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A new approach to calculate mean charged multiplicity for hadron - hadron interactions upto 8 TeV

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Past studies based on energy dependence parameters such as mean charged multiplicity compares with different proposed theoretical models to discriminate models of multi-particle production in hadron – hadron interactions. In the recent studies based on theoretical framework, attempts have been made by various researchers to analyze recorded data on mean charged multiplicities at centre of mass energy ($\sqrt{s}$) in GeV of hadron - hadron nteractions for the case of proton - proton interactions and an addition to this attempt has been made to modifies the earlier parameterizations using modified values of parameters under the study. These parameters are selected on the basis of some unambiguous phenomenon. In the present research study, the mean charged multiplicity has been calculated at different energies range for proton – proton interactions ranging between 2 GeV to 8000 GeV in hadron – hadron interactions and the result is found to be good agreement with the recent experiment data available.

Keywords: Mean charged multiplicity, Proton - proton, Hadron - hadron, Multi-particle production

1 Introduction

Last two or three decayed; the nuclear collisions at relativistic energy offer the right kind of environment to explore a variety of phases transitions related to hot and dense nuclear matter to enhance our existing knowledge about the formation and decay of highly excited nuclear matter. The compression of nuclear matter and its subsequent expansion result in production of particles along with the disassembly of the expanded nuclear system into multi particle production which is related to the state of quark gluon plasma (QGP) so that it is predicted by quantum chromo dynamics (QCD)[1].

The paper entitled “A new approach to calculate mean charged multiplicity for hadron - hadron interactions up to 8 TeV” reviews the facts and problems concerning the multi particle productions in high energy collisions. Main emphasis is laid on the qualitative and quantitative description of general characteristics and properties observed for multi particle production in such high energy collisions. Various features of available experimental data including the variations of mean charged multiplicity with centre-of-mass (cm) energies and the collisions centrality obtained from heavy ion collider experiments are interpreted in the context of various theoretical concepts and their implications. Several important scaling features observed in the measurements mainly at RHIC, LHC and CERN experiments are highlighted in the view of these models to draw some insight regarding the multi particle production mechanism in heavy ion collisions[1,2].

The concept of mean charged multiplicity arises from the multi particle production in the inelastic events of interaction process. To predict the experimental data, several authors[3-7] have proposed different parameterizations and fittings of mean charged multiplicity as a function of centre mass (cm) energy ($\sqrt{s}$). From the study of multiplicity a comparatives slow increasement in the mean charged multiplicity is also found, with the increment 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 gluons plasma (QGP) should play an important role in the process of multi particle production in the central region. The behavior mean charged multiplicity $\langle n_{ch} \rangle$ seems to be valid at lower energies and also seems that the entire mean charged multiplicities will follow a universal curve.

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Different authors have given different fittings[4-6] for mean charged multiplicity in the case of hadron - hadron collisions. In the present research paper, an attempt has been made to analyze the experimental observations, on mean charged multiplicity at energies ranging 2 GeV to 8000 GeV, (i.e., 8 TeV) for hadron - hadron collisions and also an effort is done to modify the earlier parameterization[6-11]. The values of different parameters have been fixed on the basis of some unambiguous phenomenon. In this recent study we calculate the mean charged multiplicity as a function of incident cm energy for proton - proton interactions.

2 Earlier Parameterization

To predict the experimental data, several authors[4-6] have given different fittings which were depending upon the cm energy. In the experimental study of particle production the case of hadron - hadron interactions, some following general features have been considered,

(i) limited transverse momenta (P_T) of the secondary, (ii) leading particle effect, (iii) slow increment in the multiplicities of particle production and (iv) the mean multiplicity depends on the centre of mass energy.

3 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, (i) the mean charged multiplicity $\langle n_{ch}\rangle_{pp}$ data can be parameterized low as well as high values of the energy by the same parameterization and (ii) each term may explain the related physical concept of interaction process. For it we have considered that all the parameters A, B, C, and D should be energy dependent so that they may be consistent with associated phenomenology.

In the present work, an attempt is made to modify the earlier parameterization:

$$\langle n_{ch}\rangle_{pp} = A + B\, ln\,\sqrt{S} + C\,\left(ln\,\sqrt{S}\right)^2 + D\,\left(ln\,\sqrt{S}\right)^3$$

4 Calculations

In the present paper, the calculation of mean charged multiplicity for proton-proton interactions is based on the given formula in the form as:

$$\langle n_{ch}\rangle_{pp} = A + B\, ln\,\sqrt{S} + C\,\left(ln\,\sqrt{S}\right)^2 + D\,\left(ln\,\sqrt{S}\right)^3$$

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 and parameter D are 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. Various calculated values of mean charged multiplicity at different cm energy are given in the Table 1 along with the corresponding experimental data.

The value of parameter B is considered, in this present work, to be dependent on the ratio ρ of the real to the imaginary part of the coulomb amplitude. The value of parameter C is considered, in the present work, to be dependent on the absorption coefficient α_s. The different parameters are supposed to have their origins from Quantum chromo dynamics (QCD). For the various values of α at different cm energies, we have used our earlier work to obtain the different values of the parameter C.

Graph shows the variation of mean charged multiplicity as a function of cm energy. The curve shows the present work. The experimental data has been taken from literature[3,4,8].

