charge-exchange reactions
- spontaneous deexcitement

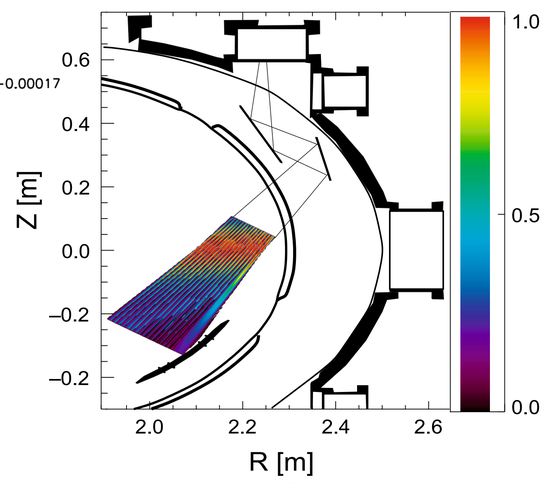
Supported beam types: Li, Na, H, D



Calculates photon current detected by the observation system



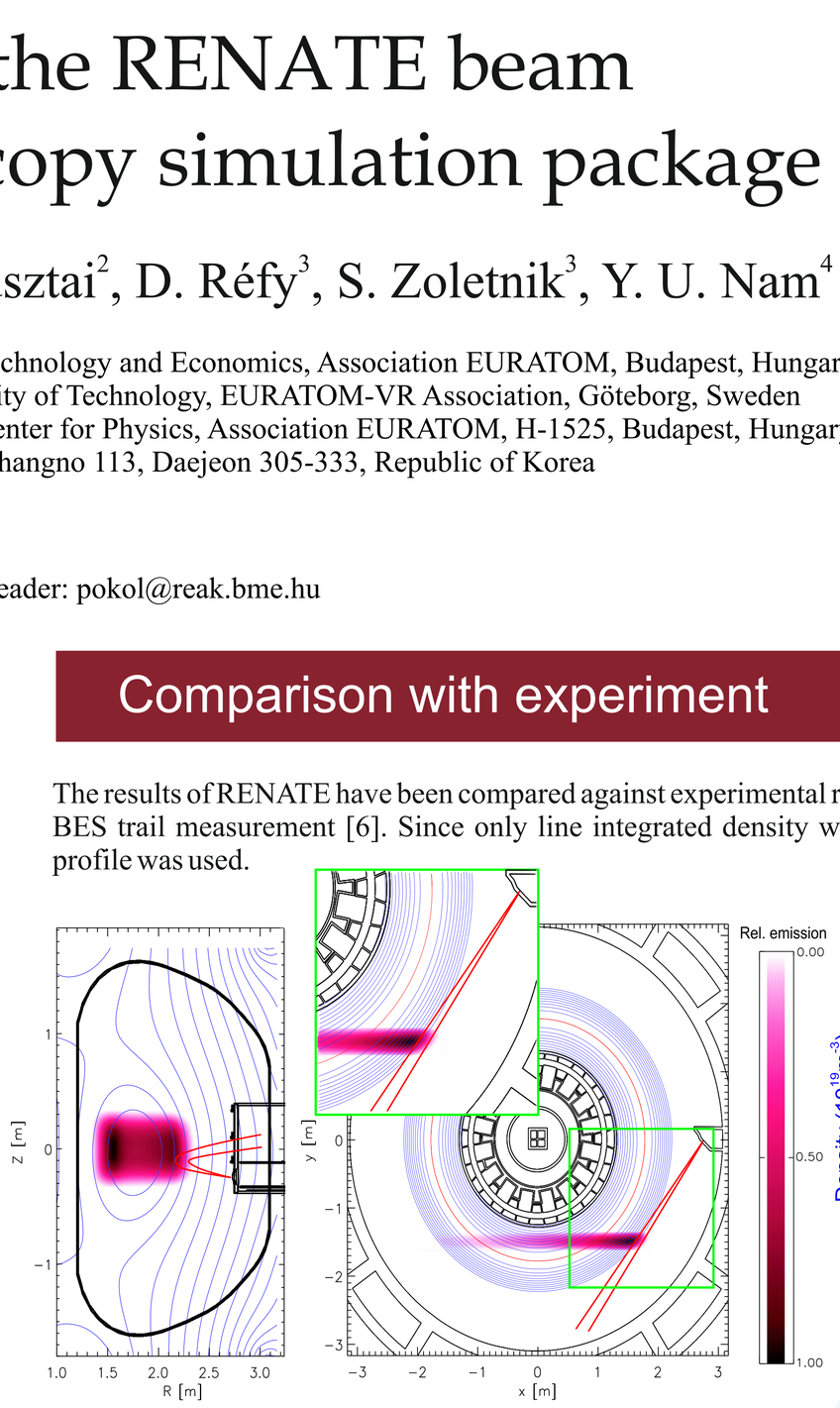
Calculates the 3D density fluctuation response matrix



Able to use simple, but flexible pinhole or a more sophisticated ray-tracing optical modelling.

