

ULTRAHIGH ENERGY COSMIC RAYS: ENERGY LOSSES AND SPECTRA

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The energy losses and spectra of ultra-high energy cosmic rays (UHECRs) are calculated for protons as the primary particles. The attention is given to the energy losses due to electron-positron pair production in the collisions with the microwave 2.73 K photons. The spectra are calculated for several models, which differ by production spectra and by the source distribution, namely:

- (i) uniform distribution of the sources with the steep generation spectra with indices $2.4 - 2.7$ with cosmological evolution of the sources and without it. In this case it is possible to fit the observational data up to 10^{20} eV .
- (ii) uniform distribution of the sources with flat generation spectrum dE/E^2 . This case is relevant for GRBs and results are in disagreement with observed spectrum.
- (ii) the case with local enhancement of the sources with the radius of the enhancement region $10 - 30 \text{ Mpc}$ and with overdensity factor from 3 to 100 . The overdensity factor larger than 30 is needed for eliminating the GZK cutoff.