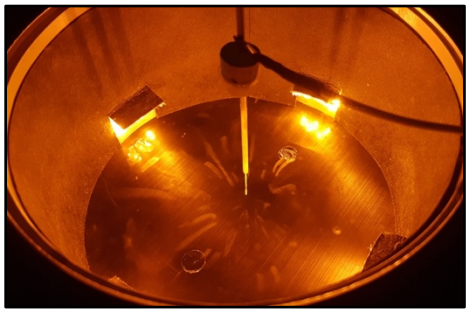
DMP01: Cloud Chamber

Objective:

To visualize radioactive decay.

Apparatus:



- PASCO Diffusion Cloud Chamber (SE-7940, bit.ly/3ECLsA6)
    - Cloud chamber with built-in LEDs and Peltier tile cooling, removable felt lining, water circulation pump, 2 rubber hoses, high voltage connection cable and 12 V (6 A) power supply.
- Isopropyl Alcohol (99%)
- Ice water
- Radioactive Source (Pb, Sr and Po from Avantor: bit.ly/44Ulq6e)
    - Pb-210 (β- emitter with 22.2 year half-life. 0.01 µCi. Purchased February 2023.)
    - Sr-90 (β- emitter with 28.9 year half-life. 0.01 µCi. Purchased February 2023.)
    - Po-210 (α emitter with 138 day half-life. 0.01 µCi. Purchased February 2023.)
    - Am-241 (α emitter with a 432 year half-life. 1.0 µCi. Taken from a smoke detector dated November 2023.)

Operational Principle

The bottom of the chamber is cooled by circulating ice water through the base and further cooling it to -35°C with a Peltier device. Alcohol placed in the chamber wicks up the inside chamber lining where it evaporates in the warmer region of the chamber and diffuses downward. The alcohol vapor is then cooled near the chamber bottom and becomes super saturated.

As energetic alpha and beta particles from a radioactive source pass through the alcohol vapor, the vapor condenses, forming droplets that appear as tracks in the strong chamber cross-lighting.

Setup

- Fill a sink with ice water, and submerge the pump in the water.
- Connect one hose from the pump to the chamber. The second hose is used as an outflow. Connect one end of the second hose to the chamber, and leave the other end free in the sink.
- Plug in the pump. Water should start to circulate immediately, as there is no on/off switch for the pump. The pump/hose may need to be primed if water does not flow. It

can be primed by pre-filling both lines with water, and holding one end in the air so that gravity feeds the pump.

- Soak the removable felt with isopropyl alcohol, either by spraying from the bottle or using a pipette. The felt should be fully covered, but you should only have a thin film of alcohol (< 0.5 mm) in the bottom of the chamber since excess alcohol will take longer to cool down.
- Insert the mounted needle source through the top of the chamber. Adjust the source height to approximately 5 – 10 mm from the chamber floor. If using a non-mounted needle source, rest the source approximately 5 – 10 mm from the chamber floor on the provided support. If using the Am-241 source, the required support is built into the source and it can be directly placed on the floor of the chamber. Insert the rubber stopper, with electrode, into the hole in the top of the chamber (this is not necessary for mounted sources).
- Connect the yellow high voltage cable from the chamber to the electrode at the top of the chamber (that comes out of the mounted source, or the rubber stopper). It is important to connect the yellow cable, which provides a clearing electric field, removing unwanted ions and greatly improving track observation.
- Connect the power supply and plug-in. The LEDs should immediately turn on, as there is no on/off switch for the power supply.
- Note: The power supply: (1) Lights the LEDs; (2) Provides the clearing field; and (3) Provides cooling via the Peltier tiles. Therefore it must remain plugged in during the entire operation of the cloud chamber, i.e., you can't unplug it and then plug it in to use the lights when you want to see the tracks, since it will not be adequately cooled without being plugged in.

Cleanup

- Soak excess alcohol from the chamber floor with a paper towel. Leave the lid off for the alcohol to evaporate before putting it away.
- Use bench compressed air to blow out the two water lines.
- Ensure the sources are completely air dried before putting away.

Tips

- You should begin to see tracks within approximately 20 minutes. If you do not see tracks:
    - Check that you can see vapour in the chamber. If not, you can wait a bit longer and also:
        - Check the power supply connection
        - Ensure that the felt is completely soaked.
        - Ensure that you do not have too much alcohol on the chamber floor.
    - If you see vapour, but no tracks:
        - Ensure that the high voltage cable is connected.

    - Remove the source, and wipe it with a kimwipe. If you do this, you will again need to wait approximately 20 min after the chamber is re-closed to see tracks.
- The cloud-chamber can run continuously for at least 2.5 hours (this is the longest it was tested before turning it off). If running the cloud chamber for an extended time, you may want to add more ice. However over the course of 2.5 hours it should not be necessary to add more alcohol.
- Every time you open the chamber (for example to change/reposition the source or to insert a magnet), you will have to wait for the vapour to settle before observing tracks. If you open and close the chamber quickly, it should not take the full 20 minutes to be operational again.
- To observe cosmic rays, remove the source. Cosmic ray events will be much less frequent, but can be observed. The high voltage connection should still be connected, even when looking for cosmic ray events.
- β particles have more penetrating power than α particles. Therefore the β tracks will be much clearer and "more dramatic".