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Investigating the atom

Activity 2: Resource card 3

E. Rutherford's calculation

Rutherford hypothesized that matter is composed of very small nuclei in which practically all the mass and positive charge of the atoms are concentrated.[1] Assuming also that the distance between these nuclei is much greater than their size, he concluded that, upon passing through a thin metal foil, an alpha particle would undergo a single collision with just one of these nuclei.

Based on these hypotheses and using classical mechanics, Rutherford calculated the probability (σ) of measuring alpha particles scattered by a thin metal target as a function of the angle at which the alpha particle exits the foil. He obtained:

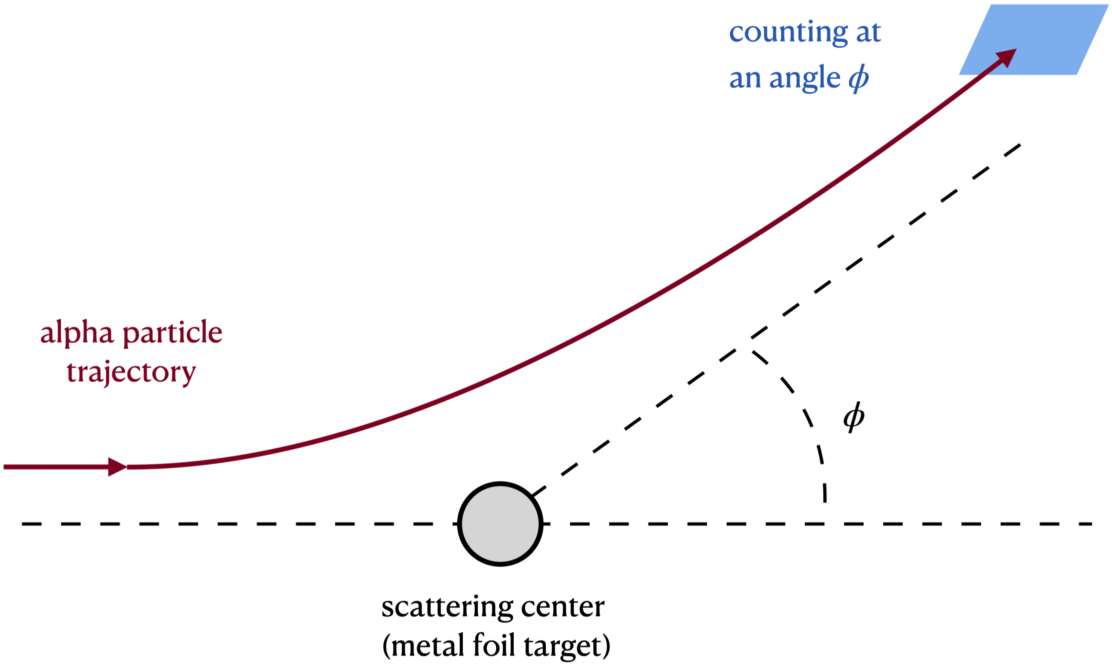
$$\sigma(\phi) = \frac{BZ^2}{sin^4\left(\frac{\phi}{2}\right)},$$

where B is a constant number, Z is the atomic number of the atoms that make up the metal foil (target), and ϕ is the exit angle of the alpha particles.

The number of alpha particles measured (counting) in the experiment at each angle is directly proportional to σ, which means that counting the alpha particles is like measuring σ from the formula above.

Although the formula he obtained looks complex, the main conclusion he derived from it was that the hypothesis that all of an atom's positive charge is concentrated in a sphere leads to a formula like the one above. It tells us how many particles we should expect to measure at each angle.

Will the measured data confirm this hypothesis?



Scattering of alpha particles by a metal foil target
Image courtesy of the authors

References

[1] Rutherford E (1911) The Scattering of α and β Particles by Matter and the Structure of the Atom. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* **21**: 669–688. 10.1080/14786440508637080