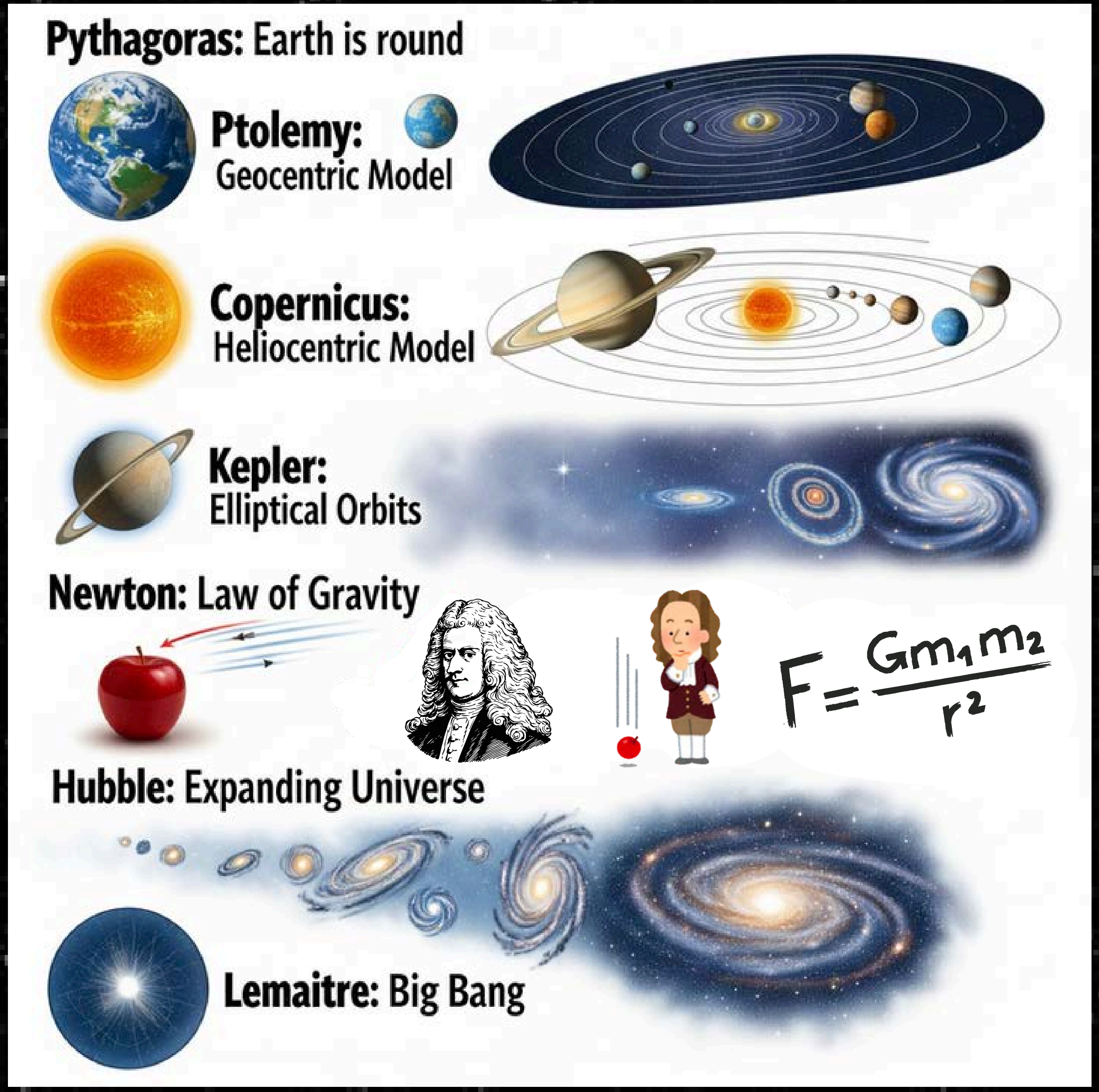
ASTRAL TRAILS

MENTORS

- Tanmay Rajput
- Chhavi Tanwar
- Akshat Dhote
- Aditya Prakhar

HISTORY OF ASTRONOMY

- Pythagoras suggested Earth is round.
- Aristotle claimed Earth is stationary, with celestial bodies orbiting it in circles.

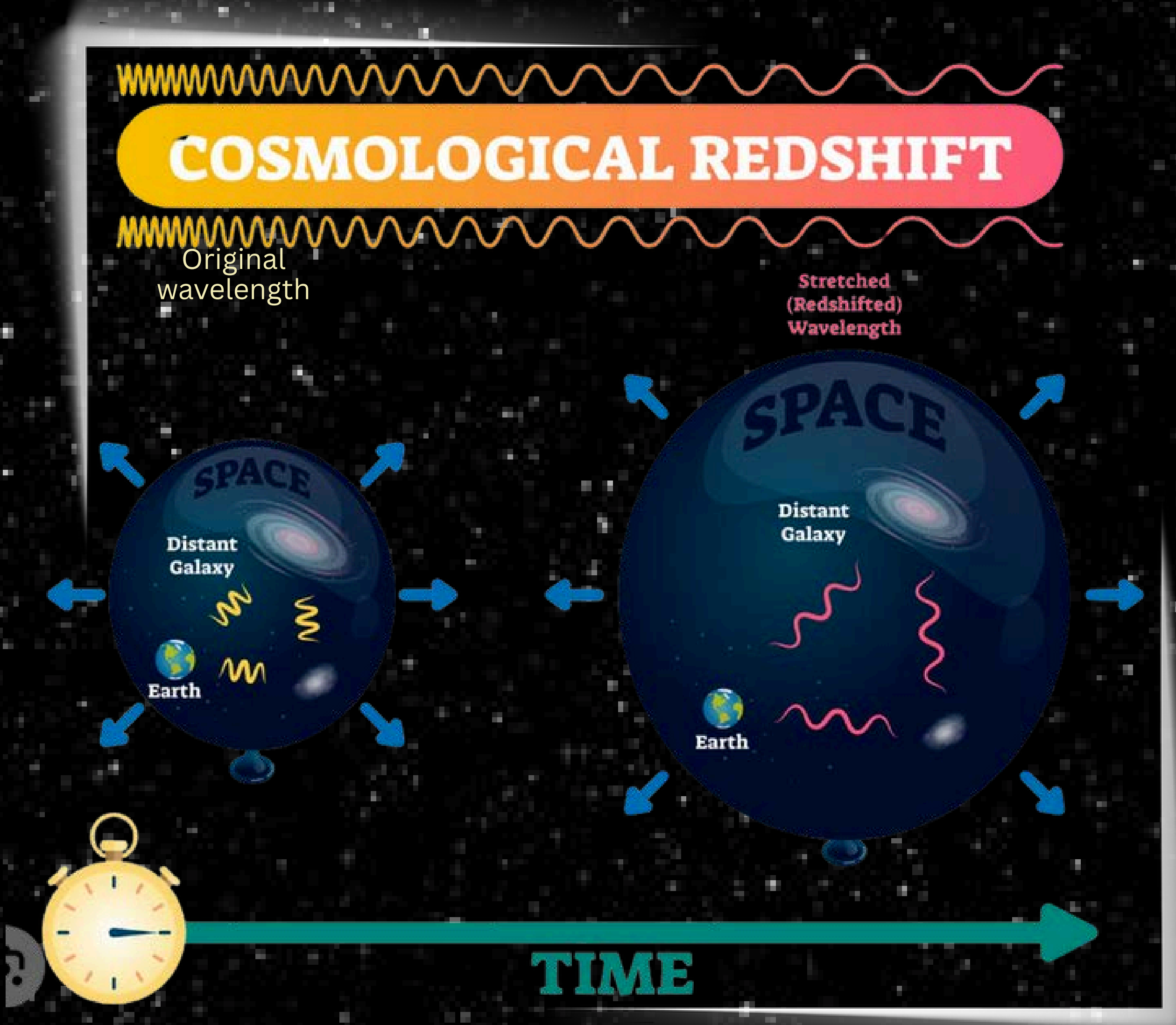


- Ptolemy built the Geocentric model to support Aristotle and explain planetary motion.
- Copernicus proposed a sun-centered Heliocentric system.
- Kepler used Tycho's data to form three laws of planetary motion.

HISTORY OF ASTRONOMY

- Newton explained Kepler's laws using his three laws of motion and gravity.
- Hubble showed the universe is larger than the Milky Way and that galaxies are moving away.

