P 1: Magnetic Confinement I/HEPP I

Time: Monday 11:00–12:35 Location: ELP 6: HS 3

Invited Talk P 1.1 Mon 11:00 ELP 6: HS 3
On the observation of Trapped Electron Modes in W7-X — •Andreas Krämer-Flecken[1], Paul Costello[2], Golo Fuchert[2], Joachim Geiger[2], Stèphane Heuraux[3], Alexander Knieps[1], Josefine Proll[4], Kian Rahbarnia[2], Roland Sabot[5], Luigui Salazar[3], Gavin Weir[2], Thomas Windisch[2], and Haoming Xiang[6] — [1]Forschungszentrum Jülich GmbH, Jülich, Germany — [2]Max Planck Institut für Plasmaphysik, Greifswald, Germany — [3]Institut Jean Lamour; Université de Lorraine, Nancy, France — [4]Eindhoven Uni- versity of Technology, Eindhoven, The Netherlands — [5]CEA, IRFM, Saint-Paul-Les-Durance, France — [6]Advanced Energy Research Center, Shenzhen University, Shenzhen, PRC

In fusion devices Trapped Electron Modes (TEM) are responsible for particle transport in general. An indication for TEMs are the so called Quasi Coherent (QC)-modes, density fluctuations visible in different diagnostics e.g. Poloidal Correlation Reflectometry (PCR) and observed in a frequency range of 50 kHz to 250 kHz. In case of TEM origin, these QC-modes propagate in electron diamagnetic drift direction and have a poloidal structure size of 20 mm to 30 mm and $k_\perp \rho^* \geq 1$. This presentation reports on the first observation of TEMs and related QC-modes at the stellarator W7-X, as observed by PCR. They show up in low collisionallity ECRH heated plasmas, within a broad frequency range, depending on magnetic configuration and heating power. From the observed frequency of the QC-modes and there poloidal velocity a scaling is developed. Linear gyrokinetic calculation confirm the existence of TEMs within the parameters obtained for these discharges.

P 1.2 Mon 11:30 ELP 6: HS 3
GPU offloading strategies for gyrokinetic edge turbulence simulations with GENE-X via OpenMP and OpenACC — •Jordy Trilaksono[1], Carl-Martin Pfeiler[1], Philipp Ulbl[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

The GENE-X code simulates plasma turbulence by solving the gyrokinetic equation using a grid-based/Eulerian discretization. The flux-coordinate independent approach allows GENE-X to simulate plasma turbulence anywhere within magnetic confinement fusion (MCF) devices, from the plasma core to the wall. GENE-X is mainly written in object-oriented modern Fortran 2008 fully utilizing MPI+OpenMP parallelization. Here, we present our development strategies and experiences to further accelerate GENE-X on GPU, which is essential for simulations towards larger, reactor-relevant fusion devices. The GPU offloading features are written on an auxiliary C++ layer interoperated by the main Fortran layer. The C++ layer provides broader selections of GPU offloading tools. MPI+OpenMP and MPI+OpenACC parallelizations are chosen to future-proof our solution against the evolution and diversification of modern GPU architectures. We present performance benchmarks and convergence analysis of our OpenMP and OpenACC implementations on GPU. The computational hotspot in GENE-X achieves a significant performance increase on GPU compared to its CPU-equivalent. The readiness of GENE-X compute capability for large-scale production runs on GPU is further investigated.

P 1.3 Mon 11:55 ELP 6: HS 3
Verification of the gyrokinetic code GENE-X for the edge and scrape-off layer of stellarators — •Marion Smedberg[1], Philipp Ulbl[1], Andreas Stegmeir[1], and Frank Jenko[1,2] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]University of Texas at Austin, Austin, TX, USA

A key open question in magnetic confinement fusion research regards plasma turbulence, particularly in the edge and scrape-off layer (SOL). This is especially true for stellarators, since optimization for low neoclassical transport has only recently been proven; the remaining transport is determined to be turbulent [1]. Numerical codes which simulate the plasma turbulence in such devices are critically important to understand the experiments and predict future reactor performance. Here we present `GENE-X`, a full-f, electromagnetic, Eulerian gyrokinetic code designed for the edge and SOL [2], and its generalization to stellarator geometries. We describe the 3D generalization, including the implementation of non-axisymmetric magnetic fields, development of an approximate flux surface label, and the newly generalized data structure. We also discuss the ongoing verification of the 3D-capable code. This includes convergence testing via the method of manufactured solutions, and could include recreating neoclassical transport predictions and a benchmark against the gyrokinetic code `GENE-3D`.

[1] T. S. Pedersen et al, Nucl. Fusion 62 042022 (2022)
[2] D. Michels, et al, Comput. Phys. Commun. 264 (2021)

P 1.4 Mon 12:20 ELP 6: HS 3
Creating a power balance database study on turbulence at Wendelstein 7-X — •Markus Wappl, Marc Beurskens, Sergey Bozhenkov, Tamara Andreeva, Sebastian Bannmann, and Håkan Smith — Max Planck Instiute for Plasma Physics, Greifswald, Germany

Power balance analysis is used to compile a comprehensive database of anomalous transport in various plasma scenarios at the stellarator Wendelstein 7-X. The anomalous transport is attributed to turbulence. As a figure of merit, an effective turbulent transport coefficient χ_{eff} is defined. The database spans a broad parameter range covering different fueling schemes, heating power values and methods as well as different magnetic configurations of W7-X.

Experiments with neutral beam or hydrogen pellet injection allow to increase the central density and ion temperature while creating steep gradients. The database unveils a characteristic dependence of χ_{eff} on the gradient lengths of density and ion temperature, a/Ln and a/LT. This hints at the prevalence of ion temperature gradient (ITG) modes. The critical parameters governing ITG stability, a/Ln_{cr} and a/LT_{cr}, are identified from the database. Based on power and density scan experiments, the scaling behaviour of the effective turbulent transport coefficient is explored. χ_{eff} positively correlates with electron cyclotron heating power, predominantly in the electron channel of turbulent transport.

The benefits of the turbulence database results in a future extrapolation to a stellarator reactor based on W7-X are discussed.