Visualizing cosmic rays with a cloud chamber

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Cosmic rays and Radioactivity

Cosmic rays are a mixture of mostly protons and helium nuclei.
Radioactive decay is a process in which an unstable atomic nucleus decays into a different state releasing energy and daughter products.
Types of decay: Alpha decay(α), Beta decay(β), Gamma decay (ɣ)

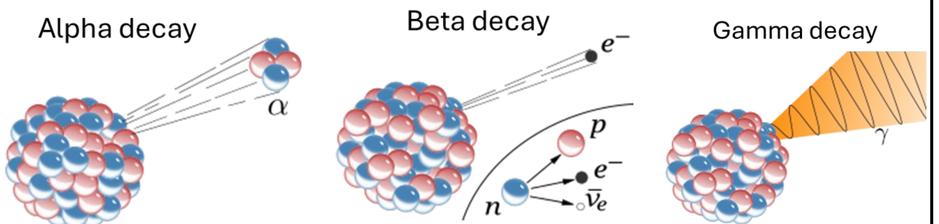
→**Alpha decay(α)** nucleus emits He2+: two protons + two neutrons.

→**Beta decay(β)** emission of electron + other decay products

→**Gamma decay(ɣ):** high energy photons/electromagnetic radiation

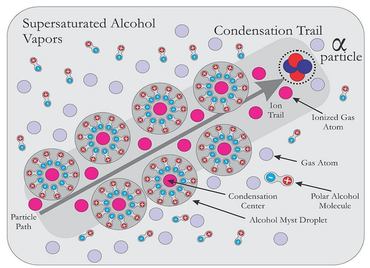
Uses of radioactivity: nuclear power, medical uses, weapons, industrial applications

- **Sources of radiation:** stars, supernovae, accelerating charges



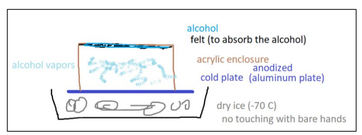
Cloud chamber: Working principle

Chamber containing supersaturated vapors of water/alcohol used to study cloud formation, and also as a particle detector.
How it works: Charged high energy particles (alpha, beta particles) leave trail of ions Ions serve as nucleation sites for condensation of (polar) water/alcohol vapors. Trails help visualize the paths of radiation!



Similar: airplane contrails (soot particles)

Miscellaneous Gallery



Experimental results: Construction and observations

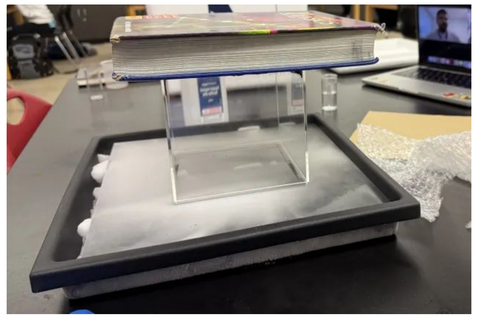
Materials:
Dry ice, anodized aluminum plate, plastic tray, acrylic box, isopropyl alcohol (IPA), felt

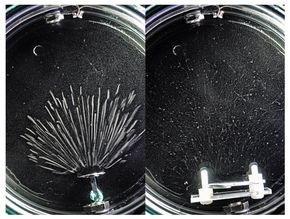
Procedure:

1. Place felt in acrylic box, soak with IPA
2. Place dry ice in plastic tray, plate on top of dry ice, acrylic cube on top
3. Dim lights and shine flashlight from side.

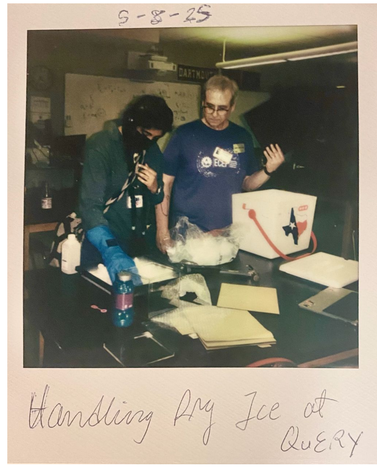
Observations:
Alcohol vapor from top of acrylic forms thick fog/trails as it condenses on reaching aluminum plate below
Different kinds of trails (length, thickness, frequency)

- Longer trails = beta decay, thicker trails = alpha decay





example trails from wiki:
alpha particles on left
beta on right



Applications

Early uses – discovery of fundamental particles – positron (anti-electron) and muon
Recent experiments use a similar complimentary setup – bubble chamber of Liquid Helium– any small disturbance from radiation causes local boiling of the superheated liquid.
Educational demos – helps visualize radiation and different types of cosmic rays for schools and museum exhibits
Aerospace – assessing radiation exposure risks to astronauts and electronic systems on board spacecraft.
Radiation Therapy – monitoring the path of protons and electrons to ensure radiation is accurately delivered to tumors – minimizing harm to healthy tissues.

References and Acknowledgements

References:
How to build a cloud chamber: https://youtu.be/xky3f1aSkB8?si=V6kUyF255r5ngBXV
Wiki: https://en.wikipedia.org/wiki/Cloud_chamber
Radioactive Decay information: https://scienceinfo.com/radioactive-decay/
Radioactivity:https://www.energy.gov/science/doe-explainsradioactivity
Applications:https://modern-physics.org/cloud-chamber/

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