Projet CEMRACS: NOTEMP
Nonlinear Temperature Evolution Simulation for tokamak plasmas.

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The description and simulation of the transport (and turbulences) of magnetically confined fusion plasmas in the edge region (SOL) of a tokamak, is nowadays one of the main problems for fusion generated energy production (ITER). The aim of this project shall be the implementation of the coupled ion/electron temperature evolution equations (energy balance equations). This system of equations is at the moment still a delicate un unsolved problem, due to the non-linearity of the equations (and boundary conditions) as well as the anisotropy. The system of equations writes

$$\partial_t T_\alpha - \partial_s(K_{||,\alpha}\, T_\alpha^{5/2}\, \partial_s T_\alpha) - \partial_r(K_{\perp,\alpha}\, \partial_r T_\alpha) = \pm\beta(T_i - T_e)\,, \quad \text{for } (s,r)\in\Omega\,,$$

where α stands for the ions ($\alpha = i$) or electrons ($\alpha = e$), T_α is the ion/electron temperature, $K_{||,\alpha}$ resp. $K_{\perp,\alpha}$ the diffusion parameters (rather different in magnitude). These equations are completed with non-linear boundary conditions, descibing the interaction with the limiter

$$\begin{cases} \partial_r T_\alpha = -Q_{\perp,\alpha}\,, & \text{for } r = 0\,, \quad s\in(0,1)\,,\\ \partial_r T_\alpha = 0\,, & \text{for } r = 1\,, \quad s\in(0,1)\,,\\ K_{||,\alpha}\, T_\alpha^{5/2}\, \partial_s T_\alpha = \gamma_\alpha\, T_\alpha\,, & \text{for } r\in(1/2,1)\,, \quad s = 0\,,\\ K_{||,\alpha}\, T_\alpha^{5/2}\, \partial_s T_\alpha = -\gamma_\alpha\, T_\alpha\,, & \text{for } r\in(1/2,1)\,, \quad s = 1\,,\\ \textit{periodic}\,, & \text{for } r\in(0,1/2)\,, \quad s = 0;1\,, \end{cases}$$

and the initial condition

$$T_\alpha(0) = T_{0,\alpha}\,.$$

Here, $\Omega = (0,1)\times(0,1)$ is our 2D simulation domain. The simulation of the uncoupled system (zero right hand side) is in prepation in [1] and can be used as a starting point of this project.

[1] F. Filbet, C. Negulescu, *Numerical study of the aniostropic and nonlinear temperature equation for the SOL tokamak plasma.*