PHYS-E0412 Computational Physics :: Homework 2

Due date 22.1.2019 at 10 am

Modified random deposition model

This homework presents a generalization of the random deposition model, see the lecture slides before you start.

Let us take a one-dimensional lattice with L sites and impose periodic boundary conditions. Furthermore, each site i has a height $h(i)$, initialized to zero at $t = 0$. The new growth process chooses a site i at random, as in the pure random deposition model. However, the height of the chosen site is only increased if the neighbouring sites are at least as high as the chosen site. In other words, if $h(i+1) \geq h(i)$ and $h(i-1) \geq h(i)$, then $h(i)$ is increased by one, otherwise it remains unchanged. At every time step this trial is performed L times.

(i) A fortran code "RD_hw.f90" implementing most of the functionality needed for this exercise is available on MyCourses. (See below for instructions on how to compile fortran codes.) You can use this code, or write your own from scratch. Note, however, that pure Matlab or Python implementations are likely to be too slow to get reasonably good data. Calculate the roughness function $w(t, L)$ for different values of L (e.g. in the range 10...500) and long enough times so that you can see the initial growth and the saturation value for each L. Plot a picture using a log-log scale. (2p)

Hint: You can import data from text files to Matlab using "data=load('filename.txt');". In python the equivalent function is "numpy.loadtxt('filename.txt')".

(ii) What is the early-time roughness exponent β defined as $w(L, t) \sim t^{\beta}$ for times before the saturation?

Hint: You can use the polyfit function in Matlab to fit a linear function to the log-log plot of the roughness function in a suitable time interval. In python the fitting can be done using numpy.polyfit. (1p)

(iii) What is the saturation-width exponent α defined as $w(L, t) \sim L^{\alpha}$ for times after the saturation has occured? (1p)

(iv) The surface roughness follows a scaling relation

$$w \sim L^{\alpha} f(t/L^{z}), \tag{1}$$

where $z = \alpha/\beta$, and $f(x)$ is a universal scaling function that first grows asymptotically as x^{β} for small x and approaches a constant for large x. Plot f. (1p)

Hint: Plot w/L^{α} as a function of t/L^{z} for various L. (But, of course, the same z and α.) You should experience the so called "data collapse".

(v) How many hours you used for problems in this exercise set?

Compiling fortran codes

Fortran is a programming language that has been used in scientific computation since the ancient times. Fortran code can be compiled into an executable using e.g. the GNU compiler gfortran. For example, in this exercise you can use the commands

```
gfortran -o RD_hw RD_hw.f90
./RD_hw
```

to compile and run the code. This compiler is typically installed in Linux systems. If you want to compile fortran on windows, you can install MinGW (`http://www.mingw.org/`). However, it might be easier to just use ssh to connect to brute.aalto.fi or force.aalto.fi and run the program there, or use the Linux computer classrooms in Otaniemi.

Upload your solution in MyCourses (mycourses.aalto.fi) to the corresponding assignment. Please remember to attach your figures and codes as well!