P 3: Magnetic Confinement II

Time: Monday 16:15–18:20 Location: KH 02.016

Invited Talk P 3.1 Mon 16:15 KH 02.016

EMC3-Eirene simulation of neutral source effects on density build-up in the W7-X island divertor — •Victoria Winters[1,2], Felix Reimold[2], Yuhe Feng[2], Victoria Haak[2], Valeria Perseo[2], Georg Schlisio[2], and The W7-X Team[2] — [1]Universität Greifswald, Institut für Physik, Greifswald D-17489 Germany — [2]Max-Planck-Institut für Plasmaphysik, Greifswald D-17491 Germany

Achieving high plasma density near the divertor target in magnetically confined fusion devices is crucial for efficient heat and particle exhaust. The W7-X stellarator is qualifying the island divertor as a potential exhaust solution for a future stellarator reactor. Simplified models of the island divertor predict that increasing the internal island field line pitch (Θ) should have a beneficial effect on density build-up at the divertor. This hypothesis was tested numerically using the EMC3-Eirene code for three different W7-X magnetic configurations with increasing Θ (low iota, standard, and high iota). While the low iota configuration showed the poorest density build-up, as expected, no improvement in density build-up was observed between standard and high iota, even with the factor of 2 increase in Θ. This deviation from predicted behavior was attributed to the proximity of the X-point to a vertical divertor plate, introducing a limiter-like component. Removing the vertical target from the simulation recovered the expected scaling from the simplified models. This work underscores the importance of the island's neutral screening efficiency on density build-up. Potential consequences, such as inducing X-point radiators, will be discussed.

Invited Talk P 3.2 Mon 16:45 KH 02.016

Optimizing divertor heat loads on Wendelstein 7-X us- ing multi-objective optimization — •Alexander Knieps[1], Michael Endler[2], Joachim Geiger[2], Jiankun Hua[3], Yunfeng Liang[1,3], Dirk Naujoks[2], Matthias Otte[2], Vincenzo Sanfratello[1], and Yutong Yang[1] — [1]Forschungszentrum Jülich GmbH, Institute of Fusion Energy and Nuclear Waste Management 1 - Plasmaphysik, Jülich, 52425, Germany — [2]Max-Planck-Institut für Plasmaphysik, Greifswald, 17491, Germany — [3]Huazhong University of Science and Technology, Wuhan, 430074, People's Republic of China

Modular stellarators such as Wendelstein 7-X offer considerable flexibility in their magnetic configuration space. Due to the many possible choices in configuration, it becomes possible to not optimize just for one target metric, but to combine multiple metrics into one study. Specialized methods exists for such multi-objective studies which can autonomously explore the Pareto front of different possible tradeoffs between objectives. In this talk, we show how to leverage multi-objective methods to explore configurations with reduced heat loads on plasma-facing components. Particularly, we explore how much heat loads can overall be reduced through tuning of the main coil currents, and then explore how much further reduction is possible by tolerating increased heat loads in other areas.

P 3.3 Mon 17:15 KH 02.016

Fast divertor plasma dynamics at Wendelstein 7-X — •Sebastian Hörmann[1,2], M. Griener[1], G. Birkenmeier[1,2], F. Reimold[3], M. Krychowiak[3], D. Gradic[3], F.B.T. Siddiki[3], C. Killer[3], A. von Stechow[3], U. Stroth[1,2], the ASDEX Upgrade Team[1], and the W7-X Team[3] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — [2]TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — [3]Max-Planck-Institut für Plasmaphysik, Greifswald 17491, Germany

Understanding and quantifying particle and energy transport at the plasma boundary, as well as detachment and its stability in the divertor region, is crucial for magnetic confinement fusion, as this determines both plasma performance and target loads. For this reason, several thermal helium beam systems, have been installed in the divertors of Wendelstein 7-X. These diagnostics allow the investigation of edge transport processes, such as modes and filaments, with high spatiotemporal resolution of 10 kHz in both n_e and T_e and up to 1 MHz in line intensity. The contribution will present the diagnostic implementation, validation and its possibilities. Furthermore, the talk will focus on the influence of large plasma events on divertor plasma and detachment in the island divertor regions, causing density and temperature changes in the island of up to 50% in a time range in the order of 0.1 ms to 10 ms. In combination with other diagnostics, as well as for different magnetic configurations and machine parameters, the nature of these events will be discussed, and the influence on the wall will be determined.

P 3.4 Mon 17:40 KH 02.016

Resilience of stellarator plasmas against thermal quenches induced by tungsten TESPEL injection — •Hjördis Bouvain[1], Andreas Dinklage[1], Naoki Tamura[1], Isabel Garcia-Cortes[2], Tomas Gonda[3], Katsumi Ida[4], Hiroe Igami[4], Andreas Langenberg[1], Hiroshi Kasahara[4], Kieran McCarthy[3], Daniel Medina-Roque[3], Keisuke Mukai[4], Yoshiro Narushima[4], Kian Rahbarnia[1], Chihiro Suzuki[4], Yuki Takemura[4], Tokihiko Tokuzawa[4], Thomas Wegner[1], Mikiro Yoshinuma[4], The W7-X Team[1], and The LHD Experiment Team[4] — [1]Max-Planck-Institute for Plasma Physics, Greifswald, Germany — [2]Laboratorio Nacional de Fusión, CIEMAT, Madrid, Spain — [3]Auburn University, Auburn, USA — [4]National Institute for Fusion Science, Toki, Japan

Plasma-terminating events, e.g. induced by the sudden influx of high-Z impurities due to mechanical failures, threaten the safe operation of large-scale fusion devices. Unlike tokamaks, in stellarators such an event cannot lead to a current disruption, but thermal quenches can still occur. To quantify the potential damage to plasma-facing components caused by the sudden energy loss, large amounts of tungsten were injected via TESPEL in W7-X and LHD plasmas. It was found that beyond a threshold of tungsten atoms and plasma parameters, impurity induced radiative losses along propagating cold fronts may induce termination. Close to this threshold, an intrinsic resilience to the perturbations was observed: despite energy losses up to ~90%, the plasmas recovered without external intervention. This underscores the improved robustness of stellarator plasmas to strong perturbations.

P 3.5 Mon 18:05 KH 02.016

Demonstrating the capabilities of the Electron Cyclotron Absorption (ECA) Diagnostic at W7-X in a case study. — •Jonas Zimmermann, Torsten Stange, Sergiy Ponomarenko, Heinrich Laqua, and W7-X Team — Institut für Plasmaphysik, Greifswald, Deutschland

Electron cyclotron resonance heating (ECRH) is the primary heating system of the Wendelstein 7-X (W7-X) device and a major component of the heating mix of most next-generation magnetically confined plasma experiments. Ensuring high heating efficiency is important for machine safety, experimental success, and cost-effectiveness. The propagation and absorption of a heating beam depend on plasma parameters as well as the coupling of the beam to the X- or O-mode at the plasma edge. The electron cyclotron absorption (ECA) diagnostic at W7-X measures ECRH beam shine-through, providing a first-pass heating efficiency measure. During X-mode operation, where full absorption is expected, shine-through power of a few percent was detected. A detector channel was upgraded to include a motorized polarization rotator. With this, the unabsorbed power could be attributed to partial O-mode coupling. Full absorption was finally achieved using a systematic optimization procedure for the coupled polarization. It was possible to measure the magnetic shear induced polarization rotation of the ECRH beam. Comparison of this measurement with the expected change in rotational transform (iota) along the beam path suggests the effective ECRH coupling point lies radially outward of the previously assumed last closed flux surface.