Characterizing the "Knee" of High-Energy Cosmic Rays

Using observations made with an array of thousands of particle detectors, researchers have uncovered an important clue about cosmic rays that originate from outside of our Galaxy.

By **Charles Day**

The cosmic rays pummeling Earth's atmosphere are atoms stripped of their electrons and accelerated to high energies. Where and how cosmic rays are accelerated remains uncertain. However, their energy spectrum is clear. The spectrum follows a descending power law that extends from 10^9 eV all the way to 10^{20} eV. One of its most important features is a kink or "knee" at around 4×10^{15} eV (4 PeV), where the slope steepens. Now researchers from the Large High Altitude Air Shower Observatory (LHAASO) in southwest China have produced the most precise characterization of the knee so far [**1**]. The LHAASO findings shed new light on the knee's origin, which has perplexed astronomers and physicists for nearly 70 years.

The LHAASO observations were made using the Square Kilometer Array (KM2A), one of the facility's three experimental setups. KM2A consists of 5216 electromagnetic particle detectors and 1188 muon detectors spread over an area of 1.36 km^2. Together, they capture the subatomic fragments produced when cosmic rays rip apart atoms in Earth's atmosphere. From those captures, researchers can infer the energy and mean mass of the cosmic-ray progenitors.

Credit: LHAASO Collaboration

Thanks to its ability to conduct calorimetric measurements, KM2A is equally sensitive to cosmic rays regardless of their atomic number. This property enabled an accurate measurement of the knee and led to the discovery that the knee coincides with a shift in the mix of cosmic rays—with increasing energy—toward elements with lower atomic number. Cosmic rays above the knee are thought to originate from outside the Galaxy. The finding that they are lighter in mass could help explain their higher energies.

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REFERENCES

1. Z. Cao *et al.* (LHAASO Collaboration), "Measurements of all-particle energy spectrum and mean logarithmic mass of cosmic rays from 0.3 to 30 PeV with LHAASO-KM2A," **Phys. Rev. Lett. 132, 131002 (2024).**