P 3: Magnetic Confinment Fusion/HEPP II

Time: Monday 16:15–18:00 Location: ZHG102

Invited Talk P 3.1 Mon 16:15 ZHG102

Flux Pumping for High Performance Tokamak Scenarios — •A. Bock[1], A. Burckhart[1], G. Pucella[2], F. Auriemma[2], D. Keeling[3], D. King[3], C. Challis[3], V. Igochine[1], R. Schramm[1], J. Stober[1], T. Pütterich[1], R. Fischer[1], J. Hobirk[1], N. Hawkes[3], H. Zhang[1], E. Joffrin[4], M. Baruzzo[2], C. Piron[2], P. Jacquet[3], JET Contributors[5], and the ASDEX Upgrade Team[6] — [1]MPI for Plasma Physics, Garching, Germany — [2]ENEA, Frascati, Italy — [3]CCFE, Abingdon, United Kingdom — [4]CEA, Saint-Paul-lez-Durance, France — [5]see author list of J. Mailloux et al. 2022 Nucl. Fusion — [6]see author list of H. Zohm et al., 2024 Nucl. Fusion

Viable tokamak fusion power plant scenarios must exhibit high energy confinement and magnetohydrodynamic (MHD) stability. To this end, the anomalous redistribution of magnetic flux caused by a central continuous self-regulating saturated MHD mode ("flux pumping") can be of great benefit: it clamps the central safety factor q to 1, i.e. limits the core magnetic field line helicity, thereby preventing the occurrence of periodic reconnection events known as sawtooth crashes which can take place whenever $q < 1$. This not only avoids the performance-degrading crashes, but can also prevent secondary resistive instabilities and their potentially disastrous consequences. Ultimately, flux pumping can result in a peaked plasma current profile just shy of sawteeth, giving additional stability against ideal MHD instabilities.

This contribution will present recent experimental evidence of flux pumping from the ASDEX Upgrade and JET tokamaks, including initial modelling results.

P 3.2 Mon 16:45 ZHG102

Hybrid kinetic-MHD and gyrokinetic simulations of the fishbone instability with JOREK and ORB5 — •Felix Antlitz[1], Xin Wang[1], Matthias Hoelzl[1], Guido Huijsmans[2,3], Philipp Lauber[1], Thomas Hayward-Schneider[1], and Alexey Mishchenko[4] — [1]Max Planck Institute for Plasma Physics, Garching b. M., Germany — [2]CEA, Saint-Paul-Lez-durance, France — [3]Eindhoven University of Technology, Eindhoven, Netherlands — [4]Max Planck Institute for Plasma Physics, Greifswald, Germany

Energetic particles (EPs) will play a central role in future burning plasma experiments, as they can strongly interact with the bulk plasma and drive magnetohydrodynamic (MHD) instabilities. For instance, the so called fishbone instability is the result of an internal kink mode destabilized by EPs in tokamaks. In this contribution, we first describe numerical simulations using the nonlinear extended MHD code JOREK, whose kinetic module is used to include EPs with a particle-in-cell technique. JOREK uses a full-f formulation for the EPs and evolves the MHD equilibrium consistently in time. Second, results from simulations with the global electromagnetic gyrokinetic code ORB5 are presented. This uses a gyrokinetic (or drift-kinetic) description not only for the fast ions, but also for the thermal ions and electrons. The two codes are run in both the linear and nonlinear regimes and the effect of the differences between the two models implemented in the codes are discussed.

P 3.3 Mon 17:10 ZHG102

Progress of Machine Learning-based Real Time Control Applications and SPI Shard Tracking at ASDEX Upgrade — •Johannes Illerhaus[1,2], Wolfgang Treutterer[1], Bernhard Sieglin[1], Alexander Bock[1], Rainer Fischer[1], Matthias Gehring[1], Paul Heinrich[1,2], Ondrej Kudlacek[1], Mohammad Miah[1,2], Gergely Papp[1], Tobias Peherstorfer[3], Thomas Zehetbauer[1], Udo von Toussaint[1], Hartmut Zohm[1], Frank Jenko[1], and the ASDEX Upgrade Team[4] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Technische Universität München, Garching, Germany — [3]Technische Universität Wien, Vienna, Austria — [4]see the author list of U. Stroth et al. 2022 *NF* 62 042006

Machine Learning (ML) is a versatile tool with unique benefits in different applications of magnetic confinement fusion research, particularly in plasma control. This contribution will discuss the progress of integrating ML models into **A**SDEX **U**p**g**rade's (**AUG**'s) **D**ischarge **C**ontrol **S**ystem (**DCS**) and towards an ML-based automated video analysis of a **S**hattered **P**ellet **I**njection (**SPI**) dataset from a test series in search of the optimal setup configuration for the ITER SPI system. A focus will be put onto the DCS integration, where a generic pipeline for quick integration of different ML models as augmentations to the DCS was constructed using real time GPU inference. The pilot project of this pipeline is a real-time capable high-fidelity electron density profile reconstructor, which now runs in routine operation during the ongoing AUG experimental campaign.

P 3.4 Mon 17:35 ZHG102

Neural Networks as Solution Ansatz for the Ideal Magnetohydrodynamic Equilibrium Problem — •Timo Thun[1], Andrea Merlo[2], and Daniel Böckenhoff[1] — [1]Max-Planck-Institute for Plasma Physics, Wendelsteinstraße 1, 17491 Greifswald, Germany — [2]Proxima Fusion, Am Kartoffelgarten 14, 81671 Munich, Germany

Quick and accurate solvers for the fixed-boundary ideal magnetohydrodynamic (MHD) equilibrium problem in non axisymmetric magnetic fields can accelerate stellarator optimisation, facilitate high-fidelity real-time control and enable other data-driven algorithms. Unfortunately, current MHD equilibrium solvers either require high computational wall-time or suffer from a lack of accuracy. Solvers based on Neural Networks (NN) enable very fast inference by transferring the bulk of computational load to model training and the creation of datasets, possibly overcoming this dilemma. Recent work presented a fast NN based ideal MHD surrogate model in the magnetic configuration space defined by the stellarator research device Wendelstein 7-X, using a dataset calculated by conventional solvers and the ideal MHD equilibrium force-residual. Training without a dataset removes implicit biases of its solution strategy and avoids computational costs associated with its creation. We present simple NN models trained solely on the physics-based force residual that achieve comparable or better flux surface averaged force residuals than conventional solvers.