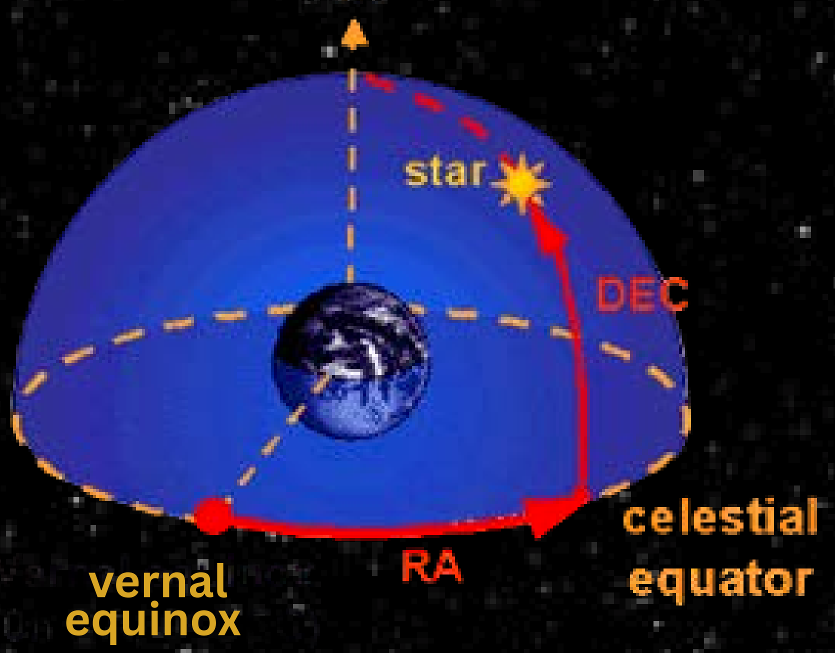
- Lemaitre proposed the Big Bang Theory
- The diagram beside shows a possible evidence of big bang theory - RED SHIFT



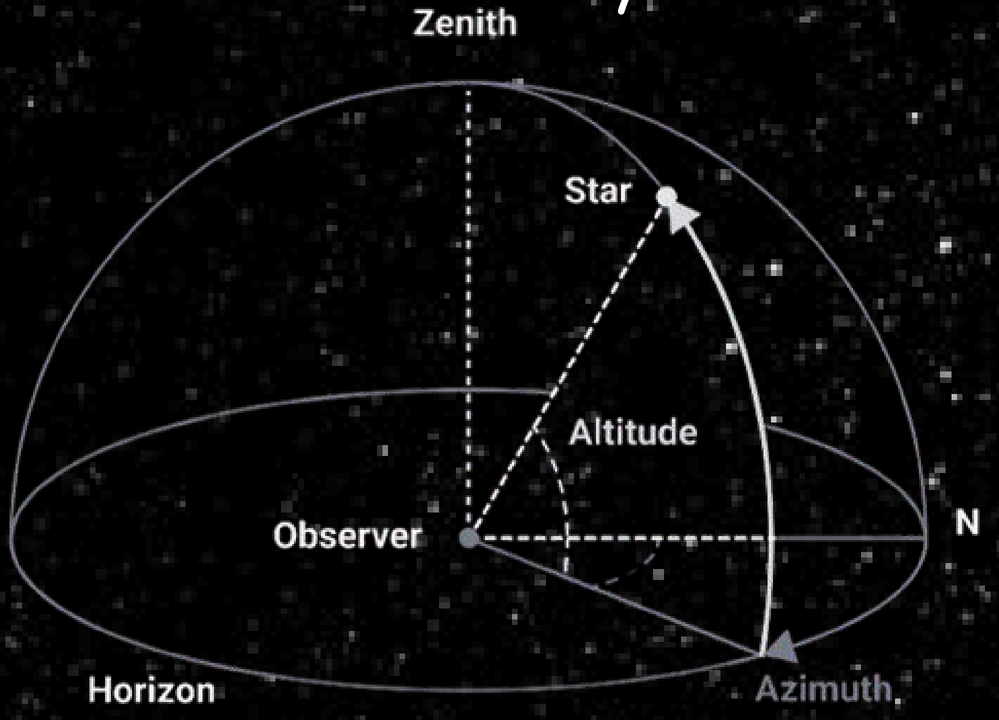
COORDINATE SYSTEM

TYPES OF COORDINATE SYSTEM:

