A semi-Lagrangian scheme with non-equidistant splines to investigate sheath physics

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The periphery of the core confined plasma is made of open magnetic field lines (the "Scrape-Off Layer" or SOL) which intercept solid elements, leading to plasma-wall interaction. To a large extent, this region governs tokamak edge plasma physics and contributes to the access to improved confinement regimes. In addition, it is here where heat and particles are lost.

The presence of a solid limiter has been successfully taken into account for the 5D non-linear gyrokinetic GYSELAX code by using immersed boundary conditions via a penalization technique. So far, only ion-wall interactions are considered, as electrons are treated adiabatically in the SOL. The more complex case with kinetic electrons is under investigation. In all cases, GYSELAX still needs to be able to address the large temperature variations --typically two orders of magnitudes-- from the very hot core to the cool edge, as this represents a major issue in core-edge turbulence interplay in tokamak plasmas. Such a large temperature variation requires refined meshes. Multi-resolution and/or multi-patch approaches are therefore necessary in order to avoid wasting large amounts of CPU time and memory resources. In GYSELAX code, the chosen strategy is to treat this intrinsic difficulty by using non-equidistant splines.

As this requires a complete refactoring of the existing splines, the numerical validity of this approach has first been tested on the VOICE kinetic 1D-1D code. The VOICE code solves the coupled set of Vlasov-Poisson equations, both for ions and electrons, along the parallel (to the guiding magnetic field) direction in the SOL. The main motivations behind developing VOICE are to study the sheath physics and determine SOL boundary conditions for turbulence and transport codes. It is a well-adapted testbed because it directly derives from the GYSELAX code, therefore it is also based on a semi-Lagrangian scheme and uses the same cubic splines and the same kind of penalization technique. We present here the first results obtained with non-equidistant splines to study sheath physics.