EXPERIMENT

53. the wilson cloud chamber

purpose

To study the operation of the Wilson cloud chamber, and to observe typical ray tracks therein.

apparatus

Diffusion cloud chamber with clearing field (Cenco, or Atomic Laboratories); sources of alpha, beta and gamma radiation; slab of dry ice about 1 in. thick and 7 in. sq; methyl alcohol; laboratory light source of high intensity; 45-volt battery to supply the clearing field for the cloud chamber.

introduction

Natural radioactivity goes on around us all the time. Radioactive ores in their normal decay processes give off *alpha* and *beta* particles and *gamma rays*. High-energy particles from outer space known as *cosmic rays* are "pelting" us continually. Atomic and nuclear reactions produce high-speed *electrons* and *neutrons*, and so-called "secondary reactions" produce a variety of atomic spare parts and emanations such as *protons, mesons, gamma rays,* and *X rays.*

These particles and rays cannot be felt, seen, heard, or sensed by the human body in the normal course of events. Certain scientific devices have been developed, however, which enable us to detect their passage. The Geiger tube (studied in Experiment 52) is one of these. Another is the *Wilson cloud chamber.*

The cloud chamber was invented by C. T. R. Wilson in England in 1911. He was awarded the Nobel prize for physics in 1927 on the basis of the research he carried on with this instrument.

The cloud chamber has been one of the atomic

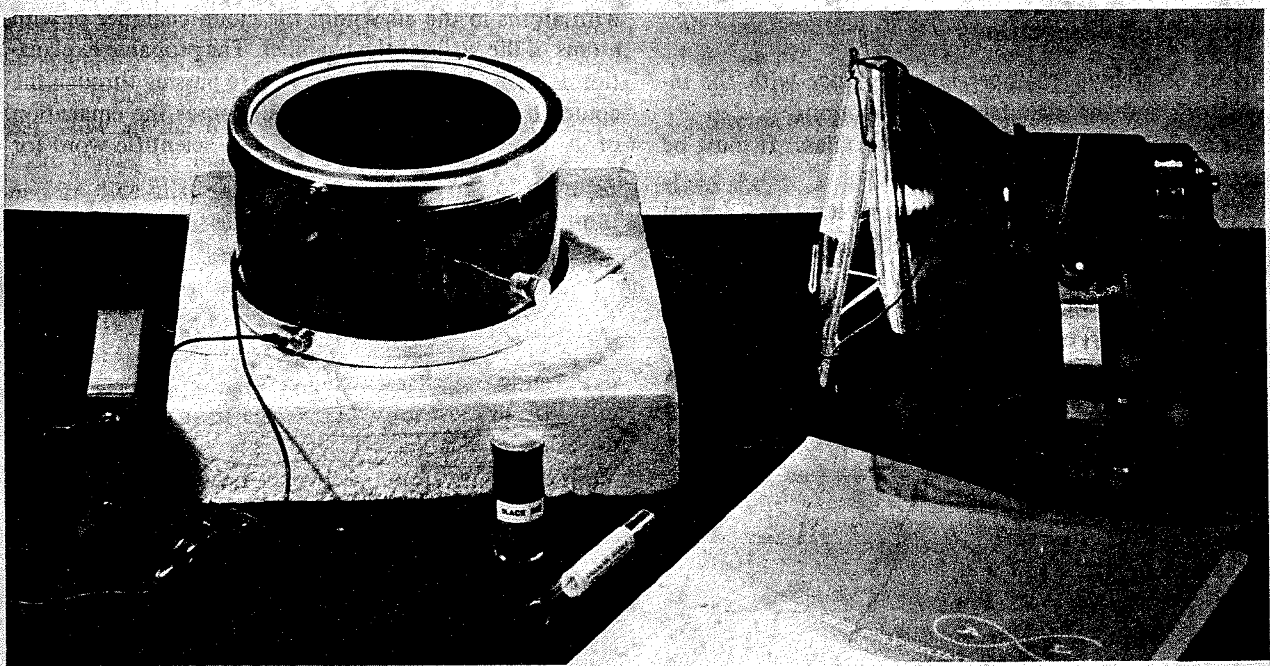


Fig. 53.1 Diffusion cloud chamber, with high intensity light source, dry ice block, and charging battery. (Atomic Laboratories, Inc., Berkeley)

scientist's most useful tools, and many of the elementary particles of matter have first been identified by its use. The first observation of a nuclear transmutation was made with a cloud chamber.

The condition of the vapor in a cloud chamber must be "just right" before visible "tracks" can be observed. The Wilson and other early cloud chambers produced the proper saturated vapor conditions for track formation by a sudden expansion of air trapped in a chamber over a water reservoir. A transient condition (lasting about 1/25 sec) favorable to track formation resulted.

