Contribution ID: **92** Type: **invited**

The EMC3-EIRENE kinetic trace ion transport module

Tuesday 16 July 2024 09:50 (25 minutes)

Impurity seeding in the scrape off layer plasma as well as controlling the contamination of the core plasma by high Z impurities are essential for ITER baseline scenarios. Predictions for the ITER baseline scenarios are often based on fluid descriptions of the impurity transport. However, especially lower ionization stages of high Z impurities (e.g. Ar, W) do not have the time to equilibrate to a Maxwellian velocity distribution and a kinetic treatment might be more appropriate than a fluid description for these short-lived ionization stages.

To simulate kinetic effects of impurities, the EMC3-EIRENE code package was extended by a kinetic ion transport module in guiding centre approximation. The kinetic ion transport module is part of the kinetic neutral Monte Carlo code EIRENE and currently contains grad-B and curvature drifts including mirror-force effects, anomalous cross-field diffusion and a model for Coulomb collisions. The kinetic ion transport itself is solved in EIRENE by a Monte-Carlo scheme in real space. The original implementation of the kinetic ion transport was thoroughly checked and some severe numerical problems including non-conservation of magnetic moment and severe numerical diffusion were identified. These shortcomings could be resolved by a complete redesign of the transport module.

In a first application for Nitrogen seeding in a medium density (attached) ITER L-mode scenario, it turned out that the original Coulomb collision model of EIRENE was oversimplified and did not include scattering of the kinetic ions. This resulted in an excessive trapping of the kinetic ions in the magnetic mirrors at the outer midplane and at the high field side of the X-point due to the missing scattering of the kinetic ions into the loss cone of the magnetic mirrors. The implementation of an improved Coulomb collision model which takes the scattering of the kinetic ions into account could resolve this issue. This new Coulomb collision model is treated by an operator splitting and solved locally by a Monte-Carlo scheme in velocity space. It is crucial to choose a small enough time-step for the Coulomb collision kernel, which led to the implementation of an adaptive time-step control with error estimates to optimize the runtime of the new and improved Coulomb collision module.

To check all the new implementations for the kinetic ion transport module of EMC3-EIRENE, it was benchmarked in a first comparison to the well-established ERO2.0 code. To focus first only on transport characteristics of both codes and avoid any influence from differences in the wall interaction models, we simulated a well-defined artificial and non-recycling beryllium source. The comparison showed good overall agreement. Only towards the inner core boundary an about 60% higher beryllium density could be observed in the EMC3-EIRENE kinetic ion transport module, which we think originates from small differences of the implementation of the reflecting core boundary condition in both codes. This density increase will be checked and analyzed further in the future to understand its origin.

Acknowledgements

The authors gratefully acknowledge the computing time granted through JARA on the supercomputer JURECA at Forschungszentrum Jülich.

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 - EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

Primary author: HARTING, Derek (Forschungszentrum Jülich)

Co-authors: REISER, Dirk; RODE, Sebastian (Forschungszentrum Jülich GmbH); ROMAZANOV, Juri (Forschungszentrum Jülich GmbH); BÖRNER, Petra; FENG, Yuhe; FRERICHS, Heinke (University of Wisconsin - Madison); KNIEPS, Alexander (Forschungszentrum Jülich)

Presenter: HARTING, Derek (Forschungszentrum Jülich)

Session Classification: A+M modelling