Cloud chamber

A cloud chamber makes the invisible visible, allowing us to see delicate, wispy proof that there are tiny particles whose story starts in outer space shooting through all of us, every minute of every day.

Apparatus

1 × cloud chamber
Propanol (aka isopropyl alcohol or IPA)
Dry ice (solid carbon dioxide)

The demonstration

The cloud chamber is prepared and placed down. Moments later, wispy streaks of cloud appear, seemingly spontaneously, inside the chamber. These tiny clouds show the path of charged particles through the chamber—and, since there are no obvious sources of charged particles around, they're evidently natural and omnipresent…

How it works

The base of the cloud chamber is filled with dry ice, and an absorbent material near the top thoroughly soaked in propanol. Propanol is quite volatile, and so forms a vapour at the top of the chamber. As the vapour falls, it cools rapidly due to the dry ice and the air becomes 'supersaturated': the propanol really wants to condense, but there is nothing for it to condense onto. Charged particles passing through the chamber cause the propanol molecules to gain an electric polarisation, and be drawn towards those particles, and one-another. This provides the impetus for them to condense into tiny liquid droplets in the chamber which show up as white streaks of cloud along the path of the particles.

Vital statistics

muon mass:
207× electron mass

muon flux at sea level:
10,000 muons/m²/minute

This demo is often done with a radioactive source, with alpha and beta particles causing propanol to condense, but it actually works in the absence of a source too, because of cosmic ray muons passing through the apparatus. The muons are produced high in the atmosphere by protons (the 'cosmic rays') smashing into the nuclei of gases. These produce a variety of daughter particles, but the only ones typically long-lived enough to make it to the Earth's surface are muons.

Muons are heavy electrons, and decay into an electon and a neutrino with a mean lifetime of 2.2 μs. This actually provides an interesting test of special relativity: muons are typically produced around 15 km up in the atmosphere, a distance which takes around 50 μs to traverse at the speed of light—over 20 muon lifetimes. Thus we'd expect barely any to make it! However, since they *are* travelling quite near the speed of light, time in their frame of reference is significantly dilated as seen by an observer on Earth, meaning that a significant fraction can, in fact, make it to the surface.