Discovering Particles

Lesson 9

Objectives

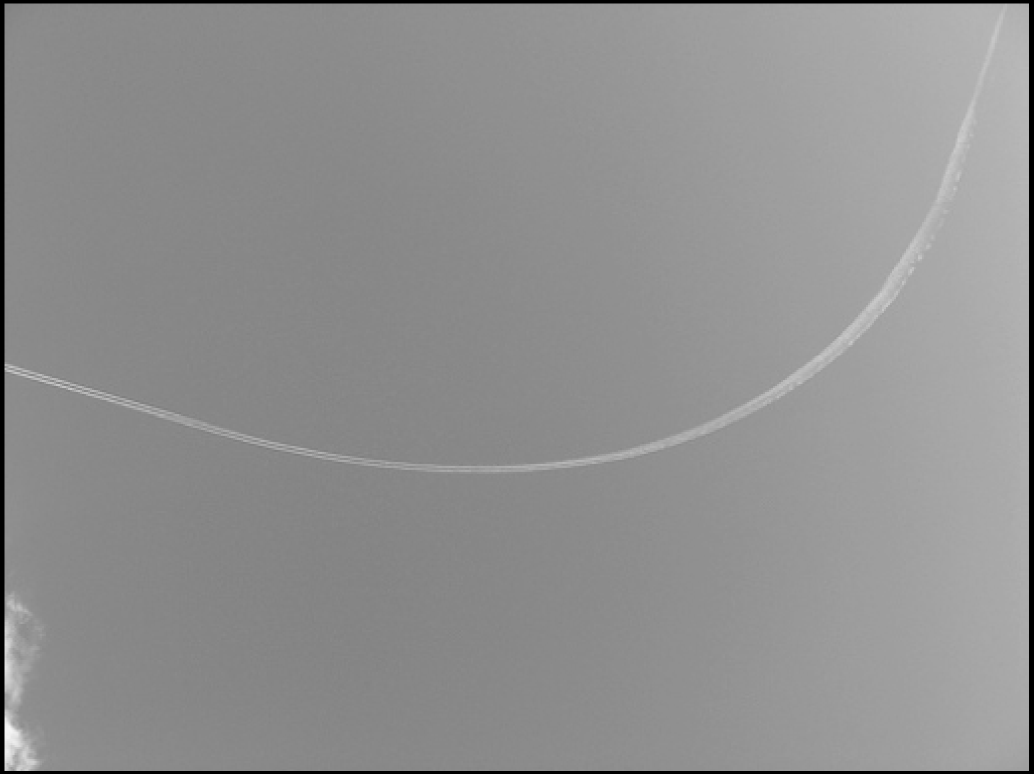
- **explain how the analysis of particle tracks contributed to the discovery and identification of the characteristics of subatomic particles.**

Review

- It was originally believed that the smallest indivisible particle was the atom.
- We now know that we can split the atom into smaller particles like protons, neutrons, and electrons.
- But can we split apart protons? Neutrons? Electrons??

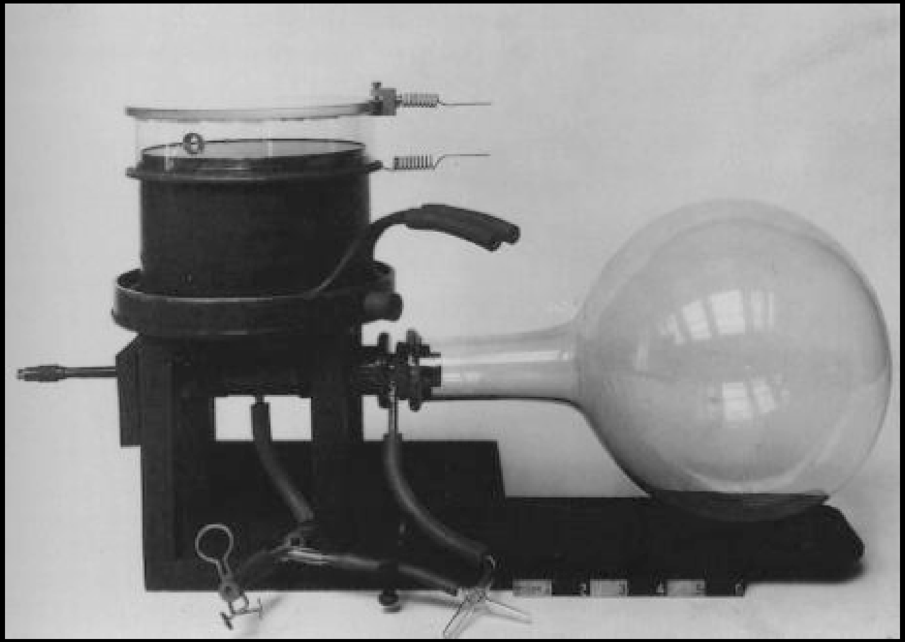
Familiar Trails

- Jets leave vapor trails as they move through the air. This is similar to what happens when ions move through various media.
- Which way is this ion moving? Describe its movement.



