5-1973

Simulated Alpha Scattering

Gerald L. Fuller

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Semulated Alpha

Scattering

S. Fuller
alpha scattering

My approach to the experiment is to use a box of certain dimensions as the "hell atom. Therefore this is a simulated alpha scattering experiment. The box is like unto the atom whereas shooting into it you cannot see what happens nor where it happens, but draw on your information taken while observing the effects outside the atom and the box like-wise. A screen is used with the atom, and I have used cardboard squares placed in what around my box to record the direction the particle enters and leaves, in this way it is like the screen. For the alpha particle I'm using a B.B., it is small in comparison to my box as the alpha particle is to the atom.

My purpose for the experiment is to relate my experiment with actual alpha scattering and to come up with the same conclusion.
Calculating the size of gold atom using
6.0 in relation with the alpha particle

According to Henry dout in his book
"Introduction to Atomic and Nuclear Physics"
the mass of an alpha particle is \( M = 6.62 \times 10^{-27} \) kg.
This is found on page 78.

The velocities of the alpha particles are in
the order of magnitude of \( 10^7 \) m/sec.

In the book "Nuclear Physics and the Funda-
mental Particle", written by Henry H. Rickman
and Paul D. Stirling, tells that the size of
an atom may be calculated by use of
Bragg's Number \( N \), the atomic weight \( Z \),
and the material density \( \rho \),

\[
\frac{A}{N \rho} = \omega \text{ cm}^3
\]

in this volume there are \( N \) atoms. Therefore
the volume of one atom is,

\[
\frac{A}{N \rho}
\]

\[
V = \frac{1979}{(6.02 \times 10^{23})(19.3 \text{ g/cm}^3)}
\]

\[
= \frac{1.97 \times 10^{-2}}{1.16 \times 10^{-25}}
\]

\[
V = 1.7 \times 10^{-23} \text{ cm}^3 \text{ size of gold atom}
\]
I have also found a formula to find the volume of a helium nucleus.

\[ V = \frac{4}{3} \pi R^3 \]

where:

\[ R_0 = 1.2 \times 10^{-13} \text{ cm} \]

\[ A = \text{Number of nucleons which it contains} \]

Therefore:

\[ V = \frac{4}{3} \pi (3.14) (1.2 \times 10^{-13})^3 \]

\[ = \frac{4}{3} (3.14) (1.728 \times 10^{-39}) \]

\[ = \frac{(50.28)}{3} (1.728 \times 10^{-39}) \]

\[ V = 8.68 \times 10^{-38} \text{ cm}^3 \text{ Size of Alpha Particle} \]

Calculation of the volume of a. p.

\[ R = 1.22 \text{ cm} \]

\[ V = \frac{4}{3} \pi R^3 \]

\[ = \frac{4}{3} (3.14) (1.22)^3 \]

\[ = \frac{(12.56)}{3} (1.0106) \]

\[ V = \frac{13.3}{3} \approx 4.44 \text{ cm}^3 \]
Volume of Alpha P = Volume of 0.8
Volume of Gold Atom = Volume of Box

\[
\frac{8.68 \times 10^{-35} \text{ cm}^3}{1.7 \times 10^{-23} \text{ cm}^3} = 5.1 \times 10^{-12} \text{ cm}^3
\]

\[x \times (8.68 \times 10^{-35} \text{ cm}^3) = 7.4 \times 10^{-26} \text{ cm}^3\]

\[x = 8.64 \times 10^{-11} \text{ cm}^3\]

\[5^2 = 5.64 \times 10^{-11} \text{ cm}^3\]

\[5^3 = 1.86 \times 10^{-12} \text{ cm}^3\]

\[5 = 205 \times 10^4 \text{ cm}\]

This would be a box 20 cm long by 20 cm wide by 20 cm deep.

This is a ridiculous size. Therefore I adopted a size of my own, a more practicable size, and drew my conclusions from there.

The size I chose was 30 cm x 30 cm x 30 cm approximately. After having my 12" x 12" top and bottom squared it came out 27 cm x 27 cm, therefore I decided to make my box (27 x 27 x 27) cm\(^3\).
Construction of box:

I used aluminum angles for my corner support. They were light and yet strong and much easier to work with. The came in an 8 ft piece, so I had to cut it and file each of the ends. After cutting my four supports, I had some aluminum angle left. I decided to use what I had left for slats to hold the construction paper. I measured what I had left and divided it into eight pieces. To make it work well I marked each piece in the center. This was to make it uniform top and bottom.

The top and bottom were two pieces of pine 12" x 12". I took them to the shop and had them squared. They left them 27" x 27". To these I drew two lines intersecting each other and at the center of the top and bottom.

```
+-----+-----+
|     |     |
+-----+-----+
```

This was used to place the center of each piece (slot) of aluminum in the center of the top and bottom of the box.

