Probing densities of hot nuclei

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Nuclear density is an important quantity in the studies related to the nuclear equation of state. A systematic decrease in fragment kinetic energy with increasing excitation energy of the fragmenting source has been considered as a signature of expansion of the fragmenting source [1]. Fragment kinetic energy spectra were used to deduce the information about nuclear density in ^{3,4}He, ^{14}N+^{197}Au reactions using a statistical emission model [2]. In the present work, this method has been applied to the fragments produced in quasiprojectile fragmentation in ^{78,86}Kr+^{58,64}Ni reactions (E_{lab}= 35 MeV/A). The calculation of Coulomb energy has been modified to account for the variation in Coulomb repulsion felt by fragments in different fragmentation events. Various cuts were applied to the experimental data to reduce the non-equilibrium effects and select quasiprojectiles with *Z* value close to that of the projectile [3].

In order to investigate the excitation energy dependence of the nuclear density, kinetic energy spectra of fragments (Z=4-8), gated on different excitation energy of the fragmenting source, were fitted using the following equation for statistical emission [2],

$$P(x)dx \propto \left\{(2x-p)\exp\left(-\frac{x}{T}\right)erfc\left(\frac{p-2x}{2\sqrt{pT}}\right)+2\sqrt{\frac{pT}{\pi}}\exp\left(-\frac{p^2+4x^2}{4pT}\right)\right\}dx \quad (1)$$

where *x* is the kinetic energy of the fragment in the projectile frame of reference, corrected for the Coulomb energy contribution. *T* is the temperature of the source and *p* is an amplification parameter governing the width of the kinetic energy spectra [2]. In order to account for the variation in Coulomb repulsion felt by a fragment in different break up events, an average Coulomb repulsion was calculated by varying the charge of the residual nucleus. There are two extreme cases possible for the Coulomb push to the fragment. In one case, the fragment of interest may be present at the center of the fragmenting system and, therefore, no net Coulomb force is acting on it at the freeze out stage. In the other case, the fragment of interest may be present at the surface of the fragmenting system as shown in FIG. 1 and, therefore, feels

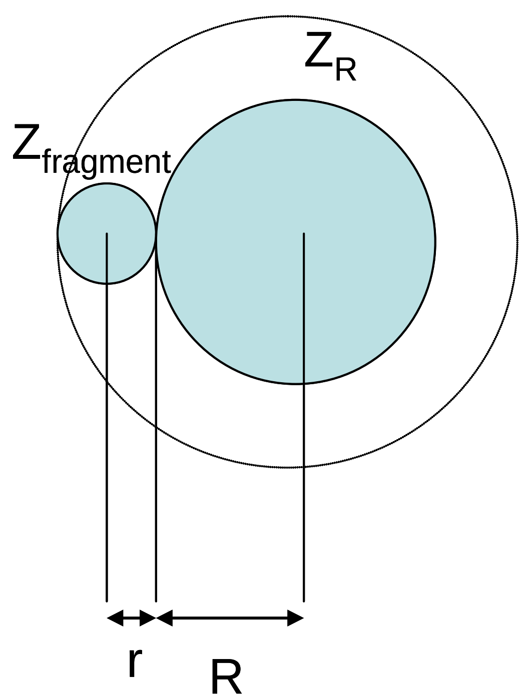

FIG. 1. Touching sphere configuration.

maximum Coulomb repulsion. For other configurations, the Coulomb energy will lie between the values corresponding the two extreme cases. The average Coulomb energy was calculated using the following equation

$$E_C = \frac{\sum_n E_C(R)}{n} \quad (2)$$

Where $E_C(R)$ is the Coulomb energy for a given configuration, and is given by the following equation

FIG. 2. r_0 values obtained by fitting the fragment kinetic energy spectra at different excitation energies for ^{78}Kr+^{58}Ni reaction.

$$E_C(R) = \frac{1.438 Z_{fragment} Z_R(R)}{r+R} = \frac{1.438 Z_{fragment}\left[R^3 (Z/A)_{QP}\right]}{r_0^4(E^*)\left[\left\{Z_{fragment}(A/Z)_{QP}\right\}^{1/3} + R/r_0(E^*)\right]} \quad (3)$$

where Z_R varies from unity to (Z_{QP}-$Z_{fragment}$), The limits on $Z(R)$ were translated into the limits on R. Z_{QP} was taken as sum of the Z of the fragments obtained after event reconstruction. In the calculations, $(A/Z)_{QP}$ was assumed to be equal to that of the projectile. In the fitting of kinetic energy spectra with eq. 1, r_0 was a free parameter. The r_0 values obtained for ^{78}Kr+^{58}Ni reaction are shown in FIG. 2. Similar trends were observed for other reaction systems. In FIG. 3, the density profile obtained using the r_0 values for different reaction system is compared to that observed in ref. [1]. The density profile determined in the present work is normalized with respect to that in ref. [1] at excitation energy of 2.5 MeV. It can be seen from this figure that the density profile obtained in the present work is similar to that in ref. [1], showing a reduction in nuclear density with increasing excitation energy of the fragmenting source up to a saturation value of about 0.2ρ_0, where ρ_0 is nuclear density in ground state.

FIG. 3. Density profiles obtained from the present work and from ref. [1].

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