Progress in RENATE-OD synthetic diagnostic

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BES diagnostics

- **Active** plasma diagnostics procedure
- Use of H-like atoms such as D, Li, Na. (which possesses one valence electron)
  - Heating beams (H, D)
  - Diagnostic beams (Li, Na)
- **Purpose:** density profile and fluctuation measurement

RENATE Simulation code

- Full 3D, based on CR model:
  1. Quasi-static for H from Open ADAS (2010)

⇒ Revise cross-section data!
Upgrade RENATE-OD with new rate calculator and cross-section import modules

Before Neutral Beams CRP

System of equations

Numeric solver

Plasma profiles

AtomicDB

RenateDB

Rates from HDF files
Upgrade RENATE-OD with new rate calculator and cross-section import modules

After Neutral Beams CRP

- AtomicDB
- Rate provider
- Plasma profiles
- System of equations
- Numerical solver
- RenateDB
- HDF files
- InternalDB
- $\sigma_{ij}(E)$
- AladdinDB
- $\sigma_{ij}(E)$
- NeutralDB
- CTMC files

The diagram illustrates the flow of data and calculations in RENATE-OD, starting with the input of plasma profiles, which lead to the system of equations. These equations are solved numerically, resulting in rate calculations. The rate information is then imported into the database and used for further analysis.
 Upgrade RENATE-OD with new rate calculator and cross-section import modules

- Improved scaling for impurities
- Corrected rates for high beam energy
- Good agreement with other codes for all cases

1 MeV H beam
Paper being written to Journal of Physics B

Outcome of the IAEA neutral beam penetration and photoemission benchmark

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Abstract. The benchmark was carried out in the scope of the IAEA Coordinated Research Project P43023 on Data for Atomic Processes of Neutral Beams in Fusion Plasma [1]. In the course of the benchmark, beam attenuation and beam emissivity (where applicable) were compared for the participating codes (RENATE, RENATE-OD, BBNBI, FIDASIM, SOS, CHERB, CRM by O. Marchuk). These codes apply different level of detail and methodology to solve the governing rate equations. Test cases were designed to evaluate the performance of underlying collisional radiative models with various constant plasma profiles. Emphasis was placed on the handling the isotope effects of the main plasma ions as well as handling a large variety of fusion plasma relevant impurities (He, Be, C, Ne, W). A small number of realistic plasma profiles were also considered, to evaluate the performance of the codes applied to different density gradient scenarios. The study focused on a wide energy range of beams of hydrogen isotopes. We found that while all participating codes agreed in general trends, some differences exist that can be attributed to modelling details or different atomic data sources. The effect of modelling details was analysed and was compared to the effects of the uncertainties in the underlying atomic data. In most
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Outcome of the IAEA neutral beam penetration and photoemission benchmark

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Abstract. Coordinated by the IAEA Atomic and Molecular Data Unit, the Coordinated Research Project on Data for Atomic Processes of Neutral Beams in Fusion Plasma is intended to provide evaluated and recommended data of the principal atomic processes relevant for heating and diagnostic neutral beams in fusion plasmas. As an instrument to achieve this goal, a code comparison benchmark on beam penetration and photoemission was organised. The purpose of the benchmark was twofold. First, to evaluate the collisional-radiative models from the perspective of the atomic data applied, level of details and complexity and the method of the closure of the system of equations. Second, to verify and explore the applicability of the different physics models. The participating codes (namely: RENATE, RENATE-OD, BHNIB, FIDASIM, SOS, CHERAB, CRM by O. Marchuk) apply different levels of detail and methodology to solve the governing rate equations. The effect of different approaches to the underlying physics on beam attenuation and beam penetration is analysed. Conclusions on the applicability of the different physics models are presented, along with some code-specific developments. As one of the consequence of the effort, we also introduce the framework that was recently set up by IAEA to store and promote the recommended atomic data.

• Accepted for poster presentation
• May include cases with REANTE-OD runs using the new ALADDIN2 data?
Beam into gas simulations

- Cross-sections from K. Tőkési by CTMC
- Li projectile 2s \( \rightarrow \) 4f (nl resolved)
- H projectile 1n \( \rightarrow \) 4n (bundled-n)

\[
\frac{dn_i}{dt} = \sum_a N_a \left( R_a^{e(i)} - R_a^{d(i)} \right) + S^{(i)}
\]

\[
P_a^{d(i)} = n_i \left( \sum_{j=i+1}^{m} R_{i\rightarrow j}^{ex} + \sum_{j=0}^{i-1} R_{i\rightarrow j}^{d\rightarrow e} + R_{i\rightarrow++}^{loss} \right)
\]

\[
P_a^{e(i)} = \sum_{j=0}^{i-1} n_j R_{j\rightarrow i}^{ex} + \sum_{j=i+1}^{m} n_j R_{j\rightarrow i}^{d\rightarrow e}
\]

\[
S^{(i)} = n_i \sum_{j=i+1}^{m} A_{j\rightarrow i} - n_i \sum_{j=i}^{i-1} A_{i\rightarrow j}
\]

\[
R = \langle \sigma v \rangle = \int [f_m(T, v)|v-v_b|\sigma_a(v-v_b)]dv \approx \sigma v_b
\]
Beam into gas simulations

- Based on nHESEL simulation on TCV, SOL emission dominated by neutral induced emissions during strong gas-puff
- Significant extension in synthetic diagnostic capabilities