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# On the nature of particles that produces extensive air showers with energires greater than 5 EeV

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In the physics of cosmic rays, there has always been a question about the primary particles that generate extensive air showers. This was especially true for particles with highest energies, since it is unclear nature of sources and mechanisms in outer space that produces such particles.

To study the nature of particles with energies greater than 5 EeV, the database of the Yakutsk array was analyzed. The experiment has been operating continuously for 50 years, and during this period, unique material has been collected on the main components of air showers: the electron-photon component, muons, Cherenkov and radio emissions. Showers coming one after the other are highlighted (let's call them "double showers") within a time interval of 1-20 hours. Some periodicity was found in the registration of such showers during the daily observation cycle with an average time of T = 6-8 hours. The characteristics of the selected showers: energy, zenith and azimuthal angles were found to be close in magnitude. Consequently, we can assume the same origin nature of the primary particles that initiate such EASs. The existing discrepancy in the arrival time of showers at the Earth's level can be attributed to the participation in various processes in outer space: the interaction of particles with different charges with galactic magnetic field, acceleration of particles due to the frictional mechanism, followed by re-emission with higher energy, and time delay at the shock front. If this hypothesis is correct, then the analysis of such air shower events will make it possible to obtain information on the processes of interaction of shock waves with the matter of the Universe.

The other possibility is that particles can be produced due to surfing of charged particles on electromagnetic waves, which is one of the main and effective mechanisms for generating jets of ultrarelativistic particles with energies $10^9$-$10^{22}$ eV in cosmic plasma. The other possibility is that the particles can be produced in pairs during the interaction of protons with the cosmic microwave background – the GZK effect. Then one should expect double showers produced by two gamma rays. An analysis of the muon component in these events can provide an answer to this question.

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