Investigation of entropy generation in relativistic heavy ion collisions

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Introduction

The properties of strongly interacting matter at extreme conditions (temperature and density),known as quark gluon plasma(QGP) has been an intense area of research over the last two decades[1, 2]. This has lead to continuous experimentation and theoretical evolution. The information about this hot and dense state of matter is not easily accessible as the life-time of this state is very small $\approx 10^{-22}$ seconds[3]. One of the promising candidates which provides a window of information about this state of matter is the entropy[4] growing rapidly during the initial stage of collision. Actually the main pupose of heavy-ion collisions is to look for the formation of QGP.

Entropy is supposed to increase during the first stage of collision because of the release of new degrees of freedom namely color[5]. Since in the deconfined phase, the color degree of freedom is melted[6], the specific entropy per baryon in the deconfined phase is greater than that in the confined phase. Thus entropy increases and once an entropy rich state is formed, the final entropy content of the hadronic particles should exceed the initial entropy of the thermalized state.

The present investigation is based on a sample run of 530 events of inteactions produced by 4.5AGeV/c ^{28}Si nuclei from synchrophasotron(Dubna). In each of the interaction the charged secondaries were recorded which include the shower particles, target recoiled proton, target evaporated fragment and projectile fragments[2, 7]. The mean multiplicities of various types of charged secondaries that have been produced in these interactions are presented in TABLE I.

TABLE I: Mean multiplicities of the various types of particles produced in the interactions.

	4.5A GeV/c		
Type of interaction	$< n_b >$	$< n_g >$	$< n_s >$
Si-Em	6.22±0.22	8.43±0.15	13.26±0.45
Si-CNO	2.93±0.07	1.53±0.06	10.82±0.48
Si-AgBr	13.31±0.30	7.38±0.30	20.54±0.82

Applying the emulsion terminology[7], the particles emitted from high energy nucleus-emulsion interactions are as follows;

1. *Black track particle* n_b: These represent the target evaporated fragments. Ionisation $I > 9I_0$, where I_0 is the minimum ionisation of a singly charged particle. Range of the particles is $R < 3mm$, with relative velocities $\beta < 0.3$. Total multiplicity is denoted by n_b.

2. *Grey track particle* n_g: These include recoiling protons. Their ionisation is $1.4I_0 \leq I \leq 9I_0$.Range of these particles is $R > 3mm$ and their relative velocities lie within $0.3 \leq \beta \leq 0.7$. Total multiplicity is denoted by n_g.

3. *Shower track particle* n_s: These are singly-charged relativistic particles mostly pions. Their ionisation is $I \leq 1.4I_0$. The relative velocity of these particles is $\beta \geq 0.7$. Their total multiplicity is denoted by n_s.

Several formalisms have been proposed for the study of entropy in heavy-ion interactions. In the present study we apply the method developed by Hwa et al[8]. The variations of entropies, represented by statistical moments with the order of moments, q are subjected to the quadratic fitting of the form;

$$y = a + bq + cq^2 \qquad (1)$$

with $y = \ln\ S_q,\ \ln\ \Sigma_q$ are the two statistical moments.

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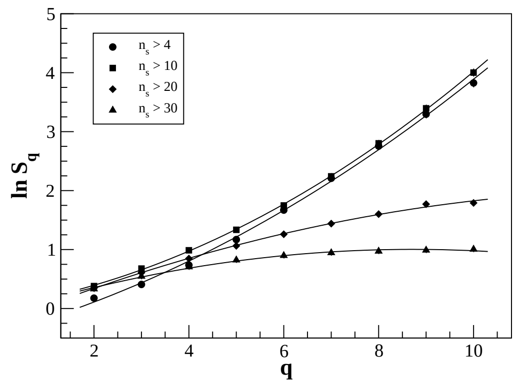

FIG. 1: Variation of ln S_q with q.

TABLE II: Values of a, b and c obtained using quadratic fits to q vs. ln S_q plots shown in Fig. 1.

(n_s **value**)	**a**	**b**	**c**
$n_s > 4$	-0.261	0.169	0.025
$n_s > 10$	-0.067	0.159	0.024
$n_s > 20$	-0.252	0.321	- 0.011
$n_s > 30$	-0.148	0.271	-0.016

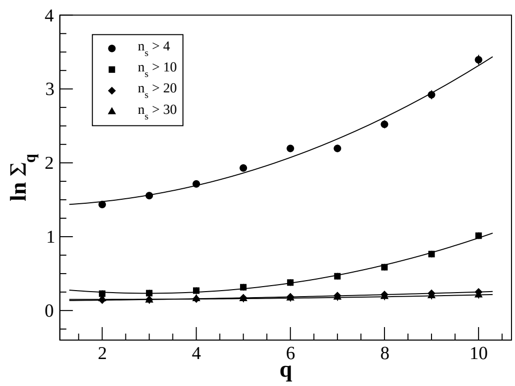

FIG. 2: Variation of ln Σ_q with q.

Results

The values of the coefficients a, b and c are presented in TABLE II and TABLE III for the variations of ln S_q and ln Σ_q with the order of the moment q respectively for different ranges of multiplicities of shower track particles. The fitting of the experimental data with the above second order polynomial disqualifies the existence of any scaling behaviour of the form $S_q \sim q^\alpha$ and $\Sigma_q \sim q^\alpha$ as suggested by some workers [9]. Further we see that entropy increase with the order of the moments, playing the role analogous to temperature. However, our observations are in agreement with what has been suggested by Shakeel et al [10], Thus citing the occurence of erraticity of event-by-event fluctuations in rapidity gap distributions.

TABLE III: Values of a, b and c obtained using quadratic fits to ln Σ_q vs. q plots shown in Fig. 2.

(n_s **value**)	**a**	**b**	**c**
$n_s > 4$	1.416	- 0.0125	0.020
$n_s > 10$	0.370	- 0.091	0.015
$n_s > 20$	0.127	0.005	0.001
$n_s > 30$	0.152	- 0.002	0.001

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