P 4: Helmholtz Graduate School 1 and Magnetic confinement 1

Time: Monday 14:00–16:00 Location: b305

Invited Talk P 4.1 Mon 14:00 b305

Physics studies with high-power electron cyclotron heating (ECRH) on ASDEX Upgrade — •Jörg Stober and ASDEX Upgrade Team — MPI für Plasmaphysik, Garching, Germany

The ECRH system of ASDEX Upgrade has been upgraded over the last 15 years from a 2 MW, 2 s, 140 GHz system to an 8 MW, 10 s, dual frequency system (105/140 GHz). The power roughly equals the installed ion cyclotron resonance (ICRF) power. The power of both wave heating systems together (> 10 MW in the plasma) is about half of the available power from the neutral beam heating (NBI), allowing significant variations of torque input, of the shape of the electron and ion heating profiles even at high heating power.

This system allows addressing important issues fundamental to a fusion reactor: H-mode operation with dominant electron heating, accessing low collisionalities in full metal devices, novel scenarios without edge eruptions (ELMs), influence of Te/Ti and rotational shear on transport, dependence of impurity accumulation on heating profiles. Experiments on these subjects will be presented here. The adjustable localized current drive capability of ECRH allows dedicated variations of the shape of the q-profile and studying their influence on non-inductive tokamak operation. The ultimate goal of these experiments is to use the experimental findings to refine theoretical models such that they allow a reliable design of operational schemes for reactor size devices. In this respect, recent studies comparing gyrofluid (TGLF) and gyrokinetic (GENE) modelling of non-inductive high beta plasmas will be reported.

P 4.2 Mon 14:30 b305

Diagnostic capabilities of X3 mode of electron cyclotron emission for electron temperature in overdense plasmas at W7-X — •Neha Chaudhary, Johan W. Oosterbeek, Matthias Hirsch, Udo Hoefel, Robert C. Wolf, and The W7-X Team — Max-Planck-Institut für Plasmaphysik, 17491 Greifswald, Germany

For magnetically confined plasmas, the lower harmonics of electron cyclotron emission (ECE) behave as a blackbody representing the electron temperature. The W7-X stellarator, for confinement reasons, is planned to work at high plasma densities aiming at detached steady state operation. For such scenarios at a magnetic field of 2.5T the ECE from the optically thick X2 mode (120-16 GHz) is in cut-off for densities more than 1.2e20/m3. Hence, electron temperature profiles cannot be accessed from ECE for over dense plasmas.

W7-X has a large aspect ratio that leads to spectrally well resolved higher harmonics of ECE compared to a tokamak with small aspect ratio. The emission from these harmonics is still present at high plasma densities and can be investigated to study plasma properties such as electron temperature and density. A Michelson interferometer was commissioned at W7-X to scan these harmonics for different plasma parameters covering broad spectral range 50-500 GHz. Initial experimental results and the radiation transport calculations (TRAVIS) suggest that X3 mode (180-220 GHz) of ECE is optically thick enough to be explored for its diagnostic capabilities as a high-density access to electron temperature. In addition, the forward modelling of experimental results is planned in the MINERVA framework.

P 4.3 Mon 14:55 b305

ECCD-induced electron temperature crashes at W7-X — •Marco Zanini, Heinrich Laqua, Torsten Stange, Henning Thomsen, Tamara Andreeva, Christian Brandt, Matthias Hirsch, Udo Höfel, Kian Rahbarnia, Robert C. Wolf, Alessandro Zocco, and W7-X Team — Max-Planck-Institut für Plasmaphysik, 17491 Greifswald, Germany

