NEW DEVELOPMENTS OF THE CEDRES++ EQUILIBRIUM CODE WITH APPLICATION TO TORE SUPRA, JT-60SA AND ITER

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Free-boundary equilibrium codes are an essential tool for tokamak design studies and scenario development. In this contribution, new developments of the CEDRES++ code are presented, with application to Tore Supra, JT-60SA and ITER. In particular, a dimensioning study for the coils and power supplies for plasma vertical control in the frame of a possible upgrade of Tore Supra is reported on. The latter would involve a new tungsten divertor and new in-vessel coils to allow for X-point configurations.

CEDRES++ is an object-oriented code which solves the free-boundary equilibrium problem for an axisymmetric tokamak using a variational formulation. The equations for the poloidal flux Ψ are solved with a Picard or a Newton algorithm by a finite element method. A boundary integral method is used in order to account for the boundary condition $\Psi=0$ at infinity.

New developments of CEDRES++ comprise the treatment of iron, the integration of an automatic mesh generator, the inclusion of an interface with the Integrated Tokamak Modelling (ITM) Kepler platform using Consistent Physical Objects (CPOs) as input and output, and finally the capability to deal with arbitrary profiles for the pressure $p(\Psi)$ and diamagnetic function $f(\Psi)$, an important step towards a dynamic code coupled with transport models.

Several applications of the code will be presented, namely:

- The satisfactory benchmark of a version of CEDRES++ without iron with the DINA code on an ITER Scenario 2 case at 30 different times across the discharge, both in direct mode (fixed currents in the Poloidal Field [PF] coils) and inverse mode (optimisation of the PF coils currents in order to obtain a given plasma geometry). In direct mode, with matched β_p and l_i, the position of the separatrix shows a maximal discrepancy with DINA of ~5% of the minor radius. In inverse mode, adjusting the PF coils currents by a few % allowed to match the DINA separatrix with a precision of ~0.5% of the minor radius (again with matched β_p and l_i).
- The cross-checking of ongoing design studies for the PF coils system of JT-60SA, performed in the frame of the Broader Approach.
- Finally, exploiting the recent implementation of iron, vertical stability studies for the possible Tore Supra upgrade mentioned above, after a successful benchmark with the PROTEUS code.