P 7: Helmholtz Graduate School III

Time: Wednesday 14:00–15:15 Location: H4

P 7.1 Wed 14:00 H4

Simplified nonlinear MHD models of external kink modes in stellarators — •Rohan Ramasamy[1,2], Matthias Hoelzl[1], Erika Strumberger[1], Guillermo Suárez López[1], Sophia Henneberg[3], Karl Lackner[1], and Sibylle Günter[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Max Planck Princeton Center for Plasma Physics, New Jersey, USA — [3]Max Planck Institute for Plasma Physics, Greifswald, Germany

Non-linear magnetohydrodynamic (MHD) codes are an important tool in improving the understanding of disruptions in tokamaks. Recently, there has been renewed interest in advancing state-of-the-art MHD codes to model stellarators. Herein, two simplified models are explored, using the nonlinear code, JOREK, and the equilibrium code, VMEC.

VMEC is used to calculate the nonlinear saturated state of ideal external kink modes in simplified $l = 2$ stellarators. These saturated states are then compared against a simpified axisymmetric approximation of the stellarator, implemented in JOREK. The axisymmetric approach includes the external rotational transform by means of a *virtual current* model.

This approach is then applied to an unstable quasi-axisymmetric configuration to assess the stabilising influence of increasing external rotational transform on the MHD activity. The results show that while the external modes are stabilised significantly, nonlinearly triggered internal modes degrade confinement further. A relatively large external rotational transform is necessary to avoid a significant loss of confinement.

P 7.2 Wed 14:25 H4

First results for stellarator simulations with JOREK — •Nikita Nikulsin[1], Rohan Ramasamy[1], Matthias Hoelzl[1], Alessandro Zocco[2], Karl Lackner[1], and Sibylle Guenter[1] — [1]Max Planck Institute for Plasma Physics, 85748 Garching, Germany — [2]Max Planck Institute for Plasma Physics, 17491 Greifswald, Germany

The JOREK code has recently been extended to allow nonlinear fully 3D stellarator simulations. This is made possible by generalizing the JOREK reduced MHD model to support stellarator geometries, and by allowing the grid to be non-axisymmetric, so that it can be aligned to the flux surfaces in a stellarator.

The models differ mainly in that the magnetic field can be represented as any curl-free field plus a perturbation in the stellarator model, whereas in the tokamak model it is a toroidal field plus a perturbation. We implement the curl-free field as a gradient of a Dommaschk potential, which in turn is calculated from the vacuum magnetic field as given by the EXTENDER code. In order to run a stellarator simulation, we must initialize the reduced MHD variables using the data from the GVEC equilibrium code.

Finally, we present the very first stellarator simulation results. While force balance is not satisfied exactly in stellarator reduced MHD, we show the error to be small. For stable plasmas, a barely noticeable shift is seen, after which equilibrium is restored and persists for thousands of Alfvén times. We also simulate unstable plasmas and benchmark the growth rates against the linear MHD code CASTOR3D.

P 7.3 Wed 14:50 H4

MHD-kinetic hybrid code based on structure-preserving finite elements with particles-in-cell — •Florian Holderied[1,2], Stefan Possanner[1], and Xin Wang[1] — [1]Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany — [2]Technical University of Munich, Arcisstraße 21, 80333 München, Germany

This talk presents a STRUcture-Preserving HYbrid code - STRUPHY - for the simulation of magneto-hydrodynamic (MHD) waves interacting with a small population of energetic particles (EPs) far from thermal equilibrium (kinetic species). Such configurations can appear e.g. in fusion reactors, where hot α-particles can resonantly interact with MHD waves and compromise confinement time. The implemented model features linear, ideal MHD equations in curved, 3d space, coupled nonlinearly to the full-orbit Vlasov equations via a current coupling scheme. The implemented algorithm is based on finite element exterior calculus for MHD and particle-in-cell methods for the kinetic part; it provably conserves mass, energy, and the divergence-free constraint for the magnetic field, irrespective of metric, mesh parameters and chosen order. The motivation for this work stems from the need for reliable long-time simulations of EP-physics in complex geometries. In STRUPHY, the finite element spaces are built from tensor products of univariate B-splines on the logical cuboid. Time-stepping is based on operator splitting with implicit sub-steps. After presenting the scheme, numerical results in different geometries including toroidal domains with a singularity at the magnetic axis are shown and discussed.