

Building a Hydrogen Atom

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In this demonstration you build a Hydrogen atom from 4 members of the audience. This gives a fun demonstration of the quarks, electrons and the EM strong and weak forces.

Apparatus

4 hats. 1 white, 1 red, 1 blue and 1 green. The sillier the better.

One piece of elastic ~3m long. You can buy French Skipping ropes from toy shops which are ideal and often come in pretty colours but knicker elastic will do.

Optional but fun is a party popper.

- 1) Invite 4 members of the audience to volunteer 2 male and 2 female.
- 2) Put the white hat on the head of one and send them to one side of the room – this is the electron.
- 3) Tie the other three together with the elastic and explain that the ladies are up quarks and the gentleman is a down quark. (For more adult audience you can make some comment about combining physics and bondage)
- 4) Send the “proton” to the opposite side of the room from the electron.
- 5) Explain the EM force is responsible for the attraction between the electron and the neutron.
- 6) Explain that the EM force is pushing apart the up quarks inside the proton but they are held together by the strong force as they have a charge called colour. Explain that quarks come in red, green and blue and put the appropriate hats on the quarks.
- 7) Explain that gluons carry the strong force and exchanging gluons makes the quarks change colours. Bright demonstratees will start swapping hats but some will need encouragement.
- 8) Explain that the proton is a complicated object with lots going on and that the electron is simple.
- 9) Discuss the scale. The quarks will settle down ~ 1m apart explain that the electron can be anywhere in a radius of 10s of km- pick a reasonably sized town about the right distance away. Point out that if the proton is 1m across the quarks and electrons are less than 1mm across.
- 10) You can also point out that within the confines of the elastic the quarks are free to move.
- 11) Summarize the forces and then explain that the weak force can change up quarks to down quarks and that in this demonstration this is changing a woman to a man or vice versa. Note that this is a relatively rare process and reassure the “quarks” that on this occasion you won't be doing that demonstration.

Optional extension

This is really HERA physics but is an introduction to jets. If you felt brave perhaps you could have two protons but it might get a bit difficult.

- 1) Tell the electron to accelerate slowly towards the proton and that when they reach the proton they will only have time to interact with one of the quarks. Explain that when they interact they will give the quark a gentle push and it will start to move away from the rest. While doing this surreptitiously put a party popper into your hand and locate the string.
- 2) As the quark moves away and the elastic gets stretched. When the quark can't go any further let off the party popper (at this point I usually comment that everyone will at least now be awake).
- 3) Release all your quarks and retrieve your hats.
- 4) Explain that the jet has formed in the direction that the struck quark was moving and point out that in the case of the party popper the audience couldn't see where the popper was pointing at the time it was let off but the trail of streamers showed the direction. To some extent the same is true of the jet. We can't see the basic interaction but we can see the tracks of the produced particles.