P 7: Magnetic Confinement III

Time: Tuesday 11:00–12:30 Location: ELP 6: HS 3

Invited Talk P 7.1 Tue 11:00 ELP 6: HS 3

Physics of Electrical Currents and Fields in the Scrape-off Layer of Tokamak Plasmas — •D. Brida[1], G. D. Conway[1], J. Adamek[2], J. Cavalier[2], H. Bergstroem[1], G. Grenfell[1], U. Plank[1], and the ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, Garching/Greifswald, Germany — [2]Institute of Plasma Physics of the CAS, Prague, Czech Republic

The outermost layer of tokamak plasmas, the so-called Scrape-Off Layer (SOL), exhibits strong electric fields and currents, which affect the plasma transport in the SOL and possibly also the confinement of the overall plasma. Understanding the physics governing SOL electric fields and currents and having accurate models describing them is therefore potentially crucial to operate and design future fusion devices. The validation and improvement of these models requires detailed comparisons to measurements obtained in present-day tokamaks, such as ASDEX Upgrade in Garching.

This contribution provides an introduction to the physics of SOL electric fields and currents and presents recent experimental studies conducted at ASDEX Upgrade and other tokamaks. The dependence of the electric field on the divertor conditions, measured by Langmuir probes, is analyzed for different plasma states. Using an analytical model, based on Ohm's law, it is shown how the divertor conditions are related to the electric field further upstream. The studies highlight the pivotal role of the divertor state in determining the electric field and show how currents can lead to substantial heat fluxes onto the divertor target.

P 7.2 Tue 11:30 ELP 6: HS 3

Edge current density distributions in the island divertor configurations on the J-TEXT tokamak — •Jiankun Hua[1,2], Yunfeng Liang[1,2,3], Qinghu Yang[2], Jie Yang[2], Song Zhou[2], and Yutong Yang[2] — [1]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung Plasmaphysik, 52425 Jülich, Germany — [2]International Joint Research Laboratory of Magnetic Confinement Fusion and Plasma Physics, Huazhong University of Science and Technology, Wuhan, 430074, China — [3]Institute of Plasma Physics, Chinese Academy of Sciences, 23003 Hefei, China

The island divertor configuration was recently operated on the J-TEXT tokamak, and the magnetic field structure can vary with the edge safe factor (qa), amplitude and phase of the island divertor coil current. A set of probes called the Directional Electron Probe (DEP) was developed to measure edge plasma current density distributions in different configurations. The qa scan was performed by increasing the total plasma current from 80kA to 110kA with a fixed toroidal magnetic field (1.6T) and island divertor coil current (+5kA or -5kA). At the same time, the m/n=3/1 magnetic island will move from the inside of the last closed flux surface (LCFS) to the outside. In this experiment, the DEP remains at the same position in the plasma, and the dynamic of plasma current density distribution can be measured as the m/n=3/1 magnetic island moves. Preliminary experimental results show that the edge current density distribution has a strong correlation with the length of the magnetic field lines and the edge magnetic configuration (such as magnetic island).

P 7.3 Tue 11:45 ELP 6: HS 3

Machine learning based fast optimization of free parameters in W7-X edge plasma modeling with EMC3-EIRENE — •Y. Luo[1,3], S. Xu[1], Y. Liang[1,3], E. Wang[1], J. Cai[1], Y. Feng[2], D. Deiter[3], A. Knieps[1], S. Brezinsek[1,3], D. Harting[1], M. Krychowiak[2], D. Gradic[2], E. Flom[2], F. Henke[2], Y. Gao[2], R. König[2], A. Pandey[2], M. Vecsei[2], and A. Dinklage[2] — [1]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, 52425 Jülich, Germany — [2]Max Planck Institute for Plasma Physics, 17491 Greifswald, Germany — [3]Faculty of Mathematics and Natural Science, Heinrich Heine University Düsseldorf, 40225 Düsseldorf, Germany

