Availability of beams of relativistic heavy-ions at JINR (USSR) during the recent years has provided an opportunity to investigate the characteristics of carbon- and silicon-nucleus interactions at 4.5 GeV per nucleon. In the present study an attempt has, therefore, been made to glean some useful and interesting information regarding the dynamics of nucleus-nucleus collisions at relativistic energies by analyzing the salient features of 852 and 1024 interactions respectively caused by carbon and silicon nuclei in emulsion.

An introduction about the general characteristics of relativistic heavy-ion collisions, classification of the interactions into peripheral, quasi-central and central collisions, nuclear fragmentation, etc., is presented in Chapter I. Details about the theoretical models describing the nucleus-nucleus collisions at high energies are also given in this chapter.

Experimental techniques used in the present work are described in Chapter II. Details of the stacks used, method of scanning, selection criteria, classification of tracks, methods of various measurements along with the procedure of the target identification are given in this chapter.

In Chapter III, the results on the interaction mean free path of the fragments having charge $Z = 2$ and its possible dependence on the distance from the interaction vertex are given. The dependence of the anomalous effect on distance, investigated by dividing the interactions into two categories in terms of the heavily ionizing particles, $N_H$, namely, $N_H > 6$
and \( N_h > 6 \) is examined. The existence of the anomalous has also been investigated by dividing their production angles into two intervals, i.e. \( \theta < 2^\circ \) and \( \theta > 2^\circ \). It may be mentioned that no clear evidence is obtained for the occurrence of the anomalous behaviour over any distance from the point of their emission.

General characteristics of secondary particles produced in carbon- and silicon-emulsion interactions are presented in Chapter IV. Results of the studies dealing with the characteristics of the interactions caused by other projectiles having the same beam momentum per nucleon are also described in this chapter.

Multiplicity distribution of grey tracks is observed to be appreciably enriched by high multiplicity events with the increase of projectile mass. This observation may be explained in terms of the predictions of the fire-ball model. On the other hand, the multiplicity distribution of black tracks is found to be insensitive to the projectile mass. Furthermore, the multiplicity distribution of the relativistic charged particles tends to become broader with increasing projectile mass. The mean multiplicities of grey and shower particles increase linearly with projectile mass satisfying the condition \( \langle N_x \rangle = \text{const.} \ A^\alpha \), where \( x \) refers to grey or shower particles. But the mean multiplicity of black particles is found to remain constant within the limit of statistical errors. The inter-correlations amongst the different types of charged secondaries have also been
investigated; the multiplicity correlations of the secondary particles have been observed to be of similar nature for carbon- and silicon-emulsion interactions. Furthermore, the $<N_g>-N_b$ and $<N_b>-N_g$ correlations are observed to saturate for $N_b, N_g$ values around 16 in heavy-ion collisions. However, in the case of p-nucleus collisions $<N_g>-N_b$ correlation saturates a little earlier than those for nucleus-nucleus collisions.

The compound multiplicity, $N_c (=N_s+N_g)$, distributions for proton-, carbon- and silicon-emulsion interactions have been investigated; the distribution is observed to change rapidly with increasing projectile mass. Correlations amongst the average compound multiplicity, $<N_c>$ and $N_b$ and $N_h$ are found to be of almost similar natures for both proton-nucleus and nucleus-nucleus collisions.

Scaled multiplicity distributions of charged shower particles have been examined for both carbon and silicon projectiles. A KNO type of scaling is observed to occur in the case of nucleus-nucleus collisions. But the distributions are observed to be insensitive to the nature of the projectile. Furthermore, a study of the dispersion as a function of the average charged particle multiplicity with the corresponding average value of the charged particles is found to be linear, which in turn, reveals a KNO type of scaling behaviour for the distribution.

An attempt is made to investigate the moments of the multiplicity distributions of the relativistic charged particles. The values of the central moments are observed to
depend strongly on the projectile mass whereas the normalized moments are independent of the projectile mass.

The shapes of the angular distributions of shower, grey and black particles do not show up any significant peculiarities and the distributions are all alike irrespective of the projectile mass. Furthermore, the angular distributions of grey and black particles do not exhibit abnormal behaviour which may be associated to the shock wave phenomenon.

Multiplicity distributions of the projectile fragments having charges $Z = 1, 2$ and $> 3$ have been investigated; the distributions for $Z = 1$ and $> 3$ are found to be strongly dependent on the projectile mass. However, the multiplicity distributions for $Z = 2$ fragments do not manifest any appreciable change with change in the projectile mass. The average multiplicity of the projectile fragments manifests weak dependence on the target mass. The value of this parameter, however, increases with the increase in the projectile mass. The variation of the average multiplicity of the projectile fragments with projectile mass is found to satisfy the condition $\langle N_Z \rangle = \text{const.} \, A^\alpha$, where $A$ is the projectile mass and $\alpha$ is the slope constant.

A detailed discussion about the pseudorapidity of the charged shower particles produced in the interactions of carbon and silicon nuclei and the rapidity-gap distributions are presented in Chapter V. The shapes of the $\gamma$-spectra are practically similar for both projectiles. But the excess of
the particles arising due to an increase in the projectile mass tend to appear in the central region of the rapidity space. It has further been observed that with increasing $N_g$, the maxima of the $\eta$-spectra shift towards smaller values of $\eta$. Incidentally, this observation is in fine agreement with the predictions of the coherent tube model. Furthermore, the values of $<\eta>$ for both projectiles are found to decrease monotonically with increasing values of $N_g$, $N_s$ and $N_h$. However, the distribution of the dispersions of the $\eta$ values for each event, $D(\eta)$, shows an appreciable change with the change in projectile mass. It has been theoretically predicted that the events having $D(\eta) \leq 0.9$ involve particle production via cluster formation. The number of events having $D(\eta) \leq 0.9$ are $(70.69 \pm 2.19)\%$ and $(68.80 \pm 2.00)\%$ respectively for carbon- and silicon-nucleus interactions. This observation clearly establishes the occurrence of clusterization in these interactions. Furthermore, the variation of $<D(\eta)>$ with the corresponding number of shower particles do not show up any appreciable change, except in the region of small values of $N_g$. The results indicate that the maxima of the shower width($R$) distributions shift towards the lower values of $R$ with decreasing projectile mass. This indicates that the shower particles are produced at relatively larger angles with increasing projectile mass. The $R$-spectra for various $N_g$-intervals are of similar type.

Finally, the characteristics of clusters produced in the interactions caused by carbon and silicon projectiles are investigated. The cluster size is found to be independent of
the projectile mass. It has further been observed that the contribution of the short-range correlation is comparatively much more in comparison to that of the long-range correlation. No evidence of the production of heavy clusters in carbon- and silicon-emulsion interactions is found in the present study. Finally, on the basis of the findings of the present study, it has been concluded that the mechanism of multi-particle production in nucleus-nucleus and hadron-nucleus collisions is probably the same.