IL NUOVO CIMENTO VOL. XIII, N. 2 16 Luglio 1959

On the Radiation of Mesons with a Constant Transverse Momentum P_T in Cosmic Ray Jets (*).

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(ricevuto l'11 Maggio 1959)

Several authors (1-3) observed that in high energy nuclear interactions ($E \geqslant 1000$ GeV) mesons are produced with a constant transverse momentum $P_T \simeq 0.4$ GeV, and that $p = P_T/\sin\varphi$, where P is the momentum of the meson emitted at direction φ with respect to the primary. The momentum spectrum of produced mesons is $\mathrm{d}P/p^2$.

The purpose of this note is to point out the resemblance of this observation to the Čerenkov Radiation.

Let us assume that the primary particle, when traversing nuclear matter, induces mesonic waves along its path, with an amplitude $\exp[i\,n\,k\,r]$. Where k is the wave number of the meson and n its refraction index describing its nuclear interaction. The condition for constructive interference of the mesonic waves is $n = \cos\varphi$. Now, according to the optical model n is a complex number connected to the forward scattering amplitude $f(0)$ by the relation

$$n^2 = 1 + \frac{4\pi\nu f(0)}{k^2},$$

(ν is the density of scattering centers). In order to obtain a radiation law with constant transverse momentum $p = P_T/\sin\varphi$, $f(0)$ must be a real negative number independent of k. This means that the complex processes of production and absorption of the highly interacting mesonic waves, that propagate along the primary path, may be described by a constant real scattering amplitude $f(0)$.

In this case, we shall write

$$-4\pi\nu f(0) = k_T^2,$$

and

$$n^2 = 1 - \frac{k_T^2}{k^2} = \cos^2\varphi \text{ or } p = \frac{P_T}{\sin\varphi},$$

$$(p = \hbar k);$$

(*) This work has been sponsored in part by the Geophysics Research Directorate of the Air Force Cambridge Research Center, Air Research and Development command, United States Air Force under contract AF61(052)-58 through the European Office ARDC.

(1) S. HASEGAWA, J. NISHIMURA and Y. NISHIMURA: *Nuovo Cimento*, **6**, 979 (1957).

(2) B. EDWARDS, J. LOSTY, D. H. PERKINS, K. PINKAU and J. REYNOLDS: *Phil. Mag.*, **3**, 237 (1958).

(3) P. CIOK, T. COGHEN, J. GIERULA, R. HOLYNSKI, A. JURAK, M. MIĘSOWICZ, T. SANIEWSKA and J. PERNEGR: *Nuovo Cimento*, **41**, 741 (1958).

which is the condition for radiating mesons with a constant transverse momentum p_T.

Similar results are obtained by attributing to mesons of the mesonic cloud an effective mass $M_{\text{eff}} = p_T/c$.

If we carry even further the analogy with Čerenkov radiation, the energy of the emitted radiation is $\sin^2 \varphi \, dE$. Using the relation $\varphi = p_T/p$ for mesons emitted at small angles, one finds a momentum spectrum dp/p^2 in good agreement with the observations of EDWARDS *et al.* (2) and HASEGAWA *et al.* (1).

This model predicts that at very high energy meson multiplicity is independent of primary energy, and increases slowly with nucleus size, as $A^{\frac{1}{3}}$.