P 7: Magnetic Confinement I - Helmholtz Graduate School III

Time: Tuesday 10:30–12:40 Location: A 0.112

Invited Talk P 7.1 Tue 10:30 A 0.112

Plasma Edge Physics with 3D Magnetic Boundaries - an Overview — •Oliver Schmitz — U of Wisconsin - Madison, USA

High temperature plasmas are confined in doughnut-shaped magnetic field cages to reach conditions which can ultimately allow production of energy by nuclear fusion. The plasma transport in the plasma boundary is governed by the parallel transport along open field lines onto material surfaces. These parallel particle and energy fluxes are sourced by particle and energy transport perpendicular to the magnetic field from the plasma core domain. This basic picture is complicated when three-dimensional (3D) magnetic structures are at play. Then, the topology of these parallel transport flux tubes is complex, sometimes chaotic, and the plasma transport is accompanied by magnetic diffusion and cross-talk between the magnetic flux channels.

In this talk, key aspects of the plasma edge transport and of the plasma material interaction in such 3D plasma boundaries are presented and discussed, based on recent selected experimental findings and accompanying modeling results from a 3D plasma fluid and kinetic neutral transport code - the EMC3-EIRENE model. The 3D aspects discussed are important in tokamak devices, where magnetic perturbation fields are applied to fine tune plasma transport and stability in the plasma edge. Also, they are inherent to stellarator devices, which feature an intrinsically highly 3D plasma boundary defining much of the system state as a possible future energy source.

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P 7.2 Tue 11:00 A 0.112

Core boron transport studies at ASDEX Upgrade — •Cecilia Bruhn[1,2], Rachael McDermott[1], Clemente Angioni[1], Pierre Manas[1], Alexander Lebschy[1,2], Volodymyr Bobkov[1], Roman Ochoukov[1], Jakob Ameres[2,1], Athina Kappatou[1], Marco Cavedon[1], Ralph Dux[1], and the ASDEX Upgrade Team[1] — [1]Max Planck-Institut für Plasmaphysik, Garching, Germany — [2]Technische Universität München, Garching, Germany

To achieve optimum fusion performance, future fusion reactors need to control the build up of both high- and low-Z impurities in the plasma core. At ASDEX Upgrade, a novel method of studying the boron transport has been developed and is being used to validate the theoretical understanding as well as the mechanisms behind low-Z impurity transport. This method utilizes the fact that a modulation of the power from the ion cyclotron resonance frequency antennae induces a modulation of the boron density, which can be measured with the charge exchange recombination spectroscopy diagnostics. This method allows D and v to be separately determined and it has been applied to a wide variety of plasma discharges. From this, a database of transport coefficients has been assembled. This database and how the transport coefficients depend on the local plasma parameters will be presented in this contribution as well as an in-depth comparison to theory. For the bulk of the database, there is quantitative agreement between the measured and the predicted theoretical diffusion coefficients. However, in all cases the convection is predicted to be more inward than is measured. These results and possible explanations will be discussed.

P 7.3 Tue 11:25 A 0.112

Quantitative study of kinetic ballooning mode theory in magnetically confined toroidal plasmas — •Ksenia Aleynikova[1,2], Alessandro Zocco[1], Pavlos Xanthopoulos[1], and Per Helander[1] — [1]Max-Planck-Institut für Plasmaphysik, EURATOM Association, Greifswald, Germany — [2]MIPT, Dolgoprudny, Russian Federation

In this work, we report a systematic quantitative comparison of analytical theory and numerical gyro kinetic (GK) simulations of kinetic ballooning modes (KBMs) in a magnetically confined toroidal plasma. A physics-based ordering for plasma beta with small asymptotic parameters is found. This allows us to derive several simplified limits of previously known theories and to identify regimes where quantitative agreement between theory and numerical simulations can be achieved. For the axisymmetric case, in simple s-α geometry, it is found that, for large pressure gradients, the growth rate and frequencies computed by the gyrokinetic codes show excellent agreement with those evaluated by using, in the quadratic forms, a diamagnetic modification of ideal MHD. For moderate pressure gradients, a new finite-beta formulation of KBM theory is proposed.

The theory is also extended to treat the stellarator device W7-X. We show results of finite-beta electromagnetic GK simulations of KBMs for various W7-X configurations with different ideal MHD stability properties. This is important since, at present, it is not clear how the KBM and the ideal MHD ballooning mode thresholds relate to each other in stellarator geometry.

P 7.4 Tue 11:50 A 0.112

First results of turbulence investigations at the Wendelstein 7-X stellarator with the phase contrast imaging diagnostic — •Lukas-Georg Böttger[1,2], Olaf Grulke[1,2], Eric Matthias Edlund[3], Adrian von Stechow[1], Jorge Alberto Alcusón[1], and the W7-X Team[1] — [1]Max-Planck Institute for Plasma Physics — [2]Technical University of Denmark — [3]MIT Plasma Science and Fusion Center

Wendelstein 7-X (W7-X) is currently the world's largest optimized stellarator with a plasma volume of 30 m^3. As the reduction of neoclassical transport is one of the optimization criteria, turbulent transport mechanisms are believed to play a much more important role now. Numerical gyrokinetic simulations suggest a significantly different appearance of turbulence in stellarators than in tokamaks. However, a systematic experimental investigation of turbulence in optimized stellarators has not been done yet. To address this topic the phase contrast imaging (PCI) diagnostic was installed at W7-X and successfully put into operation in the recent experimental campaign OP 1.2a. The PCI diagnostic allows for non-invasive spatiotemporal measurements of electron density fluctuations. Ion temperature gradient turbulence and trapped electron modes can be resolved – in the hot core up to the colder edge. This talk presents an analysis of the obtained experimental data and a comparison to GENE simulation results. One key focus is the characterization of turbulence in different magnetic field configurations, which are expected to have a major influence on the growth of the instabilities and the resulting spatial localization.

P 7.5 Tue 12:15 A 0.112

Influence of plasma backgrounds including neutrals on SOL filaments using 3D simulations — •David Schwörer[1,2], Nick Walkden[2], Huw Leggate[1], Fulvio Militello[2], and Miles M. Turner[1] — [1]Dublin City University, Dublin, Ireland — [2]Culham Centre for Fusion Energy, Culham, UK

Filaments are field aligned density and temperature perturbations, which can carry a significant amount of particles and heat from the last closed flux surface to the far scrape-off layer (SOL). In order to design next generation machines, understanding this non diffusive transport mechanism is beneficial to predict wall fluxes.

We have carried out non-linear, three-dimensional simulations, including neutral-plasma interactions, using the STORM module for BOUT++. The heat and particle influx is varied, generating self-consistent 1D profiles that reproduce both low and high recycling regimes. Filaments were seeded on the backgrounds, and the resulting filament motion was studied. Our previous studies found a strong target temperature dependence of the filament velocity. This has been observed for filaments of critical size and larger, whereas smaller filaments showed a stronger density dependence. While investigating the role of viscosity, it was found that sheath currents and the plasma viscosity at the target strongly influence the filament velocity. Here we extend the neutrals model, to allow access to higher density scrape-off layer regimes. This analysis has been carried out using a new python interface for BOUT++, which will also be discussed.