Density Fluctuation and Correlation Study of Multiparticle Production in ^{28}Si-Ag/Br Interaction at 14.5A GeV

ABSTRACT

The present thesis is written on the basis of some results obtained from the physics analysis of local densities and cluster formation of singly charged particles produced in ^{28}Si-Ag/Br interaction at an incident energy in the laboratory system E_{lab} = 14.5A GeV. We systematically compare the experimental results with those obtained from a set of simulated data. A nuclear transport model namely the Ultra-relativistic Quantum Molecular Dynamics (UrQMD) is used for the simulation purpose. In addition a charge reassignment algorithm that mimics the Bose-Einstein Correlation (BEC) between identical mesons, considered to be primarily responsible for local cluster formation, has been implemented to the UrQMD output as an after burner. On a few occasions similar data on ^{32}S-Ag/Br interaction at E_{lab} = 200A GeV have also been used for comparison purposes.

In **Chapter One** we review various issues related to high-energy nucleus-nucleus (AB) interaction, the main objective of which is to subject the nuclear matter to extreme thermodynamic conditions, so that one can create and characterize a color conducting extended QCD state like the Quark-gluon Plasma (QGP). The global scenario of high-energy heavy-ion experiments (past, present and future) is summarized. The kinematic variables required to describe various features of AB collision are introduced. Our present understanding of the spacetime evolution of AB collision are described. General features of QGP like its thermodynamics, its hydrodynamics, the QCD phase diagram, and the observables that are capable of diagnosing the formation of a QGP-like state are summarily outlined. Several Monte Carlo simulation methods commonly used to model high-energy AB collisions are briefly described. Finally, some statistical techniques employed to investigate multiparticle distribution are highlighted, with a special reference to the characterization of local fluctuations in particle number density. In **Chapter Two** the experimental aspects of the present investigation along with the simulation methods adopted are outlined. Salient features of nuclear photographic emulsion technique and the data collection process are summarily discussed. Gross features of the experimental and the simulated data samples on ^{28}Si-Ag/Br interaction at E_{lab} = 14.5A GeV are presented.

Chapter Three presents an intermittency analysis on spatial fluctuations of the shower track density function in ^{28}Si-Ag/Br interaction at E_{lab} = 14.5A GeV. The experimental results are compared with the UrQMD simulation, with the UrQMD+BEC simulation, and on occasions with the results available from similar other experiments. Our analysis on the scaled factorial moments shows that small but significant nonstatistical components in the fluctuations are present in the experimentally obtained particle densities that are self-similar in one-dimension (i.e., either in η or in φ), and self-affine in two-dimensions (η, φ). The factorial correlator, factorial cumulant and oscillatory moments are also determined. In most cases however, the UrQMD simulation fails to replicate the experiment, while inclusion of Bose-Einstein correlation in the UrQMD could recover only partially the difference between experiment and simulation. Event-by-event fluctuation study of factorial moments in the pseudorapidity space has been presented in **Chapter Four** in terms of erraticity moments for ^{28}Si-Ag/Br interaction at $E_{\rm lab}$ = 14.5A GeV. The erraticity parameters are extracted by analyzing the experimental data and two sets of simulated data. To check the noise level present in the experiment as well as in the simulations, we perform the same analysis for a set of purely random number generated events. The erraticity moments for all four data samples used in the analysis follow similar scaling-laws with phase space resolution size. Values of erraticity parameters suggest that the event-space fluctuation of factorial moments as predicted by the UrQMD and UrQMD+BEC models are closer to the experiment than their random number generated counterpart. The multifractal structure of the pseudorapidity density distribution of singly charged particles produced in ^{28}Si-Ag/Br interaction at $E_{\rm lab}$ = 14.5A GeV is presented **Chapter Five**. Four different statistical techniques are used for this purpose. We observe that widely fluctuating density values that apparently lack any definite pattern, can be described in terms of a finite set of regularly behaving multifractal parameters. The analysis confirms the existence of a multifractal structure in the experimental as well as in the simulated data. We also observe that the differences between experiment and simulation, however large or small that may be, depend on the technique of analysis used.

In **Chapter Six** we look for unusual azimuthal structures of particle distribution within the framework of Cherenkov gluon emission and/or Mach shock wave formation in the nuclear/partonic medium. Shower track emission data of ^{28}Si-Ag/Br interaction at 14.5A GeV and ^{32}S-Ag/Br interaction at 200A GeV are used. Presence of unusual azimuthal structure in the data is established with respect to the model simulations. Our analysis confirms the presence of 'jet-like' structures in the central collisions for both interactions. As expected such structures are more pronounced in the ^{32}S data than in the ^{28}Si data. A continuous wavelet analysis is performed in **Chapter Seven** for pattern recognition of shower track emission data of ^{28}Si-Ag/Br interaction at 14.5A GeV and ^{32}S-Ag/Br interaction at 200A GeV. Making use of the event wise local maxima present in the scalograms, we try to identify the collective behavior in multiparticle production, if there is any. Statistically significant difference between the experiment and the simulation can be interpreted only in terms of some hitherto unknown dynamics of multiparticle production. We have also performed a collective flow analysis of our ^{28}Si-Ag/Br data and compared the results obtained thereof with those of ^{84}Kr-Ag/Br interaction at $E_{\rm lab}$ = 1.52A GeV. Evidences of collective flow are found from both the data, of which ^{84}Kr-Ag/Br behave more systematically. However, to fulfill our university norm, in stead of making a separate chapter, a reprint of our published paper on this work has been attached at the end. The thesis concludes with a critical and analysis of our results that would help us better understand the underlying physics of multiparticle production at the collision energy range/colliding system(s) under consideration.