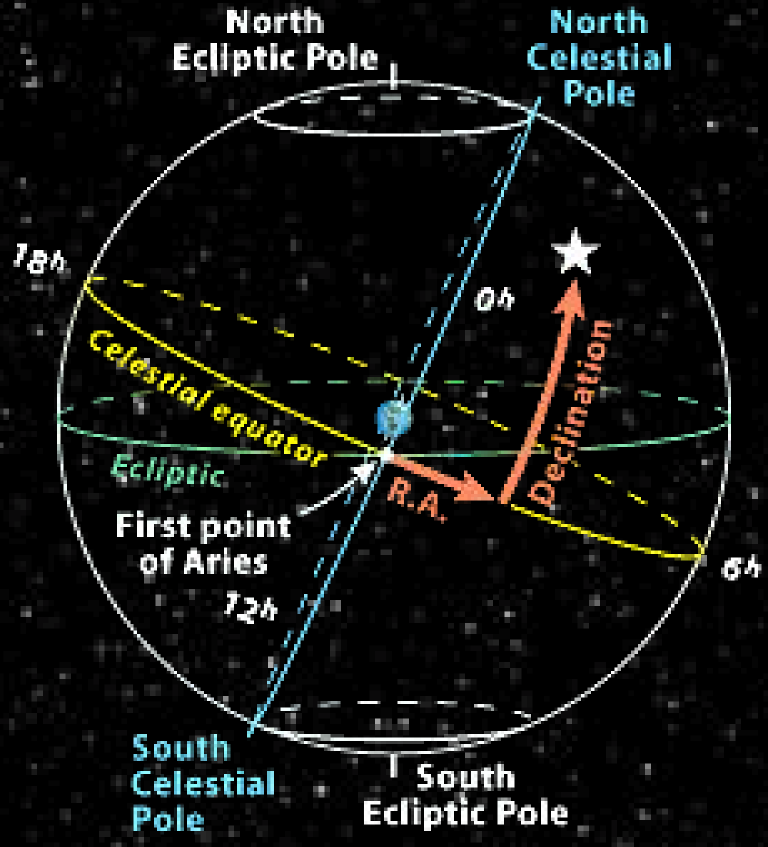
Equatorial coordinate system

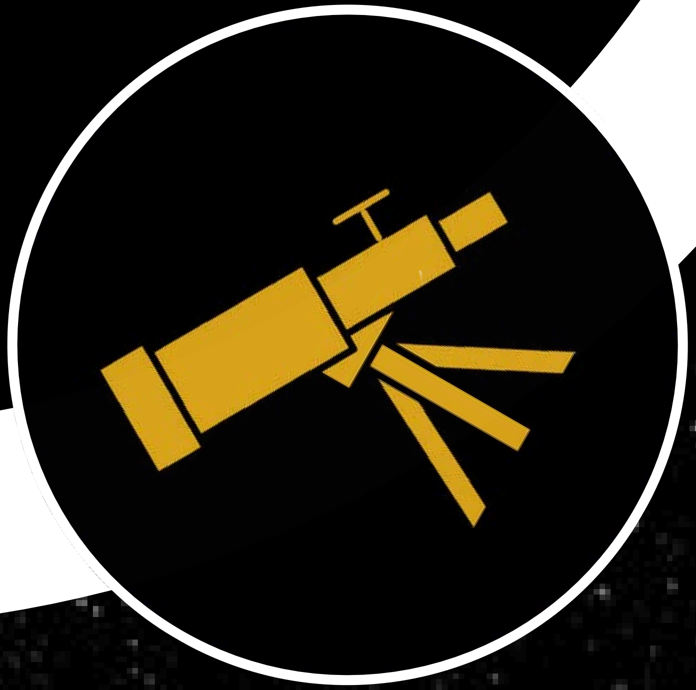


Altitude-Azimuth coordinate system



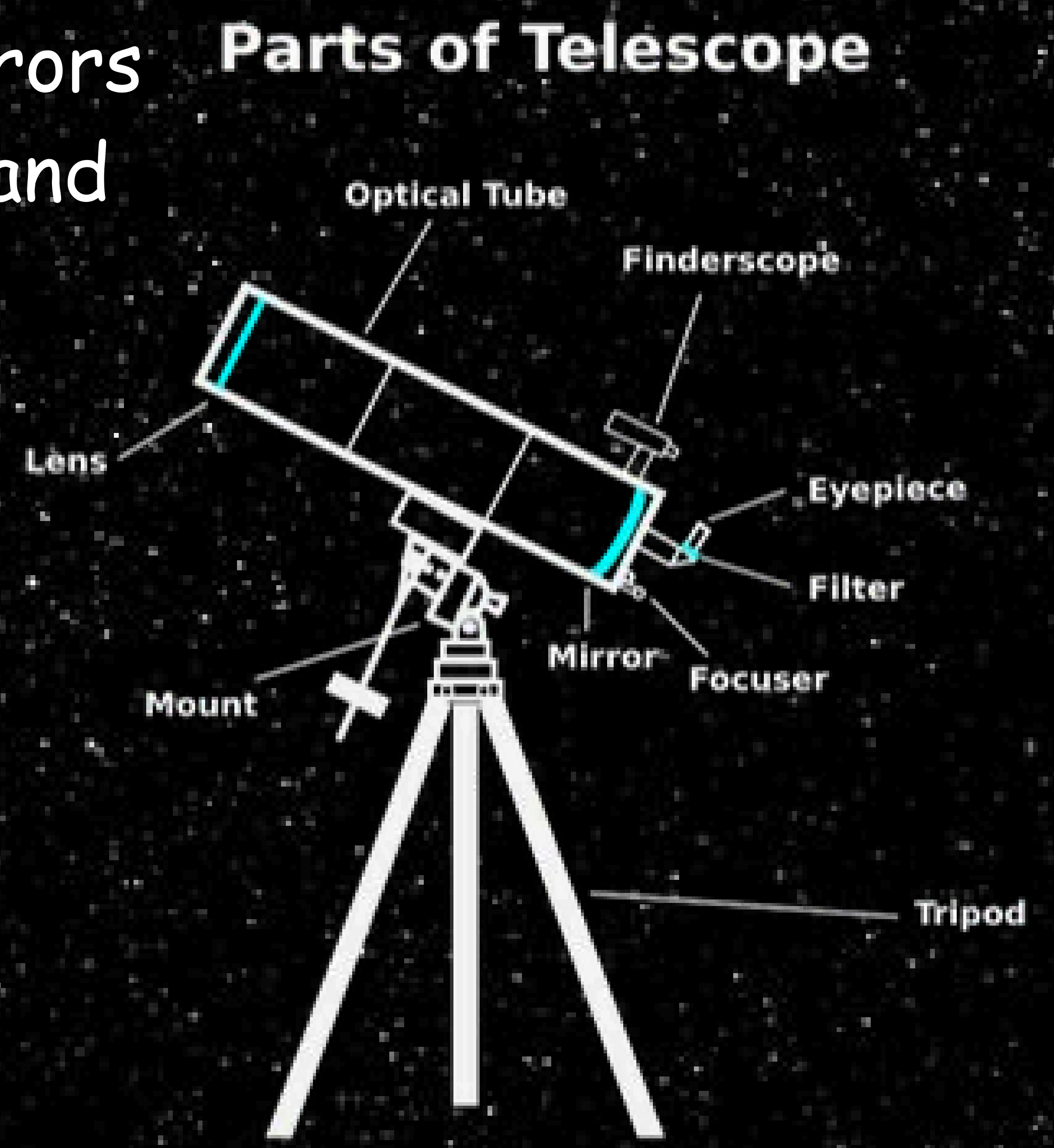
Ecliptic Coordinate system





TELESCOPES

An optical instrument which magnifies distant objects using curved mirrors and lenses based on refraction and reflection principles.



FUNCTIONS OF A TELESCOPE

a.) Magnification - makes distant objects appear larger
b.) Light gathering power - allows telescopes to collect more light than the human eye, making faint objects visible
c.) Resolving power - determines how much detail can be seen in an image

TELESCOPES

TYPES OF TELESCOPES

A) Optical Telescopes - uses purely lens or mirrors or combination of these

Reflecting telescopes (uses mirrors)

Refracting telescopes (uses lens)

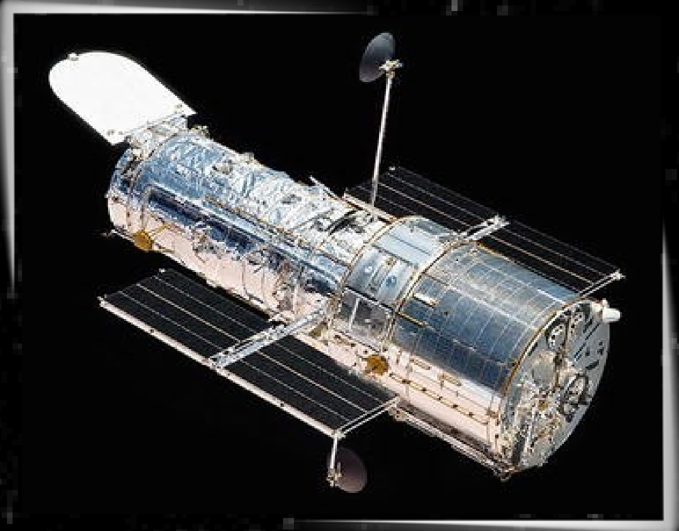
Catadioptric telescopes (uses combination of lens and mirrors)

TELESCOPES

On basis of wavelength of light they observe

X-ray telescopes

UV telescopes



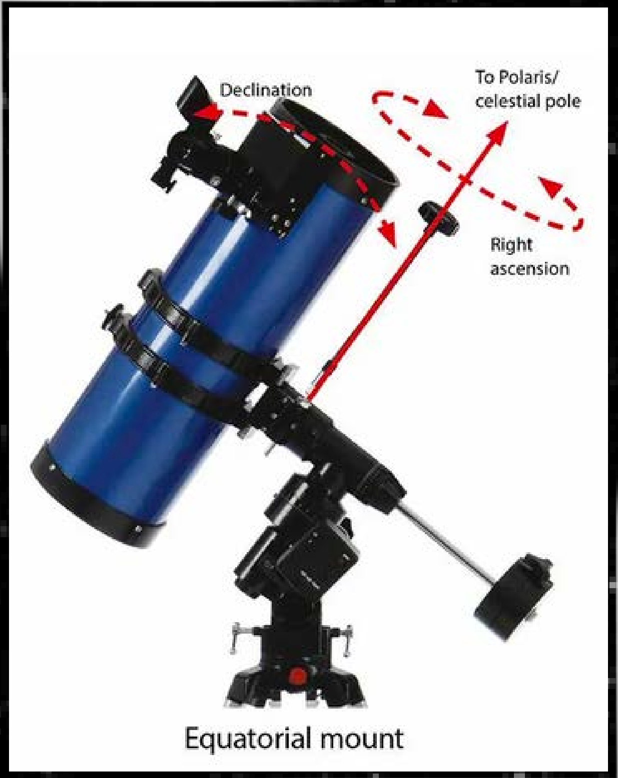
INFRARED telescopes

RADIO telescopes

TELESCOPES

TYPES OF TELESCOPIC MOUNTS

Alt-Azimuth Mounts



Equatorial Mounts

Dobsonian Mounts

STAR MAPS

the
star map
of the
sky

NORTHERN HEMISPHERE

SOUTHERN HEMISPHERE

CONSTELLATIONS

Constellations are recognizable star patterns named and cataloged by astronomers.

Earth's rotation and revolution around the sun impacts the view of constellations. Here's how-

1) DIURNAL MOTION - This phenomenon, makes it appear as though the constellations move across the sky throughout the night, just like the Sun 'moves' from East to West each day.

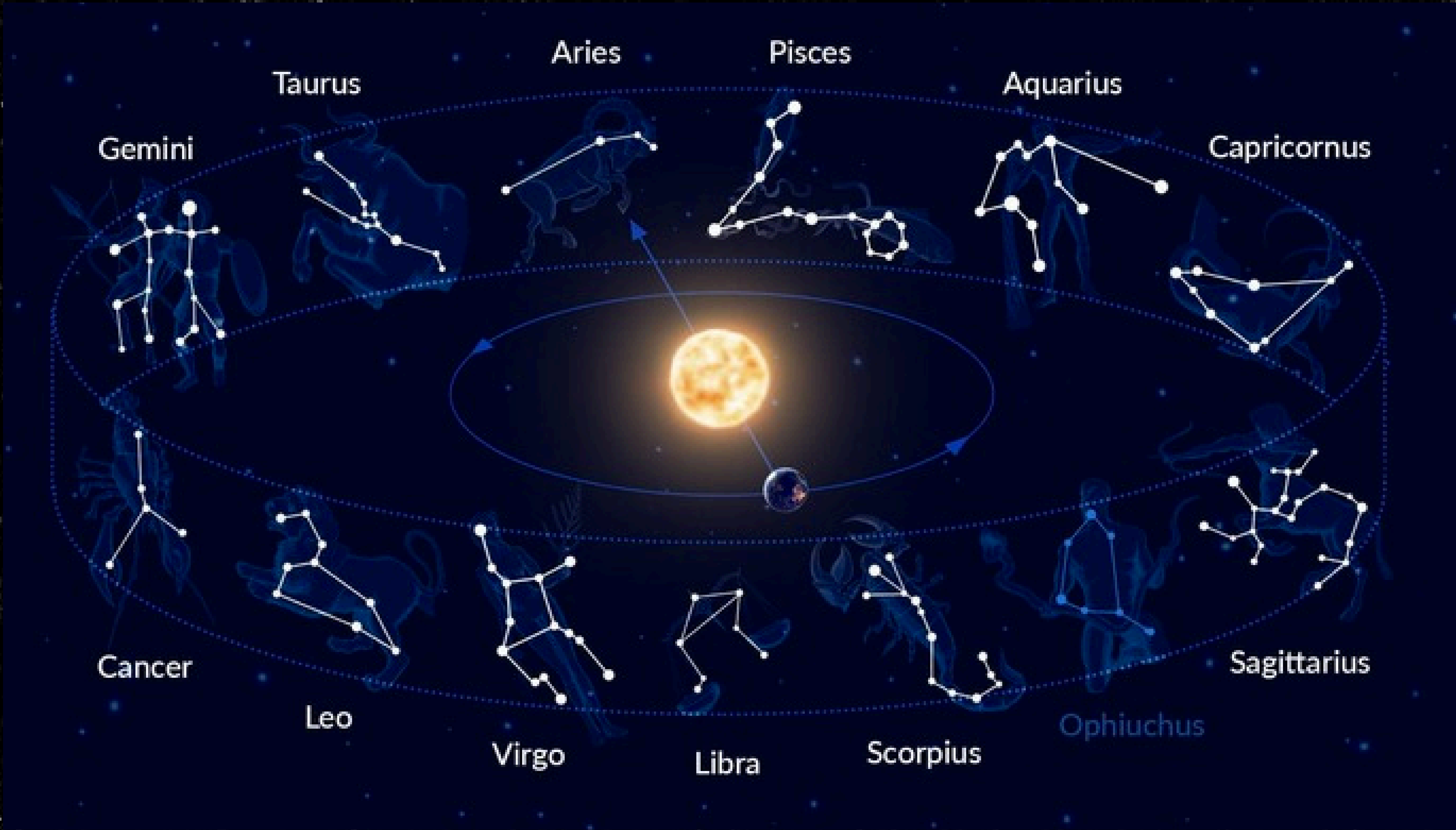
2) ANNUAL MOTION - Throughout the year, constellations gradually shift West due to Earth's revolution around the Sun. This is called annual motion

Celestial Objects (Deep Sky) -

- GALACTIC - Stars, open clusters, globular clusters, diffuse and planetary nebulas.
- SUPER GALACTIC - Galaxies

CONSTELLATIONS

Constellations are recognizable star patterns named and cataloged by astronomers.