The plasma in the superconducting optimized stellarator Wendelstein 7-X is mainly heated by an electron cyclotron resonance heating (ECRH), which allows up to 7.5 MW of injected power. ECRH itself can also be used to drive net toroidal current in the plasma (electron cyclotron current drive, ECCD). Toroidal current is not necessary for plasma confinement in stellarators, but the small amount of intrinsic toroidal current makes W7-X a perfect testbed for ECCD experiments. During ECCD experiments, fast and repetitive crashes of the electron temperature have been detected. A 1-D model for current evolution shows that the current drive deforms the rotational transform profile in such a way that low order rational values are crossed, leading the plasma in a condition where instabilities can be triggered. An initial attempt of mode analysis suggested an odd poloidal and toroidal number, thus being coherent with sawtooth oscillations in tokamaks. The pattern of collapses changes in time for long discharges, as the toroidal current evolves, and it was observed that, for relatively high toroidal currents, the change of magnetic topology coupled with these crashes can significantly affect plasma performances.

P 4.4 Mon 15:20 b305

Integrated modeling of tokamak plasma confinement — •Teobaldo Luda[1], Clemente Angioni[1], Micheal Dunne[1], Emiliano Fable[1], Arne Kallenbach[1], Philip Schneider[1], Mattia Siccinio[1], Giovanni Tardini[1], The ASDEX Upgrade team[1], and The EUROfusion MST1 Team[2] — [1]Max–Planck–Institut für Plasmaphysik, Boltzmannstrasse 2, D–85748 Garching, Germany — [2]See author list of B. Labit et al., 2019 Nucl. Fusion 59 086020

The design of future fusion reactors and their operational scenarios requires an accurate prediction of the plasma confinement. We have developed a new model that integrates different elements describing the main physics phenomena which determine plasma confinement. In particular, we are coupling a new pedestal transport model, based on empirical observations, to the ASTRA transport code, which, together with the TGLF turbulent transport model and the NCLASS neoclassical transport model, allows us to describe transport from the magnetic axis to the separatrix. We also coupled a simple scrape-off layer model to ASTRA, which provides the boundary conditions at the separatrix, which are a function of the main engineering parameters. By this way no experimental data of the kinetic profiles is needed, and the only inputs of the model are the magnetic field, the plasma current, the heating power, the fueling rate, the plasma geometry, and the effective charge. In the modeling work-flow, first a scan in pedestal pressure is performed, by changing the pedestal width. Then the pedestal top pressure is determined using the MISHKA MHD stability code. The model is tested by simulating ASDEX Upgrade discharges.

P 4.5 Mon 15:45 b305

Control of neoclassical tearing modes in fusion reactors — •Raphael Schramm[1], Ondrej Kudlacek[1], Hartmut Zohm[1], Emiliano Fable[1], Filip Janky[1], Olivier Sauter[2], Mattia Siccinio[1,3], Wolfgang Treuterer[1], and Emanuele Poli[1] — [1]Max-Planck-Institut für Plasmaphysik(IPP), D-85748 Garching b. München, Germany — [2]École Polytechnique Fédérale de Lausanne (EPFL), Swiss Plasma Center (SPC), CH-1015 Lausanne, Switzerland — [3]EUROfusion Consortium, PPP&T department, Boltzmannstr. 2, Garching

Neoclassical tearing modes (NTMs) are magneto-hydrodynamic instabilities in tokamak plasmas, that can cause a degradation of plasma confinement and eventually trigger a disruption. Since both of these are critical issues for a future tokamak reactor, NTM control is essential. This work presents a closed loop control simulation with realistic diagnostics and actuators, based on the tokamak plasma model implemented in ASTRA. The NTM amplitude evolution is based on the modified Rutherford equation and was benchmarked against an independent analytical estimate. The control action is executed by directing an electron-cyclotron (EC) beam, which drives a current in the island. The proper injection angles to hit the island are found by monitoring the NTM amplitude, while sweeping the beam around the estimated island position. Based on this work, first power estimates for the stabilization of the 2/1 NTM mode in EU-DEMO will be provided. This contribution will also deal with mode locking and study the effects of the EC beam broadening due to density fluctuations.