AUGERINFOCUS

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THE ENERGY SPECTRUM OF ULTRA-HIGH ENERGY COSMIC RAYS

The energy spectrum of the Ultra High Energy Cosmic Rays (UHECR) describes quantitatively how the flux of particles depends on the energy. It has been measured at the Pierre Auger Observatory using more than 960,000 events, over an extremely wide energy range, from $6 \cdot 10^{15}$ eV to $2 \cdot 10^{20}$ eV, well above the energy reachable at the largest human-made accelerator, the LHC.

If we represent it as flux multiplied by the third power of energy as a function of energy itself, we can observe some changes of slope.
The energies at which they are observed are generally indicated with names related to the anatomy of a leg:

- A second knee, the energy at which the contribution of galactic cosmic rays is presumed to be complete (there is a first one at lower energy, around 10^{15} eV);
- An ankle, in the energy region where the transition from cosmic rays (CRs) of galactic origin to extragalactic one is thought to take place;
- The instep, observed for the first time in Auger thanks to its huge exposure;
- The suppression region, where the flux strongly drops.

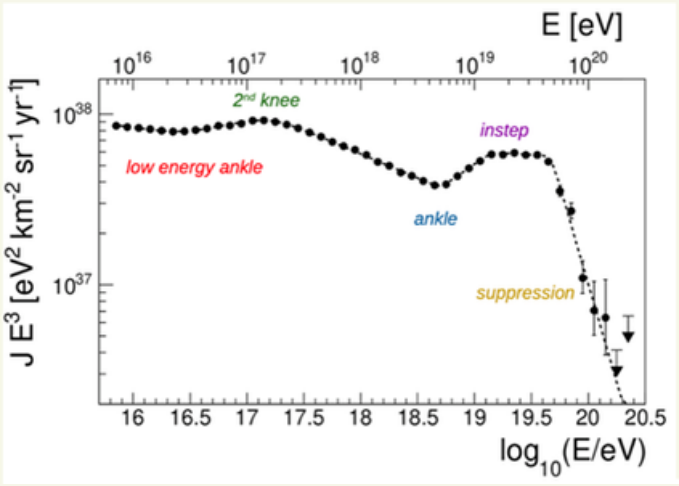

FIGURE 1: THE FLUX OF UHECRS AS A FUNCTION OF ENERGY, MULTIPLIED BY E^3, TO UNDERLINE THE CHANGES OF SLOPE.

FINGERPRINTS OF THE UHECR SOURCES

The structures of the energy spectrum are fingerprints left by the UHECR sources, providing information about how powerful they are, how they can accelerate particles to such extreme energies, how far and common they are.
The energy at which the cut-off of the flux takes place is found to be very low, pointing to an origin of the flux suppression, mostly due to the exhaustion of the sources rather than to propagation effects.

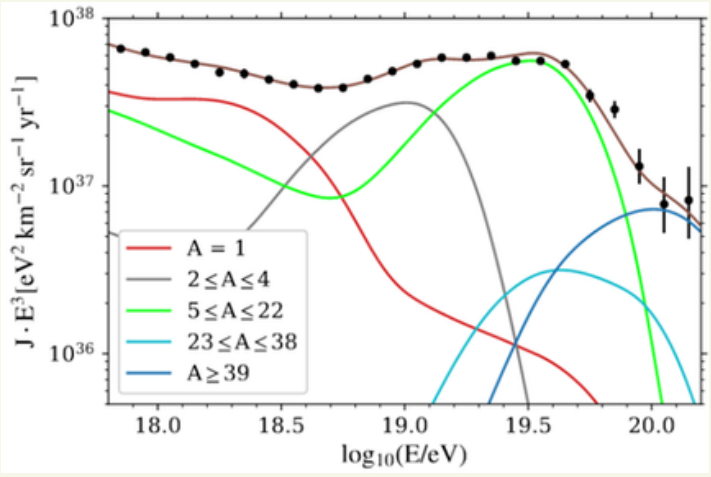

FIGURE 2: PARTIAL CONTRIBUTIONS TO THE ENERGY SPECTRUM AT THE TOP OF THE ATMOSPHERE, GROUPED ACCORDING TO NUCLEAR MASS A.

Under simplified assumptions, considering together the energy spectrum and the X_{max} (the depth at which the shower reaches its maximum, a proxy of the CR mass composition), the spectral changes of slope can be correlated to the evolution of the CR masses, becoming heavier as the energy increases:

- Below the ankle, heavy Galactic CRs fade away and a light extragalactic component takes over;
- In the ankle region, the UHECR composition is intermediate and not light as previously assumed ;
- The instep feature appears to be due to the interplay of the helium and carbon-nitrogen-oxygen components and their secondaries.

Credit: Antonella Castellina

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