5 Results and Discussion

The mean charged multiplicities $\langle n_{ch}\rangle_{pp}$ for proton-proton interactions is calculated in this present work, at different energies using present parameterization. Various values of $\langle n_{ch}\rangle_{pp}$ at different cm energy are given in the Table 1 and these mean charged multiplicities are plotted in the Fig. 1. The energy range to calculate $\langle n_{ch}\rangle_{pp}$ for proton-proton interaction is considered between 2.0 GeV to 8000 GeV. In the case of proton-proton interactions, a slow increasement in $\langle n_{ch}\rangle_{pp}$ are found as the incident energy increases. The results of the present parameterization are well in consistent with the

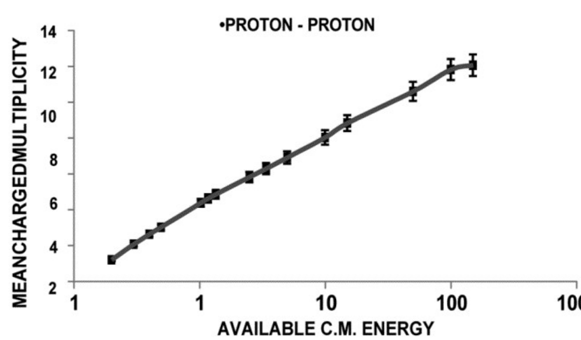

Fig. 1 – Variation of mean charged multiplicity $\langle n_{ch}\rangle_{pp}$ as a function of available cm energy (GeV). The curve shows the present work.

Table 1 – Mean charged multiplicity $\langle n_{ch} \rangle_{pp}$ at different cm energy in the proton – proton interactions. Here A = 2 and D = 0.01 but parameter B and C are calculated as a function of cm energy.

$\sqrt{S}$ In GeV	Parameter (B)	Parameter (C)	$\langle n_{ch} \rangle_{pp}$ (Present work)	$\langle n_{ch} \rangle_{pp}$ (Experimental)
2	0.73	0.17	2.59	2.18 ± 0.09
3	0.74	0.16	3.01	2.54 ± 0.03
3.08	0.74	0.16	3.04	2.54 ± 0.03
3.5	0.74	0.16	3.19	2.71 ± 0.01
3.65	0.74	0.16	3.25	2.94 ± 0.03
3.78	0.74	0.16	3.29	2.85 ± 0.03
4	0.74	0.16	3.36	2.85 ± 0.03
4.53	0.74	0.16	3.51	3.24 ± 0.03
4.93	0.74	0.16	3.62	3.43 ± 0.03
5.64	0.76	0.15	3.81	3.92 ± 0.11
5.97	0.76	0.15	3.89	3.91 ± 0.06
6.12	0.78	0.15	3.96	4.02 ± 0.02
6.3	0.78	0.15	4.00	4.10 ± 0.04
6.43	0.78	0.15	4.03	4.11 ± 0.06
6.63	0.78	0.15	4.07	4.22 ± 0.0
6.84	0.78	0.15	4.12	4.23 ± 0.15
6.85	0.78	0.15	4.13	4.31 ± 0.06
7.24	0.79	0.15	4.22	4.41 ± 0.04
7.36	0.79	0.15	4.24	4.46 ± 0.04
7.42	0.79	0.15	4.27	4.37 ± 0.07
7.43	0.79	0.15	4.27	4.41 ± 0.04
8.21	0.82	0.15	4.48	4.46 ± 0.04
9.78	0.83	0.15	4.73	4.37 ± 0.07
10.25	0.83	0.14	4.81	4.52 ± 0.07
11.5	0.86	0.13	5.02	5.89 ± 0.07
11.7	0.86	0.13	5.04	6.22 ± 0.04
13.8	0.858	0.12	5.25	6.49 ± 0.10
13.9	0.88	0.12	5.26	6.32 ± 0.07
19.4	0.92	0.12	5.90	7.64 ± 0.17
19.6	0.92	0.12	5.97	7.68 ± 0.07
21.7	0.92	0.11	6.16	8.80 ± 1.9
23.3	0.93	0.11	6.33	9.24 ± 0.92
23.7	0.93	0.11	6.36	9.00 ± 1
23.9	0.94	0.11	6.40	8.50 ± 0.12
25	0.97	0.08	6.28	8.42 ± 0.2
25.7	0.97	0.08	6.33	8.99 ± 0.14
31.8	0.97	0.08	6.67	10.1 ± 1
33.95	1	0.07	6.87	6.4 ± 0.2
50	1.04	0.06	7.58	6.4 ± 0.60
100	1.09	0.05	9.05	7.65 ± 0.17
152	1.13	0.05	10.29	12.5 ± 3.0
200	1.13	0.04	10.69	8.99 ± 0.14
500	1.13	0.04	13.09	10.6 ± 0.6
900	0.84	0.04	12.70	11.8 ± 0.4
1000	0.84	0.04	12.99	11.5 ± 1.1
1500	0.841	0.029	13.59	12.6 ± 0.7
2760	0.838	0.021	14.92	14.2 ± 0.7
7000	0.834	0.012	17.26	17.5 ± 0.6
8000	0.833	0.012	17.70	17.8 ± 1.1

experimental data. A slight deviation of experimental data from the proposed fitting is due to some experimental errors.

6 Conclusions

On the basis of our analysis and calculations in the present paper, we conclude that:

(i) the different models, proposed by different physicists, have their own identities, and are found to be capable of explaining the hadronic collisions. But it is found that the Quark-Parton model is most capable of explaining the different types of interaction processes of hadron-hadron interactions,

(ii) an attempt is made to modify the parameterization of mean charged multiplicity $< n_{ch} >_{pp}$ in proton-proton interactions. The modified form of our parameterization provides batter agreement with experimental data as compared to the earlier parameterizations and

(iii) the calculated values of mean charged multiplicity ($< n_{ch} >_{pp}$) at different energies ranging between 1.0 GeV and 8000 GeV, are in good agreement with corresponding experimental results and is found to be slightly energy dependent, but not completely independent of energy.

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