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EXPERIMENT: SCATTERING

NUCLEAR SCATTERING GAME

Until the event of the scanning tunnelling microscope it was impossible to observe any details at the atomic level. Previous to this, only indirect measurements could be made on atomic systems and one powerful method is the scattering high speed projectiles from a target in large and expensive particle accelerator machines. It was scattering experiments performed by Rutherford that lead to the discovery of the atomic nucleus. This game illustrates how information on scattering can lead to an estimate of the size of a "nucleus".

Take a sheet of A4 paper and draw a square on it with dimensions of about 100 mm x 100 mm. Randomly fill the square with about 15 circles (diameter about 15 mm). The square represents the target area and the circles the nuclei. Alternatively use the template for the experiment.

Place the paper on the ground so that it does not move. Drop a pen onto the target area from a height between 1 to 2 m at least 50 times. Do not aim the pen as the target area needs to be hit in a random fashion. The pen represents the high speed projectile fired at the atomic nuclei. When the pen hits the paper it leaves a small mark. Place a small cross at this point so that it is easy to identify and counted.

Count the total number of impact marks within the target region (rectangle or square), N_{target} and the number of hits made in the regions covered only by the nuclei (circles), N_{nuclei}.

We can define the following parameters for our scattering experiment:

A_{target}	area of the target (rectangle or square)
N	number of nuclei (circles)
R	radius of nuclei (circle)
$A_{nucleus} = \pi R^2$	area of nucleus (circle)
$A_{nuclei} = N\, A_{nucleus} = N(\pi R^2)$	total area covered by all the nuclei.
N_{target}	number of hits inside target region (rectangle or square)
N_{nuclei}	number of hits inside nuclei (circles)

The radius of a nuclei (circle) can be found from the ratios of hits to area:
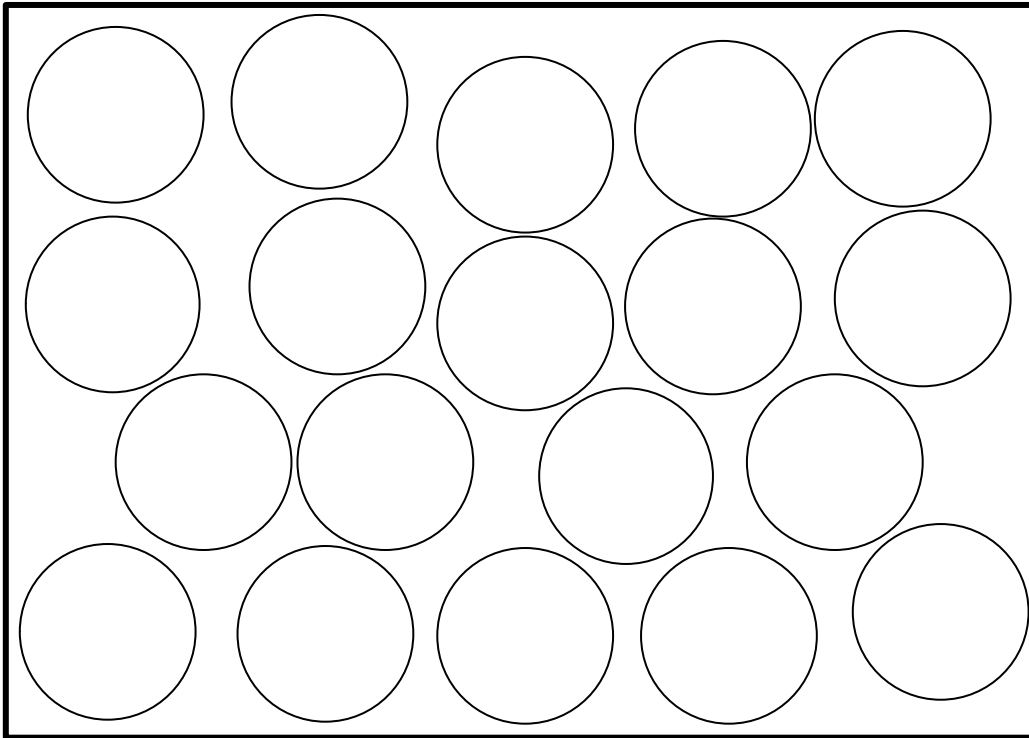
$$\frac{A_{nuclei}}{A_{target}} = \frac{N_{nuclei}}{N_{target}}$$

$$\frac{N\pi R^2}{A_{target}} = \frac{N_{nuclei}}{N_{target}}$$

$$R = \sqrt{\frac{A_{target}}{N\pi}\left(\frac{N_{nuclei}}{N_{target}}\right)}$$

From your data, calculate the radius of a nucleus and compare it with your measured value.

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Results:

L_1 =   mm

L_2 =   mm

R_m =   mm   (measured from template)

A_{target} $= L_1 L_2$ =   mm^2

N =

N_{target} =

N_{nuclei} =

$$R = \sqrt{\frac{A_{target}}{N\,\pi}\left(\frac{N_{nuclei}}{N_{target}}\right)} = \qquad \text{mm}$$

Conclusions

Compared the two measurements for the radii R_m and R.