ITS RAINING CATS AND DOGS

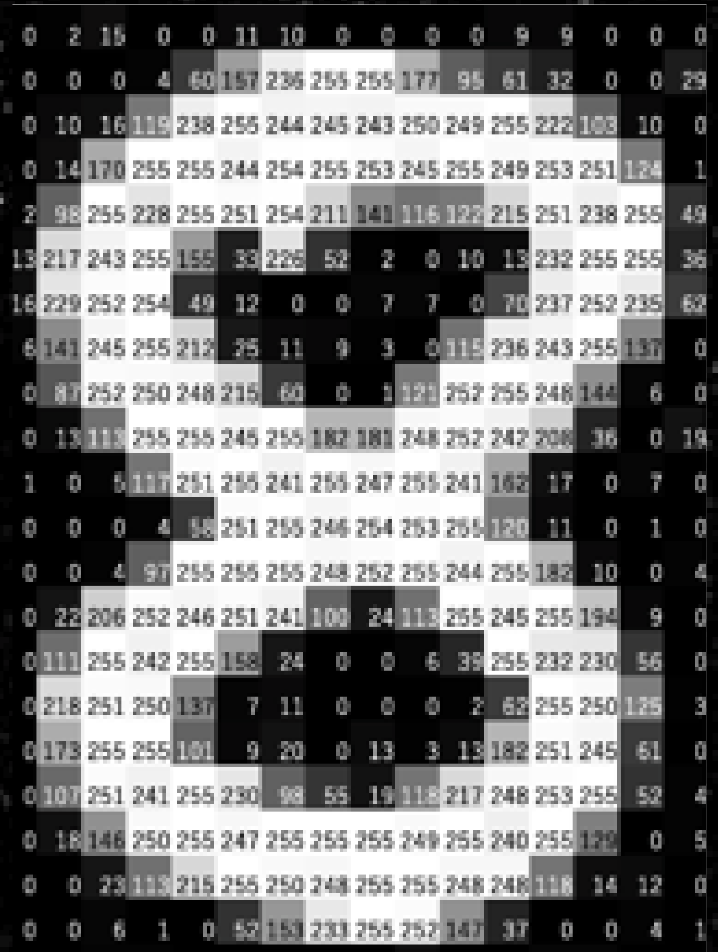
Tools utilized-
(1) Python
(2) OpenCV**[cv2]**
(3) Pandas
(4) NumPy
(5) Matplotlib

Objective - Image processing is an integral part of Observational Astronomy, as it is used for refining the raw data collected from telescopes like images of distant galaxies, supernovae, black holes, exoplanets and many more.

Through this task, we aim to apply some of the image processing techniques like filtering, edge detection, contrast enhancement, and geometric transformations - over a set of images of Cats and Dogs.

ITS RAINING CATS AND DOGS

Image into arrays

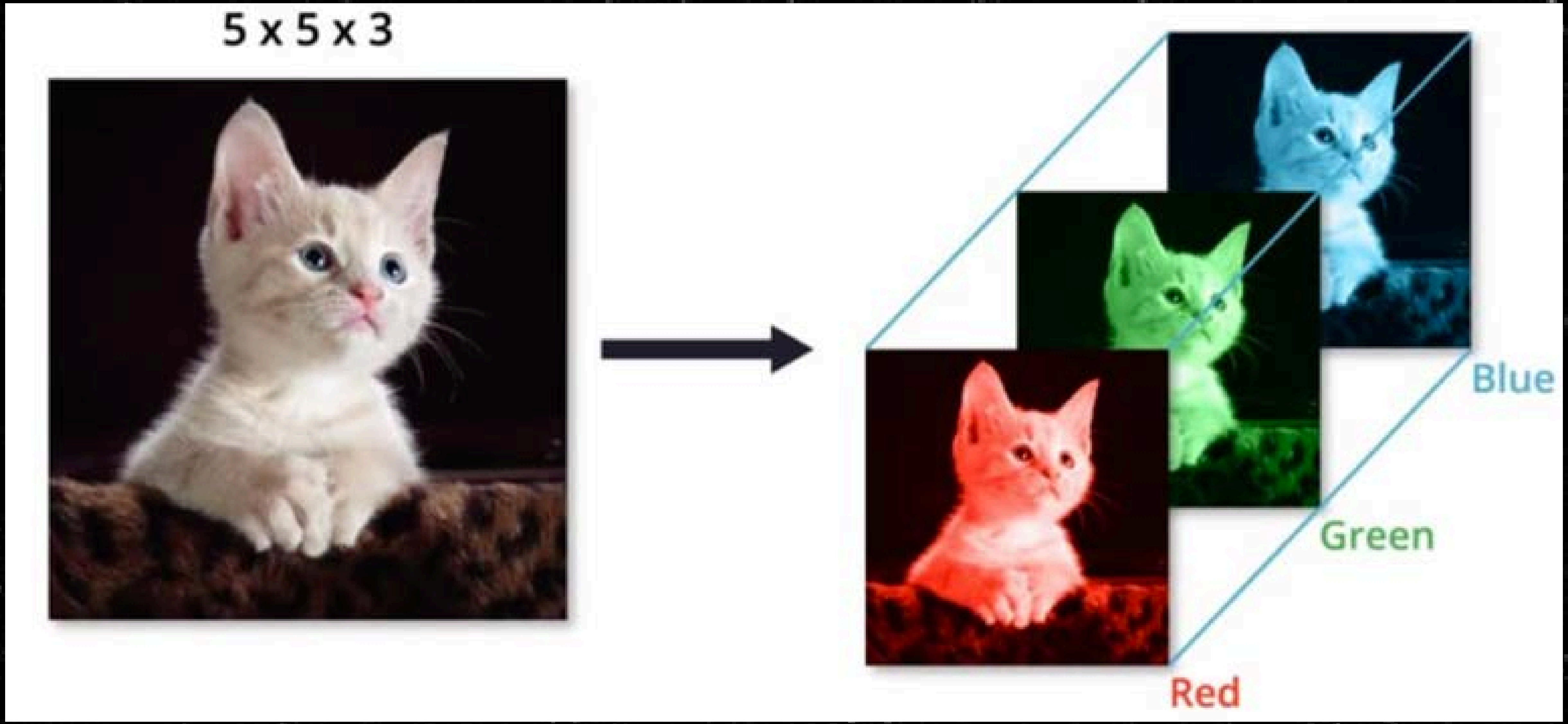


0	2	15	0	0	11	10	0	0	0	0	9	9	0	0	0
0	0	0	4	60	157	236	255	255	177	95	61	32	0	0	29
0	10	16	119	238	255	244	245	243	250	249	255	222	103	10	0
0	14	170	255	255	244	254	255	253	245	255	249	253	251	124	1
2	98	255	228	255	251	254	211	141	116	122	215	251	238	255	49
13	217	243	255	155	33	226	52	2	0	10	13	232	255	255	36
16	229	252	254	49	12	0	0	7	7	0	70	237	252	235	62
6	141	245	255	212	25	11	9	3	0	115	236	243	255	137	0
0	87	252	250	248	215	60	0	1	121	252	255	248	144	6	0
0	13	113	255	255	245	255	182	181	248	252	242	208	36	0	19
1	0	5	117	251	255	241	255	247	255	241	162	17	0	7	0
0	0	0	4	58	251	255	246	254	253	255	120	11	0	1	0
0	0	4	97	255	255	255	248	252	255	244	255	182	10	0	4
0	22	206	252	246	251	241	100	24	113	255	245	255	194	9	0
0	111	255	242	255	158	24	0	0	6	39	255	232	230	56	0
0	218	251	250	137	7	11	0	0	0	2	62	255	250	125	3
0	173	255	255	101	9	20	0	13	3	13	182	251	245	61	0
0	107	251	241	255	230	98	55	19	118	217	248	253	255	52	4
0	18	146	250	255	247	255	255	255	249	255	240	255	129	0	5
0	0	23	113	215	255	250	248	255	255	248	248	118	14	12	0
0	0	6	1	0	52	153	233	255	252	147	37	0	0	4	1
0	0	5	5	0	0	0	0	0	14	1	0	6	6	0	0

ITS RAINING CATS AND DOGS

An **RGB image** is composed of three color channels: Red, Green, and Blue — which correspond to the way human eyes perceive color. Each channel having intensity between 0-255.

'**Cv2**' - reads these channels as **BGR** and '**matplotlib**' reads **RGB**.



