

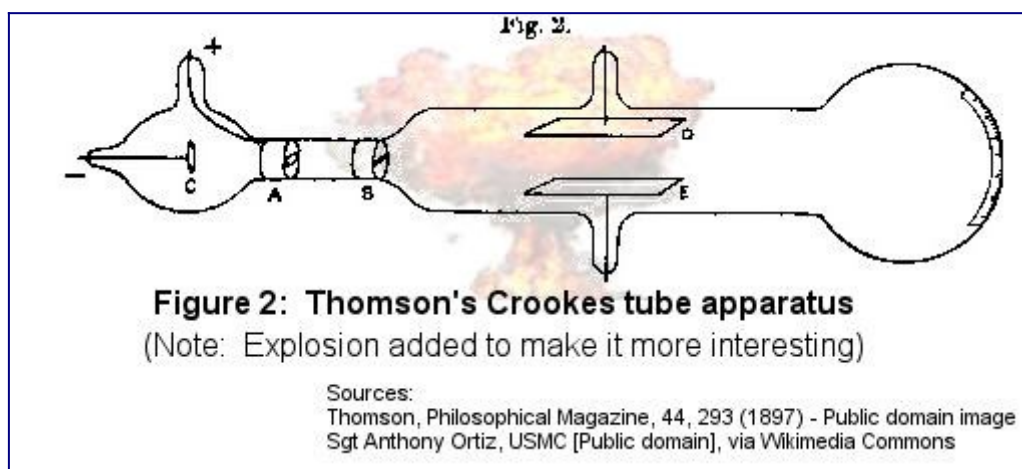
Atomic theory: Plum pudding and gold foil

Now that we've discovered [what everybody from the Greeks through Dalton believed](#), it's time to start getting to more recent models of the atom. Some of these models are extremely weird, but they all give us some idea of what's going on in the actual atom. As a result, you have to learn them.

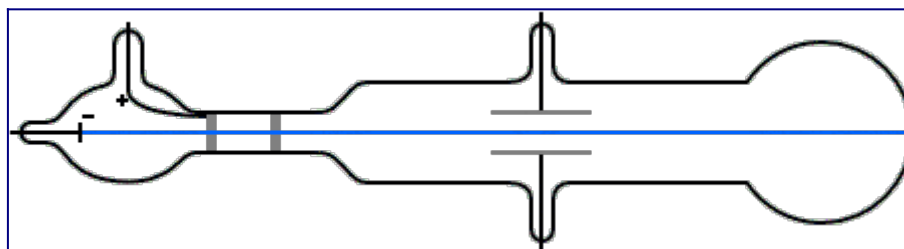
OK. Let's do this.

Thomson – A man and his tube

In 1897, a man named J.J. Thomson made a Crookes tube (which we also refer to as a cathode ray tube) and started messing with it.



Anyhow, Thomson was doing some experiments with this thing and found the following:



Scientists refer to this as “Figure 2” rather than labeling it on the image because they don’t know how to add stuff to animated GIFs. They also can’t attribute properly on the image for the same reason, which is why they usually state that the image is in the public domain, produced by somebody called Kurzon and posted to Wikimedia Commons.

What you’re looking at in this picture is something called a “cathode ray”. It’s called that because it originates at the negatively-charged cathode (that’s the little thing with the minus sign at the left of the drawing) and is accelerated toward the positively charged anodes (that’s the little thing further down the tube that’s connected to the wire with the + sign). Not surprisingly, the ray moves from the negative cathode to the positive anode, which has a little hole in it that some of the ray goes shooting through by accident.

As for the yellow part with the moving line and the dotted line, here’s what that means:

- When Thomson turned on the apparatus, the cathode rays just shot through in a straight line to the bulb at the end. Essentially, it just made a nice, straight beam.
- When Thomson turned on those little things in the middle of the tube (the things with the yellow space between them) such that the top plate had a negative charge and the bottom plate had a positive charge, he found that the cathode rays shifted downward, indicating that the beam had negative particles in it – after all, it was attracted to the positive plate and repelled by the negative plate.
- Reversing that process so that the negative plate was on the bottom and the top plate was positive, he found that the beam bent upward toward the positive plate and away from the negative plate. This also indicates that the beam has a negative charge.

From all of this, Thomson concluded the following things about the atom:

- There are negative things in the atom that you can pull out (with a little effort).
- Those negative things are very small.
- Those negative things are identical to one another, regardless of what atom they come from.

