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Cosmic rays – origin, composition, interactions and applications

This presentation highlights the origin of cosmic radiation, their interactions in the earth's atmosphere, their measurements and their applications. The work by Theodore Wulf and Victor Hess showed increased rates ionization with height above the ground. This observation led to the conclusion that the source of ionization is not from the earth but from space. That marked the discovery of cosmic radiation. Over the years, there has been extensive research work carried out in order to understand cosmic radiation. It is now known that the primary cosmic ray particles comprise of about 85% protons, 12% helium, 3% iron and other heavier elements. These primary cosmic ray particles interact with nuclei in the earth's atmosphere to produce secondary particles such as kaons, pions, neutrons. The kaons and pions decay into muons which further decay into electrons. Neutrinos are produced in these decay processes. Experimental data shows that the all-particle cosmic ray energy spectrum follows a simple power law with a spectral index of about 2.7. However, the value of the spectral index changes at cosmic ray energies of about 10^6 GeV – known as the "knee" region and 10^9 GeV known as the "ankle" region. The bending of the spectrum at the knee region is attributed to the varied energy loses due to the difference in masses of the cosmic ray particles at those energies. Cosmic ray particles with energies beyond 10^9 GeV have been observed by several experiments. These are known as Ultra-High-Energy-Cosmic-Ray (UHECR) particles. The UHECR particles are thought to be of extra-galactic origin. These particles lose a large fraction of their energies when they interact with photons from the Cosmic Microwave Background Radiation (CMBR). This leads to a drastic cut-off on the cosmic ray energy spectrum – known as the Greisen-Zatsepin-Kuzmin (GZK) cut-off. The earth's magnetic field acts as a shield for charged cosmic ray particles. Exposure to cosmic radiation is therefore not only dependent on the altitude but also on the latitude on the earth surface. The dose due to cosmic radiation is minimum around the equator and increases as one moves away from the equator. On the earth surface, cosmic radiation comprises mostly of cosmic ray muons. These cosmic ray muons are useful in imaging large structures like volcanos and pyramids on the earth. They are also useful in security applications and in the nuclear industry. In the field of agricultural science, the flux of cosmic ray neutrons on the earth surface provides a reliable and efficient means of monitoring the moisture content of the soil. The knowledge of cosmic radiation in our earth's atmosphere and on the earth has applications in diverse fields of science and technology in support of our development goals at the national, regional and global levels.

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