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Title: A new high-fidelity model for predicting plasmas profiles in stellarators

With the reduction of neoclassical transport in modern optimized stellarators like Wendelstein 7-X (W7-X), the magnetic confinement is turbulence-limited and appears to control the profiles' behavior. As the first experimental campaign of W7-X has shown, the ion temperature profile is clamped to around 1.5 keV in electron-heated plasmas, despite the different heating power, plasma density, and magnetic configurations employed. It has been proposed that as the electron cyclotron resonance heating (ECRH) power increases, the electron-to-ion temperature ratio rises, enhancing the ion temperature gradient (ITG) driven turbulent transport and consequently clamping the ion temperature profile. However, to date there still exists no reduced transport model that is able to correctly capture the turbulent transport and to reliably predict plasma profiles in stellarators. On the other hand, high-fidelity gyrokinetic codes can still only be run on turbulence time scales, which does not allow to capture the dynamics of the equilibrium profiles. Therefore, we are unable to predict important plasma phenomena such as the ion temperature clamping.

In this contribution, we present a new integrated modeling tool especially designed for stellarators. For the first time, the ion profile evolution for electron-heated plasmas in W7-X is simulated from first principles, using a multi-time-scale approach. This is achieved by coupling the gyrokinetic turbulence code GENE3D and the neoclassical code KNOSOS to the transport code TANGO. This approach captures turbulence and transport phenomena only on their respective natural time scales, thus considerably reducing the overall computational cost of the simulations. First simulation results show that the GENE3D/KNOSOS/TANGO integrated model is able to reproduce the ion temperature clamping observed in electron-heated plasmas in W7-X. Moreover, it allows to identify the main mechanism causing this clamping. The present work represents first steps in scenario development w.r.t. improved confinement regimes in W7-X by means of a high-fidelity transport model.