P 5: Helmholtz Graduate School I

Zeit: Montag 14:00–16:10 Raum: HS 21

Hauptvortrag P 5.1 Mo 14:00 HS 21

On plasma-surface model coupling realized through machine learning — •Jan Trieschmann, Florian Krüger, Tobias Gergs, and Thomas Mussenbrock — Brandenburg University of Technology Cottbus-Senftenberg, Electrodynamics and Physical Electronics, Siemens-Halske-Ring 14, 03046 Cottbus, Germany

The time and length scales of the dynamics at the solid surface and in the gas-phase during sputter deposition span orders of magnitude. While methods to kinetically describe the surface processes and the gas-phase transport take advantage of solving the respective sub-problem independently, their consistent coupling is a prerequisite. A viable plasma-surface model bridges these sub-models, allowing for complex surface and gas compositions encountered in reactive sputtering. For this objective, a machine learning plasma-surface interface is proposed based on a multilayer perceptron network. The latter has been trained and verified with sputtered particle energy and angular distributions obtained from TRIDYN simulations [1] for Ar sputtering an Al-Ti composite target. As verified with reference data, the trained network accurately predicts sputtered particle distributions for arbitrary incident ion energy distributions, which have not been previously trained. To conclude, additional examples where machine learning model interfaces may establish a reliable sub-model coupling are discussed.

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[1] W. Möller and W. Eckstein, Nucl. Instr. and Meth. B2, 814 (1984)

P 5.2 Mo 14:30 HS 21

Machine learning approximations of Bayesian models — •Andrea Pavone[1], Jakob Svensson[1], Andreas Langenberg[1], Sehyun Kwak[1], Udo Hoefel[1], Novimir Pablant[3], Matthias Brix[2], and Robert C. Wolf[1] for the The Wendelstein 7-X Team-Collaboration — [1]Max-Planck-Institut für Plasmaphysik, Teilinstitut Greifswald, D-17491 Greifswald, Germany — [2]Princeton Plasma Physics Laboratory, 08540 Princeton, NJ, US — [3]Culham Centre for Fusion Energy, Culham Science Centre, Abingdon OX14 3D8, UK

Neural network (NN) models are trained as approximations of Bayesian models for fast data processing, opening the way to the possibility of quick inter-shot data analysis in cases where it was not possible due to computation time limitations. The NN models were tested on different diagnostic data for the inference of plasma parameters such as electron and ion temperature profiles at W7-X and JET experiments. The Bayesian models upon which they are based are developed within the Minerva framework: a common framework for modeling complex systems allows to formalize the training procedure in a way that it is mostly general and abstracted way from the single, specific diagnostic model. The training data are collected exclusively by sampling from the joint distribution of the model, so that the trained NN constitutes a surrogate of the full Bayesian models. The NN inferred plasma parameters are compared to the full Minerva Bayesian inference results. Moreover, in order to assess the reliability of the NN predictions, uncertainties of the NN output are calculated within a Bayesian framework of the NN training.

P 5.3 Mo 14:55 HS 21

PIC simulations of the extraction region of one beamlet of an ITER NBI relevant ion source — •Ivar Mauricio Montellano Duran, Serhiy Mochalskyy, Dirk Wünderlich, and Ursel Fantz — MaxPlanck-Institut für Plasmaphysik, 85748 Garching, Germany

For ITER NBI ion sources will be used to produce large and intense negative hydrogen or deuterium ion beams. Negative ions are produced predominantly by the surface process in a low temperature plasma. In order to gain a better understanding of the complex ion source physics, close to the surface, self-consistent models are needed. The magnetic field topology close to the extraction system demands 3D models to study the particle transport in the plasma. The 3D Particle in cell (PIC) ONIX code has been already validated and applied for the extraction of negative hydrogen ions and co-extracted electrons for one extraction aperture of the ITER NBI prototype source. The source performance is typically limited by the amount of co-extracted electrons which is significantly higher in deuterium than in hydrogen. In the experiments several parameters can be modified to reduce the co-extracted electron current such as strength and topology of the magnetic fields. Simulations with different magnetic field configurations were done to study their effect on the electron transport. A comparison between deuterium and hydrogen plasma simulations was realized to obtain an insight of the isotope effect. The results of these simulations and a discussion on the transport of the electrons are presented.

P 5.4 Mo 15:20 HS 21

Gyrokinetic Vlasov-Maxwell equations from variational averaging — •Edoardo Zoni[1,2] and Stefan Possanner[1,2] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — [2]Technische Universität München, Zentrum Mathematik, 85748 Garching, Germany

Nonlinear gyrokinetics is the major formalism used in theoretical and numerical studies of low-frequency microturbulence in magnetized fusion plasmas. A set of gyrokinetic Vlasov-Maxwell equations is derived with the method of variational averaging (Possanner, 2018) in a field-theoretic framework, without relying on the more complex mathematical formalism of Lie transform perturbation theory. The gyrokinetic ordering considered in this work is obtained by introducing a rigorous normalization scheme for the Vlasov-Maxwell equations and looking at physical scenarios relevant for realistic fusion devices. The gauge invariance of the resulting gyrokinetic model is also discussed.

P 5.5 Mo 15:45 HS 21

Relaxation to magnetohydrodynamics equilibria via collision brackets — •Camilla Bressan[1,2], Michael Kraus[1,2], Philip James Morrison[3], and Omar Maj[1,2] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Technische Universität München, Zentrum Mathematik, Garching, Germany — [3]The University of Texas at Austin, Physics Department and Institute for Fusion Studies, USA

It is well known that three-dimensional Magnetohydrodynamic (3D MHD) equilibrium equation has multiple solutions. In order to select a unique solution, existing numerical approaches either constrain suitable plasma parameters or relax an initial condition by means of suitable relaxation terms added to ideal MHD equations (relaxation methods). Concerning in particular the latter approach, ideas and results from Geometric Mechanics have been successfully applied to select a unique solution of the equilibrium problem which is consistent with external constrained profiles. The method presented fits into the framework of metriplectic dynamics, developed by Morrison ([Morrison, 1984, *Phys. Lett. A*, **100**, 423-7], [Morrison, 1986, *Physica D*, **18**, 410-9]), in which energy-preserving dynamics is combined with entropy dissipation. Convergence to the desired equilibrium state compatible with experimental data can be investigated by techniques similar to the Boltzmann's H-theorem [Lenard, 1960, *Ann. of Phys.*, **3**, 390-400]. Relevant applications of the new approach are presented: the vorticity form of the 2D Euler equations, the Grad- Shafranov equation, Taylor-relaxed states (3D Beltrami fields).