Demonstrating the tracks of α particles in the Wilson cloud chamber

Objects of the experiment

- To produce supersaturation of a mixture of air and water/alcohol vapor through adiabatic expansion in a Wilson cloud chamber.
- To observe the tracks of α particles from a point source

  or
- To observe the tracks of α particles from a source distributed over the entire chamber.

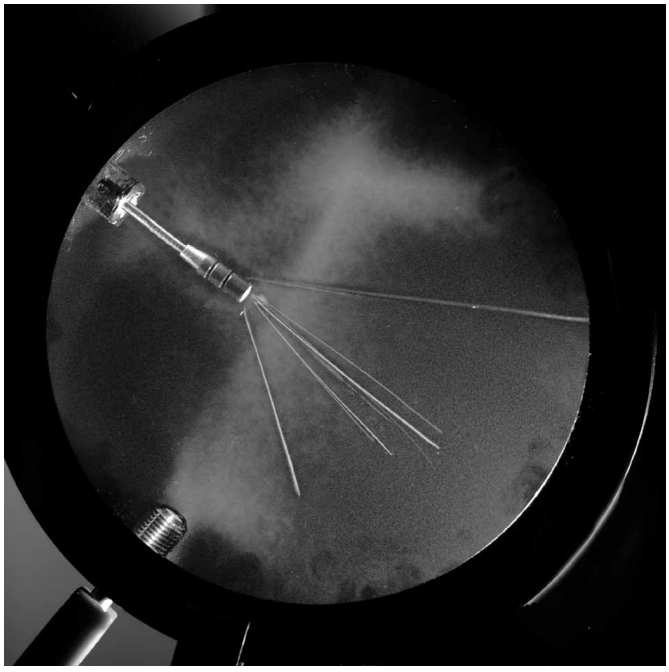
Principles

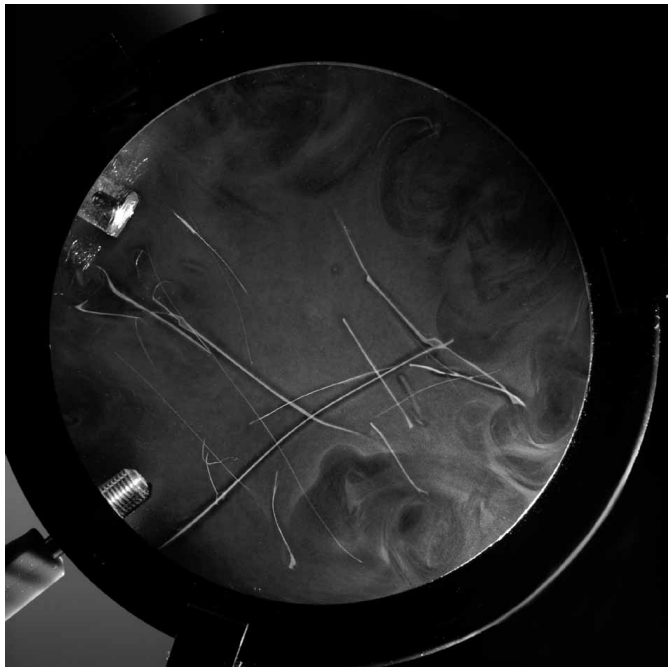
The tracks of α particles can be made visible using the Wilson cloud chamber. In comparison to α radiation, both β and γ radiation are much less ionizing, and are thus unsuitable for this experiment. In the Wilson cloud chamber, a saturated mixture of air, water and alcohol vapor is briefly cooled, and caused to assume a supersaturated state, due to adiabatic expansion by means of a vacuum pump. This causes the vapor to condense in the form of small mist droplets; this effect is promoted by condensation seeds. Ions, which are formed e. g. through collisions of α particles with gas molecules in the cloud chamber, make particularly efficient condensation seeds. Each time the vacuum pump is actuated, the supersaturated vapor suddenly condenses around the condensation seeds along the tracks of the α particles to form cloud droplets, which remain visible for one to two seconds in transverse illumination. An electric field in the chamber clears the space of residual ions.

In this experiment, you can use either a radium preparation or a thorium preparation as an α radiator.

The Ra–226 preparation is placed inside the Wilson cloud chamber. The preparation is sealed in a hollow cylinder with an aperture at one end, so that the α particles emerge from this aperture as from a point-type source. Ra–226 decays to Rn–222 with a half-life of 1622 a, emitting α particles with the dominant energy E_α = 4.78 MeV.

Fig. 1 Tracks of α particles in the Wilson cloud chamber
a) from a point source (radium preparation)
b) from a source distributed over the entire chamber (thorium preparation)





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Apparatus

1 Wilson cloud chamber	559 57
1 Radium preparation for Wilson cloud chamber	559 59
or	
1 Thorium source	546 36
1 Power supply 450 V DC	522 27
1 Lamp housing	450 60
1 Lamp, 6 V/30 W	450 51
1 Aspherical condenser	460 20
1 Transformer, 6 V AC, 12 V AC/30 VA	562 73
1 Bench clamp	301 06
1 Saddle base	300 11
Ethanol, denaturated, 1 l	671 972
or	
Methanol, 1 l	673 272
1 Pair of cables, 1 m, red and blue	501 46
Distilled water	
Additionally recommended:	
1 Bottle with screw cap e.g. Polyethylene bottle, 250 ml	661 222

Safety notes

Be sure to observe all laws, regulations and directives for working with radioactive preparations which apply in your country. The radioactive substances used in this experiment are type-approved for school use in Germany according to the stringent German regulations. However, as these generate ionizing radiation, you still need to observe the following safety rules at all times:

- Keep the preparations secure from access by unauthorized persons.
- Before using the preparations, check to make sure that they are undamaged.
- To ensure the *shortest possible exposure time,* remove the radium preparation from its protective container only while conducting the actual experiment; if you are using the thorium source, open the hose clamp on the vessel with thorium salt only while conducting the experiment.
- To maintain *the greatest possible distance* from the radioactive preparation, hold it only by the needle.
- To ensure proper *shielding,* always store the radium preparation in the protective container.
- To ensure *minimum activity,* keep only the preparation required for the current experiment at hand on the laboratory bench.