A color image is actually just three grayscale images stacked together - one for each color (R, G, B).

ITS RAINING CATS AND DOGS

Difference between an image read by CV2 and another by Matplotlib

CV2 Image

Matplotlib Image

ITS RAINING CATS AND DOGS

Greyscaling

```
img_gray = cv2.cvtColor(img, cv2.COLOR_RGB2GRAY)
fig, ax = plt.subplots(figsize=(8, 8))
ax.imshow(img_gray, cmap='Greys')
ax.axis('off')
ax.set_title('Grey Image')
plt.show()
```

before

after

ITS RAINING CATS AND DOGS

Resizing

```
img_resize = cv2.resize(img, (100, 200))
fig, ax = plt.subplots(figsize=(8, 8))
ax.imshow(img_resize)
ax.axis('off')
plt.show()
```

This snippet resizes the image into half the size along x-axis of that of initial image

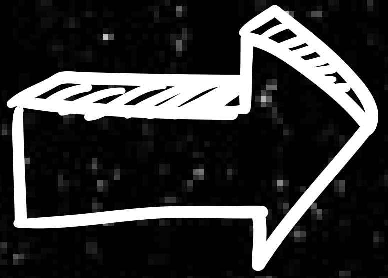
ITS RAINING CATS AND DOGS

Sharpening

```
kernel_sharpening = np.array([[-1,-1,-1],
                              [-1,9,-1],
                              [-1,-1,-1]])
sharpened = cv2.filter2D(img, -1, kernel_sharpening)

fig, ax = plt.subplots(figsize=(8, 8))
ax.imshow(sharpened)
ax.axis('off')
ax.set_title('Sharpened Image')
plt.show()
```

This snippet uses matrix to perform kernel sharpening. It increases the number of pixels in a unit area of pixels.



ITS RAINING CATS AND DOGS

Scaling

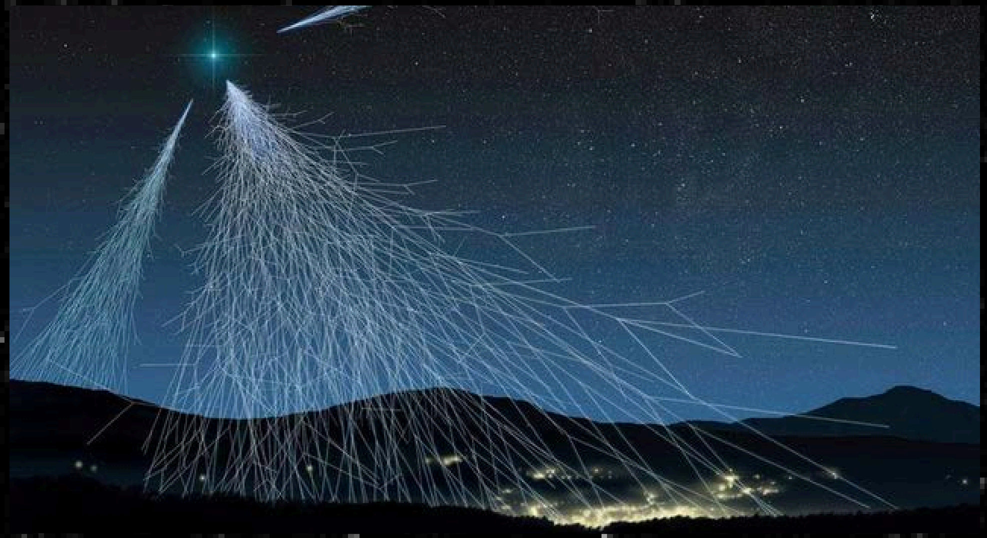
```
img_resized = cv2.resize(img, None, fx=0.25, fy=0.25)
fig, ax = plt.subplots(figsize=(8, 8))
ax.imshow(img_resized)
ax.axis('off')
plt.show()
```

This snippet scales the images pixels to 25% of what it initially had
Say 1000 x 800 pixels, now it has 250 x 200 only

COSMIC RAYS

WHAT ARE COSMIC RAYS?

- Cosmic rays are high-energy particles originating from outer space that travel through the universe at relativistic speeds.
- These particles come from outer space (the 'cosmos') and our solar system.



BUT THEY ARE NOT RAYS AT ALL THEY ARE PARTICLES!

- They consist predominantly of protons and atomic nuclei.

COSMIC RAYS

1902

RUTHERFORD, MCLENNAN, BURTON

Discovered that penetrating radiation passes through the atmosphere

1912

VICTOR HESS

Discovered cosmic rays by measuring radiation at high altitudes using a balloon. He found that radiation increased with altitude, proving it originated from space. He won the Nobel Prize in 1936 for this discovery.

1975

CHARLES COULOMB

He discovered that charged body, in the atmosphere, gets discharged.
Conclusion: There are ions in the atmosphere

COSMIC RAYS

- INTRODUCTION
- HISTORY
- DISCOVERY
- COMPOSITION
- TYPES OF TRACK

1933

SIR ARTHUR COMPTON

Concluded that radiation intensity depends on magnetic latitude

1937

STREET AND STEVENSON

Discovery of muon particles

1938

PIERRE AUGER AND ROLAND MAZE

Found that cosmic ray showers spread over large distances at ground level, enabling the study of incoming cosmic rays' direction and energy.

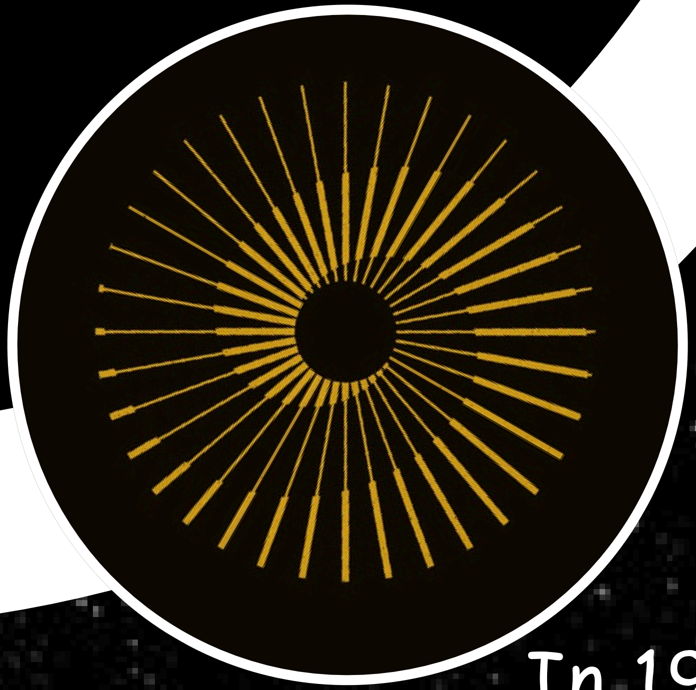
1982

SEKIDO AND ELLIOT

Gave the first correct explanation of what Cosmic Rays are.

COSMIC RAYS

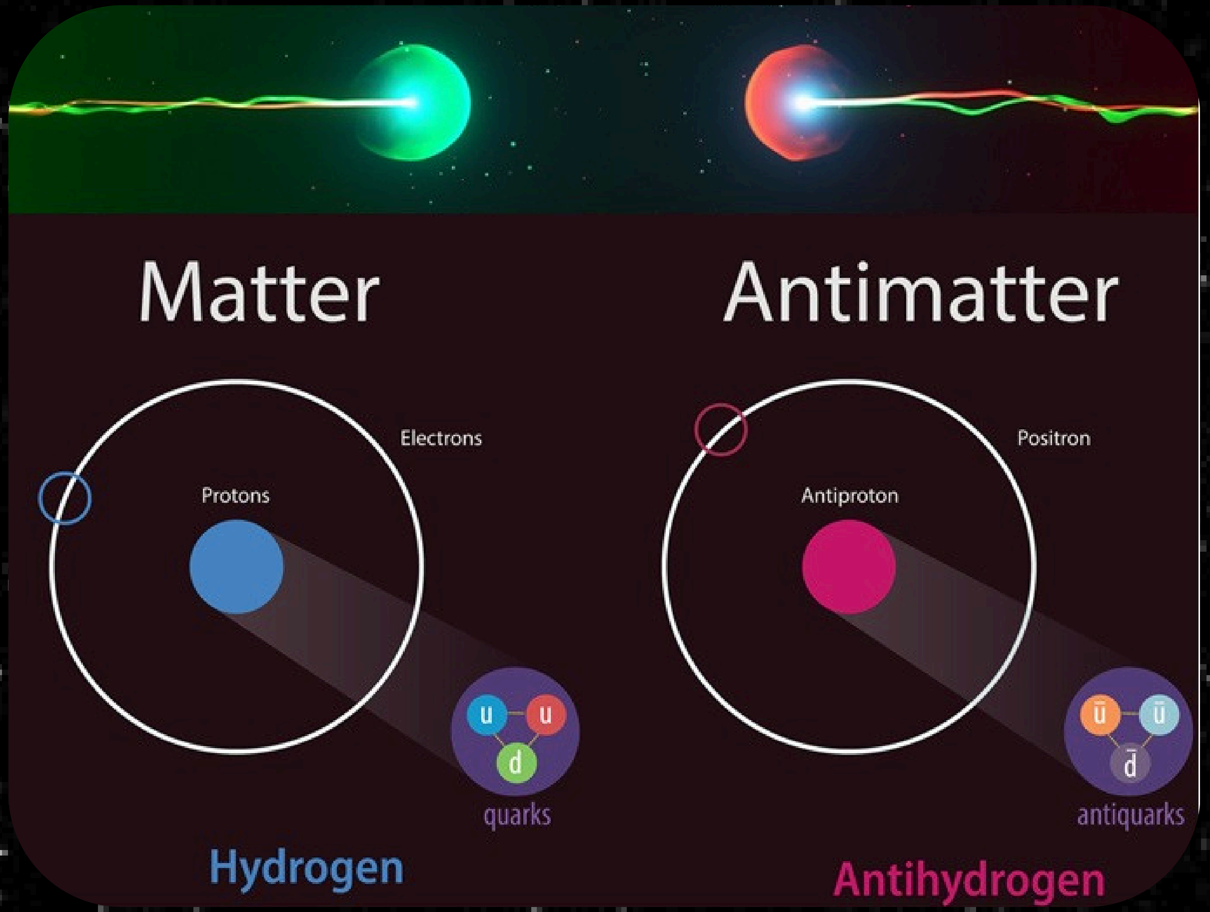
- In 1912, Austrian physicist Victor Hess conducted a series of balloon experiments measuring ionizing radiation at various altitudes.
- Hess discovered that the intensity of radiation increased with altitude, suggesting an extraterrestrial origin.
- This finding led to the term “cosmic rays,” coined by American physicist Robert Millikan in the 1920s.
- Hess received the 1936 Nobel Prize in Physics for his discovery.

