Calculation of Mean Charged Multiplicity in Hadron-Hadron Interactions

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Introduction

During last several years, the Hadron-Hadron [1-2] and Hadron-Nucleus [3-4] 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. And the theoretical studies of energy dependence of charged multiplicity could discriminate among the different theoretical models of particle production.

Different authors have given different fittings [1-5] for multiplicity, produced in Hadron-Hadron and Hadron-Nucleus collisions. But there is a large discrepancy in different fittings. In the present work, an attempt has been made to analyses the experimental observations on mean charged multiplicity at various energies for Hadron-Hadron interactions. Different parameterizations proposed by different authors, have been studied and an efforts is done to modify the earlier parameterization. The values of different parameters have been fixed on the basis of some unambiguous phenomenon. The present parameterization has been used to calculate the mean charged multiplicity as a function of incident c.m. energy for proton-proton and proton-antiproton interactions.

Earlier Parameterization

To predict the experimental data, different authors have given different fittings, depending upon the c.m. ($\sqrt{s}$). In experimental studies of particle production in Hadron-Hadron interactions, some following general features have been considered,

a) Limited transverse momentum of the secondary's.
b) Leading particle effect i.e. the incident Hadron retains on an average half of its initial energy.
c) Slow increase in the multiplicities of produces particles, consisting mainly of pions, with increase in energy and these are on an average 2/3 charged and 1/3 neutral particles in the final state.
d) The multiplicity depends on the centre of mass energy.

Some models predict, at asymptotic energies, an energy dependence of mean charged multiplicity $\langle n_{ch} \rangle$ of the 'ln s' type and the others, a dependence faster than 'ln s' or power dependence on 'ln s' and 's', also more specifically,

i) The Cheng-wu model gives $\langle n_{ch} \rangle \sim S^B$ i.e. $\langle n_{ch} \rangle = A\, S^B$
with $A = 1.42 \pm 0.01$, $B = 0.28 \pm 0.01$
ii) The multiperipheral model and the Mueller-Ragge analysis predict
$\langle n_{ch} \rangle \sim \ln s$ i.e. $\langle n_{ch} \rangle = A + B \ln s$;
$A = -0.67 \pm .04$, $B = 1.32 \pm 0.01$
iii) The Thermo dynamical model predict an energy dependent multiplicity faster than 'ln s' i.e. $\langle n_{ch} \rangle = A + B (\ln s)^2$; $A = 1.73 \pm 0.02$, $B = 0.17 \pm 0.01$ and $\langle n_{ch} \rangle = A + B + C (\ln s)^2$; $A = 1.73 \pm 0.02$, $B = 0.17 \pm 0.01$ and $C = 0.13 \pm 0.01$
iv) Fermi's old statistical model and Belenjki and Landau's Hydrodynamical model predict that $\langle n_{ch} \rangle = A + B \ln s + C\, S^{-1/2}$; with $A = -4.55 \pm 0.20$, $B = 1.99 \pm 0.04$ and $C = 8.16 \pm 0.42$

Present Parameterization

In the present work, an attempt is made to modify the earlier parameterization [6, 7]

$\{\langle n_{ch} \rangle = A + B \ln s\ C (\ln s)^2\}$

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 [8, 9],

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

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.

Result and Discussion

The mean charged multiplicities $< n_{ch} >_{pp}$ and $< n_{ch} >_{p\bar{p}}$ for proton-proton and proton-antiproton interactions respectively are calculated in this work, at different energies, using present parameterization. Various values of $< n_{ch} >_{pp}$ and $< n_{ch} >_{p\bar{p}}$ at different c.m. energy are given in the Table 1 and Table 2 along with the corresponding experimental data. As a function of incident energy for proton-proton interactions, the available energy has been calculated by the subtraction of rest mass energy of the projectile and target protons {i.e. $\sqrt{S_A} = \sqrt{S} - 1.862$} GeV. But in the case of proton-antiproton interactions, due to the annihilation of proton and antiproton, their rest mass energy is also included in the available energy, and hence in the case of p-$\bar{p}$, the subtraction of 1.862 GeV (the rest mass energy of target and projectile) from the total energy is not required. These mean charged multiplicities are plotted in the Fig.1.

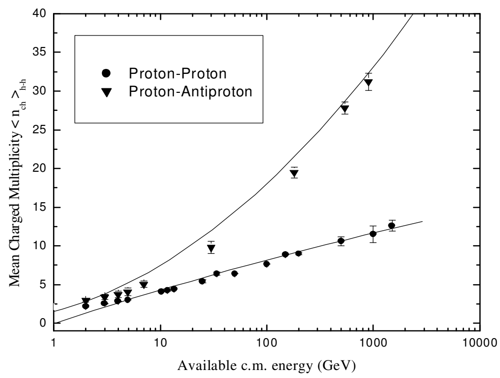
Table 1: Mean Charged Multiplicity at different c.m. energies in the case of p – p interactions.

($\sqrt{S}$) GeV	$< n_{ch} >_{pp}$ (Cal.)	$< n_{ch} >_{pp}$ (Exp.)
4.95	3.04	3.24 ± 0.003
10.25	4.40	4.22 ± 0.004
13.5	4.88	4.41 ± 0.004
25	5.84	5.35 ± 0.11
50	6.93	6.36 ± 0.06
100	8.05	7.64 ± 0.17
150	8.85	8.86 ± 0.16
500	10.95	10.60 ± 0.60
1000	11.84	----
1500	12.08	12.60 ± 0.70

Table 2: Mean Charged Multiplicity at different c.m. energies in the case of p - $\bar{p}$ interactions.

($\sqrt{S}$) GeV	$< n_{ch} >_{p\bar{p}}$ (Cal.)	$< n_{ch} >_{p\bar{p}}$ (Exp.)
2	2.92	2.9 ± 0.20
3	3.70	3.4 ± 0.30
5	4.82	4.05 ± 0.50
30	10.59	9.8 ± 0.80
50	12.84	----
100	16.26	----
180	19.73	19.5 ± 0.70
540	26.59	27.8 ± 0.80
900	28.32	31.2 ± 1.10
1500	31.80	----

Fig.1: Variation of mean charged multiplicity $< n_{ch} >_{pp}$ and $< n_{ch} >_{p\bar{p}}$ as a function of energy ($\sqrt{S}$). The curve shows the present work.



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