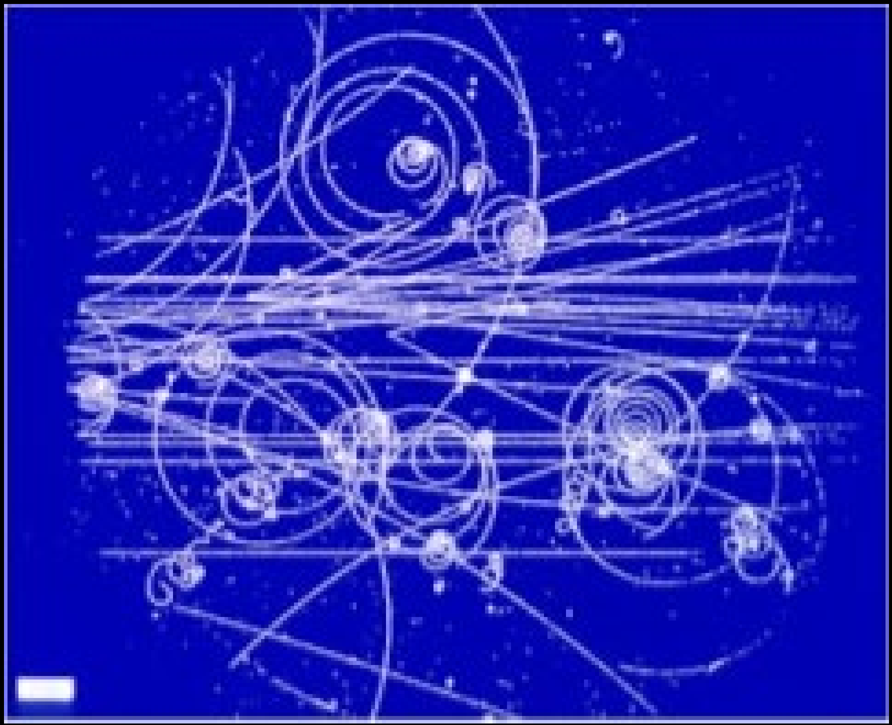
The Cloud Chamber

- Thomson Rees Wilson devised an apparatus for observing some of these hypothetical particles: The Cloud Chamber
- In a cloud chamber, air is supersaturated with a liquid like ethanol. If a charged particle passes through the air, the liquid will condense, turning into a cloud.



