

Why do electron tracks spiral?

Spiralling tracks are a common feature of bubble chamber pictures, and they are caused by electrons e^- (or positrons e^+ , which – key point – have the same mass).

What a spiral tells us is that an electron (we will not continue to say ‘or positron’) loses energy at a considerable rate as it travels through a bubble chamber liquid. All other charged particles, unless they collide with a nucleus, very gradually slow down – get more curved – as they lose energy by ionisation (making bubbles in the bubble chamber).

Electrons are able to lose energy more quickly by another process known as ‘bremsstrahlung’ (braking radiation). This process, which is a consequence of the fact that all accelerated charges radiate, is important for electrons because they have small masses. (The mass of the next most light particle, the muon, is about 200 times that of the electron.)

One can argue as follows:

- the amount of energy lost by bremsstrahlung depends on the acceleration;
- the acceleration is caused by the electric force exerted on the moving charged particles by the nuclei of the liquid;
- by Newton’s second law, the acceleration for a given force (and it will be the same for all particles because all particles seen in a bubble chamber have the same charge, apart from sign) varies inversely with the mass.

So, electrons accelerate at least 200 times more than any other particles in response to the Coulomb forces exerted by the nuclei of the liquid.

Since the bremsstrahlung rate depends on the acceleration (actually it is proportional to the square of the acceleration), electrons lose energy very quickly and spiral characteristically in the magnetic field of the bubble chamber

NOTE 1: Since bremsstrahlung results from the Coulomb force between the moving particle and the nuclei of the liquid, a heavy liquid such as neon (with a nuclear charge of 10) is much more effective at producing this spiralling effect.

In passing, the same is true for ‘pair-production’, a process by which a high energy photon ‘materialises’ into an e^+e^- pair in the electric field of a nucleus.

NOTE 2: ‘Magnetic bremsstrahlung’ or ‘synchrotron radiation’.

Since these electrons are moving in a magnetic field, they experience magnetic forces that also produce accelerations and hence radiation and spiralling.