Rn–220, the gaseous decay product of thorium, is pumped into the Wilson cloud chamber via a valve and spreads uniformly throughout the entire chamber. It is possible to see particle tracks propagating in different directions. Rn–220 decays to Po–216 with a half-life of 55.2 s, emitting α particles with the dominant energy E_α = 6.28 MeV.

Setup

Preparing the alcohol-water mixture:

– Prepare approx. 200 ml alcohol-water mixture using 50 % methanol or ethanol and 50 % pure water in the polyethylene bottle.

Setting up the cloud chamber

Note: The condensation of the vapor saturated through expansion may only be caused by the ions generated by α particles, and not by any grains of dust which may happen to be inside the chamber.
Keep the inside of the chamber free of dust; if necessary, rinse it out with distilled water.

Set up the experiment as shown in Fig. 2.

– Attach the bench clamp to a stable lab bench or table and mount the Wilson cloud chamber with guide tube in the bench clamp so that you have room to operate the vacuum pump (see Fig. 2 and the Instruction Sheet for the Wilson cloud chamber).
– Hold the chamber cover tightly with one hand and open the clamps with the other; then remove the cover and take out the bottom plate.
– Moisten the felt mat of the bottom plate thoroughly with the alcohol-water mixture, but do not soak it.
– Place the bottom plate with its feet on the rubber O-ring. Be sure that the rubber O-ring rests uniformly on the edge of the chamber bottom.

Variant a) using the radium preparation:

– Observing all safety precautions, remove the radium preparation for the Wilson cloud chamber (559 59) from its glass container and insert it in the preparation holder of the base plate.
– Put on the chamber cover, making sure that it rests properly on the rubber gasket, and lock it down with the clamps. Test the tightness of the chamber by briefly actuating the vacuum pump (a slight resistance in expansion, or a hissing noise, indicate a leak); grease the rubber gasket as necessary (e.g. with vacuum grease or a drop of high-viscosity oil) and reseal the chamber.
– Apply a DC voltage of approx. 150 V or greater to de-ionize the chamber.

Setting up the lamp:

Note: A strong one-sided warming of the chamber can cause convection currents which will interfere with the experiment: do not place the lamp too close to the Wilson cloud chamber.

– Mount the lamp housing with the lamp and aspherical condenser in the base and set it up about 15 cm from the Wilson cloud chamber. Adjust the lamp so that it is at the level of the observation window of the cloud chamber.
– Connect the lamp to the transformer (U = 6 V).
– Align the lamp filament horizontally and create a parallel or slightly divergent light beam which passes through the cloud chamber transversely.

Variant a) using the radium preparation:

– Set up the lamp so that the cloud chamber is illuminated along the expected path of the α particles.

Carrying out the experiment

– After sealing the chamber, wait at least 10 min before performing the first experiment cycle, so that a saturated mixture of air, water and alcohol can form inside the cloud chamber.

Variant b) using the thorium preparation:

– Remove the rubber cap from the thorium source (546 36) and attach the hose clamp with hose.
– Remove the cover of the ventilation valve on the Wilson cloud chamber and slide the hose of the thorium source over the valve as far as the union nut of the valve (see Fig. 2 and the Instruction Sheet for the Wilson cloud chamber).
– Open the hose clamp and squeeze the plastic bottle vigorously several times to pump radon into the cloud chamber (you can support this process by gently pumping the evacuation pump on the cloud chamber).

On account of radon's short half-life of 55.6 s, carry out the following steps quickly:

– Close the hose clamp, remove the hose from the ventilation valve and screw the cover onto the valve.
– Push down the handle of the vacuum pump once vigorously, hold it down in the end position and observe the droplet tracks of the particles from above directly through the window.

Variant a) using the radium preparation:

– Push down the handle of the vacuum pump once vigorously, hold it down in the end position and observe the droplet tracks of the particles from above directly through the window.
– If necessary, expand the mixture several times until the vapor in the cloud chamber is sufficiently saturated.
– Wait at least 1–2 minutes before repeating the experiment so that the equilibrium state in the vapor mixture can become re-established.
– When the experiment is finished, remove the cover of the cloud chamber and allow the felt mat of the chamber bottom to dry.
– Keep the chamber as free of dust as possible.

Measuring example

Fig. 1 shows a measuring example for both variants of the experiment.

Additional information

In the variant with the thorium source, you can increase the radon content in the cloud chamber by leaving the thorium source attached when operating the evacuation pump. This version requires greater manual dexterity during expansion, as it is not possible to close the ventilation valve.

Fig. 2 Experiment setup
a) using the radium preparation
b) using the thorium preparations