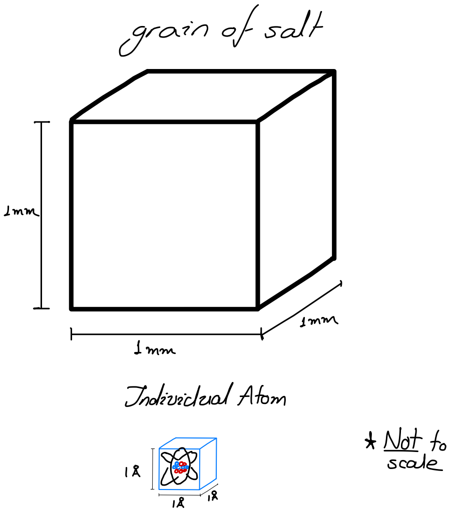
# Length scales of the Universe

## P1 Solution

We want to estimate how many atoms would be in a grain of salt whose volume is given by $1\,mm \times 1\,mm \times 1\,mm$.

Since we want an <u>estimate</u>, we can make some assumptions even if they are not very precise. Namely, you can assume an atom to be a cube as well. The problem now turns into finding how many small cubes (atoms) we can fit into a large cube (grain of salt).




Here is where physics helps us to answer this question. If the large cube is completely filled by N atoms, then the volume of both has to be the same. This allows us to write the following equation:

$$\underbrace{V_{grain}}_{\text{volume of the salt grain}} = \underbrace{N}_{\text{Number of atoms}} \; \underbrace{V_{atom}}_{\text{Volume of an individual atom}}$$

Then, the number of atoms in a grain of salt would be

$$N = \frac{V_{grain}}{V_{atom}}$$

To find the explicit result we need to substitute the value of each volume. From what we saw in class, you can approximate the size of an atom to be $1\,Å = 10^{-10}\,m$. Then,

$$V_{grain} = 1\,mm \times 1\,mm \times 1\,mm = (10^{-3}\,m) \times (10^{-3}\,m) \times (10^{-3}\,m) = 10^{-9}\,m^3$$

$$V_{atom} = 1\,Å \times 1\,Å \times 1\,Å = (10^{-10}\,m) \times (10^{-10}\,m) \times (10^{-10}\,m) = 10^{-30}\,m^3$$

So the number of atoms we can find in a grain of salt is

$$N = \frac{10^{-9}\,m^3}{10^{-30}\,m^3} = \frac{10^{-9}}{10^{-30}} \; \frac{10^{30}}{10^{30}} \; \frac{\cancel{m^3}}{\cancel{m^3}} = 10^{21}$$