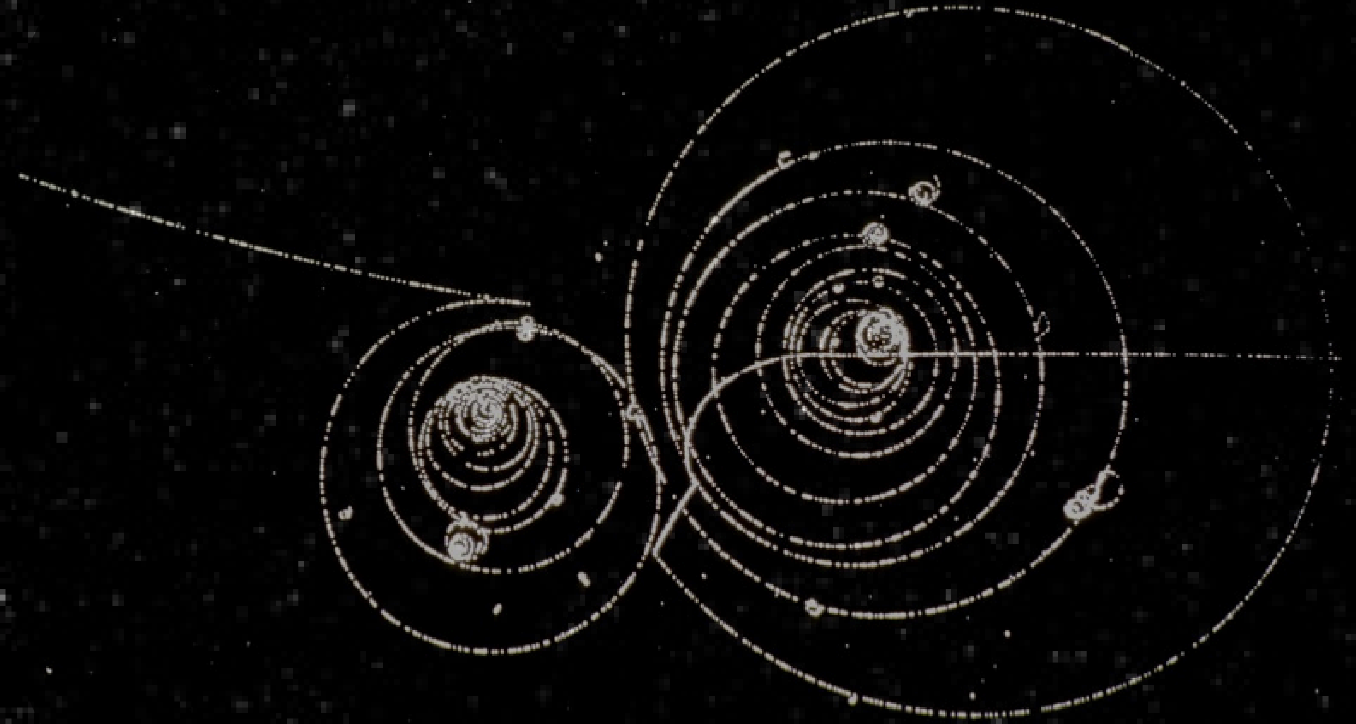


COSMIC RAYS

DISCOVERY OF ANTI MATTER

In 1932, physicist Carl Anderson, while studying cosmic rays, observed a particle in a magnetic field that curved in the opposite direction to an electron but had the same mass. This particle was identified as the positron—the electron's antiparticle—marking the first experimental confirmation of antimatter.





COSMIC RAYS

PRIMARY COSMIC RAYS

The primary cosmic rays, which travel through space before hitting Earth's atmosphere, are composed mostly of protons (~90%), followed by alpha particles or helium nuclei (~9%), and a small fraction (~1%) of heavier nuclei like carbon, oxygen, and iron. Electrons make up about 1%, while antiparticles such as positrons and antiprotons are present only in trace amounts.

SECONDARY COSMIC RAYS

When these primary particles collide with atoms in Earth's atmosphere, they produce secondary cosmic rays. They contain "shower particles" This is known as the CASCADING EFFECT, or a shower.

These include Pions, muons, electrons, positrons, neutrinos, gamma rays, and neutrons. Can travel faster than the speed of light in air (still slower than the speed of light in vacuum).

COSMIC RAYS

- INTRODUCTION
- HISTORY
- DISCOVERY
- COMPOSITION
- TYPES OF TRACK

Cosmic ray tracks in nuclear emulsions can be classified into three main types: fission tracks, galactic cosmic ray tracks, and solar flare tracks. These tracks are distinct due to the different energies and sources of the particles that create them.

1. **FISSION TRACKS:**
   a. These tracks are formed by the fission of heavy nuclei, such as uranium and thorium, found in some materials.
   b. Fission is a process where a nucleus splits into two or more smaller nuclei, releasing energy and neutrons.
   c. Fission tracks are relatively long and have a characteristic shape due to the energy and direction of the fission fragments.
2. **GALACTIC COSMIC RAY TRACKS:**
   a. These tracks are produced by high-energy particles, primarily protons and heavier nuclei, that originate from outside our solar system, including the Milky Way galaxy.
   b. Galactic cosmic rays are accelerated in various astrophysical environments, such as supernova remnants and black holes.
   c. They have a wide range of energies and are characterized by their high speed and penetrating power.

COSMIC RAYS

3. SOLAR FLARE TRACKS:
   a. These tracks are created by energetic particles, mainly protons and alpha particles, emitted during solar flares, which are powerful eruptions on the sun's surface.
   b. Solar flares are associated with intense magnetic activity on the sun and can release high-energy particles into space.
   c. Solar flare tracks are generally shorter and have a lower energy compared to galactic cosmic ray tracks.

In addition to these three main types, there are also:

- **Ultra-high-energy cosmic rays (UHECRs):**

These are the most energetic cosmic rays, thought to originate from outside the Milky Way.

- **Anomalous cosmic rays:**

These are a specific type of solar cosmic ray, characterized by their relatively low energy and composition.

CLOUD CHAMBER

WHAT IS A CLOUD CHAMBER?

- INTRODUCTION
- HISTORY
- TYPES
- WORKING
- TYPES OF TRACK

- A particle detector that makes the invisible tracks of ionizing radiation visible to the naked eye through supersaturated vapor condensation.

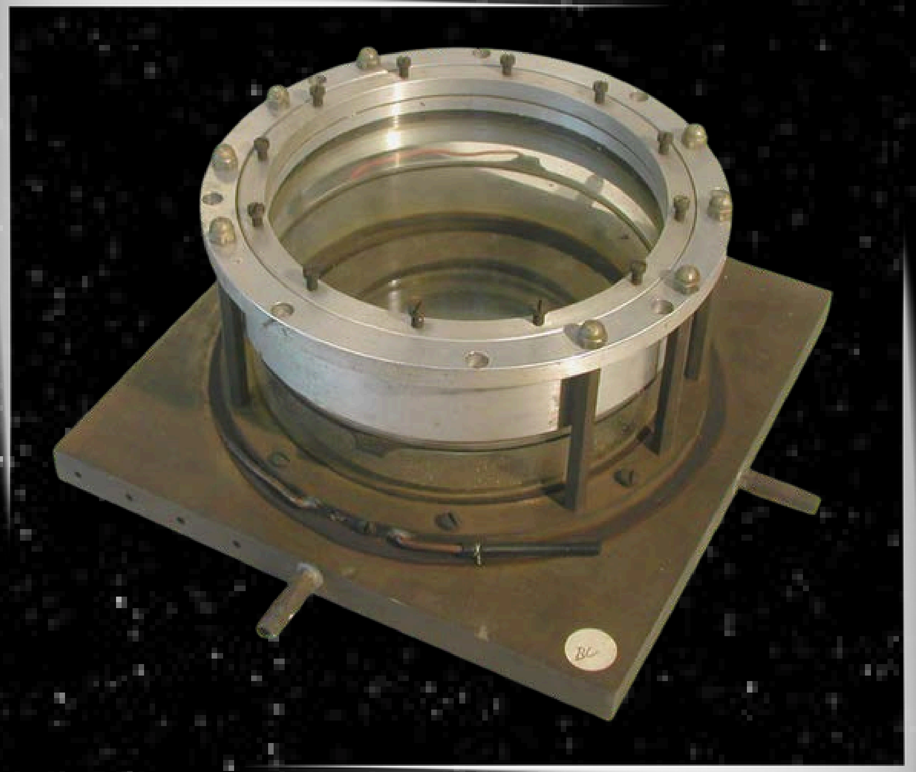
- Visualize cosmic rays, radioactive decay, and other forms of ionizing radiation that constantly pass through our environment. And to analyse the effect of cosmic rays on the human body and atmosphere.

