PHYS-GA 2000 Computational Physics PS3

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Prob 1:

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In [5]: print(derivative( 1, 1e-2))

1.010000000000001
```

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In [6]: print(derivative( 1, 1e-4))
        print(derivative( 1, 1e-6))
        print(derivative( 1, 1e-8))
        print(derivative( 1, 1e-10))
        print(derivative( 1, 1e-12))
        print(derivative( 1, 1e-14))

1.0000999999998899
1.0000009999177333
1.0000000039225287
1.000000082840371
1.0000889005833413
0.9992007221626509
```

Figure 1: This picture showed the output of the derivative using the given function

The derivative is actually $\frac{df}{dx} = lim_{\delta \to 0} = \frac{f(x+\delta)-f(x)}{\delta}$.

It is obvious that on $1e-8$ the function behaves the best and later the error goes up. The error is caused by the systematic error, which is the error produced

by the derivative function we are using here(simple Euler method). On the other hand, the reason of the $1e-8$ has the best result, is that considering the way computer deal with small float number, there will be errors with the number itself. So it is not proper to use such small number in computation.

Prob 2:

We used two ways solving the problem.

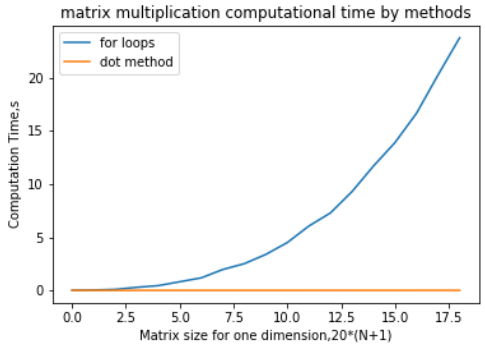

Figure 2: This figure gives the time difference between two different methods on different sizes of matrix

We use the size from $20*20*20$ to $400*400*400$ and take the matrix computation, using time package to calculate the time. It is so obvious as the sizes goes up, the time difference between using for loops and dot methods are higher and higher. The speed python deal with nested for loops is comparatively slow according to this problem.

Prob 3:

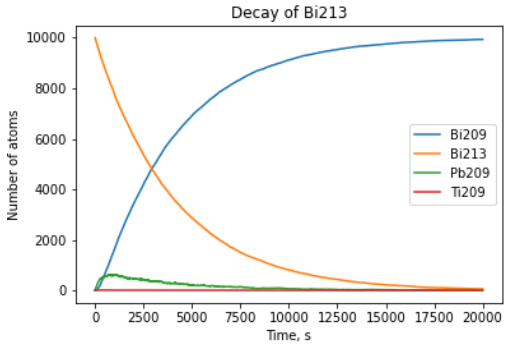

Figure 3: This figure shows the decay process of $Bi_2 13$ and all the products in the process.

It is a decay problem of $Bi_2 13$ using the form $p(t) = 1 - 2^{-\frac{t}{\tau}}$. We use

separately counting for loops for each atoms involved in the decay process. The figure proved the program is running well for the simulation.

Prob 4:

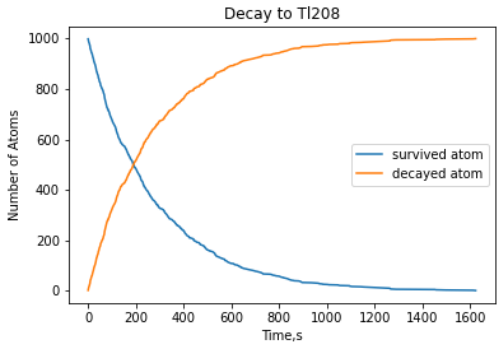

Figure 4: This figure gives the decay progress simulation. We use two counters for survived and decayed atoms.

The method we adopt here is just pick uniform random numbers stands for the decay time for each atoms. We pick 1000 random numbers to simulate the decay situation of each atoms. From the figure we see the atom numbers should be conserved in the process as we want.

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