Steady-state flows in tokamak plasmas under the visco-resistive MHD setting

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Abstract

In tokamaks, plasma rotation plays a crucial role on heat and particle confinement including the appareance of the H (high confinement) mode. The classical equilibrium equation for tokamak plasma is the Grad-Shafranov equation, that neglects the plasma velocity and involves the pressure gradient although pressure is just a passive scalar and not an actuator. We must then go further to consider the issue of plasma velocity within a magnetohydrodynamic framework. In [Oueslati, Firpo, Physics of Plasmas 27, 102501 (2020)], the axisymmetric steady states of the visco-resistive magnetohydrodynamic equations, including the non-linear (v.∇)v term, have been computed using the finite element method. Playing on boundary conditions with external magnetic perturbations offers a way to break the natural up-down symmetry of the system and produce a net toroidal flow. Using realistic parameters, numerical results indicate that small perturbations of the magnetic configuration may be used to increase steady-state speeds and promote tokamak plasma confinement while preserving axisymmetry (which is a good way to prevent turbulence).
Another path to break the up-down symmetry is also explored with an up-down inhomogenous heating [Roverc'h, Oueslati, Firpo, Journal of Plasma Physics 87, (2021)].

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