The cloud chamber used in this experiment however, by making use of dry ice and methyl alcohol and a charging field, maintains a supersaturated atmosphere which is favorable to ray track formation over a period of several hours.

What is observed in a cloud chamber is *not* the particle or the ray itself, but the path that it takes through the chamber. In an atmosphere which contains more vapor than it normally should for the existing temperature and pressure conditions (the condition of *supersaturation*), any foreign object may serve as a starting point for the growth of a visible droplet of fog or mist. Dust particles serve this purpose in the earth's atmosphere, and fog forms. The passage of a jet plane at high altitudes causes *contrails* (*con*densation *trails*) of condensed vapor to form. Charged particles and/or ions have the same effect. Neutrons and gamma rays carry no charge and cause no ionization. They do, however, produce charged secondaries whose "tracks," made up of fog droplets, may be observed in the cloud chamber.

method and observations

Set up the cloud chamber in accordance with the instructor's and the manufacturer's directions.

Carefully wash and dry the cover glass. It must be clean.

Fill the bottom of the chamber with methyl alcohol to a depth of about ¼ in., and add ½ teaspoonful of black dye and stir until dissolved. Or, in lieu of the black dye, black blotting paper may be used to cover the bottom and part way up the sides. A perfectly black background makes the ray tracks more easily visible. Be sure the alcohol level is such that it touches the bottom of the black blotter which serves as the inner liner of the chamber.

Replace the cover glass, making sure that the aluminum ring fits snugly over the top.

Place the chamber on a slab of dry ice about 1 in. thick and 7 in. sq.

Attach the positive terminal of the clearing field battery (45 to 90 volts!) to the bottom tray and the negative terminal to the top aluminum ring, which makes contact with the electrode on the under side of the glass cover.

Place the high-intensity light source (ordinary incandescent lamps or a flashlight are not satisfactory) about 6 in. from the open space in the chamber side wall, with its beam directed so that it glances off the alcohol surface in the bottom of the chamber.

Allow to stand about 5 to 10 min for the cloud chamber to cool sufficiently to establish the condition of supersaturation. The "clearing field" voltage is applied in order to sweep out ionized particles caused by cosmic rays or other "background" radiations.

1. Cosmic ray tracks. After operating conditions have been achieved, observe the cloud chamber without any source of radiation nearby. In this situation almost all the tracks seen will be caused by *cosmic rays.* These ray tracks are thin and somewhat faint. They may be straight but are more usually crooked or "wiggly." The sketches of Fig. 53.2 show typical cosmic ray tracks. Observe these tracks for several minutes and make sketches of the several patterns you see.

Rarely, you may see a "cosmic ray shower." This event occurs when a high-energy cosmic ray interacts with atoms in the air within the cloud chamber or with atoms of the walls of the chamber. The probable explanation is that a high-energy electron in passing through the coulomb field of a heavy nucleus causes the emanation of a "shower" of gamma rays. The scientific word for

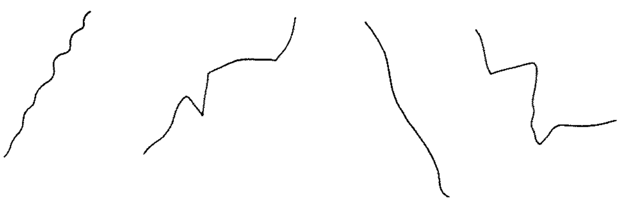


Fig. 53.2 Typical cosmic ray tracks.

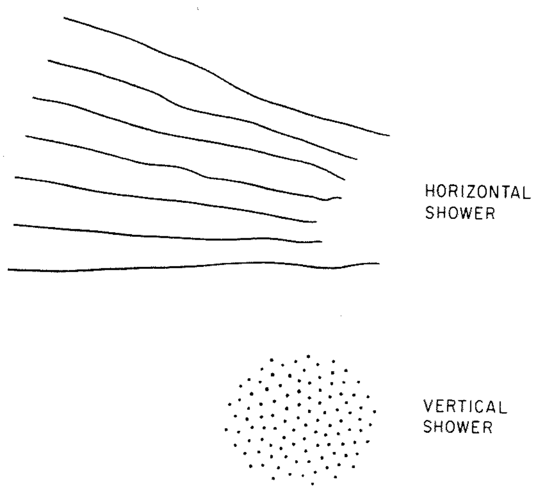


Fig. 53.3 Cosmic ray showers.

