Universality of projectile fragmentation model

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Presently projectile fragmentation reaction is an important area of research as it is used for the production of radioactive ion beams. In this work, our recently developed projectile fragmentation model with an universal temperature profile is used for studying the charge distributions of different projectile fragmentation reactions with different projectile target combinations at different incident energies.

The model for projectile fragmentation [1] consists of three stages: (i) abrasion, (ii) multifragmentation and (iii) evaporation. In heavy ion collision, if the beam energy is high enough then at a particular impact parameter three different regions are formed: (i) projectile like fragment (PLF) or projectile spectator moving in the lab with roughly the velocity of the beam, (ii) participant which suffer direct violent collisions and (iii) target like fragment (TLF) or target spectator which have low velocities in the lab. Using straightline geometry average number of protons and neutrons present in the projectile spectator at different impact parameters are calculated. The total cross-section of abraded nucleus having Z_s protons and N_s neutrons is

$$\sigma_{a,N_s,Z_s} = \sum_i \sigma_{a,N_s,Z_s,T_i} \qquad (1)$$

where the sum is done over all impact parameter intervals and

$$\sigma_{a,N_s,Z_s,T_i} = 2\pi\langle b_i\rangle \Delta b P_{N_s,Z_s}(\langle b_i\rangle) \qquad (2)$$

with $P_{N_s,Z_s}(\langle b_i\rangle)$ is the probability of formation of a projectile spectator having Z_s protons and N_s neutrons obtained by minimal distribution within the impact parameter interval Δb around $\langle b_i\rangle$.

The multifragmentation stage calculation

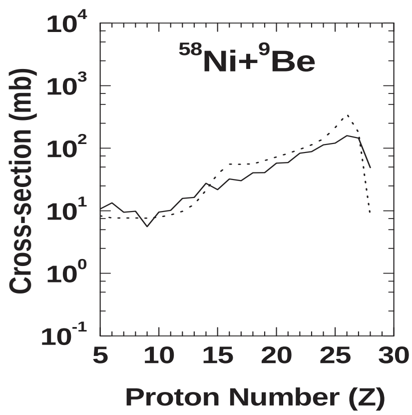

FIG. 1: Theoretical charge distribution (dotted line) for ^{58}Ni on ^{9}Be compared with experimental data (solid line).

of each PLF created after abrasion at different impact parameters is done separately by the Canonical Thermodynamical Model (CTM) [2]. The canonical thermodynamical model assumes that due to density fluctuations each nuclear system (here projectile like fragments produced after abrasion stage) breaks up and reaches to an expanded freeze-out configuration at a particular temperature. The impact parameter dependence of freeze-out temperature is considered as $T(b) = 7.5 - 4.5(A_s(b)/A_0)$ where $A_s(b)$ is the mass of the projectile spectator created at impact parameter b and A_0 is the mass number of original projectile. So freeze-out temperature of the projectile spectator is independent of the incident beam energy but it depends on the wound in the projectile. The freeze-out vol-

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ume in multifragmentation is $V_f(b) = 3V(b)$ where $V(b)$ is the volume of projectile spectator created at b. Using CTM for an abraded system N_s, Z_s at temperature T_i average population of the composite with neutron number n, proton number z is calculated in the multifragmentation stage. Denoting this by $M_{n,z}^{N_s,Z_s,T_i}$ and summing over all the abraded N_s, Z_s that can yield n, z, the primary cross-section for n, z is

$$\sigma_{n,z}^{pr} = \sum_{N_s,Z_s,T_i} M_{n,z}^{N_s,Z_s,T_i} \sigma_{a,N_s,Z_s,T_i} \qquad (3)$$

Finally, the decay of excited fragments n, z at temperatures T_i are calculated by recently developed evaporation model based on Weisskopf's formalism.

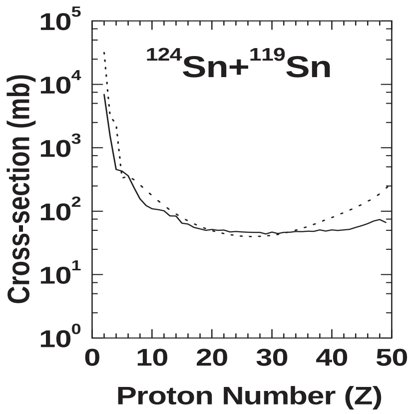

FIG. 2: Comparison of theoretical charge distribution (dotted line) for ^{124}Sn on ^{119}Sn with experimental data (solid line).

Theoretically, the charge distribution is studied by using universal temperature profile and compared with experimental data of ^{58}Ni on ^{9}Be (Fig. 1) reaction at 140 Mev/nucleon (MSU), ^{124}Sn on ^{119}Sn (Fig. 2) at 600 MeV/nucleon (ALADIN collaboration at GSI), ^{136}Xe on ^{208}Pb (Fig. 3) at 1GeV/nucleon (GSI) and ^{129}Xe on ^{27}Al (Fig. 4) at 790 MeV/nucleon (GSI).

Hence we can conclude that, the charge distributions of different projectile fragmentation reactions with different projectile target combinations at different incident energies are nicely reproduced by single temperature profile in projectile fragmentation model and in each reaction limiting fragmentation condition is archived.

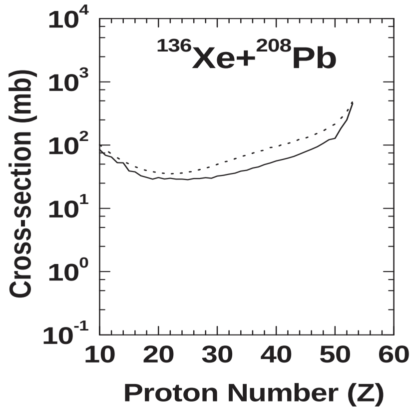

FIG. 3: Theoretical charge distribution (dotted line) for ^{136}Xe on ^{208}Pb compared with experimental data (solid line).

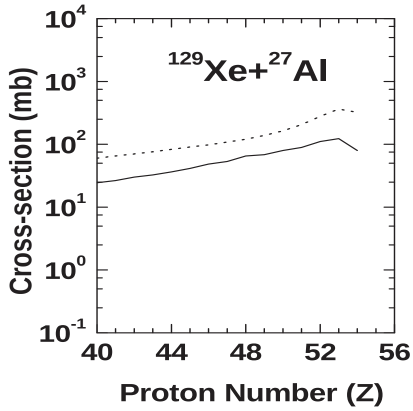

FIG. 4: Comparison of theoretical charge distribution (dotted line) for ^{129}Xe on ^{27}Al with experimental data (solid line).

References

[1] S. Mallik, G. Chaudhuri and S. Das Gupta, Phys. Rev. **C 84**, 054612 (2011).

[2] C. B. Das et al., Phys. Rep **406**, 1, (2005).