I found a steel rod in my father's workshop and decided to use this for my supports. I cut it approximately 31 cm long. It was 9 mm in diameter or 7/32" diameter, so I used a 7/32" bit and drilled a hole in the top and bottom.
To make sure I had it centered I draw two
diagonals in each.

Top

Bottom

Putting the box together I used my corner
pieces first. I drilled holes in the corner pieces
alternating them, so the screws would not hit.
I used small wood screws to hold the box to-
gether. I top and bottom on each corner piece

Nailed & put my slat pieces in. I
measured each slat, divided it into 3 parts and
measured 1/3 from each end

\[
\frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{2}{3}
\]

This is where I drilled the holes for the wood
screws.

Now I put this (slat) on the box. I then
slotted the slots to the middle of each side.
Having the holes already drilled in the top
and bottom, my box was completed on putting
my rod through the slot.
Experiment:

I bought four different colors of construction paper. Each one was to be for a different experiment. They were #1 Green, #2 Orange, #3 Red, #4 Black.

I measured the distance between my datum and also between my corner support. I made my cardboard pieces a fraction smaller, 23.4 cm x 25.8 cm. I cut this out on the paper cutter in lab.

During the experiment I placed cardboard and styrofoam around it to capture and stop the BB's from scattering all over the room.

Experiment #1

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Experiment # 2

Orange

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Having enough data and my time running out, I did not go on with experiment #4.
Proving Hyperbolic Path

I am going to use the data from experiment #1 to show that the 6.0 is traveled in a hyperbolic path.


The next page consists of hyperbola proof, and some formulas used.
**Definition of Hyperbola:** The locus of points the difference of whose distances from two fixed points is constant is a hyperbola.

\[ \sqrt{(x+c)^2 + y^2} - \sqrt{(x-c)^2 + y^2} = 2a \]

\[ \sqrt{(x+c)^2 + y^2} = 2a + \sqrt{(x-c)^2 + y^2} \]

\[ x^2 + 2cx + c^2 = x^2 - 2cx + y^2 + 4a \sqrt{(x-c)^2 + y^2} + 4a^2 \]

\[ c \cdot x^2 - 2c \cdot x + c^2 = a^2 \cdot x^2 - 2acx + a^2 + 2y^2 \]

\[ x^2 (c-a^2) - a^2 y^2 = a^2 (c-a^2) \]

let \( c^2 = a^2 + b^2 \)
\[ x^2 b^2 - a^2 y^2 = a^2 b^2 \]
\[ \frac{x^2}{a^2} - \frac{y^2}{b^2} = 1 \]

I cannot use the rod as my origin as they could with the gold nucleus. The reason being, there isn't any electromagnetic repulsive force. Therefore, it is actually more like simulated neutron scattering.
Experiment #1

Shot #5 went through the front side (\(d\)) and the right side (\(r\)).

I have to use the center of the rod as the origin.

Since my hyperbola is so close to being a rectangular hyperbola, that I used \(e = 0.5\)

\[ f = e^2 \]

\[ A = 4.5 \text{ cm} \]
\[ e = 1.414 \]

\[ f = (4.5 \text{ cm})(1.414) \]

\[ F = 6.36 \text{ cm} \]

Point \((1.25, -12.2)\)

Focus \((1.636, -6.39)\)
\[ D_1 = \sqrt{(25 - (-36))^2 + (-3.2 + 636)^2} \]

\[ D_1 = \sqrt{158.0274} \]

\[ D_1 = 12.6 \]

Point (25, -13.2) and (-366, 636)

\[ D_2 = \sqrt{(25 + 636)^2 + (-13.2 - 636)^2} \]

\[ D_2 = \sqrt{192.1902} \]

\[ D_2 = 13.8 \]

\[ D_2 - D_1 = 13.8 - 12.6 = 1.2 \]

which is supposed to be equal to \( 2A \)

\[ 2A = 2(45) = 90 \]

\[ 12 \]

\[ -9 \]

\[ +3 \]

which is 33.3\% error

I account for this error in assuming a hod a rectangular hyperbola. I should have rotated my axis.

Also I believe I could have made a error in my measurement.
Conclusion

This experiment was to come to the same conclusion as the actual alpha
scattering experiment.

There were a pattern and scattering also a very large percentage of the shot missed the
bar which is logical because the size of
the nucleus is quite small compared to
the size of the atom.

Although my calculations on the hypothesis
were off by 32%, I believe it was an error
on my part, not the experiment. I wish
I'd had more time.

I have learned so much more from this
experiment than I have in actual class
work. I would attribute this to finding some-
thing I'm interested in and that I work
as an individual.

I conclude that the experiment was
a success.