P 7: Magnetic Confinment Fusion/HEPP IV

Time: Tuesday 13:45–15:55 Location: ZHG102

Invited Talk P 7.1 Tue 13:45 ZHG102

Impurity Transport in Wendelstein 7-X: Basics and Experimental Observations — •Birger Buttenschön[1], Thomas Wegner[1], Thilo Romba[1], Daihong Zhang[1], Felix Reimold[1], Alice Bonciarelli[1,2], and the W7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]Politecnico di Milano, Italy

The presence of impurities in a fusion plasma can have significant influence on the plasma performance. While impurities generally dilute the fuel and thus reduce fusion efficiency, their line radiation is often used in the boundary plasma to reduce power fluxes to plasma-facing components. A high concentration of impurities in the confined plasma and the resulting radiation, however, is a critical loss channel for plasma energy and can lead to a radiative collapse of the plasma.

In the optimized stellarator Wendelstein 7-X, plasma scenarios featuring high energy and particle confinement inherently tend to accumulate impurities in the plasma center due to inwards directed neoclassical convective transport in the turbulence reduced ion-root regime. Understanding the (impurity) transport mechanisms is therefore a crucial step on the path to maintaining plasma performance by adjusting the impurity content and radiation within tolerable ranges.

This talk will give an overview on impurity transport in stellarators, introducing both theoretically expected transport mechanisms and suitable impurity transport diagnostics. Recent findings on the impurity transport in W7-X will be presented.

P 7.2 Tue 14:15 ZHG102

Characterizing scenarios of suppressed anomalous impurity transport in W7-X — •Thilo Romba[1], Felix Reimold[1], Sebastian Bannmann[1], Alejandro Banon Navarro[2], Hugo Cu Castillo[2], Oliver Ford[1], Peter Zsolt Poloskei[1], Markus Wappl[1], Thomas Klinger[1], and the W7-X team[3] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]Max Planck Institute for Plasma Physics, Garching, Germany — [3]O. Grulke et al 2024 Nucl. Fusion 64 112002

In view of dilution and radiative losses, the understanding and subsequent tailoring of impurity transport in fusion plasmas depicts a crucial step towards self-sustained burn. While the impurity transport in the Wendelstein 7-X stellarator is typically benign [Geiger19], certain experimental scenarios exhibit a central accumulation of impurities with transport of impurities reducing to neoclassical level [Romba23].

This work aims to characterize such scenarios. While a high density is identified as a necessary condition for impurity peaking to occur, no fundamental dependence on magnetic field configuration is identified. In addition to high density, a local normalized density gradient a/L_{n_e} above unity is identified as a necessary, yet not sufficient, condition for impurity accumulation to occur. Transport simulations across impurity species with different charges Z are found to match with neoclassical transport predictions, indicating a suppression of anomalous transport across impurities.

P 7.3 Tue 14:40 ZHG102

Prototype Coils and Engineering Design for the EPOS Stellarator — •Paul Huslage[1], Tristan Schuler[2], Pedro Gil[1], Dylan Schmeling[1,3], Diego A. R. Orona[1,4], Elisabeth von Schoenberg[1,5], Robert Luerbke[1], Jason Smoniewski[1], and Eve V. Stenson[1] — [1]Max-Planck Institut für Plasmaphysik — [2]SchulerTec — [3]Columbia University — [4]Massachusetts Institute of Technology — [5]Concordia University

The EPOS stellarator (a tabletop device to confine electron positron plasmas) will use high-temperature superconductors (HTS) to generate its quasi-axisymmetric magnetic field. Non-planar, non-insulated coils made from rare-earth barium copper oxide (ReBCO) tapes will be used to create a 2 T magnetic field on axis and enable a plasma volume of ~10 L.

In this contribution, we present the results of the hardware test campaign in preparation of the EPOS experiment design and assembly. During this effort, we are designing, manufacturing, and testing a series of coils from planar manufacturing demonstrators to a full-size, full-current coil.

Results from the coils tests inform the design of the EPOS stellarator. We will present the current state of the engineering design, as well as the road map for manufacturing and assembly.

P 7.4 Tue 15:05 ZHG102

Exploration of Instabilities in Weakly Magnetized Plasmas: A Hybrid Gyrokinetic Approach. — •Sreenivasa chary Thatikonda[1], Felipe nathan De Oliveira lopes[1], Aleks Mustonen[2], Karen Pommois[2], Rainer Grauer[2], Daniel Told[1], and Frank Jenko[1] — [1]Max planck institute for plasma physics, Garching, Germany — [2]Ruhr-Universität Bochum, Germany

Instabilities, turbulence, and reconnection in weakly magnetized plasmas, such as those encountered in the solar wind, present significant challenges to our understanding of plasma dynamics. High-frequency dynamics of space plasmas challenge the foundational assumptions of Gyrokinetic theory, especially for ions. To overcome these constraints, we developed a hybrid gyrokinetic model that preserves Gyro/Drift kinetic physics for electrons while integrating full kinetic physics for ions. The hybrid gyrokinetic model was incorporated into the Super Simple Vlasov (ssV) code. The code was verified against standard benchmark configurations after numerical diffusion, oscillations, and Ampere cancellation issues were effectively resolved. In particular, this study uses the hybrid-gyrokinetic framework in the ssV code to investigate the dynamics of Lower Hybrid Drift Instabilities (LHDIs) in reconnecting current sheets. Temperature, mass ratio, and plasma beta are among the parameters that are methodically investigated. Among the important findings are the analyses of growth rate dependences on temperature ratios, mass ratios, plasma beta, and the temporal development of electric field amplitudes. Future work will validate these results through comparisons with in-situ reconnection data from MMS.

P 7.5 Tue 15:30 ZHG102

Dependence of turbulent transport on the divertor flux expansion in ASDEX Upgrade — •Jan Pfennig, Wladimir Zholobenko, Andreas Stegmeir, Konrad Eder, Kaiyu Zhang, and Frank Jenko — Max Planck Institute for Plasma Physics, 85748 Garching b. Muenchen, Germany

Predictive turbulence simulations represent a key tool to describing and understanding the anomalous transport of particles and energy across magnetic flux surfaces of tokamak fusion devices, which is commonly believed to be the main factor determining their confinement properties, and thus economic viability. Previously, extensive validation efforts for the locally field-aligned fluid turbulence code GRILLIX against ASDEX Upgrade attached L-Mode have been performed and resulted in good agreement with both mean-field and turbulence diagnostics. As a successive step, simulations with similar physical parameters but in the geometry of the new AUG upper divertor are performed for different levels of low-field side divertor flux expansion. Due to the global, full-f capabilities of GRILLIX it is possible to connect the effect of local changes in magnetic geometry to both local and global changes in the turbulent transport. By these means it is possible to disentangle the purely geometrical gain in exhaust performance by poloidal flux expansion from that of turbulent cross-field transport. The simulation results show a strong influence of the flux expansion on divertor heat flux peaking while global properties such as input power, edge confinement time, outboard mid-plane profiles and in fact the turbulence in the complete plasma edge remain nearly unchanged.