



# HomeWork #3



## Operating Instructions:

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ gcc -o ex3 -fopenmp ex3.c -lm
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ export OMP_NUM_THREADS=1
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 1000 10000000
```

First line compiles the project, after which it appears that a second line refers to how many Threads we want the program to run. In order to run the program, we will have to enter 2 parameters. The first is the number of stars and the second parameter is the physical time that will pass between iterations, for us it is 10000000.

### 1. General explanation of the experiment:

In this experiment we will simulate the movement of stars in space, using basic mechanics laws. Each star will have its own mass, position as a vector ( $x\_location$ ,  $y\_location$ ), speed of movement as a vector ( $v\_x$ ,  $v\_y$ ) and acceleration as a vector ( $a\_x$ ,  $a\_y$ ).

In the simulation we will perform many iterations, so that in each iteration  $dt$  time passes when each user chooses this time when running the code.

All stars advance one step in their direction of motion. The progress is calculated using the formula:

$$\vec{D}_{new} = \vec{D}_{old} + \vec{V}(d_t) + \frac{\vec{a}(d_t)^2}{2}$$

- $\vec{D}$  tells us the position (vector)

### 2. performance analysis

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ gcc -o ex3 -fopenmp ex3.c -lm
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ export OMP_NUM_THREADS=1
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 1000 10000000
```

Simulation time: 75.845122

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$
```

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$
```

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ gcc -o ex3 -fopenmp ex3.c -lm
```

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ export OMP_NUM_THREADS=2
```

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 1000 10000000
```

Simulation time: 37.570621

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ gcc -o ex3 -fopenmp ex3.c -lm
```

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ export OMP_NUM_THREADS=4
```

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 1000 10000000
```

Simulation time: 19.062517

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ gcc -o ex3 -fopenmp ex3.c -lm
```

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ export OMP_NUM_THREADS=6
```

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 1000 10000000
```

Simulation time: 26.233116

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ gcc -o ex3 -fopenmp ex3.c -lm
```

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ export OMP_NUM_THREADS=8
```

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 1000 10000000
```