- BASIC PRINCPLE;-Uses supersaturated alcohol vapor that condenses around ions created by charged particles, forming visible droplet trails

CLOUD CHAMBER

CHARLES T.R. WILSON (1911)

Scottish physicist who invented the first cloud chamber while studying cloud formation and optical phenomena in moist air.



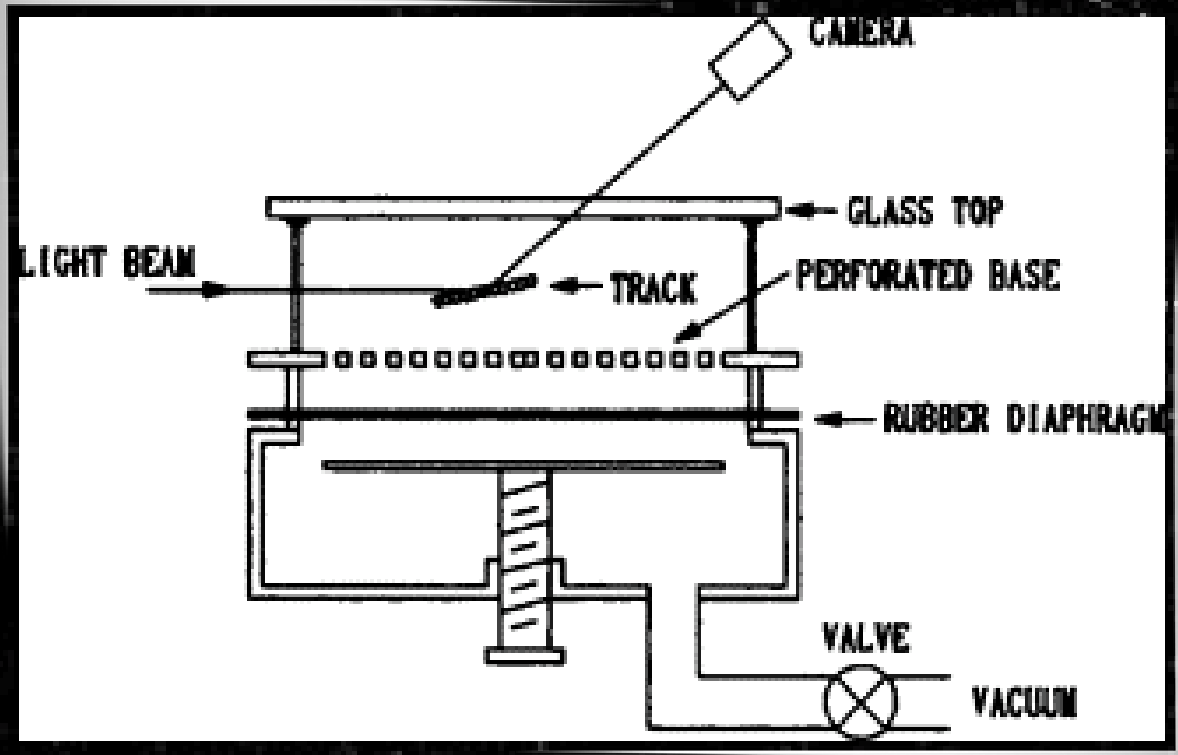
CARL ANDERSON (1932-1936)

American physicist who discovered the positron (1932) and muon (1936) using cloud chambers.

CLOUD CHAMBER

1. Expansion cloud chamber (Wilson cloud chamber)

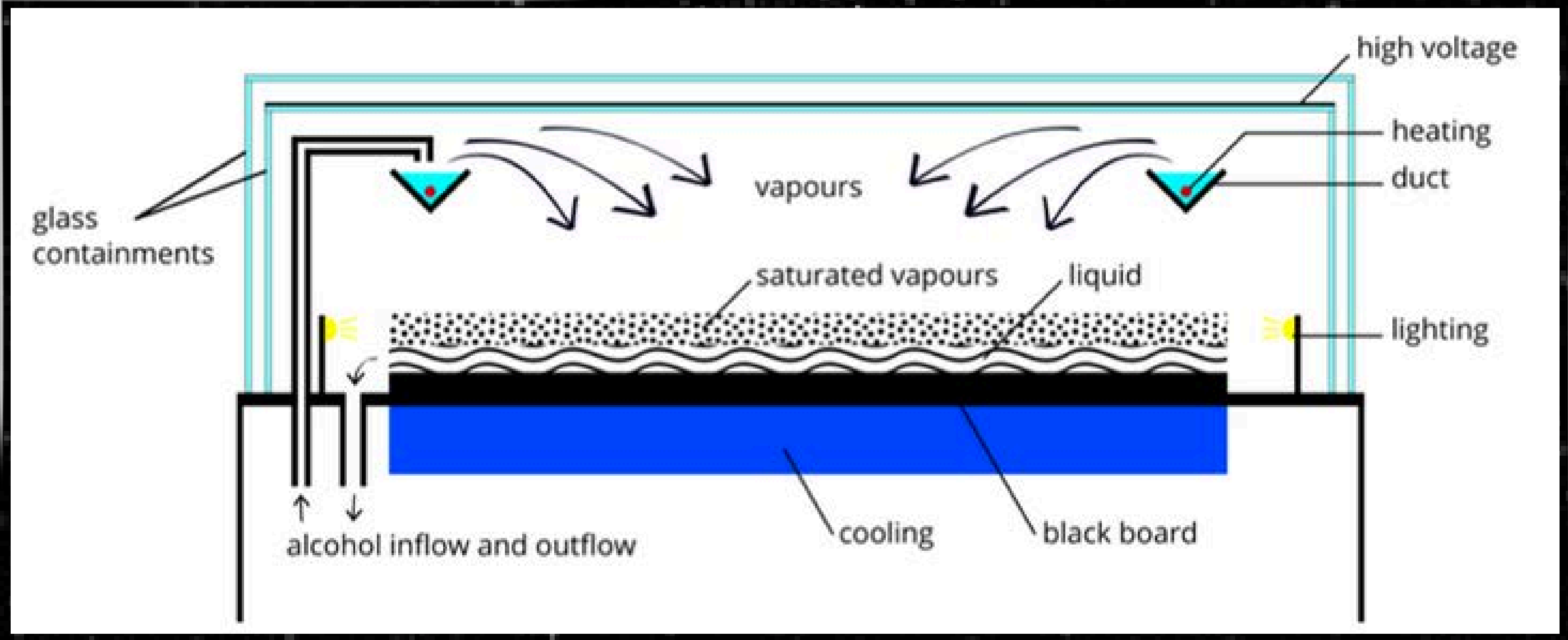
It relies on rapidly changing the pressure within the chamber to create a supersaturated environment. A sudden adiabatic expansion cools the air, causing the vapor to condense around ionized particles.