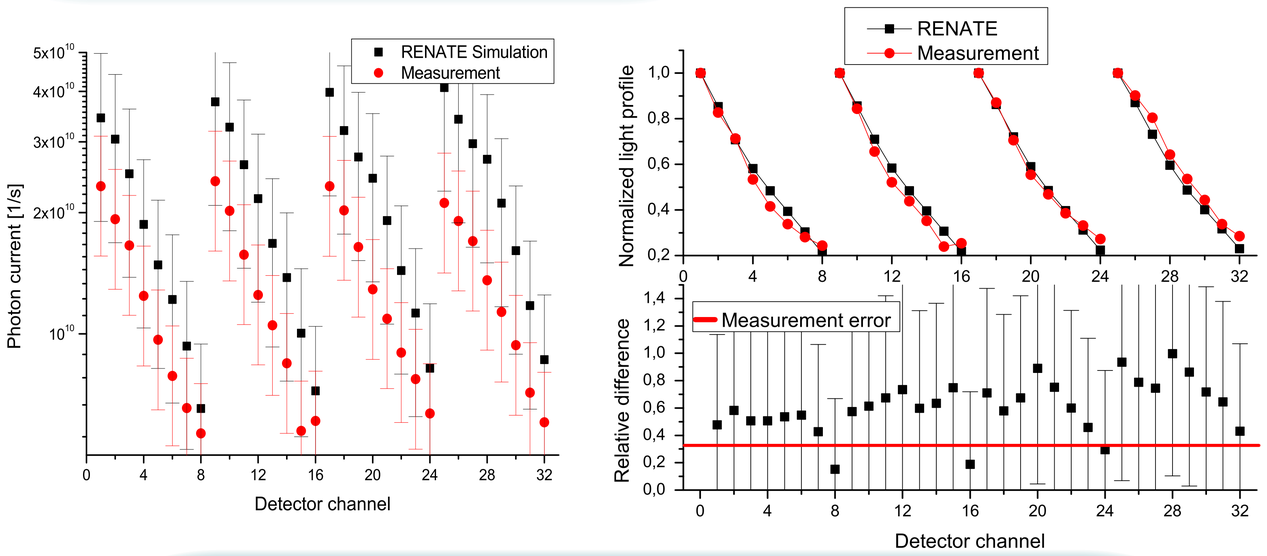
Comparison with experiment

The results of RENATE have been compared against experimental results using data from the KSTAR BES trail measurement [6]. Since only line integrated density was measured an arbitrary density profile was used.



Poloidal and toroidal projections of the simulated configuration, showing the emission distribution.

Density and temperature profiles used in simulation



Measured and simulated photon currents for individual detector channels for KSTAR #6123 at 1744 ms. The detectors are sorted into a 4 × 8 matrix, indexing start from the detector of the first row observing the innermost part of the plasma.

Conclusions

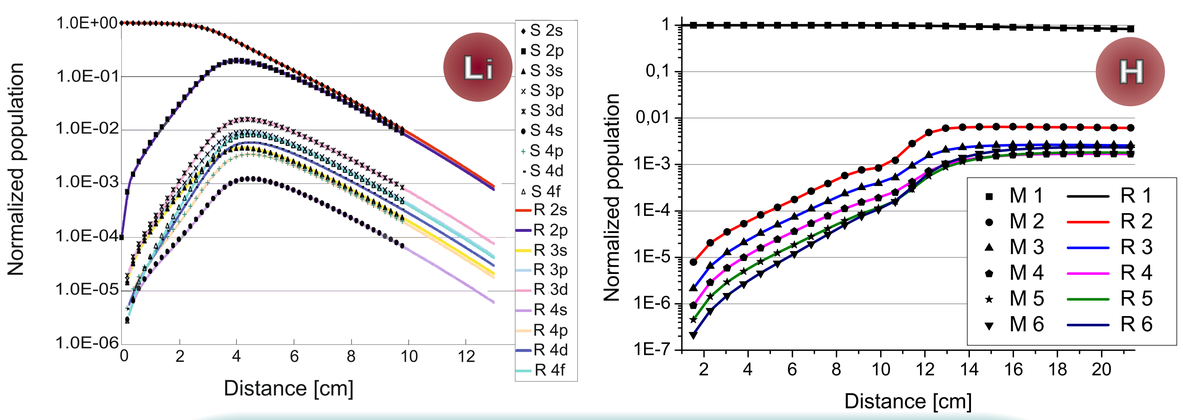
The RENATE is a simulation tool that is capable of simulating most key processes of the beam emission spectroscopy. RENATE is able to model the three-dimensional geometry of the simulated system in detail, including the inner structure of the beam and the optical setup, allowing it to model complete BES systems, in particular heating beam measurements.
Its rate equation solver core has been benchmarked against other known CRM codes. Its results have also been compared against KSTAR data.

Future development

In the future RENATE is to be compared against other experimental results. It is also going to be upgraded to be able to take more wavelength shifting effects (e.g. motional Stark-effect) into account.

Benchmarking

The rate equation solver module of RENATE has been benchmarked against the CRM code developed by O. Marchuk [4] for hydrogenic beams, and against the SIMULA code [5] for lithium beams.



Evolution of the population of atomic levels along the beam normalized to the initial particle number, calculated by RENATE (R), CRM code by O. Marchuk (M) and Simula (S).

References

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