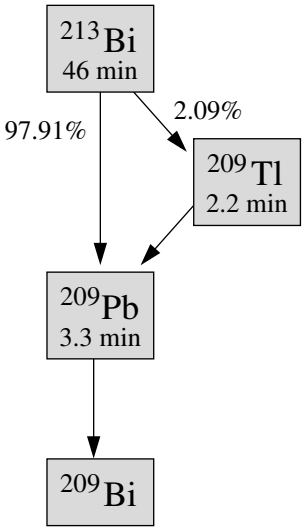
COMPUTATIONAL PHYSICS (PHY241)

HOMEWORK ASSIGNMENT 9

Due Date: **Friday, April 15, 2022**

This exercise looks at a more advanced version of the simple radioactive decay simulation in the example we showed in class.

The isotope ^{213}Bi decays to stable ^{209}Bi via one of two different routes, with probabilities and half-lives thus:



(Technically, ^{209}Bi isn't really stable, but it has a half-life of more than 10^{19} years, a billion times the age of the universe, so it might as well be.)

Starting with a sample consisting of 10 000 atoms of ^{213}Bi, simulate the decay of the atoms by dividing time into slices of length $\delta t = 1$ s each and on each step doing the following:

1. For each atom of ^{209}Pb in turn, decide at random, with the appropriate probability, whether it decays or not. The probability can be calculated from $p(t) = 1 - 2^{-t/\tau}$. Count the total number that decay, subtract it from the number of ^{209}Pb atoms, and add it to the number of ^{209}Bi atoms.
2. Now do the same for ^{209}Tl, except that decaying atoms are subtracted from the total for ^{209}Tl and added to the total for ^{209}Pb.
3. For ^{213}Bi the situation is more complicated: when a ^{213}Bi atom decays you have to decide at random with the appropriate probability the route by which it decays. Count the numbers that decay by each route and add and subtract accordingly.

Note that you have to work up the chain from the bottom like this, not down from the top, to avoid inadvertently making the same atom decay twice on a single step.

Keep track of the number of atoms of each of the four isotopes at all times for 25 000 seconds and make a single graph showing the four numbers as a function of time on the same axes.