

Global electromagnetic gyrokinetic particle-in-cell simulation

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Abstract

Over the last two decades the particle-in-cell (PIC) method has become quite popular to solve the gyrokinetic Vlasov-Maxwell equations. Especially the so-called delta f method made it possible to make nonlinear global plasma simulations achievable. In a more general framework, the delta f method can be identified with the usage of a control variate. This is a specific procedure for variance reduction of Monte Carlo methods. In particular, the control variate method can be used to reduce the intrinsic statistical noise of the PIC method beyond the scope of the delta f method. This is of special interest when it comes to electromagnetic PIC simulations. Such simulations were computationally unaffordable in the past. However, an enhanced control variate method gives the possibility to reduce the number of markers by more than four orders of magnitude compared to a conventional delta f scheme in the electromagnetic regime. As a result, just recently, both linear global PIC simulations in the reduced MHD regime and nonlinear global PIC simulations of turbulence have been achieved in tokamak geometry.