CLOUD CHAMBER

2. Diffusion cloud chamber

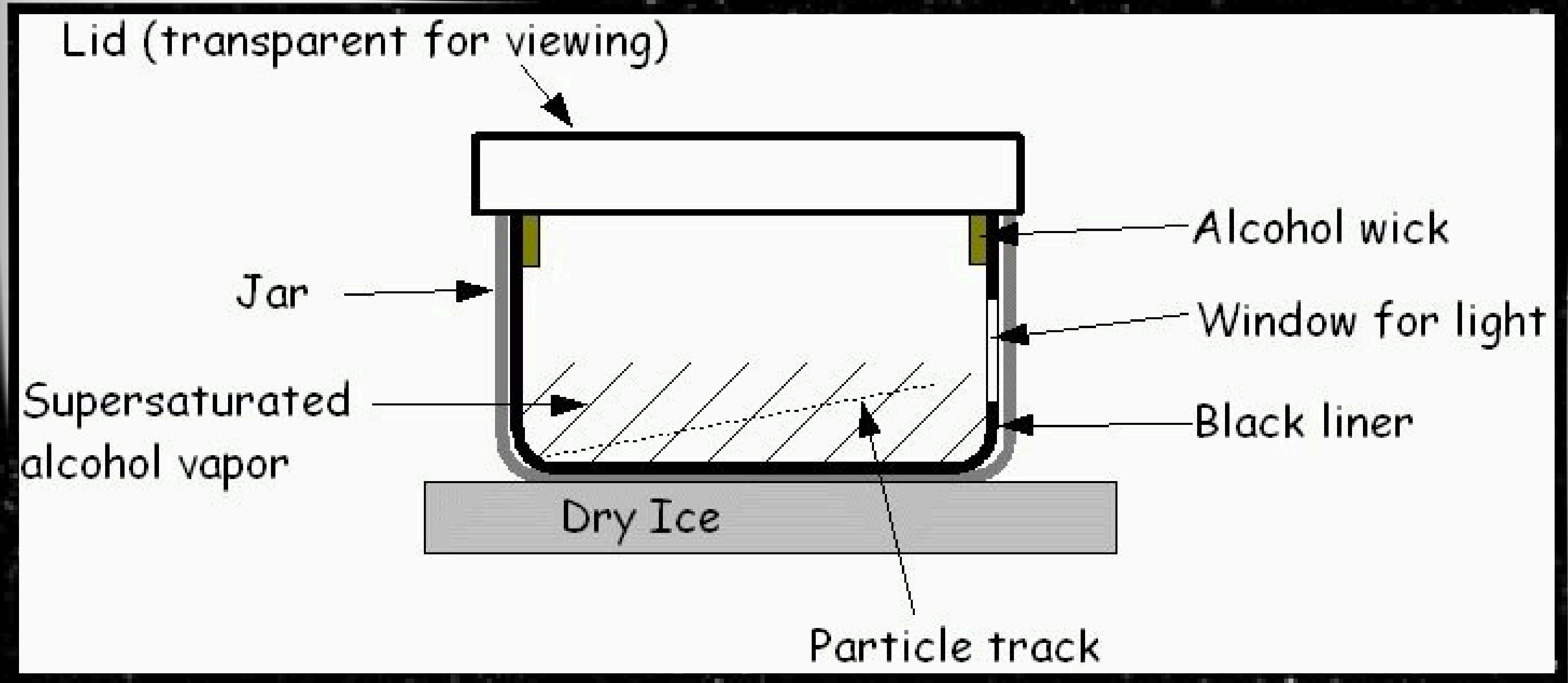
It creates a supersaturated environment by maintaining a temperature gradient, typically with a very cold surface (like dry ice) at the bottom and a warmer top where alcohol evaporates. Alcohol vapor diffuses downwards, becoming supersaturated near the cold plate, allowing for continuous observation of particle tracks.



CLOUD CHAMBER

3. Tronic cloud chamber (Refrigeration cloud chamber)

It's based on the refrigeration principle, where a coolant is circulated through the system to efficiently transfer heat from the region to be cooled



CLOUD CHAMBER

- INTRODUCTION
- HISTORY
- TYPES
- WORKING
- TYPES OF TRACK

1. Evaporation

Isopropanol evaporates from felt at the top, creating alcohol vapor that sinks down due to its higher density than air.

2. Supersaturation

Dry ice cools the bottom, creating a temperature gradient that produces a supersaturated environment near the cold plate.

CLOUD CHAMBER

3. Ionization

Charged particles passing through ionize alcohol molecules, creating positively charged ions along their path.

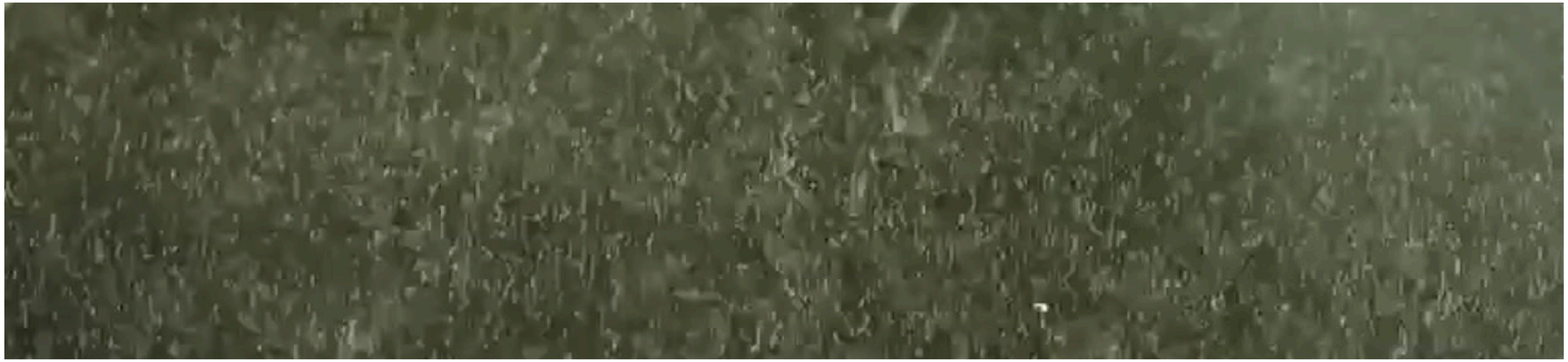
4. Condensation

Alcohol vapor condenses around the ions, forming visible droplets that reveal the particle's track as white trails against a dark background.

CLOUD CHAMBER

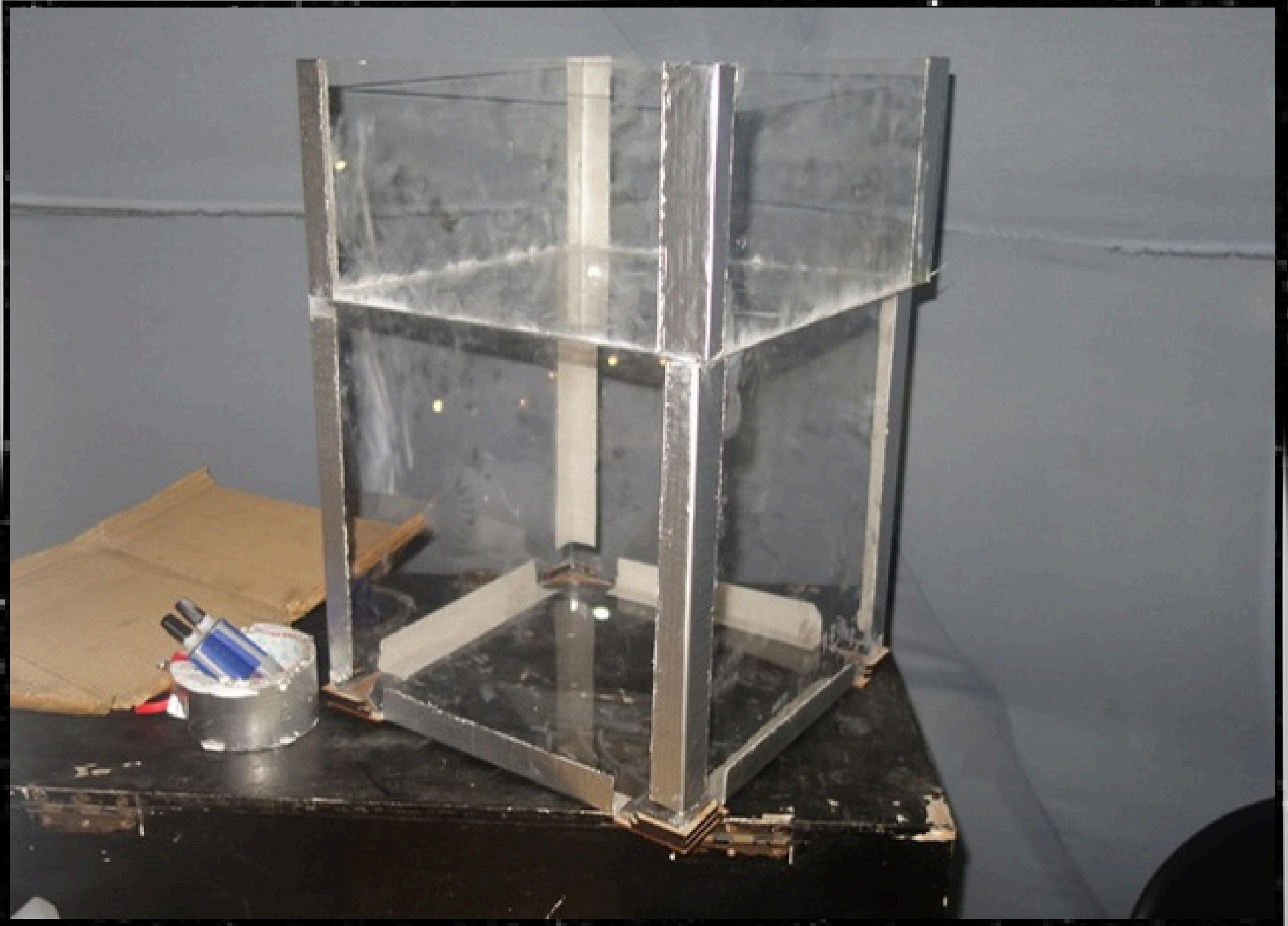
TYPES OF PARTICLE TRACKS

PROPERTY	ALPHA PARTICLE	BETA PARTICLE	MUONS
APPEARANCE	Thick, straight tracks	Thin, curved tracks	Long, straight, penetrating
BEHAVIOR	Heavy particles, minimal scattering	Easily scattered by electromagnetic interaction	Less visible deflection



CLOUD CHAMBER

While constructing



Intermediate Product


THANK YOU