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Energy dependence of cross sections in proton-proton and antiproton-proton collisions

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Energy dependence of cross sections, mostly total and elastic, is studied for proton-proton and antiproton-proton collisions. Particularly, the range of very high collision energies larger or about 10 TeV is considered. The interest to that energy domain is driven by the following reasons. The large-scale projects of hadronic colliders of next generation assume the measurements for proton-proton interactions at collision energies about 100 TeV in order to magnitude. Phenomenological study of cross sections as one the most important global quantities for (anti)proton-proton scattering at very high collision energies can be helpful for search for the onset of the asymptotic regime in energy dependence of cross sections and related parameters as well as for the establish of more precision and mathematically rigorous criteria for asymptotic domain. Exploration of discussed dependence is promising tool for future developments in the physics of cosmic rays. Data samples included all available high-energy measurements up to date are analyzed for (anti)proton-proton collisions in order to derive analytic forms of energy dependence for total cross section as well as for the ratio of the elastic-to-total cross sections within various models. In the case of total cross section the set of approximation functions under consideration consists of equations within axiomatic quantum field theory [1], model with multiple reggeon exchange [2] and semiclassical approach with saturation [3], which admits the phenomenon of bosonic condensation. Also analytic functions [4] are used for approximation of the experimental energy dependence of the ratio of the elastic-to-total cross sections in (anti)proton-proton interactions. Most of model dependencies of total cross section on collision energy show the behavior close to the Froissart–Martin limit in functional sense. On the basis of the resulting approximations, the total cross section and the ratio of the elastic-to-total cross sections for proton-proton collisions are estimated at various collision energies up to an ultra high values about of 10 PeV in order of magnitude. In general, Bose–Einstein condensation (BEC) can provide the noticeable growth of multiplicity of secondary pions at sufficiently high energies [5] which can affect the behavior of cross sections. Thus, perhaps, BEC can be suggested as one of the possible dynamical mechanisms which may lead to some novel feature in energy dependence of cross sections. The investigation of bosonic condensation will shed new light on the nature of superfluidity of strongly interacting matter which can influence on the ratio of cross sections mentioned above. Studying the possible BEC effect on the pion yield may be one of the perspective research directions for better understanding of the muon enhancement in ultra-high energy cosmic ray (UHECR) measurements [5]. Therefore phenomenological studies of energy behavior of cross sections for (anti)proton-proton interactions, in particular, in collision energy domain of 100 TeV and even up to 10 PeV in order of magnitude are important for various fields of fundamental physics and these investigations have large interdisciplinary value. References [1] S. D. Campos, V. A. Okorokov, Int. J. Mod. Phys. A 25, 5333 (2010); V. A. Okorokov, S. D. Campos, ibid 32, 1750175 (2017). [2] V. A. Petrov, V. A. Okorokov, Int. J. Mod. Phys. A 33, 1850077 (2018). [3] V. A. Okorokov, Phys. At. Nucl. 81, 508 (2018). [4] V. A. Okorokov, Phys. At. Nucl. 82, 134 (2019). [5] V. A. Okorokov, Phys. At. Nucl. 87, 172 (2024).

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