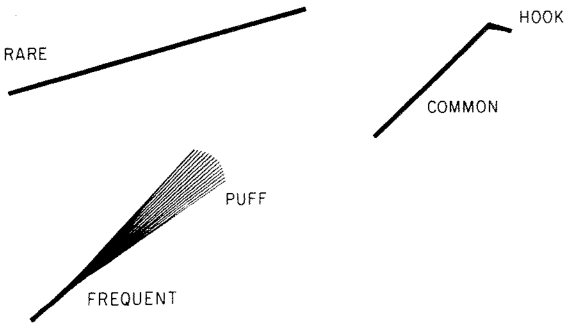


Fig. 53.4 Typical alpha particle tracks from natural (radon) disintegration.

this occurrence is *bremsstrahlung*. Each gamma ray formed "dies" while liberating two new high-energy electrons. Thus a cascade or "shower" of tracks is produced in the cloud chamber. Look for the patterns as shown in Fig. 53.3.

2. *Alpha particle tracks.* Alpha particles are continually emanating from the gas *radon*, which is present in very small quantities in the air. Alpha particles are actually helium nuclei, and they carry a double positive charge. They are therefore heavily ionizing and make a broad, easily-recognized track in the cloud chamber. They have a range which averages about 4 cm. The tracks frequently have a "hook" at the end. The disintegration of the track into a "puff" at the end is a phenomenon also frequently observed. (Note: Handle all radioactive materials with extreme care! Keep them away from the face and body. Wash your hands thoroughly when the lab period is over.)

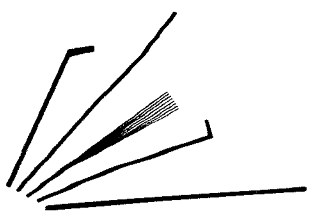
First, see if you can find some alpha-particle tracks from natural radon disintegration. Look for the patterns shown in Fig. 53.4.

Then place the alpha source within the cloud chamber. Now all the tracks will start from the source, and there should be many of them to observe. Look for a pattern like that in Fig. 53.5. Alpha tracks from an alpha-particle source will undergo some self-absorption, and the tracks will not have a definite range, some being much shorter than others.

Observe alpha tracks for several minutes, and make careful sketches of what you see.

3. *Beta particle tracks.* The tracks you observed in Step 1 as a result of cosmic radiation were mostly beta tracks (high-energy electrons). Placing a beta source in the chamber produces many beta tracks for observation.

Fig. 53.5 Alpha particle tracks produced by particles from an alpha source.



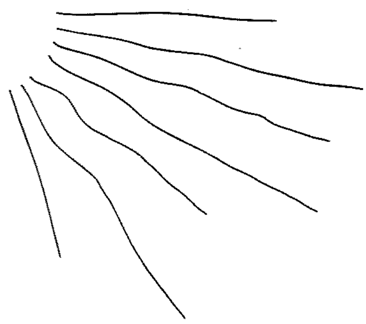


Fig. 53.6 Beta particle tracks.

They will be somewhat straighter and better defined than those produced by betas from cosmic radiation.

Insert the beta source, and look for a pattern like that in Fig. 53.6.

Sketch carefully the result of your observations.

4. *Gamma rays and neutrons.* Gamma rays and neutrons leave no tracks in cloud chambers. Since they are electrically neutral, they cause no ionization and therefore no train of condensed fog particles. They may (and frequently do) produce charged "secondaries" (photoelectrons and recoil protons) whose tracks are observable.

By placing a gamma source outside and near the chamber, one may observe what appears to be cosmic showers from the direction of the source. See if you can set up this condition. Sketch what you observe.

5. *Nuclear interactions.* Rarely, you may see some cloud-chamber tracks which result from nuclear interactions. Nuclear interactions occur as the result of such events as particles (alphas or protons) striking gas atoms and knocking one or more particles out of the nucleus of the atom.

Look for such patterns as those in Fig. 53.7.

Sketch any such patterns that you see.

data sheet

None. The observations, notes, and sketches constitute the data for this experiment.

presentation of results

There are no calculations for the experiment. All sketches should be re-done carefully for the final report, and each should be accompanied by a full explanation of what was done, and what was observed.

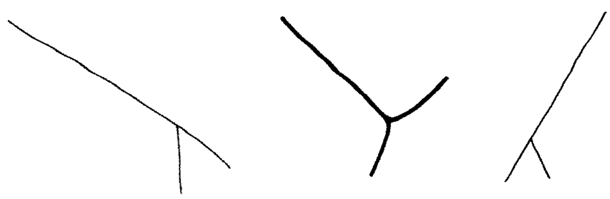


Fig. 53.7 Typical tracks resulting from nuclear interactions.