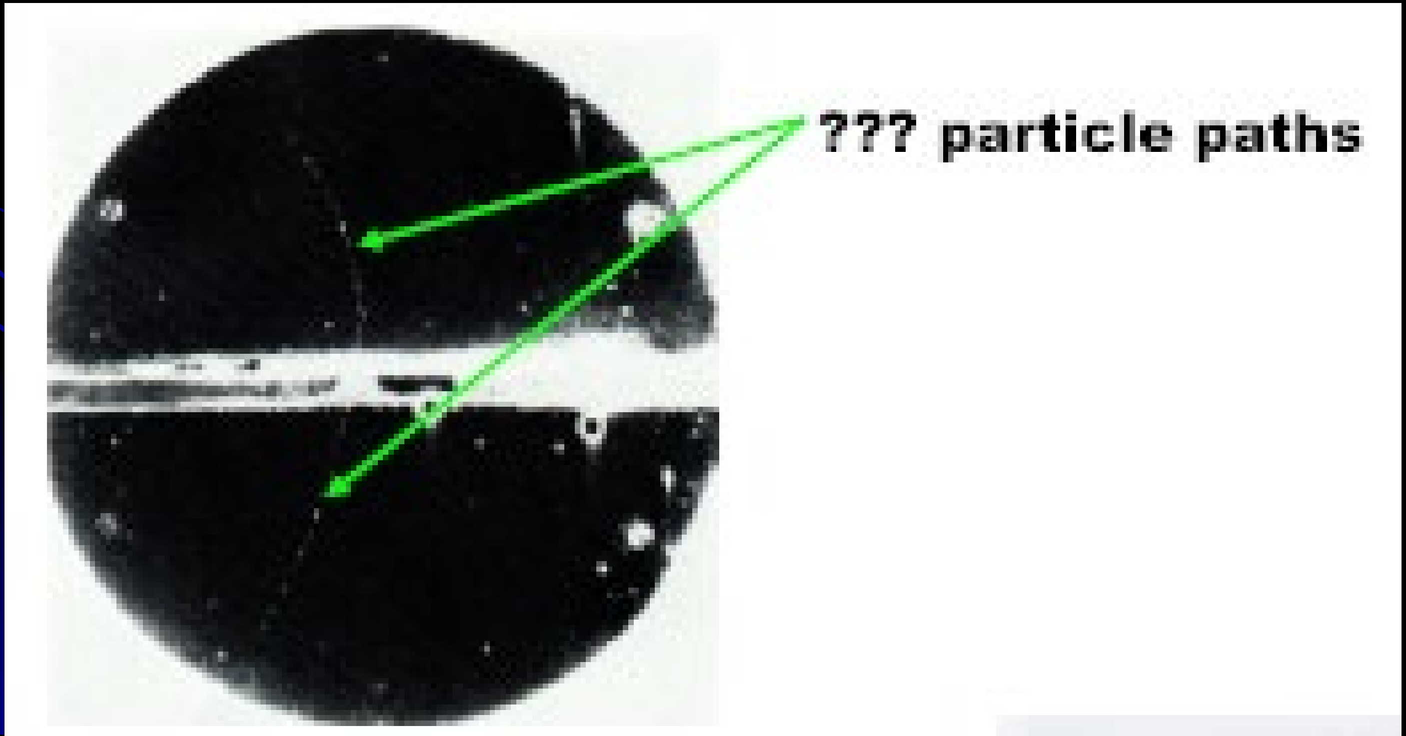
The Bubble Chamber

- This technology was later improved upon in the 1950's by Donald Glaser.
- In a bubble chamber, liquified gases (hydrogen, helium) are held at low pressures.
- When a charged particle moves through the chamber, the liquid boils, leaving a track of bubbles.



Particle Analysis

- **Charged particles leave particle tracks which can be observed. (Similar to jets leaving cloud tracks behind)**



Analysis, con't

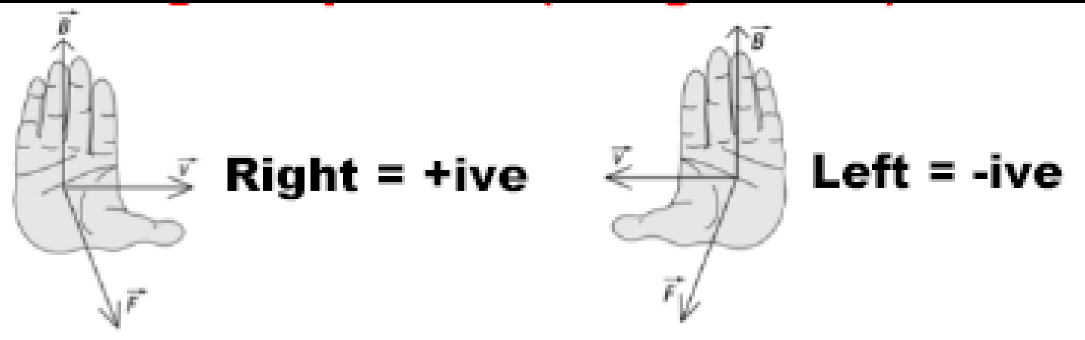
- If a magnetic field is placed across the cloud chamber, charged particles will be deflected.
- From this deflection, we can determine charge nature.

http://www.kcvs.ca/site/projects/physics.html

Analysis

- What can the tracks tell us?

1. Nature of charge on particle (using 3rd HR)



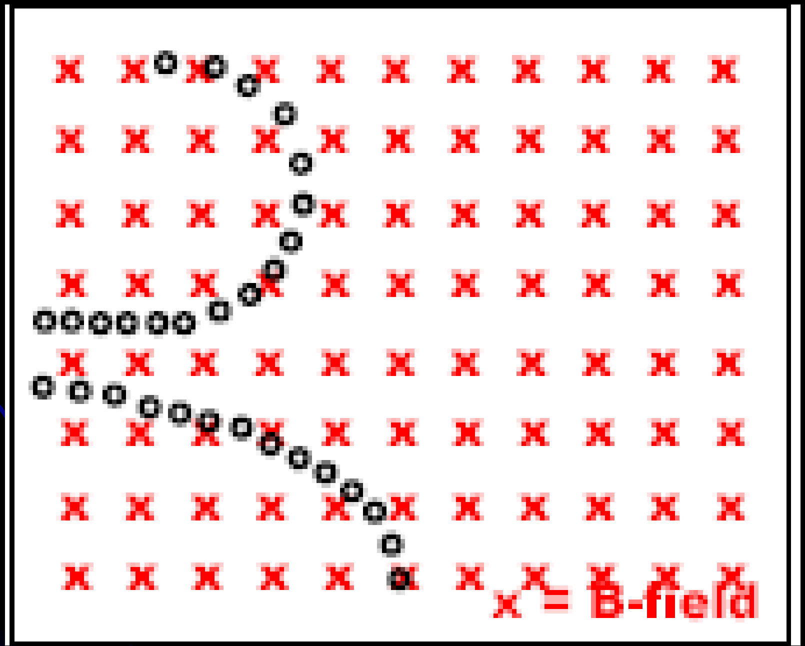
2. Charge to mass ratio (if radius, B-field and speed of particle are known).

