P 14: Magnetic Confinement IV/HEPP VI

Time: Thursday 11:00–13:10 Location: CHE/0091

Invited Talk P 14.1 Thu 11:00 CHE/0091

Experimental validation of turbulence codes — •Klara Höfler — Institut für Plasmaphysik, Greifswald, Germany

Turbulence is a main driver of heat transport, which deteriorates the performance of fusion reactors. Simulation codes aiming for identifying turbulence optimized devices need to be validated against experiments.

The comprehensive set of experimental turbulence data presented here is measured at the ASDEX Upgrade tokamak for two plasma scenarios. It includes wavenumber spectra, electron density and temperature fluctuation amplitudes and radial correlation lengths as well as the cross phase between density and temperature fluctuations. These quantities are measured for comprehensive code validation by Doppler reflectometers and an electron cyclotron emission radiometer. In this talk they are compared to the gyrokinetic code GENE because of its mature capabilities to assess and reproduce core turbulence. In addition synthetic diagnostic modeling is included to account for diagnostic effects on measurements.

The work presented in this talk shows the encouraging example of code validation where a remarkable number of measured physics quantities is successfully reproduced by the code. It comprises contributions of a variety of collaborators both on the experimental side – Institut für Plasmaphysik (IPP) in Garching, Plasma Science and Fusion Center of MIT in Cambridge and Laboratoire de Physique des Plasmas of the Ecole Polytechnique in Palaiseau – and on the theory side – IPP Garching and Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie in Stuttgart.

P 14.2 Thu 11:30 CHE/0091

Turbulence in stellarators with GENE-3D — •Felix Wilms, Alejandro Banon Navarro, and Frank Jenko — Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, 85748 Garching b. München, Germany

GENE-3D is a code that is capable of simulating gyrokinetic plasma turbulence in stellarators globally (Maurer et al., Journal of Computational Physics, 2020). It has recently been upgraded to an electromagnetic version, expanding the variety of turbulent features that can be studied with it (Wilms et al., Journal of Plasma Physics, 2021). In this work, we present an overview over the most recent achievements of the code, including the study of electromagnetic effects on global turbulence (Wilms et al., Journal of Plasma Physics, 2021) as well as the impact of a surface-global effects on turbulence stabilisation (Wilms et al., to be submitted to Nuclear Fusion).

P 14.3 Thu 11:55 CHE/0091

Gyrokinetic simulations of turbulent transport in the edge and scrape-off layer of TCV — •Philipp Ulbl[1], Andreas Stegmeir[1], and Frank Jenko[1,2] — [1]Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany — [2]University of Texas at Austin, Austin, TX 78712, USA

Turbulence in the edge and scrape-off layer (SOL) region of magnetic confinement fusion devices is of high relevance for the feasibility of fusion energy. Two important properties of a future fusion reactor, confinement and heat exhaust, are largely affected by turbulence. This requires the development of predictive edge turbulence codes.

In this work, we present the latest improvements to the grid-based gyrokinetic turbulence code, `GENE-X` [1], with applications to the TCV tokamak [2]. `GENE-X` is specifically targeted for edge and SOL simulations, since it can perform simulations in realistic, diverted geometries. It features a full-f, electromagnetic, gyrokinetic turbulence model and recently, collisional effects were introduced.

We present the results of multiple `GENE-X` simulations using different collision models, which vary in their physics fidelity. We analyze the resulting plasma profiles and heat fluxes, and compare against the experiment. The code validation improves with the fidelity of the collision model. Based on this, we assess and discuss collisional effects on gyrokinetic turbulence in the edge and SOL.

[1] D. Michels, et. al., Comput. Phys. Commun. 264, 107986 (2021)
[2] D. S. Oliveira, T. Body, et. al., Nucl. Fusion 62, 096001 (2022)

P 14.4 Thu 12:20 CHE/0091

Investigation of driving mechanisms of dominant Alfvén eigenmodes at the Wendelstein 7-X stellarator — •Sara Vaz Mendes[1], Kian Rahbarnia[1], Henning Thomsen[1], Christoph Slaby[1], Charlotte Bueschel[1], Matthias Borchardt[1], Ralf Kleiber[1], Axel Könies[1], Jan-Peter Bähner[2], and Adrian von Stechow[1] — [1]Max-Planck-Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]MIT Plasma Science and Fusion Center, Cambridge, MA 02139, USA

The basis for characterizing dominant Alfvén mode activity in the Wendelstein 7-X (W7-X) stellarator plasmas is presented with the investigation of possible driving mechanisms. In previous W7-X operational phases, Alfvén mode activity was frequently observed during plasmas operated solely with electron cyclotron resonance heating. A broad range of frequencies is observed in measurements of the fluctuating poloidal magnetic field, $\dot{B}_\theta$. An essential analysis was developed to track the dominant frequency bands (DFBs) from the spectrograms of $\dot{B}_\theta$ between $f = 100 - 450$ kHz. The DFBs studies allowed us to draw novel and integral analyses of the dynamics of Alfvén modes through the entire length of W7-X plasmas. Correlations between the modes dynamics with general plasma parameters are determined, and we present in which plasma conditions the spectral properties of the Alfvén DFBs show relevant changes. The amplitude of the DFBs shows a strong correlation to turbulent density fluctuations measured with the Phase contrast Imaging (PCI) diagnostic in most W7-X regimes.

P 14.5 Thu 12:45 CHE/0091

Model based optimization of Advanced Tokamak scenarios — •Raphael Schramm[1], Alexander Bock[1], Emiliano Fable[1], Jörg Stober[1], Simon van Mulders[2], Maximilian Reisner[1], Hartmut Zohm[1], and the ASDEX Upgrade Team[1] — [1]Max-Planck Institut für Plasmaphysik, Garching, Germany — [2]École Polytechnique Fédérale de Lausanne, Switzerland

Advanced Tokamak scenarios increase the plasma safety factor (q) profile via external actuators in order to increase the bootstrap current, thereby reducing the inductive current fraction. In order to avoid an intermittent drop in q the actuators need to be applied already during the current ramp-up. A model in the transport code ASTRA, capable of predicitvely designing such a scenario by calculating temperature and q profiles based on the actuator setup has been developed and validated on AUG.

A scenario, considerably different from the validation case has been analyzed. In order to increase magnetohydrodynamic stability, the q-profile has been optimized. This is done by using an optimizer, running on simpler model to propose changes, which are then double-checked in the ASTRA model. Effects of the plasma current on stability and the performance of different setups have been explored. Results of the last AUG campaign will be shown.

The model can also be applied on different devices with minor changes. Results for JET, based on data from previous shots will be shown. Using the model to design a scenario to show the flux-pumping phenomenon on a larger device for the first time is planned.