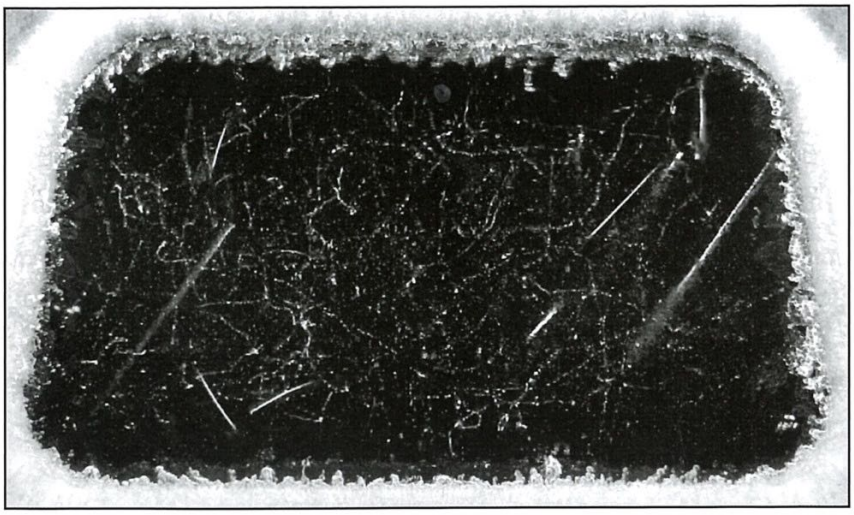

◀ A composite image of multiple cosmic ray tracks. Typically, tracks are visible at a rate of about one per second. Each type of subatomic particle (muons, electrons, protons) can be distinguished by the appearance of the tracks. All photos credit: Steve Barrett.

Steve Barrett shows how you can build yourself a cloud chamber and take a peek into the world of subatomic particles that have travelled across the galaxy.

How to view cosmic rays

Most of us think that astronomy is about seeing the light from distant stars and galaxies, whether with the naked eye or with optical aid like binoculars or telescopes. It is easy to overlook the fact that, as well as light, stars and galaxies are also sending out different types of messengers across the vastness of space – energetic subatomic particles of matter called cosmic rays. Each particle is the nucleus of an atom such as hydrogen, helium or a heavier element.

It is thought that the most energetic of these particles are accelerated to speeds very close to the speed of light by extremely violent events such as supernovae or the jets emitted by supermassive black holes. Details of the acceleration mechanisms involved are not fully understood and are the subject of intense research.

Detecting cosmic rays

Cosmic rays are continuously raining down on the Earth. Any particles that get past the Earth's protective magnetic field will hit the upper atmosphere and produce a shower of new subatomic particles (such as muons, electrons and protons) and some of these will reach ground level. How can we detect these cosmic ray particles? Modern cosmic ray observatories located around the world use large numbers of sophisticated electronic detectors to identify the particles and measure their energies.

A hundred years ago the detectors were much less complex and hence more suitable for amateurs to reconstruct today. A cloud chamber was the first type of detector that allowed the passage of cosmic ray particles to be seen and photographed. The particles themselves are too small for us to see directly, but they can be detected in the same way that we can see aircraft flying many miles above our heads. Just as aircraft can leave visible condensation trails, or contrails, in the sky so subatomic particles can leave condensation tracks in a cloud chamber.

◀ The cloud chamber comprises a glass or plastic jar with a heater at the top and a small refrigeration unit at the bottom. All the essential components of the design are readily available from online retailers.

The Wilson cloud chamber

In the early years of the last century Charles Wilson developed chambers for studying cloud formation and optical phenomena in moist air, inspired by sightings of the Brocken Spectre (a shadow seen in mist) from the top of Ben Nevis. He soon realised that when charged particles passed through a cloud chamber water droplets condensed to form visible tracks. As a result, his cloud chambers had an important role in experimental particle physics for decades and he was awarded the Nobel Prize for the "most original and wonderful instrument in scientific history".

Building a cloud chamber

My cloud chamber is a distant cousin of Wilson's original invention. I wanted to build a cloud chamber for myself to provide a practical demonstration of how we can visualise cosmic rays. I intended to use it at outreach events as a compact tabletop demonstration and so it had to be able to run continuously for at least two hours without intervention and without the need for any dry ice (a limitation of other designs I have seen). Also, to allow others to copy the design and construction, it had to be easy to make out of readily available components at a modest cost of about £25 to £50, depending on what items were on hand.

I have published all the design and construction details in an online document available here: bit.ly/CloudChamberSPA. Construction may involve a bit of soldering and operation of the chamber needs small amounts of isopropyl alcohol to form the tracks, so youngsters should have adult supervision. The photos show what the cloud chamber looks like and what you can expect to see when it is operational.

More than a century on from Wilson's first cloud chamber, my design is compact, cheap to make and, most importantly, easy to operate – just add a little alcohol, switch it on, and wait for the subatomic particles from the cosmos to reveal themselves.

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