P 6: Magnetic Confinement II/HEPP III

Time: Tuesday 11:00–12:50 Location: CHE/0091

Invited Talk P 6.1 Tue 11:00 CHE/0091

The physics of ELM-free regimes — •Michael Dunne[1], Michael Faitsch[1], Georg Harrer[2], Lidija Radovanovic[2], Wolfgang Suttrop[1], Eleonora Viezzer[3], Matthias Willensdorfer[1], and Elisabeth Wolfrum[1] — [1]Max-Plank Institute for Plasma Physics, Bolzmannstr. 2, 85748 Garching-bei-München, Germany — [2]Institute of Applied Physics, TU Wien, Fusion@ÖAW, Wiedner Hauptstr. 8-10, 1040 Vienna, Austria — [3]Dept. of Atomic, Molecular and Nuclear Physics, University of Seville, Avda. Reina Mercedes, 41012 Seville, Spain

High performance tokamak scenarios rely on an edge transport barrier (ETB) to reach the pressure and confinement time necessary for high fusion gain. The ETB is characterised by a steep pressure gradient, which provide energy for edge-localised modes (ELMs), quasi-periodic explosive instabilities, which are projected to cause significant damage to the walls of a fusion reactor. Ensuring the longevity of tokamak reactors requires, therefore, alternative operational scenarios where large ELMs are avoided. We present a general framework in which the occurrence of ELMs is understood as a combination of turbulent transport and magnetohydrodynamic (MHD) stability. Predicting and controlling ELM-free regimes is then a matter of increasing transport such that the MHD instabilities are avoided. Three ELM-free regimes are highlighted; the quasi-continuous exhaust (QCE), quiescent H-mode (QH-mode), and operation with magnetic perturbations (MPs). We present the current understanding of the physical mechanisms as well as projections to future devices.

P 6.2 Tue 11:30 CHE/0091

Gyrokinetic turbulence simulations in the pedestal — •Leonhard A. Leppin[1], Tobias Görler[1], Marco Cavedon[1], Mike Dunne[1], Elisabeth Wolfrum[1], Frank Jenko[1], and ASDEX Upgrade Team[2] — [1]Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching b. München, Germany — [2]See author list of U. Stroth et al. 2022 Nucl. Fusion 62 042006

The theoretical investigation of relevant turbulent transport mechanisms in H-mode pedestals is a great scientific and numerical challenge. In this study we address this challenge by global, nonlinear gyrokinetic simulations of a full pedestal up to the separatrix, supported by a detailed characterization of gyrokinetic instabilities at pedestal top, center and foot. We present ASDEX- Upgrade pedestal simulations (and first comparisons to other experiments) using the gyrokinetic, Eulerian, delta-f code GENE (genecode.org). We investigate the differences in turbulence characteristics between the pedestal regions via local simulations and obtain global heat flux profiles employing a new code upgrade which enables stable simulations at experimental beta values. In agreement with experimental measurements [Viezzer, PPCF, 2020] our global GENE simulations reveal a complex structure with different radial transport regimes. The dominant drive of electron turbulent transport transitions from ion-scale TEMs at pedestal top to small-scale ETG modes in the steep gradient region. Ion turbulent transport is relevant at the pedestal top but suppressed towards the pedestal center. A combination of linear and nonlinear stabilization mechanisms is identified to contribute to this heat flux structure.

P 6.3 Tue 11:55 CHE/0091

Linear MHD stability studies of pedestals in magnetically perturbed Tokamak plasmas — •Jonas Puchmayr, Mike Dunne, Erika Strumberger, Hartmut Zohm, and Matthias Willensdorfer — Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany

In H-mode Tokamak plasmas, edge localized modes (ELMs) limit the achievable pressure-gradient in the edge region and may cause severe damage in future fusion devices. For this reason, it is important to understand the onset conditions of ELMs and develop methods to avoid them. The ELM onset is well-described by the theory of peeling-ballooning (PB) modes which are magnetohydrodynamic (MHD) instabilities at the edge. This provides a framework to analyze the operational space of ELMs and their mitigation/suppression.

One method to suppress/mitigate ELMs is the application of magnetic perturbation (MP) fields. However, the impact of MPs on MHD stability is not well understood. In this talk, we use the CASTOR3D code for the numerical stability analysis of a range of plasmas. Results on the toroidal localization of PB modes in magnetically perturbed Tokamak plasmas are shown and successfully compared to experimental observations. We show that PB modes are predicted to appear only at selected toroidal locations when MP fields are applied and two different kinds of localization are distinguished. Finally, results on the effect of the MP fields on the linear MHD stability limit, i.e. the marginally stable edge pressure, are presented. In general, MP fields lead to a reduction of the stability limit, as experimentally observed.

P 6.4 Tue 12:20 CHE/0091

Experimental Evidence for the Drift Wave Nature of the Weakly Coherent Mode — •Manuel Herschel[1,2], Tim Happel[1], Daniel Wendler[1,3], Michael Griener[1], Joey Kalis[1,3], Peter Manz[4], Ulrich Stroth[1,3], and The ASDEX Upgrade Team[5] — [1]MPI für Plasmaphysik, Garching — [2]Universität Ulm — [3]Physik Department E28, TUM, Garching — [4]Institut für Physik, Universität Greifswald — [5]See Author list of "Stroth, U. et al., Nuclear Fusion 62 (2022) 042006"

Improved confinement regimes will play a key role in the operation of future fusion power plants. I-mode, one of these regimes, combines good energy confinement with the absence of ELMs. It features a characteristic edge transport barrier in energy but not in density. This selective transport reduction is not understood. An edge density fluctuation called the Weakly Coherent Mode (WCM) is often brought forward as a possible explanation

Measurements obtained from Doppler reflectometry and thermal helium beam spectroscopy at ASDEX Upgrade (AUG) are combined to analyze the WCM in unprecedented detail. A phase velocity of the WCM consistent with the dispersion relation of a near ideal drift wave is found for the first time at AUG.

This marks a novel experimental verification of a specific mechanism for the WCM and sheds new light on a long-standing debate on the underlying physics.

P 6.5 Tue 12:35 CHE/0091

Numerical studies of the O-X mode conversion process in MAST Upgrade — •Alf Köhn-Seemann[1], Bengt E. Eliasson[2], Simon J. Freethy[3], Lou A. Holland[4], and Roddy G.L. Vann[4] — [1]IGVP, University of Stuttgart, Germany — [2]SUPA, Department of Physics, University of Strathclyde, Glasgow, U.K. — [3]Culham Centre for Fusion Energy, Culham, U.K. — [4]York Plasma Institute, York, U.K.

Microwaves in the GHz-range play an indispensable role for heating and current drive in plasmas. If, however, the plasma density exceeds the cut-off density of the injected microwave, it can no longer reach its electron cyclotron resonance layer. To overcome this limitation, heating at electron cyclotron harmonics is an often applied method. Another possibility is to couple to the electrostatic electron Bernstein wave which has no high-density cut-off and is very well absorbed at the electron cyclotron resonance layer. Spherical tokamaks can in particular benefit from EBWs as their current drive efficiency exceeds those of O- or X-mode. Here, we present numerical investigations of coupling to the EBW via the O-X-B mode conversion process in the spherical tokamak MAST Upgrade. These studies are to be understood as a feasibility study of an EBW heating system in MAST Upgrade.