$$\frac{q}{m} = \frac{v}{Br}$$

3. That sometimes, one particle will break into two! Remember: ALL conservation laws must be in effect (charge, mass, and momentum)

Example

- Shown is a diagram of a bubble track of two particles.
  a) What is the nature of the charge on each particle?
  b) Given that the magnitude of the charge and mass is the same for both particles, which one is moving faster?

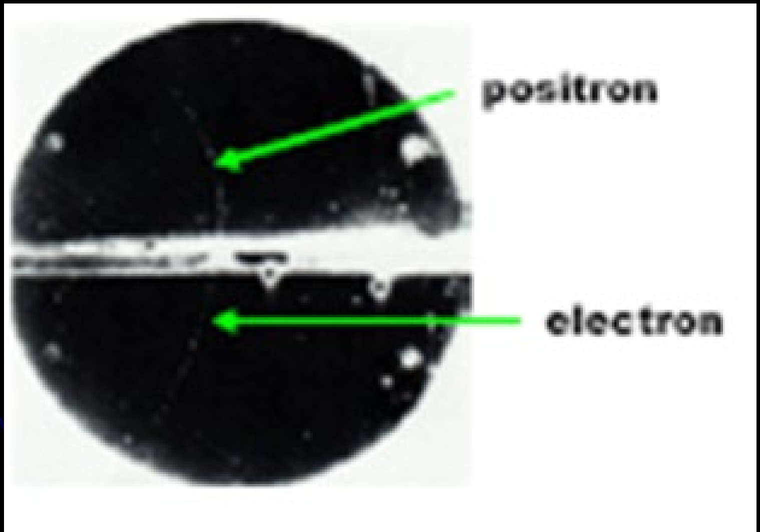


Strange Results

- One result of cloud/bubble chamber tracks is that some particles would break apart into smaller, oppositely charged particles.
- American physicist Carl Anderson was the first to observe this phenomenon in 1936 while working with Millikan. He was shooting gamma rays from thallium-208 at a lead plate from below.
- He found two particles were produced: they appeared to have similar masses and equal but opposite charges.

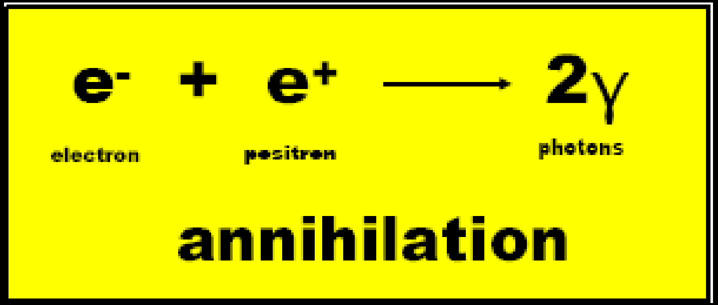
The Positron – Proof of Antimatter

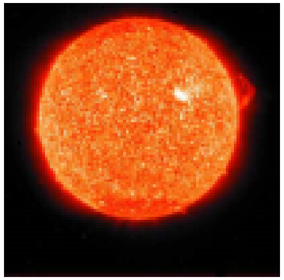
- **Anderson recognized the negative particle as an electron. He called the new particle produced a positron.**
- **This was the first experimental proof of what quantum theorists had called antimatter.**



Antimatter Annihilation

- When the two pieces of antimatter collide, they annihilate, producing two gamma ray (high energy) photons.





Annihilation is one process taking place in nuclear reactions in the sun.

- Concept Check: Consider the e- and e+ with equal speeds colliding head on. Why would momentum not be conserved if only 1 photon was produced?

Subatomic Zoo

- **The discovery of these and many other subatomic particles soon lead the creation of the <u>subatomic zoo</u>, a whole barnyard of weird particles:**
- **EX: Bosons: mediating particles that carry fundamental forces**

Strong Nuclear

Weak Nuclear

Gravity

Electromagnetic

Recently discovered

Masses of Subatomic Particles

- **Most of these particles are very small (well, smaller than protons, larger than electrons), and as such, are given new units to describe their masses:**
- **The unit comes from the mass-energy equivalence equation:**

$$E = mc^2 \longrightarrow m = \frac{E}{c^2} = \boxed{\frac{eV}{c^2}}$$

$$\boxed{1\ eV/c^2 = 1.7827 \times 10^{-36}\ kg}$$