In 1904, all of these results led to the famous plum pudding model⁹ of the atom:



Figure 3: Plum pudding

It's thought that Thomson was making a joke when he named his model of the atom the "plum pudding" model, because seriously, what the hell?

By Lachlan Hardy [CC-BY-2.0], via Wikimedia Commons

Because this picture doesn't appear to make any sense at all, let's look at a somewhat more illustrative drawing:

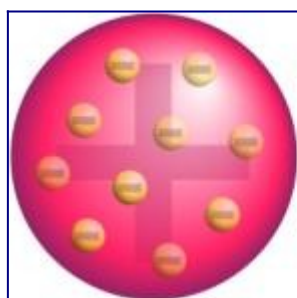


Figure 4: Thomson's plum pudding model of the atom

Thomson's model of the atom featured a big ball of positive charge into which little negatively-charged particles were embedded.

Source: Public domain / Wikimedia Commons

Thomson's model explained his observations in the following way:

- The reason he saw negative particles and not positive particles was because the negative particles are small and the positive particles are not. By this reasoning, it's easier to move the negative particles around.¹⁰
- The reason the positive charge must be in a big ball like this is that atoms are solid spheres.

In any case, Thomson came up with this model of the atom in 1904, and by 1909-1911 was disproved by various gold foil-related experiments. Fortunately for him, people liked his discovery of the electron (and related discoveries about electricity in gases) and gave him the Nobel prize in Physics in 1906. After that he bought gold teeth and constantly told (untrue) stories about how "the ladies love me."

Rutherford – A man with a use for gold teeth

In the years between 1908 and 1911, a relatively unknown New Zealander¹¹ changed the world of atomic physics forever. Well, he wasn't *totally* unknown, because he won the Nobel Prize in 1908 for his research into radioactive decay processes. In other words, he was a rock star among scientists.¹²



Figure 5: Ernest Rutherford conducting research in his laboratory, circa 1910.

U.S. Navy photo by Photographer's Mate 1st Class Richard Kiroy [Public domain], via Wikimedia Commons

Anyhow, in 1908 some guys who worked for Rutherford named Geiger and Marsden did some experiments (called, unsurprisingly enough, the Geiger-Marsden experiments) in which they shot positively-charged alpha particles at a very thin sheet of gold. Here's what the experiment looked like:

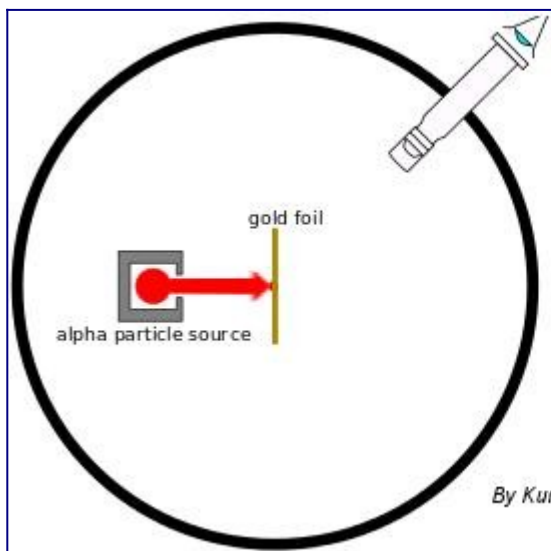
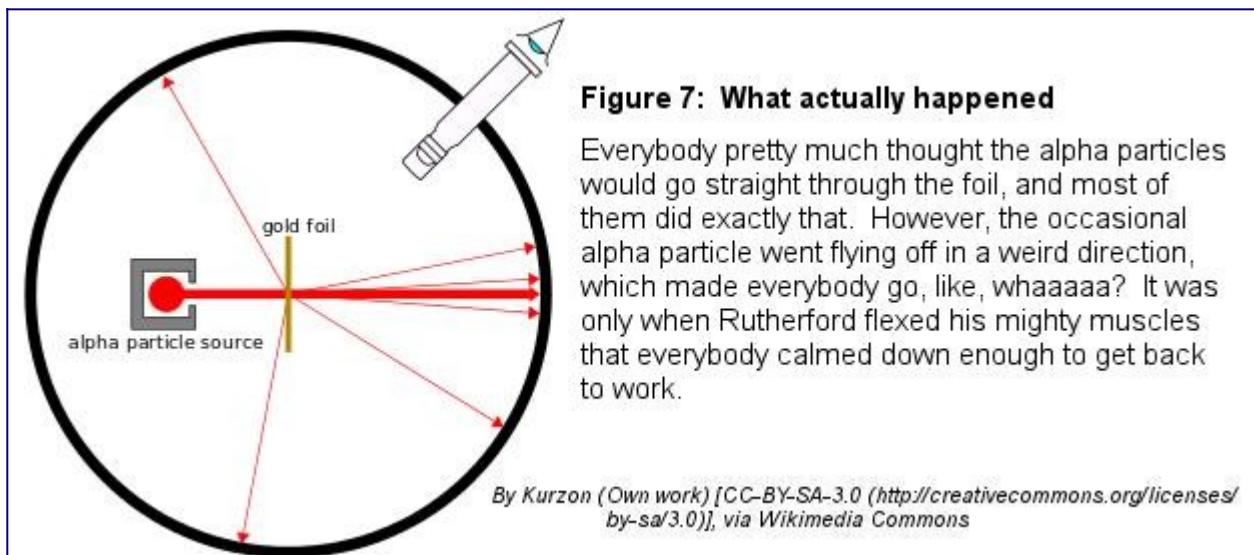


