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Study of Fractality and Chaoticity in ^{28}Si+Emusion Collisions at Energy 14.6A GeV

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Abstract An approach has been made to study the fractality and chaotic behaviour of relativistic charge particles produced in the collisions of ^{28}Si beam (projectile) + nuclear emulsion (fixed target) at an energy (14.6 × 28) ≈ 409 GeV by using new parameters named as entropy index, μ_q. The distributions of Scaled Factorial Moments (SFMs) are measured and referred a scaling behaviour which supported to chaoticity or spatial fluctuations in relativistic heavy-ion collisions at high energies. The values of entropy indices (μ_q) are calculated which indicates the chaotic nature of multiparticle production system with a specific self-similar structure. Finally, the present experimental results have been compared with the predictions of Ultra-relativistic Quantum Molecular Dynamics (UrQMD) model and find a good agreement between the experimental and theoretical data.

Keywords Dynamical fluctuations, Fractality and chaoticity, Nuclear emulsions experiment

1. Introduction

The interest in the study of high-energy nuclear matter has increased many folds due to the possibility of studying unstable states of nuclear matter under extreme condition of high energy density and high temperature. Physicists are very keen to see its outcomes as they expect that it would throw its flashes towards the evolution of the universe and deconfined state of freely interacting quarks and gluons known as quark-gluon plasma (QGP) [1-3], which is believed to have existed in the form of QGP for few microseconds after the Big Bang. It is also interesting to study about the strong forces present between the quarks and gluons in the hadronic matters. It is believed that shortly after the creation of the Big Bang all matters were in a state called the QGP. Due to rapid expansion of the universe, this plasma went through a phase transition to form large number of hadrons like pions, protons and neutrons etc. Such a new phase of matter might be produced experimentally in heavy ion collisions at ultra-relativistic energies. A variety of possible signatures for the transient existence of a deconfined state of matter in nucleus-nucleus (A-A) collision has been proposed theoretically and studied experimentally by various workers [4,5]. The experimental observation of large rapidity fluctuations [6] has provided interest and excitement about their nature and origin. Bialas and Peschanski [7] have suggested that a power law scaling behaviour of normalized SFMs $(<F_q> \propto M^{\alpha_q})$ on the bin size and described the phenomenon as "intermittency", a term coined from hydrodynamic turbulence [8]. The SFMs method cannot only predicts the existence of large non-statistical fluctuations but it could also investigate the pattern of fluctuations and their origin.

It is generally believed that through the heavy ion collisions at ultra-relativistic energies big systems with very high energy density [9] might be produced. In these systems novel phenomena, such as colour deconfinement [10], chiral-symmetry restoration [11], discrete-symmetry spontaneous-breaking [12], etc., are expected to be present and different events might be governed by different dynamics. In recent, the event-by-event (E-by-E) studies of multiplicity fluctuations in high-energy collisions have much more attraction and also give more attention to recognize the dynamics of multiparticle production [13]. As it is already stated before that, the power law dependence of SFMs referred to as the intermittency [7,8] has been extensively used to investigate fluctuations and chaos in multiparticle production in high-energy hadronic and heavy-ion nucleus-nucleus collisions [14,15]. On the basis of E-by-E the values of scaled factorial moments, F_q^e, are envisaged to help disentangle some interesting and very much useful informations about the chaotic behaviour of multiparticle production. A few moments of F_q^e distribution, for example, the normalized moments $C_{p,q}$ are likely to serve the purpose. If $C_{p,q}$ shows a power law behaviour then such behaviour is referred to as erraticity [16,17]. It may be

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