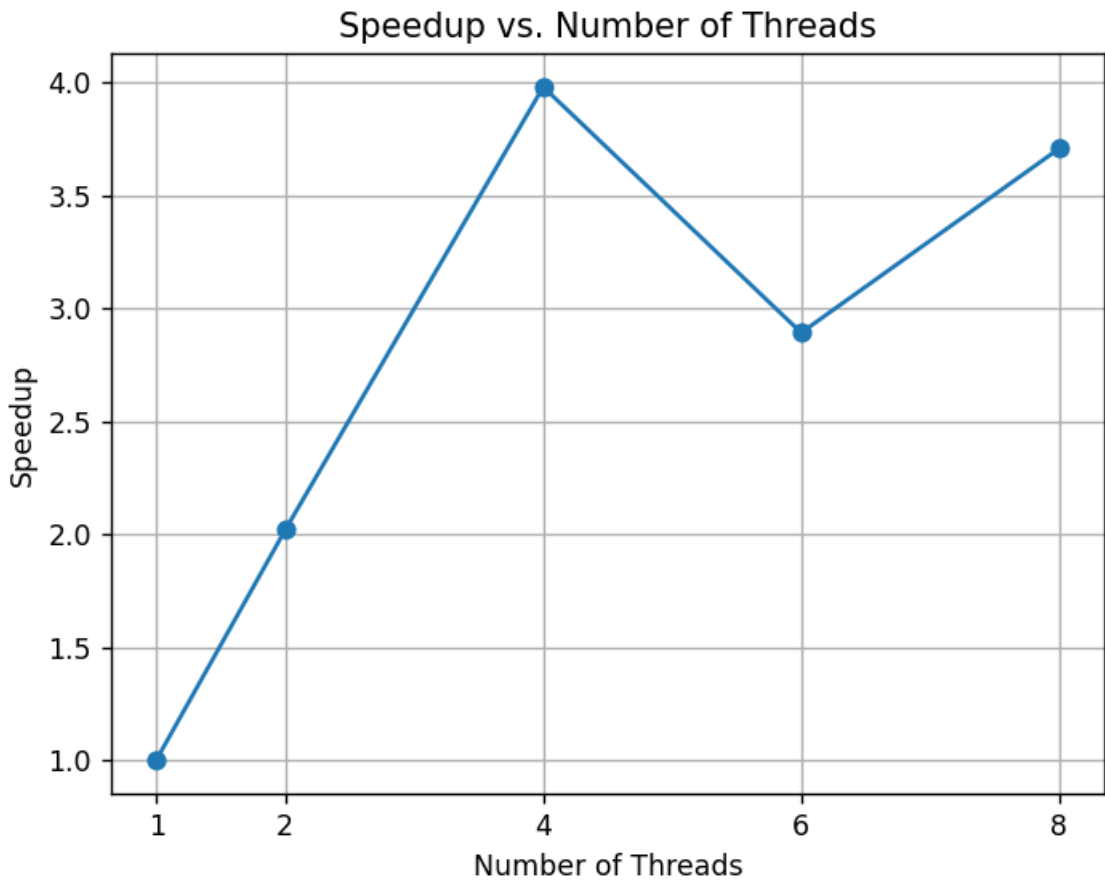
Simulation time: 20.464166

The code was executed on the PC, as the hobbits crashed, so performance may vary elsewhere.



**graph speedup:**

The graph shows the ratio in times between serial running  $p=1$  and  $p=1,2,4,6,8$  and you can see almost an acceleration Linear, especially for a low number of threads.

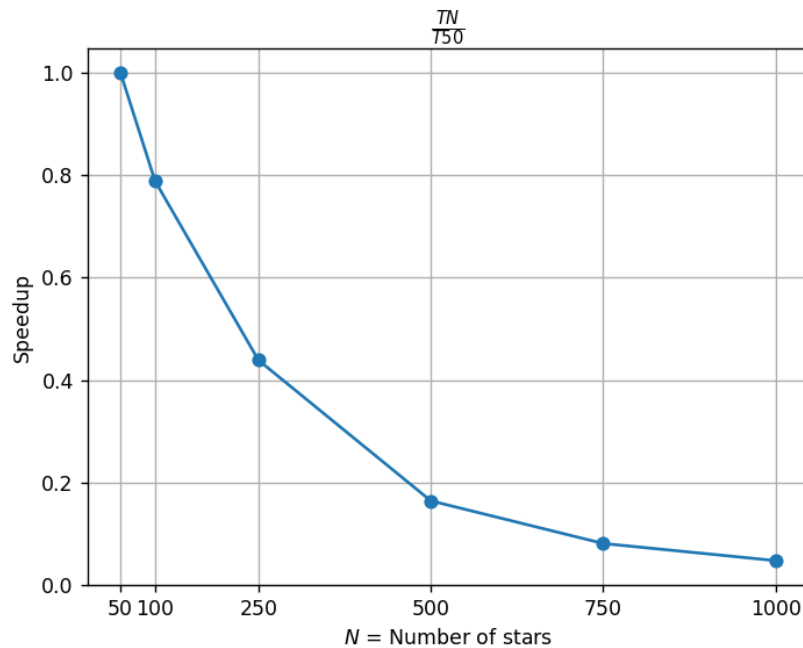




### 3. Simulation on a different number of stars

Experimental settings threads is equal to 8 And our variable is the number of stars on top of the simulation

```
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ gcc -o ex3 -fopenmp ex3.c -lm
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ export OMP_NUM_THREADS=8
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 50 10000000
Simulation time: 0.972475
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 100 10000000
Simulation time: 1.232872
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 250 10000000
Simulation time: 2.215993
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 500 10000000
Simulation time: 5.923131
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 750 10000000
Simulation time: 12.018312
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$ ./ex3 1000 10000000
Simulation time: 20.482378
shahaf@shahaf-VirtualBox:~/Workspaces/Workspace3/ex3$
```

