

Gauging a Thundercloud

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Manifest Pedagogy:

Material physics or meteorology may seem as a very deep science topic but UPSC has asked questions in those sections. For example: Higgs Boson and Einstein's theory of relativity. Even though the topics look tougher to digest by the students from Humanities background but they need to remember some key points and keywords.

In news

Ooty's muon detection facility measures the potential of thundercloud

Placing it in the syllabus

Awareness in the field of space

Static dimensions

- What is GRAPES-3?
- What is the Muon particle?
- Structure of cloud

Current dimensions

- Measurement of thundercloud
- Significance of learning about properties of Thunderclouds

Content

What is GRAPES-3 (Gamma Ray Astronomy PeV Energies phase-3)?

It is located at Ooty in India, it started as a **collaboration of the Tata Institute of Fundamental Research, Mumbai, India and the Osaka City University, Osaka, Japan and Nagoya Women's University, Japan.** At present many institutions from India and Japan are in collaboration.

GRAPES-3 is designed **to study cosmic rays with an array of air shower detectors and a large area muon detector.**

Aim

It aims to probe the acceleration of cosmic rays in four astrophysical settings.

Objective of the GRAPES-3 Experiment is to study:

1. The origin, acceleration, and propagation of $>10^{14}$ eV cosmic rays in the galaxy and beyond.
2. Existence of "Knee" in the energy spectrum of cosmic rays.
3. Production and/or acceleration of highest energy ($\sim 10^{20}$ eV) cosmic rays in the universe.
4. Astronomy of multi-TeV γ -rays from neutron stars and other compact objects.
5. Sun the closest astrophysical object, the accelerator of energetic particles and its effects on the Earth.

Structure of cloud

Generally, In their lower side, the clouds have negative charges and in the top they have positive charges or it may have both and it can be several kilometers thick.



Measurement of thundercloud

For the first time in the world, researchers at the GRAPES-3 muon telescope facility in Ooty have measured the electrical potential, size, and height of a thundercloud that passed

overhead on December 1, 2014. At 1.3 gigavolts (GV), this cloud had 10 times higher potential than the previous record in a cloud.

Using GRAPES-3 facility muons were studied to understand thundercloud properties. Muon intensity variation measured was related to thundercloud potential.

Detection of the potentiality of the thundercloud in Ooty

- A record-breaking thunderstorm electric potential of about 1.3 **GV** detected by a telescope in south India's hill resort Ooty has stunned scientists. **The thunderstorm potential – 10 times greater than the largest value ever reported** – has been recorded by the GRAPES-3 Muon Telescope (G3MT)
- From April 2011 to December 2014, the group in GRAPES-3 studied the variation of muon intensity during 184 thunderstorms. In seven events they came across thunderclouds that corresponded to a large change in muon intensity, of above 0.4%. They also simultaneously monitored the profiles of the clouds using four ground-based electric field monitors. Only the cloud that crossed on December 1, 2014, had a profile that was simple enough to simulate.
- Using computer simulation and the observed muon intensity variations, the group worked out the relationship with the electric potential of the cloud.
- **They calculated that the potential of the cloud they were studying was approximately 1.3 GV.** According to the scientists, no one has ever measured the potential, size, and height of a thundercloud simultaneously.

Significance of learning about properties of Thunderclouds

- **It can be useful in the navigation of aircraft and preventing short circuits. This serendipitous discovery might provide the means to making headway in this**

direction.

- The finding may also help researchers explain the mystery of high energy gamma-ray flashes sometimes observed during thunderstorms and first discovered 25 years back.

What is Muon particle?

These elementary particles(similar to electron) are **produced through the interaction of cosmic rays with atoms in the atmosphere.** But they are many times **heavier than the electrons.** **In other words** Muons and other particles are produced when cosmic rays bombard air particles surrounding the earth. It has two forms, the negatively charged muon and its positively charged antiparticle.

Detection of Muon particle

- The muons produced can have positive or negative charge. When a positively charged muon falls through a cloud, it loses energy.
- If its energy falls below 1 Giga electron volt (GeV), which is the **threshold of detection** of the GRAPES-3 muon telescope, it goes undetected.
- On the contrary, a **negatively charged muon gains energy** when falling through the cloud and **gets detected.**
- Since there are more positive than negative muons produced in nature, the two effects don't cancel out, and a net change in intensity is detected.