Figure 6: The gold foil experiment

In the gold foil experiment, very small particles with positive charge (called alpha particles) were aimed at a very thin sheet of gold foil to see what, if anything, would happen. The reason given for this experiment was that "I'm Ernest Rutherford, so do it already." And then he ripped into an awesome guitar solo.

By Kurzon (Own work) [CC-BY-SA-3.0 (<http://creativecommons.org/licenses/by-sa/3.0/>)], via Wikimedia Commons

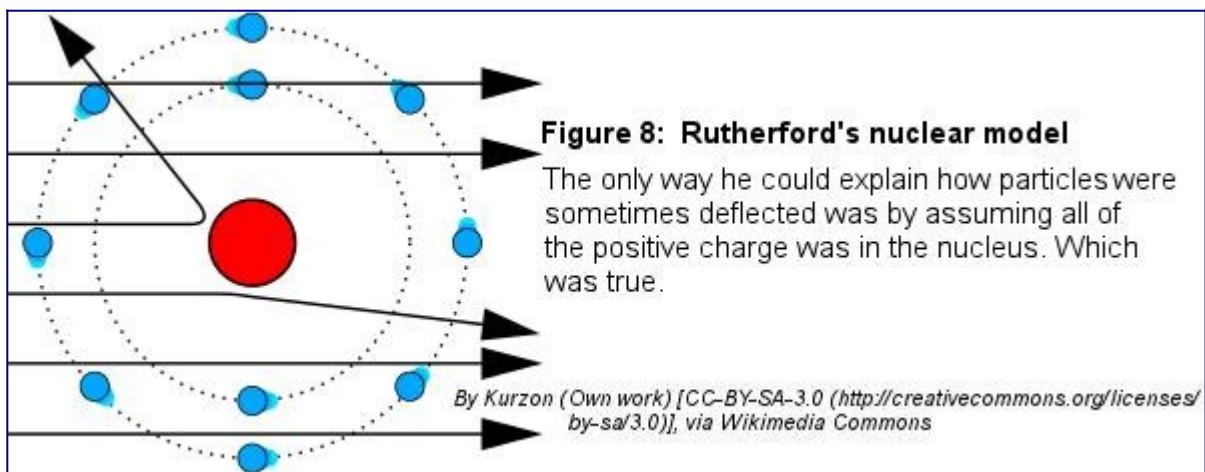
Now, nobody really had any idea what would happen. If the Thomson model was right, the alpha particles should just blast through the gold foil in a straight line. However, what they observed was something super weird:



Here's how Rutherford explained these results:

- As everybody has said before, the atom contains positive and negative charge.
- Because some of the positively-charged alpha particles got deflected in weird directions, the positive charge in an atom must be concentrated in a small area. By this reasoning, the particles only deflect when they pass near this small, positive thing.
- Most of the particles passed straight through because they didn't come near the positive charge. In other words, they passed through empty space.

Or, to sum this up in cooler terms, Rutherford was the guy who came up with the idea that the positive charge in the atom was all concentrated in the nucleus, while the electrons orbited it in circular paths. Check it out:



Thus, Rutherford was considered even more awesome than before. And he totally bought a tropical island and filled it with attractive women and unicorns and lived the rest of his life playing guitar and generally being super-awesome