Modeling radio frequency heating in tokamaks using a 3-D Fokker-Planck code accounting for drift orbit effects

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A simple semi-analytical method (see [D. Van Eester, Pl. Phys. Contr. Fusion, **47**, 459], and the references therein) is adopted to evaluate the dielectric response of a plasma to electromagnetic waves in the ion cyclotron domain of frequencies accounting for drift orbit effects in an axisymmetric tokamak. The method relies on subdividing the orbit into elementary segments in which the integrations can be performed analytically or by tabulation, and it hinges on the local bookkeeping of the relation between the variables defining an orbit and those describing the magnetic geometry. The adopted method allows computation of elementary building blocks for either the wave or the Fokker-Planck equation, but the focus here is on the latter. Based on this evaluation scheme, a 3-D Fokker-Planck code was developed which accounts for the radial width of the guiding center orbits and thus not only describes RF induced velocity space diffusion, but equally accounts for the RF induced radial drift. Some results of this new 3-D Fokker-Planck code are presented and discussed. The adopted numerical resolution relies on a subdivision of the integration domain in tetrahedres. This specific shape of the elementary volumes allows imposing the boundary conditions (in particular the non-local conditions across the curved trapped/passing boundary connecting one trapped to two passing orbits) elegantly. The particular chosen shape also readily permits zooming in on regions where more detail is required. Casting the equation in its weak Galerkin form, it is solved relying on the finite element technique. Unless special attention is devoted to the optimization of the inversion of the system of linear equations resulting from projecting the 3-D Fokker-Planck equation onto proper base functions, the computer memory and time required is excessive. Off-the-shelf algorithms permitting speedy and accurate inversion of systems of linear equations with sparse matrices proved to be extremely useful to cope with this difficulty.