Pauli-blocking check in BOX Simulations

Dear Colleagues,

Thanks a lot for your efforts and the time you have devoted to the box simulations, which helped us to understand and fix the differences observed, among the different codes, for the nucleon-nucleon collision number, for the case of cascade calculations without Pauli-blocking. This is an important progress for us, to construct more reliable models in the future. Our comparison of the box simulations has also evidenced that the Pauli-blocking treatment, in the different codes, leads to divergent predictions of the number of effective collisions for option 1 (Cascade with Pauli-blocking). The same problem was evidenced in the comparison of heavy ion collisions, discussed at Shanghai 2014. Thus, understanding the differences among the different treatments of the Pauli-blocking becomes urgent.

In order to understand the Pauli-blocking factor in detail, we wish that all of you can do the following test calculations and provide the following information:

- **Consider a cascade calculation, with your own Pauli-Blocking, at T=5 MeV (the case OP1T5 of the homework 1) and run the calculation only up to t= 1fm/c. Consider just one event for BUU-like codes (with 100 test particles) and 100 events for QMD-like codes.**
  (The test calculations can be finished within a coffee time if the code has been set down.)
- **For each attempted collision, no matter whether the collision is successful or not, output the values of the occupation probability f for outgoing nucleons (or test particles) *i* and *j*, exactly as it is evaluated, in your collision integral routine, to define the Pauli blocking factors and decide whether the collision can happen or not.**
  Since the case considered corresponds to about 120 attempted collisions in 1 fm/c, this calculation will provide about 120*2*100 = 24000 evaluations of the occupation probability. These values should be given in a file and in a plot (see detailed instructions below).

- **Please provide the total number of attempted and successful collisions at t = 1 fm/c.**

For your convenience, we attach the box calculation requirements here again.

We should use a cubic box, of size L_k = 20 fm.

Particles interact only through two-body collisions, i.e. the mean-field interaction is suppressed.

- **The simulation should be followed until t=1 fm/c, with a recommended step of Δt=0.5 or 1.0 fm/c.**

1) Initialization:

- Uniform density ρ_0=0.16 fm^{-3}, with isospin asymmetry equal to zero. With the above size of the box this corresponds to 1280 nucleons, 640 neutrons and 640 protons. Particle positions are initialized randomly from 0 to L_k.
- **In momentum space, we consider one case, corresponding to the temperature T=5 MeV.**

  Particle momenta are initialized randomly with the Fermi distribution, $f=1/(1+\exp((E-\mu)/T))$, with $E=p^2/2m$ (relativistically $E=\sqrt{p^2+m^2}$), corresponding to T = 5 MeV.

  The chemical potential can be estimated in the non-relativistic case from the expression:

  $\mu(T)\approx\mu(0)(1-\frac{\pi^2}{12}\left(\frac{T}{\mu(0)}\right)^2)$, where $\mu(0)$ is the Fermi energy.

  At the density considered, we get μ(T=5 MeV) = 36.84 MeV.

  In the relativistic case it has to be obtained from the normalizing condition $2\int f\, d^3p=\rho_{n,p}$ for neutrons and protons, respectively.

2) Pauli-blocking:

In order to better investigate the difference on the treatment of Pauli-blocking in the different codes, the simulations **should be performed with your own Pauli-blocking option (OP1).**

- **OP1: Just consider your standard treatment, that you usually adopt in your simulations;**

3) Number of runs:

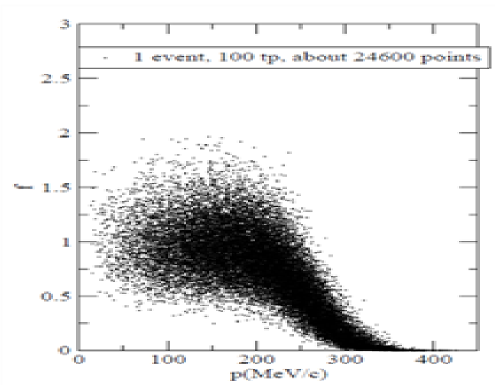
BUU-like: 100 test particles per nucleon, 1 run

MD: 100 runs

4) Output files: We need 2 files :

a) **the output file to record the momentum and the occupation probability f, for each attempted collision. The format is "p_i, f_i, p_j, f_j" where p_i (p_j) is the modulus of the momentum for outgoing nucleons (or test particles) i (j). (please do not use min(1,f)).**
This file should be named f.txt

b) **a figure like the following one, but generated by yourself, for our double check. The figure is a scatter plot of the f values as a function of p, which denotes the modulus of the momentum of particle *i* or *j* .**



We would appreciate very much if you can finish the simulations by Dec. 20, 2016.

Many thanks for your efforts, and many greetings,

The Box Simulation Organizing Committee
Maria Colonna
Akira Ono
Yongjia Wang
Jun Xu
Yingxun Zhang