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P2.037 Automatic identification of the plasma equilibrium operating space in tokamaks

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Identifying the plasma equilibrium operating space in terms of e.g. plasma current Ip, internal inductance li(3) and magnetic flux state ψ is a central task in the design of future tokamaks. The operating space is typically limited (for a given plasma shape) by constraints on the Poloidal Field (PF) system such as maximal allowable currents, fields and forces in PF coils. The typical tool to identify this operating space is an inverse Free-Boundary Equilibrium (FBE) solver, which is used to find a set of PF coils currents that minimizes a cost function comprising two terms: the first one, which we call here the objective, quantifies the distance between the actual and desired plasma shape and the second one is a regularization term, typically a weighted sum of the squares of the PF coils currents. This formulation does not however directly take into account the above-mentioned PF coils limits. Identifying the operating space in these conditions is time-consuming (usually several days) and needs heavy human intervention to tune the weights in the cost function.

Here, we replace the regularization term in the cost function by new terms which penalize the violation of the limits in PF coils currents, fields and forces. This way we can obtain the operating space by scanning parameters (e.g. Ip, li(3), Ψ), running an inverse FBE problem for each point in the scan. The operating space is then defined by an iso-value contour of the shape deviation metric (this contour being entirely located within all PF limits).

As an example, we applied our method to the ITER 15 and 17 MA scenarios and found, within a few hours of simulation and with little human intervention, results similar to previous studies.

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