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The Cloud Chamber

Charles T. R. Wilson (1869 - 1959)

Charles T.R. Wilson first developed cloud chambers around 1911 for experiments on the formation of rain clouds. Wilson knew that water vapor condensed around ions, atoms that have become charged by gaining or losing electrons. However, an alpha particle, for example, which had an electric charge, would leave a trail of ions as it passed through a gas. If water vapor condensed on these ions, the track of the alpha particle would become visible to the human eye as a line of water droplets.

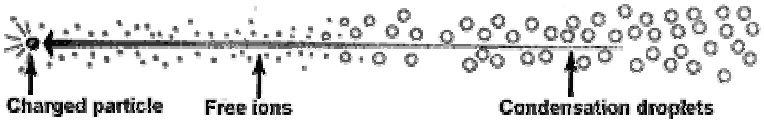
First Cloud Chamber Created by Wilson

This process of visible tracks is also known as the expansion method, a discovery that earned Charles T.R. Wilson a share of the 1927 Nobel Prize. Perfecting that method, P.M.S. Blackett received the 1948 Nobel Prize for the development of the Wilson cloud Chamber. Today, cloud chambers are used for classroom presentations. They are easy to build and can be used to watch cosmic ray particles.

So how does this work? When air cools, the water vapor it holds eventually condenses to form a cloud. But as scientists have long known, air can be chilled well below its normal dew point without such condensation taking place. The trick is to remove the dust particles on which the water droplets normally form. The cooled air can

then become supersaturated and water vapor gathered around the ions in the path of the cosmic and radial rays leaves visible tracks. Subatomic particles leave visible trails when they pass through supersaturated vapors. The particles convert some neutral atoms in the air into charged ions, which, like dusting specks, inducing droplets to form as seen in Figure 1.

Figure 1.



Cloud chambers are highly useful in the world of physics. A cloud chamber was used to prove Compton scattering and discover positive electrons as well as study the clash of atomic nuclei and cosmic rays. Today, we mostly use particle accelerators in our studies, and a drift chamber and various other devices are assembled to process detected phenomena on the computer.

So what are radial and cosmic rays? Radial rays are released from all kinds of substances including human bodies. Natural radial rays are detected coming especially from rocks (granite) and concrete. We can observe plenty of radial rays on mountain tops and in jet planes at high altitudes. High-energy radial rays fly around cosmic space at near light speed. They fall onto the earth and collide with atoms in the air to produce cosmic rays. The components are atomic nuclei such as hydrogen, helium, carbon, nitrogen, oxygen, iron and others. A cosmic ray is a general term for a high-energy (108eV or more) radial ray passing in cosmic space at near-light speed with almost isotropic dimensions.

The year is 2001 and even though the cloud chamber works pretty much the same, it now has a brand new look as seen in Figure 2 to the right. So how are these cloud chambers different from the ones Wilson pioneered from?

Figure 2.
Diffusion Cloud Chamber

The diffusion cloud chamber has various yet simple parts and instructions. The top of the chamber is lined with a felt that is immersed in ethanol alcohol and becomes saturated. The saturated felt along with a positive 3V charge creates a clearing field inside the chamber. Thus, positive ions are attracted to the top and negative ions and electrons are attracted to the bottom. The bottom of the chamber is covered with a thin layer of ethanol alcohol. Underneath the chamber lays a thick layer of dry ice. The dry ice is arranged uniformly on an insulated base. This is used to cool the bottom of the chamber. A projection (or any type of light source) is then shined directly along the bottom layer of the chamber. This allows the droplets inside the chamber to become very visible in a dark room. The figure below show exactly what the chamber look like on top of the dry ice when the light source is provided.

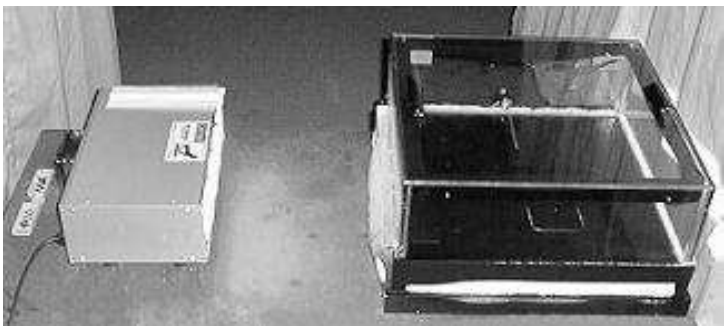


Figure 3. Picture of Diffusion Cloud Chamber accompanied by dry ice underneath & light source to the left.

