ON TOTAL CROSS SECTIONS AND SLOPES AT SUPERHIGH ENERGIES

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ABSTRACT

Hadron-hadron and hadron-nucleus interactions are investigated in the framework of the Reggeon field theory with critical and supercritical pomerons and multiple scattering theory. A good agreement is obtained with experimental data on cross sections of proton-proton and proton-nucleus interactions at high energies.

The theory with the renormgroup critical pomeron (RCP) ($\alpha_P(0) \equiv 1$) is compared with the supercritical one ($\alpha_P = 1+\Delta$) - froissarton. The theory with RCP is considered in detail in /1/, and with froissarton - in /2/, therefore, we will present here the basic results only.

In fig.1 total cross sections of pp-interaction at energies E_{LAB} from 10 to 10^{12} GeV are presented. Both models describe well the region of mean and high energies and practically coincide up to $\xi \lesssim 15$. The cross section given by RCP is presented in the figure by a coarse line. At mean values of energies it grows like ξ^2, at $\xi > 15$ the rate of growth gradually slows down and turns into asymptotic $\sim \xi^{0.277}$.

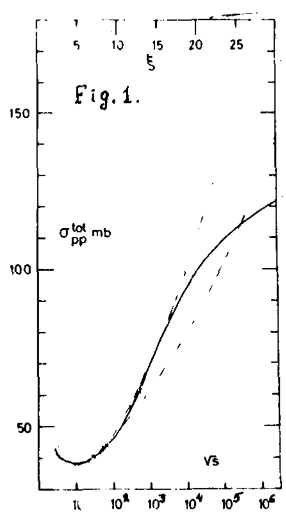
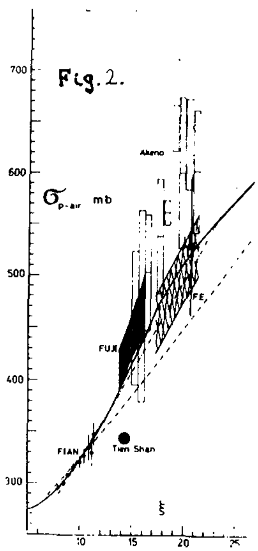
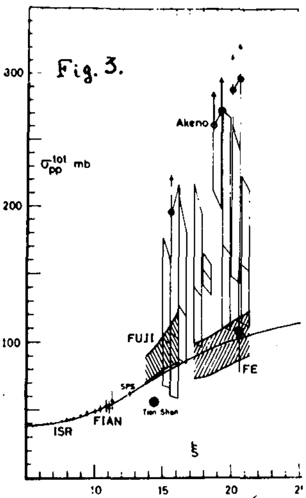


Fig.1. Total cross section of pp-interaction σ^{tot}_{p-air}

The cross section given by the froissarton is presented by thin lines. The upper line corresponds to $\Delta = 0.12$, and the lower one to $\Delta = 0.07$. The cross section with $\Delta = 0.12$ rapidly grows from the very beginning and at $\xi \geqslant 15$ begins to exceed the RCP and passes to its asymptotic regime $\sim \xi^2$. It is seen that σ_{pp}^{tot} cannot serve as a test for separating a correct model.





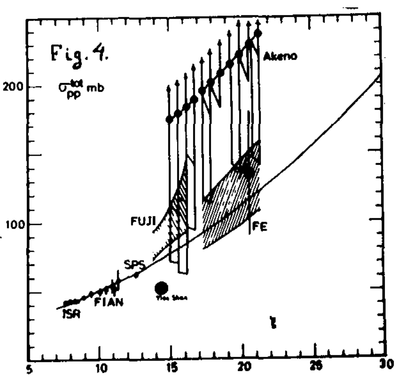


Fig.2. Production cross section on the nuclei of air atoms σ_{p-air}^{prod} in theories with critical and supercritical pomerons (—— RCP, —·— froissarton).

Fig.3. Total cross section of pp-scattering in the theory with a critical pomeron.