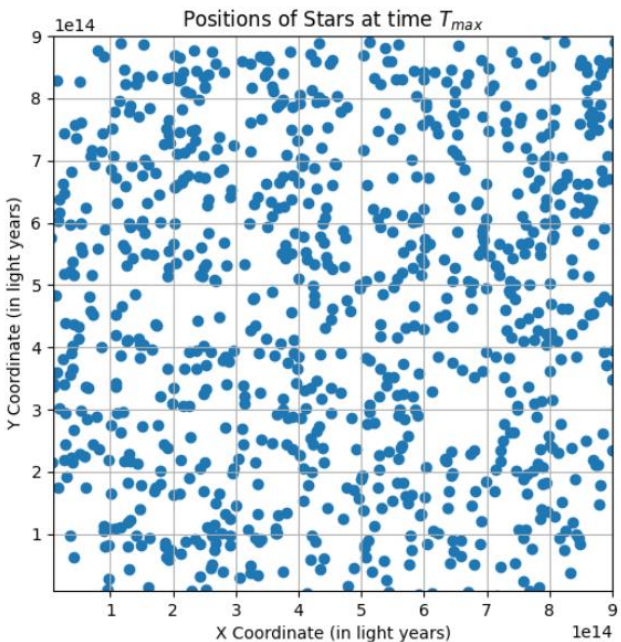
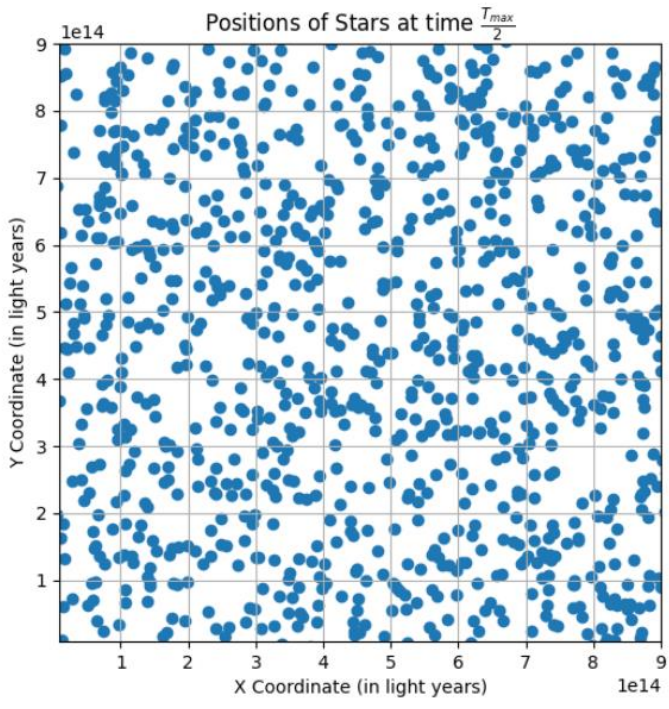
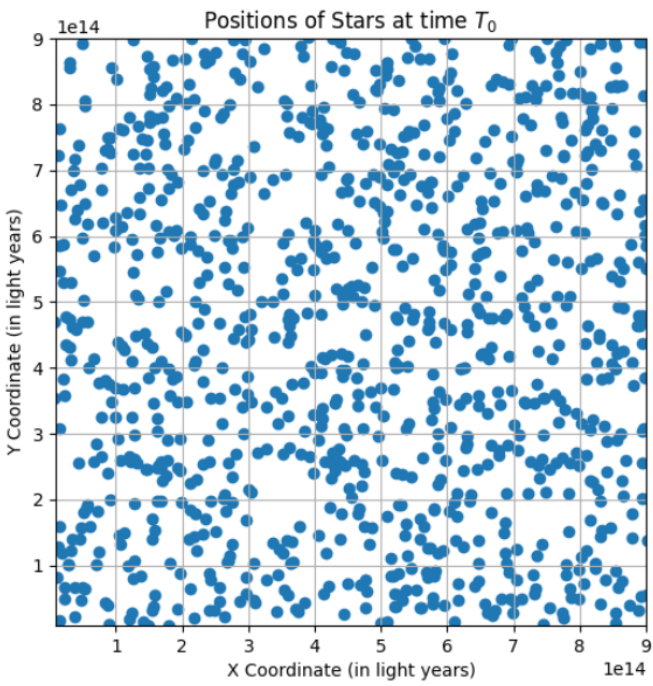


You can see a very fast decay, since the size of the problem is quadratic, we do  $N^2$  calculations. At each iteration, we then observe that the running time increases significantly when stars are added.



4. graphs of the stars

The results of the experiment in times for threads=8 and in each iteration  $10^7$ seconds pass





## 5. conclusions

In this work we worked with the openmp library which gives us the option of receiving events, that is, for serial work we had to perform  $T$  calculations and now we use  $N$  threads that help us in the form of calculation, the calculation we have is  $\frac{T}{N} + \varepsilon$  where  $\varepsilon$  is the overhead resulting from the synchronization between the threads the different ones that the scheduler needs to synchronize between. And with the help of working with one process that controls  $N$  threads, our running becomes significantly more efficient depending on the hardware we have, which of course can accept accordingly.