P 18: Codes and Modeling/HEPP

Time: Thursday 11:00–12:35 Location: ZHG102

Invited Talk P 18.1 Thu 11:00 ZHG102

Simulating W erosion, transport, and deposition in Ne-seeded discharges in ITER with full-W wall — •Christoph Baumann[1], Juri Romazanov[1], Sebastian Rode[1], Andreas Kirschner[1], Sebastijan Brezinsek[1,2], Tom Wauters[3], and Richard Pitts[3] — [1]FZ Jülich, Germany — [2]HHU Düsseldorf, Germany — [3]ITER Organization, France

Plasma-wall interaction processes like erosion are a challenge for efficient long-term operation of fusion devices. Numerical modelling of such processes is inevitable to get better understanding of experiments in present day machines like AUG, but also to make predictions for future machines like ITER. Especially the recent re-baselining to a full Tungsten (W) ITER requires dedicated studies on seeding impact on first wall erosion due to higher W sputter yields as compared to hydrogen isotopes in the plasma fuel. The present work therefore investigates W erosion and migration in Ne-seeded Q=10 H-mode ITER plasmas using the three-dimensional Monte-Carlo code ERO2.0. The code calculates both the erosion under ion or charge-exchange neutral impact and the migration of eroded impurities through the plasma, including atomic processes like ionization/recombination, as well as impurity re-deposition/re-erosion. The simulations reveal highly-charged Ne and W self-sputtering to be the main source of erosion, which is related to high far-SOL temperature conditions for electrons, 20 eV, and ions, 40 eV. The contribution of D on W erosion in contrast is smaller by two orders of magnitudes. In addition, strong W net deposition is observed in the inner divertor, indicating strong W transport into the divertor.

P 18.2 Thu 11:30 ZHG102

Structure-preserving Hybrid Code, STRUPHY: Energy-conserving Hybrid MHD-driftkinetic Model — •byung kyu na[1,2], stefan possanner[1], xin wang[1], and yingzhe li[1] — [1]Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany — [2]Technical University of Munich, Boltzmannstraße 3, 85748 Garching, Germany

A Python package STRUPHY (STRUcture-Preserving HYbrid codes) features a collection of PDE solvers based on Geometric finite element method (FEEC) and Particle-in-cell method (PIC). One of the main applications of the STRUPHY is a simulation of hybrid MHD-kinetic systems in curved three-dimensional spaces where the bulk plasma is treated as MHD fluid and energetic particles (EPs)are described kinetically. We introduce energy-conserving hybrid MHD-driftkinetic models which were newly implemented in STRUPHY. Existing hybrid MHD-kinetic models often suffer from not conserving the total energy, especially when reduced kinetic models are used to describe EPs such as driftkinetic or gyrokinetic. However, this property was recently restored by adding additional terms derived from variational principles. The capabilities and properties of the implemented scheme will be investigated with the preliminary results of the ITPA benchmark case.

P 18.3 Thu 11:55 ZHG102

A Stochastic Variational Principle for a Two-Fluid Model Arising in Fusion Plasma Physics — •Sayyed Amin Raiessi Toussi[1], Omar Maj[1], and Tomasz Tyranowski[2] — [1]Max Planck Institute for Plasma Physics, D-85748 Garching, Germany — [2]Faculty of Electrical Engineering, Mathematics and Computer Science, University of Twente, 7522NH Enschede, The Netherlands

This work proposes a stochastic variational principle for a quasi-neutral, two fluid model of a plasma in a fixed magnetic field, including dissipative effects such as particle diffusion, viscosity and heat fluxes. The variational formulation is motivated by the development of a variational smooth particle method for transport simulation in complex stellerator geometries. In the absence of dissipative effects the model admits both a Lagrangian and a corresponding Euler-Poincaré reduced variational principle. The main variables in the Lagranigan picture are the fluid flows, which describe the displacement of the ion and the electron fluid, respectively. Dissipative effects are incorporated by stochastic perturbation of the underlying flows, closely following the work of Chen et al [X. Chen, A. B. Cruzeiro and T. Ratiu, J. Nonlinear Sci. 33, 5 (2023)]. In this formulation elements of the theory of compressible, viscous flows are combined with Lagrangian constraints coming from quasi-neutrality. Finally, using particle methods, we will present a semi-discretized version of the proposed variational principle.

P 18.4 Thu 12:20 ZHG102

Energy- and angle-dependent boundary condition for the electron kinetics of a plasma — •Clemens Hoyer[1], Felix Willert[1], Gordon K. Grubert[2], Detlef Loffhagen[3], Markus M. Becker[3], and Franz X. Bronold[1] — [1]Institut für Physik, Universität Greifswald, 17489 Greifswald, Germany — [2]Universitätsrechenzentrum, Universität Greifswald, 17489 Greifswald, Germany — [3]Leibniz-Institut für Plasmaforschung und Technologie, 17489 Greifswald, Germany

For an electron Boltzmann equation we derive a Marshak type energy- and angle-dependent boundary condition, containing the electron microphysics inside the wall. It uses the electron surface scattering kernel [1], describing electron reflection as well as secondary emission from a microscopic solid-state physics point of view. We incorporate the kernel within an Legendre polynomial expansion approach for solving the electron Boltzmann equation [2], but the kernel can be also used for PIC-MCC simulations of the plasma's electron kinetics. Numerical results for an argon plasma in contact with a silicon surface are presented, showing the significance of the microphysics-based boundary condition compared to an energy- and angle-independent phenomenological one.
[1] F.X. Bronold and F. Willert, Phys. Rev. E **110**, 035207 (2024). [2] M. M. Becker, G. K. Grubert, and D. Loffhagen, Eur. Phys. J. Appl. Phys. **51**, 11001 (2010). F.X.B. and F.W. acknowledge support by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)–495729137.