

## Box calculations for homework2

Dear participants,

Thanks a lot for your efforts and the time you have devoted to the box simulations. We have collected some preliminary results for homework1, which was focused on the test of collision integral and Pauli blocking, looking at the number of collisions obtained, in the different codes, as a function of time and energy, for cascade mode (with or without Pauli blocking). The results are exciting and we believe that, at this stage, we should push the project towards further tests of the critical ingredients entering the transport codes and the description of nuclear reactions, such as the mean-field dynamics. We know the time is short, but that we would appreciate very much if some people could do the homework2, so that we will get a first impression of the results.

We would like to propose homework2 and try to finish the analysis by NuSYM16, Jun 10, 2016. The homework2 consists of the 'Vlasov mode', and its requirements are listed as follows:

**Vlasov mode: no collisions, only mean field,  $T = 0$ .**

In this mode we can check the dispersion relation for the mean field propagation of density fluctuations (zero sound). We consider a cubic box, of size  $L_k = 20$  fm, 1280 nucleons (640 neutrons, 640 protons) as in homework1. The simulation should be followed until  $t=140$  fm/c, with a recommended step of  $\Delta t=0.5$  or  $1.0$  fm/c. The way to introduce the Periodic BC can be found in the announcement of homework1.

### 1) Initialization

Consider symmetric nuclear matter at saturation density,  $\rho_0 = 0.16$  fm<sup>-3</sup>.

Initialize with a standing wave impressed on the box, along the z direction for instance:  $\rho(\mathbf{r}) = \rho_0 + a_p \sin kz$ . (Since it is hard for MD type model to give the specified density distribution by using the Gaussian wave packet, here, we simply require the centroid of wave packet satisfy the specified distribution).

The wave number  $k$  may take the values:  $k = n \frac{2\pi}{L_k}$  ( $n=1, \dots, n_{\max} = L/(2dz)$ ). **In the homework, we will test  $n=1$  and  $n=2$  and we take  $a_p = 0.2 \rho_0$ .**

For the initial distribution in momentum space, the Fermi sphere has to be defined as a function of the local density.

### 2) Details of nuclear interaction

The same simplified force employed for the calculations of transport 2014 (Shanghai) should be considered:

- For non-relativistic transport codes:

use a standard soft Skyrme parametrization (without momentum dependence) with the following parameters:  $a = -209.2$  MeV,  $b = 156.4$  MeV,  $\tau=1.35$ ,  $M_n=M_p=938$  MeV and a symmetry potential energy with linear density dependence  $S_{pot}*(\rho/\rho_0)$ ,  $S_{pot} = 18$  MeV.

The total single-particle potential is then:

$$U_{\frac{n}{p}} = a \left( \frac{\rho}{\rho_0} \right) + b \left( \frac{\rho}{\rho_0} \right)^\tau \pm 2S_{pot} \frac{\rho}{\rho_0} \delta.$$

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(Properties of this parameterization: compressibility  $K_0=240$  MeV, saturation density  $\rho_0 = 0.16$  fm<sup>-3</sup>, binding energy at saturation density  $E_0 = -16$  MeV, symmetry energy  $S(\rho_0) \sim 30.3$  MeV)

- For relativistic transport codes:  
use a nonlinear  $\sigma$ - $\omega$ - $\rho$  RMF parameterization “NL $\rho$ ” (see parameter set I in PRC65, 045201, by Liu B et al.)  
(Properties of this parameterization:  $K_0=240$  MeV,  $\rho_0=0.16$  fm<sup>-3</sup>,  $E_0=-16$  MeV,  $S(\rho_0) \sim 30.3$  MeV)
- Turn off the Coulomb interaction

### 3) Number of runs:

BUU-like: 100 test particles per nucleon, 10 runs  
MD: 200 runs

### 4) Output files:

a) (Test) particle files (please name your file as “particle.\*”): 10 runs for BUU codes and 200 runs for MD codes,

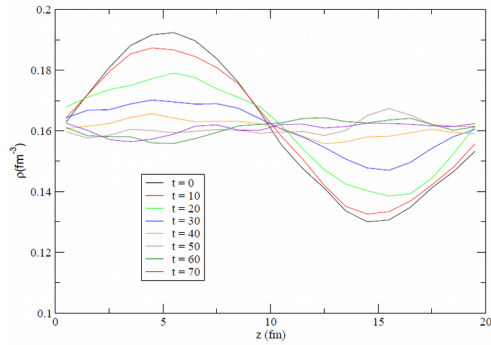
at times **0,20,40,60,80,100,120,140** fm/c the following information for each (test) particle:

**ID=0, charge (0 or 1), mass [GeV], (x,y,z) [fm], (px,py,pz) [GeV]**

The variables “charge” and “ID” are *integer* variables, the others are *real*. (The variable ID, used previously to identify proj and target nucleons, is not needed in a box calculation. We keep it anyway, to have the structure of the files the same as before.)

b) Figures:

If possible, please also generate the figures representing the density, averaged in the whole x-y plane, and averaged over all the events, as a function of z at the different time instants, in order to avoid misunderstandings, from our side, when analyzing your output files. Following is an example.



Alternatively, please output a table of the density along  $z$  direction (averaged over all events and over the  $x$ - $y$  plane). To do so, introduce a grid, of size  $dz$ , inside the box and we adopt  $dz = 1$  fm.

### 5) Reading program and uploading

a) Please provide a simple Fortran program to read your files, and check that this program indeed works. This sounds simple, but in Trento we had considerable difficulties. This may be caused by trivial things like a blank line between runs or a line with the time or impact parameter.

b) Compress your files using “gzip” or “bzip2”, otherwise we will have again problems to uncompress your files. The files will be very large!

**PLEASE send your results before Jun. 10, 2016.**

Many thanks for your efforts,  
and many greetings,

**the Box Simulation Organizing Committee**

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