An Analysis of Mean Charged Multiplicity for Proton-Proton and Proton-Antiproton Collisions

Hardik P. Trivedi[1], Pallavi Bhatt[1], Anil Kumar[1&2]*, Lalit K. Gupta[3], Jai Prakash Gupta[4], and Arhcana Kansal[5]
[1]Department of Physics, Mewar University, Gangrar Chittorgarh (Rajasthan) – 312 901, INDIA
[2]Deptartment of Applied Science, Vivekananda College of Technology & Management, Aligarh – 202 002, INDIA
[3]Deptartment of Applied Science, Krishna Engineering College, Ghaziabad – 201 007, INDIA
[4]Department of Physics, D. S. College, Aligarh (UP) – 202 001, INDIA
[5]Department of Physics, ITM University, Gwalior (Madhya Pradesh) - INDIA
* email: akguptaphysics@gmail.com

Introduction

During last several years, the Hadron-Hadron and Hadron-Nucleus interactions have been attracting considerable attention of high energy physicists. In the field of high energy physics, the mean charged Hadron multiplicity has been an important phenomenological parameter to study the properties of particle production. During last few decades, a considerable amount of the data on mean charged multiplicities has become available at high energies [1-3]. And the theoretical studies of energy dependence of charged multiplicity could discriminate among the different theoretical models of particle production.

The concept of multiplicity arises from the production in the inelastic events of interaction process. To predict the experimental data, several authors [1-4] have proposed different parameterizations and fittings of charged multiplicity as a function of centre of mass (c.m.) energy (√s). At high energies, the concept of secondary production reveals, that the number of relativistic charged particles, produced in any collision, increases as the incoming beam energy increases. A comparatives slow increasement in the charged multiplicity is also found, with the increasement in the size of target nucleus. Such an increase in the multiplicity occurs only in the central region of the rapidity space of particle production and it is believed that quarks and gluons should play an important role in the process of particle production in the central region. The available data [1-3] on multiplicities as a function of energy indicates that at high energies, the mean charged multiplicity $\langle n_{ch} \rangle$ in different Hadron-Hadron collisions (p-p, p-$\bar{p}$, $\pi^+ p$ etc.) tends to become independent of the type and the charge of the incident and target particles. This behavior of $\langle n_{ch} \rangle$ seems to be valid also at lower energies and also for photon-Hadron, lepton-Hadron and lepton-lepton collisions. Thus it would seem that the entire mean charged multiplicities will follow a universal curve.

Present Parameterization

An analysis of the available data on mean charged multiplicity has been considered, in the present work, with a view to finding whether, the mean charged multiplicity $\langle n_{ch} \rangle$ data can be parameterized low as well as at high values of the energy, by the same parameterization.

(i) Each term may explain the related physical concept or phenomena of interaction process. For it, we have considered that all the parameters A, B and C should be energy dependent so that they may be consistent with the associated phenomenology.

(ii) Any regular feature of mean charged multiplicity $\langle n_{ch} \rangle$ as a function of c.m. energy may be inferred.

In the present work, an attempt is made to modify the earlier parameterization {$\langle n_{ch} \rangle$ = A + B ln s C (ln s) ^{2}} on the basis of some phenomenological concepts. The various terms of the present parameterization have their own identity and may express the contribution of particular type of interaction process. To predict the experimental data, the value of the parameter A is considered to be constant, but the values of the parameters B and C are considered to be variable, depending upon some other factors, based on the concerned interaction process. The present parameterization for mean charged multiplicity in Hadron-Hadron interaction has the following form,

$< n_{ch} >_{hh}$ = A + B ln $\sqrt{S_A}$ + C (ln $\sqrt{S_A}$)^2

Here $\sqrt{S_A}$ represents the available centre of mass energy (i.e. $\sqrt{S_A}$ = $\sqrt{S}$ - m_p – m_t), $\sqrt{S}$ the centre of mass energy, m_p the mass of projectile and m_t the mass of target nucleus. The values of the parameters A, B and C are considered on the basis of interaction process. The different terms of the above equation signifies their individual contribution, viz. the first term {i.e. A} gives the mean charged multiplicity {$\langle n_{ch} \rangle$}, even at threshold energy of particle production in hadronic interaction {i.e. 1GeV}. Since the particle production in any interaction is the result of the formation of quark-gluon plasma and this state is found near 1GeV interaction energy, therefore the minimum charged multiplicity, in charged hadronic interactions may be two. The second term {i.e. B ln $\sqrt{S_A}$ } represents the contribution due to direct interaction process. The value of parameter B is considered, in this work, to be dependent on the ratio ρ of the real to the imaginary part of the coulomb amplitude, which is related with the total and scattering cross-section as $\rho = \frac{\sigma_{tot.}}{\sigma_{el.}}$ and is energy dependent. The parameter B is related with ρ by the relation B = (1+ ρ). The various values of ρ at different c.m. energies may be obtained by its above relation with $\sigma_{tot.}$ and $\sigma_{el.}$ for proton-proton and proton-antiproton interactions. And finally the third term {i.e. C (ln $\sqrt{S_A}$)^2} gives the contribution due to fire-ball formalism in the interaction process. The value of parameter C is considered, in the present work, to be dependent on the absorption coefficient α_s as C = $\frac{4\alpha_s}{3\pi}$ = 0.4246 α_s where π = 3.14 also α_s = (1- α) where α is inelastic coefficient and has different values at different incident energies. The different parameters are supposed to have their origins from QCD. For the various values of α at different c.m. energies, we have used our earlier work to obtain the different values of the parameter C.

Figure

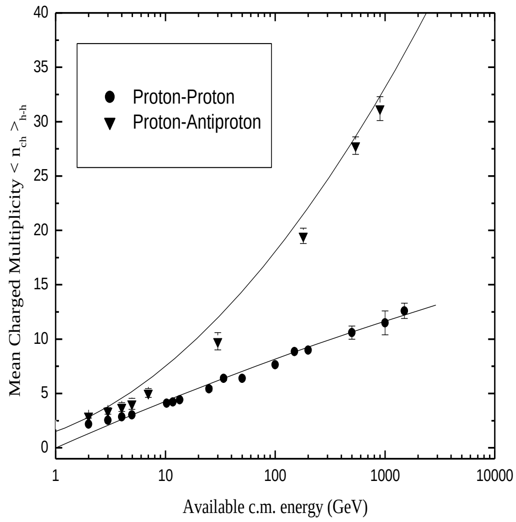

Fig. Variation of mean charged multiplicity $< n_{ch} >_{pp}$ and $< n_{ch} >_{p\bar{p}}$ as a function of energy $(\sqrt{S})$.

Result

(i) The present parameterization of mean charged multiplicity $\langle n_{ch} \rangle$in Hadron-Hadron interactions provides simple and unambiguous results, which are in well consistent with experimental data for the entire range of incident energy.

(ii) The present parameterization is capable of explaining the mean charged multiplicity even at threshold c.m. energy (i.e. 1.0 GeV). It may be 2, one for projectile Hadron and one for target Hadron.

References

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