A STUDY OF PROTON-PROTON INTERACTIONS AT HIGH ENERGIES

THESIS

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SUMMARY

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The present work deals with a theoretical study of proton-proton interactions at high energies (from a few Gev to around 2000 Gev incident energy) in the framework of a parton two-fireball model based on an impact parameter analysis. The objective of the study is to derive a variety of pp interaction features and compare the predictions of the model with experimental data from accelerators to check the validity of the model.

For this purpose, some average characteristics of the pp interaction have been derived and include the interaction cross-sections, inelasticity and multiparticle production features such as mean multiplicity, topological cross-sections and multiplicity dispersion.

A preliminary analysis without specifying the emission distribution of secondary pairs of particles yields the following results :

(1) The model predicts a general increase of inelastic cross-section with energy . in qualitative agreement with observation. Also, the ratios of elastic/total and inelastic/total cross-sections generally agree with observations at high energies.

(2) The total inelasticity exhibits a nearly constant behaviour at high energies, in agreement with experiment.

(3) The mean charged multiplicity shows an asymptotic behaviour with lab energy, $\langle n_{ch} \rangle \sim E_L^{\frac{1}{2}}$. At low energies there is an agreement with observations, but there are deviations at high energies.

(4) The calculated multiplicity dispersion agrees well with observations for $E_L \geqslant 50$ Gev but not at lower energies.

To improve the predictions a binomial distribution for particle emission is introduced in the calculations of charged particles. The results obtained are as follows:

(1) The calculated topological cross-sections for charged secondaries become in good agreement with observations both in the shapes of the charged pair distributions and in the dependence on incident energy.

(2) Better agreement is obtained with regard to inelasticity and mean charged multiplicity.

(3) The predictions exhibit KNO scaling in topological cross-section at high energies which is in accordance with observations.

(4) Better agreement is obtained in multiplicity dispersion which exhibits a constant value of 2 at high energies.

Two other variants of the model have also been investigated which relate to a pion energy in the fireball C.M.S. being linearly dependent on multiplicity and an enhancement is the ratio of neutral/charged secondaries. Both variants proved to be unlikely in the form of the model.

Finally, the pseudo-rapidity distributions of secondaries have been derived with the following results:

(1) The central region particle density increases with energy in accordance with observations.

(2) The distributions exhibit the central plateau and fall-off regions with rapidity as observed experimentally . However, the distributions are generally narrower than those observed particularly at high energies.

The above study indicates that the frame of a parton two-fireball model is generally adequate to describe pp interactions at high energies. Although some predicted features are not in agreement with observations ,the model generally predicts many of the characteristics of multiparticle production in pp collisions.Further improvements of the model are suggested.

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INTRODUCTION

INTRODUCTION

High energy physics treats mainly the innermost structure of matter. Therefore, it is a logical development of the ways of scientific thinking which were initiated by the Greek philosophers. Investigations on the subnuclear level demand the high energies which follow from the uncertainty principle. This uncertainty principle is the location of the study of matter within very small distances. It needs illumination with radiation of the highest possible frequency and energy. Therefore, experiments in this fields are carried out with giant particle accelerations which have now reached energies of the order of 10^4 Gev.

There is no wonder then that high energy physics proper has its foundation in experiments with cosmic rays, which contain nuclear particles with energies higher than the biggest present accelerators.

One of the fundamental interactions in high energy physics is the proton-proton interaction particularly above the threshold of pion production. The history of studies of this interaction is therefore very long and extremely interesting from both the experimental and theoretical pionts of view. Although the detailed dynamics of that fundamental interaction are not yet solved, yet in recent years QCD theory proved to be quite promising. The essential feature of this theory is that protons are not elementary particles but consist . of quarks and glouns which interact through the color field inside the proton. Hence the pp interaction is essentially a collective interaction.

The basic ideas which supported the QCD theory led to the consideration of the proton as a collection of point-like particles called partons, which can be identified with quarks and gluons. Parton models of pp interaction are therefore very promising.

The present work deals essentially with a theoretical study of pp interactions at high energies in the framework of a parton two-fireball model based on an impact parameter analysis. The aim of the study is to derive a variety of pp interaction features and compare the predictions of the model with observations from accelerators to check the validity of the model.

The thesis is divided into four chapters. In the first chapter, a review of the essential features of pp interactions is made as observed experimentally as well as of the various classes of theoretical models put forward to explain these features. In the second chapter, we state the basic assumptions of the parton two-fireball model and develop its basic features using an impact parameter analysis. From this treatment, some general characteristics of the pp interaction are derived including the cross-sections, inelasticity and multiplicity of produced secondaries. In the third chapter, we investigate the predictions of the model for the various features of the interaction and derive more characteristics including the topological cross-sections, multiplicity distributions and multiplicity dispersion in multiparticle production. These features are compared with experiment for various variants of the model.

In the fourth and final chapter, we present a theoretical treatment by which we derive the pseudorapidity distributions of secondaries in the centre-of-mass system and compare the model predictions with experiment .

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CHAPTER [1]