Fig.4. Total cross section of pp-scattering in the theory with a supercritical pomeron.

In fig.2 theoretical curves are presented that describe the production cross section on nuclei of air atoms in the two theories considered (the calculation technique of the hadron-nucleus interaction characteristics is presented in /1/). The coarse curve corresponds to RCP, and the dot-and-dash curves to the supercritical pomeron with $\Delta = 0.07$ and 0.12. The curve corresponding to the froissarton lays systematically lower than RCP in the range $15 < \xi < 25$.

In figs. 3 and 4 total cross sections of pp-interactions in both theories as well as results of the pp cross sections extraction from experimental data on proton-nucleus interaction at cosmic energies are presented. The rings with arrows denote the values of separated points that lay above the unitarity limit for the given theory. It should be noted that according to /1/ the cross-section values σ^{prod}_{p-air} depend essentially on the slopes of diffraction cone of the pp-interaction predicted by the given theory. It is clear that experiments with cosmic rays require a more rapid growth of slopes than the one which may be given by both theories. The theory with RCP seems preferable.

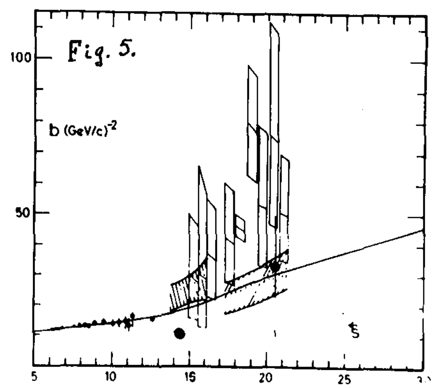


Fig.5. Slope of the diffraction cone of pp-scattering in the theory with a critical pomeron.

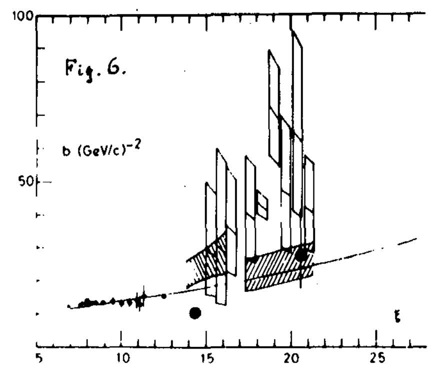


Fig.6. Slope of the diffraction cone of pp-scattering in the theory with a supercritical pomeron.

In figs. 5 and 6 diffraction cone slopes in RCP and froissarton theories are presented. The experimental data presented were extracted proceeding from the fixed cross sections of the elementary act in the given theory and are conventional, nevertheless, they indicate a necessity in a more rapid growth of slopes as compared with the theoretical one.

In fig.7 the ratio σ^{el}/σ^{tot} is presented. This value is crucial for the revelation of the question, which of these two theories is consistent at superhigh energies. In the RCP theory this ratio at $S \to \infty$ behaves like $\xi^{-0.862}$. In the froissarton theory we have $\sigma^{el}/\sigma^{tot} \to 1/2$. However, in the region of attainable energies we have an inverse picture: up to $\xi \lesssim 17$ σ^{el} and σ^{el}/σ^{tot} in RCP grow much more rapidly than in the froissarton, after which the RCP begins to slowly fall, and the froissarton continues to grow.

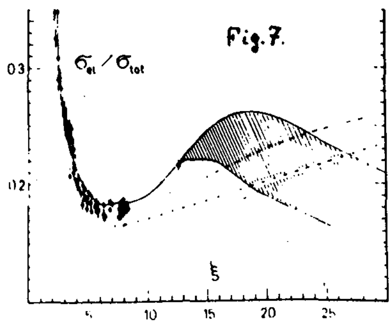


Fig. 7. Ratio σ^{el}/σ^{tot}
(—— RCP,
——·—— froissarton).

Summing up the abovementioned, one may state that even at ultracosmic energies it is apparently impossible to obtain an unambiguous answer to the question: which of these theories is consistent at superhigh energies?

REFERENCES

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