EMC3-EIRENE is a powerful tool for simulating edge plasma transport, capable of providing insights into transport parameters based on limited local experimental measurements. However, achieving a closer match between simulations and actual experiments often requires extensive scanning of input-free parameters. To address this challenge, we have developed a machine learning model that, by learning from a simulation database, can predict optimal edge cross-field transport coefficients, based on multiple edge measurements. To quantify the performance of the trained model, we calculate mean squared error in the test set, resulting in an error magnitude of 0.024. Moving forward, our plan is to expand the range of learned parameters and significantly enhance the simulation database, thus trying to employ the machine learning technique for directly forecasting plasma information of all EMC3-EIRENE cells based on local experimental measurements.

P 7.4 Tue 12:00 ELP 6: HS 3

Fast 2D n_e and T_e profile measurements with the divertor helium beam at ASDEX Upgrade — •Sebastian Hörmann[1,2], Marco Cavedon[3], Michael Griener[1], Daniel Wendler[1,2], Ulrich Stroth[1,2], and The ASDEX Upgrade team[4] — [1]Max-Planck-Institut für Plasmaphysik, Garching — [2]Physik-Department E28, Technische Universität München, 85747 Garching, Germany — [3]Dipartimento di Fisica "G. Occhialini", Università di Milano-Bicocca, Milano, Italy — [4]See author list of U. Stroth et al. 2022 Nucl. Fusion 62 042006

The divertor is an important element to achieve magnetic confinement fusion, reducing the impurity content of the core plasma and increasing the pumping efficiency. Too high heat loads on the target plates of the divertor can be mitigated by a layer of neutral gas which forms in front of the target plates, such a state is called detachment. To study the condition of the divertor and the detachment process, a new thermal helium beam diagnostic with high spatiotemporal resolution has been installed in the outer divertor of ASDEX Upgrade. It is capable to measure two-dimensional electron density, temperature and hence pressure profiles by means of a collisional radiative model. This makes it possible for the first time to observe the change in these profiles from an attached to a partially detached divertor state on a fast time scale and therefore contribute to the understanding of the dynamics during this transition. In particular, the movement of the detachment front and divertor plasma oscillations during the transition to detachment are presented within this contribution.

P 7.5 Tue 12:15 ELP 6: HS 3

Electromagnetic particle-in-cell simulation of the tokamak scrape-off layer — •Annika Stier[1], Alberto Bottino[1], David Coster[1], Thomas Hayward-Schneider[1], Andreas Bergmann[1], Frank Jenko[1], and Laurent Villard[2] — [1]Max-Planck Institute for Plasma Physics, Boltzmannstrasse 2, Garching, 85748, Bavaria, Germany — [2]Ecole Polytechnique Federale de Lausanne (EPFL) Swiss Plasma Center (SPC), Rte Cantonale, Lausanne, CH-1015, State Two, Switzerland

The particle-in-cell code PICLS is a full-f finite element tool intended to simulate turbulence in the tokamak scrape-off layer using gyrokinetic ions and drift-kinetic electrons. Up until now however, PICLS has been a purely electrostatic code with a prescribed background magnetic field. This approach is not perfectly suited to represent unstable regimes occurring in the scrape-off layer, since although $\beta = 2\mu_0 p/B^2$ can be small, turbulence there is still dominated by electromagnetic effects [1]. In order to capture those effects, an Ampère-solver is added to the code and the evolving magnetic field is taken into account in the particle pusher stage. In order to combat the Ampère-cancellation problem that arises from the Hamiltonian canonical Lagrangian formulation that PICLS is based on, we combine the newly added Ampère-solver with a pullback scheme akin to the one used in ORB5 [2]. This improved version of PICLS opens up possibilities in simulating β-dependent ITG-KBM transitions like illustrated in ref. [3] for the codes GENE, GKW, EUTERPE and ORB5, shear Alfvén waves, microtearing modes and more.