The coupling of Monte-Carlo methods for solving Fokker Planck equation with ICF codes requires them to be economical and to preserve gross conservation properties. Besides, the presence in FPE of diffusion terms due to collisions between test particles and the background plasma challenges standard M.C. techniques if this phenomenon is dominant. We address these problems through the use of a fixed mesh in phase space which allows us to handle highly variable sources, avoiding any Russian Roulette for lowering the size of the sample. Also on this mesh are solved diffusion equations obtained from a splitting of FPE. Any non-linear diffusion terms of FPE can be handled in this manner. Another method, also presented here is to use a direct particle method for solving the full FPE.

INTRODUCTION

Monte-Carlo methods have been under development for many years. Quite recently, they have been used for solving Fokker Planck Equation, with many possible applications, such as $\alpha$-particle transport [1,5], thermal electron transport, and suprathermal electron transport [2,3]. Any of these problems presents specific difficulties. Concerning the first example, one problem pertains to the fact that there is energy deposition from $\alpha$-particles to the background plasma, which in turn allows for the propagation of the combustion in the DT plasma. This nonlinear coupling between FPE for fast ions and hydrodynamics may induce highly variable $\alpha$-particles sources, then lead to some difficulties in the sampling procedure. To address this problem, we present in section II a sampling method, which preserves conservation properties of the particles distribution function [1]. This technique has been implemented in hydro codes FCI1 and FCI2 and gives very good results [4]. Both fast ions and suprathermal electrons usually encounter small deflections due to collisions with the particles constituting the background plasma. In this case, a standard explicit M.C. method can be used for a numerical simulation [2]. However, whenever exists a dense region in the plasma the collision terms are dominant, and have to be treated implicitly. In section III, an implicit method for collision terms is described. It is based on a
splitting of FPE. A standard finite differences scheme is used for solving the resulting diffusion equations. We then sample the obtained distribution function. This technique permits the treatment of general nonlinear terms, such as e-e collision terms. It shows that a possibility for solving collision terms with a M.C. method is to use a variable weight method, and to work in the phase space of all independent variables. We present here numerical results in the case of fast ions transport. This technique is strongly supported by its simplicity, but one might want to avoid the necessary calculation of the distribution function at each time step. To skip this step one can use a direct variable weight particle method for solving FPE. This technique has been used for other equations, such as hydrodynamics equations [7], and its convergence properties have been studied for the diffusion equation in [9]. Numerical applications of this method are under investigation at Limeil [9]. The method itself is based on an approximation of any variable by a sum of Dirac measures. From this approximation, a system of ordinary differential equations is deduced, which has to be solved implicitly. A short presentation of this method is performed in section IV. Numerical results for collision terms are expected soon, to be presented elsewhere [10].

II/ DISTRIBUTION FUNCTION SAMPLING

We start here with the Fokker-Planck Equation /11/, where we presently neglect collision terms. We can use a standard M.C. method for solving this equation. However, in the case of highly variable sources, and due to the fact that this equation is coupled to a hydro-code (FC11 or FC12), we cannot allow the size of the sample to grow too large. To avoid this problem, we consider a 6-dimensional grid in phase space \((x,v)\), which is fixed in time. The source term is then approximated by a sum of 5 functions products. We thus define a sample of size \(N\). After this sampling we use any particle pusher to obtain positions of the particles at the advanced time \(t + \Delta t /11\). At the end of the time step, some particles may have been thermalized, whilst at the beginning of the new time step, new test particles are created. Their number may be larger than the maximum size allowed. Each particle in now related in the phasespace grid with a CIC or NGP technique. For any choice of the grid, local and global conservation properties are preserved. Moreover, the mesh may be adapted to any special physical problem of interest when this method is coupled to a hydro-code like FC11 (or FC12 - 2.D) the simplest choice for the projection of the grid on the physical space is the lagrangian mesh used in the code itself. Thus, there are possible coarse parts in this mesh, which can alter the precision of this approximation if the position of the new test particles is not chosen carefully. For a new particle created in cell \((j,g,m)\), a good location in the physical space is the centre of mass of the positions of the old particles found in the cell \((j,g,m)\). In energy space, a weighted average of the old particles energies preserves energy conservation and gives good results, even with a rather coarse grid in 1.D [4], and 2.D calculations [15].