Numerical treatment of stiff transport in the ASTRA code

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Transport processes taking place in strongly magnetized plasmas as in a tokamak are generally driven by free-energy available from kinetic profiles gradients. As the long-time-scale transport is modeled as convective/diffusive, gradients reappear also in the general form of the kinetic profiles fluxes. This means that the flux will be generally non-linear in the transported quantity and its gradient. Moreover, the dependence of the diffusion and convection on the gradients can be step-like (so-called critical gradient models). The resulting transport model suffers then from the 'stiffness' problem, i.e. small change in gradients lead to large changes in flux, which makes the usual numerical schemes readily unstable in time and space. A specific solution to this problem has been devised in [G. V. Pereverzev and G. Corrigan 2008], via a numerical scheme that smoothly couples the shallow and steep regions of flux/gradient dependence. In this talk, the physical origin of the stiff transport problem for strongly magnetized plasmas will be first briefly presented, followed by a detailed description of the algorithm as it is implemented in ASTRA, with discussion of the numerical accuracy in time and space. Applications to transport simulations for tokamak plasmas will be shown in the final part of the talk.