It takes about 30 minutes for the cloud chamber to cool sufficiently for proper operation after it has been placed upon the dry ice. However, almost immediately a light precipitation of droplets can be observed. These droplets form on dust particles and fall to the alcohol pool. Gradually this precipitation begins to subside and, if you observe the bottom area very carefully, tracks will begin to appear.

The diffusion cloud chamber also has a second part that includes radioactive sources. If the radioactive alpha and beta sources are applied, alpha and beta tracks will appear. The Alpha source is a thin alloy rod consisting of 2% natural thorium that is inserted in the middle of the chamber. Alpha particles produced along its length leaves a thick condensation trails in the supersaturated environment. The large alpha particle mass is primarily responsible for a spectacular ionization density as shown in the figure below.

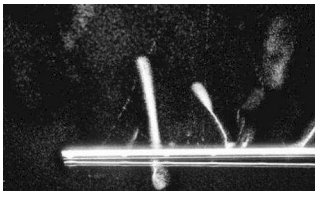


Figure 4. Alpha particle tracks produced from alloy 2% natural thorium rod.

Beta tracks are easily seen with the help of Carbon-14. The Carbon-14 is placed outside the chamber near the supersaturated area. Particle tracks emanated from a Carbon-14 source are small and obtain curvature as seen in the figure to the right. Note the frequent scattering, as well as the increase in ionization per unit length.

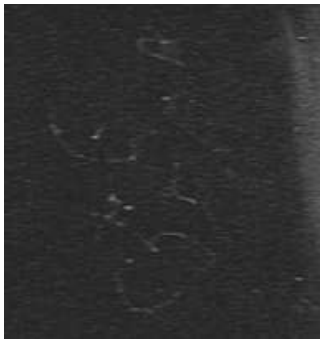


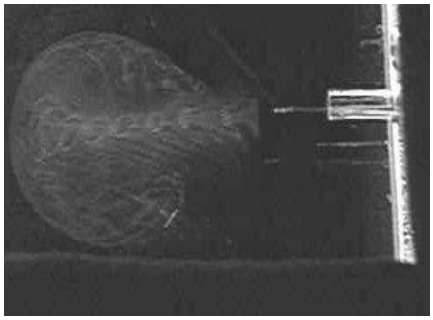
Figure 5. Beta Tracks

Cesium-137 is another beta source that will produce visible gamma rays. In the figure to the right a Cesium-137 source is placed outside a Supersaturated Environments Cloud Chamber. This source produced 667 keV gamma rays, which interacted with the air filling the chamber, upon passing from bottom to top. The most common mode of interaction under these conditions is Compton scattering.

Figure 6. Gamma Rays from Cesium-137

The diffusion cloud chamber has a third and final part known as the corona electrode. The corona electrode should be inserted inside the chamber when the alpha rod is removed. The electrode potential should begin at zero, than slowly increased not to exceed three kilovolts. When the potential grows above two kilovolts you should observe puffs of condensation around the electrode. This condensation is an avalanche of electrons ionized over the supersaturated field. The electrode in the figure to the right is at a positive potential of about two kilovolts with respect to the Supersaturated Environments Cloud Chamber bottom. The electric field at the tip is sufficient to produce corona ionization. It is believed that the positive ions reduce the electric field and ionization, causing the pulsed cloud of droplets. Pulse frequency is proportional to electrode potential.

Figure 7. Corona Electrode



As you can see the cloud chamber is an excellent tool in observing the everyday particles around us. It's simple to operate and easy to understand. There have even been simpler cloud chambers made from everyday household equipment. The cloud chamber is safe and is found in many public classrooms around the world. Not only is fun to observe, but also important discoveries have been made through cloud chambers. Through a simple C.T.R. Wilson invention, history has been made.

Reference List

Sourcebook on Atomic Energy, Samuel Glasstone (Van Nostrand, 1967).

Electrical Coronas, L. L. Loeb (University of California Press, 1965).

Elements of Nuclear Physics, W. E. Meyerhof (McGraw-Hill, 1967).

Cosmic Rays, B. B. Rossi (McGraw-Hill, 1964).

Introduction to Nuclear Engineering, J. R. Lamarsh (Addison-Wesley, 1983).

Cosmic Rays at Ground Level, Wolfendale (Institute of Physics: London, 1973).

An Atlas of Typical Expansion Chamber Photographs, W. Gentner (Pergamon Press, 1954)