Cluster correlation and fragment emission in ^{12}C + ^{12}C at 95 MeV/nucleon

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Particle production mechanism in intermediate heavy ion collisions is extended to IMFs, using an extended version of antisymmetrized molecular dynamics (AMD) of Ono et al., [1,2]. In the new version, the cluster correlation is taken into account in the final stage of two nucleon (NN) collisions. In a standard AMD, two nucleons N1,N2 collide and end up a final state, N1', N2', same two nucleons, but have different momenta. If the final state is Fermi allowed, the collision is allowed. Otherwise the collision is canceled. In the new version, cluster correlations are taken into account in the final state, that is, other nucleons are within a certain distances, N1' and N2' can be B1, B2, where B1 and B2 can be one of clusters, such as d, t up to A=9. Since the coalescence is examined stochastically at the final state, the dispersion of the wave packet is taken into account. Therefore no quantum branching process, which is used in the version in Ref. [3], are not used in this version.

The program is applied to the experimental data of the 12C + 12C reaction at 95MeV/nucleon [4]. The calculated energy spectra of isotopes with 3≤Z≤6 are shown by blue histograms in Fig.1.

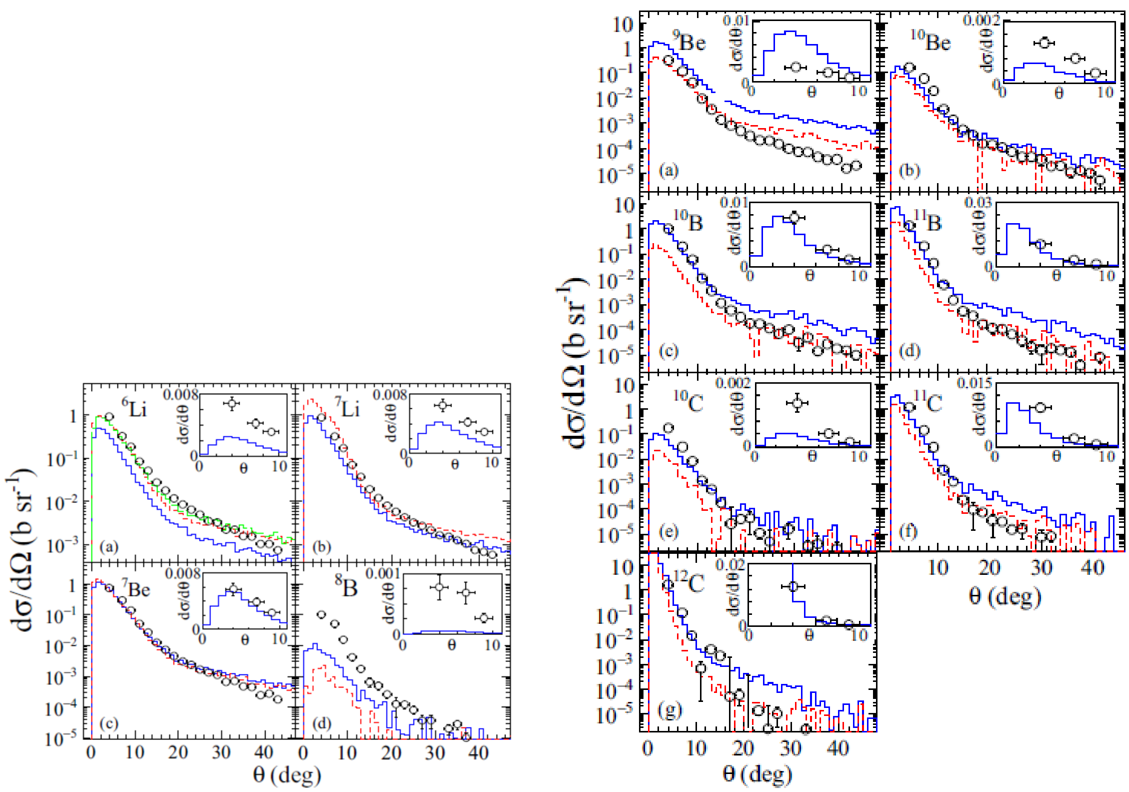

FIG. 1. Calculated energy spectra for isotopes with 3≤Z≤6 (blue by AMD (blue histograms) with the experimental data of 12C+12C at 95 A MeV [4] (circles) . For red dashed lines, see text.

It is clearly noted that the most of the spectra are significantly over-predicted at larger angles, $\theta \geq 20^{o}$. In contrast to the light particle emission, most of isotopes with $Z \geq 3$ are in an excited state when they are emitted. Therefore the final yield is the result of the two processes, the primary (AMD) and the secondary process. We used Gemini for the secondary process.

In Fig.2, the excitation energy distribution of isotopes are plotted for the primary (red solid) and secondary (blue dashed) when they are emitted at $\theta \geq 20^{o}$. It is quite surprising that many secondary fragments have the excitation energy, E_X, above their particle-decay energy threshold, E_{pth}. When the secondary isotopes with $Ex > E_{pth}$ are forced to decay, the results are shown in Fig.1 by the red-dashed

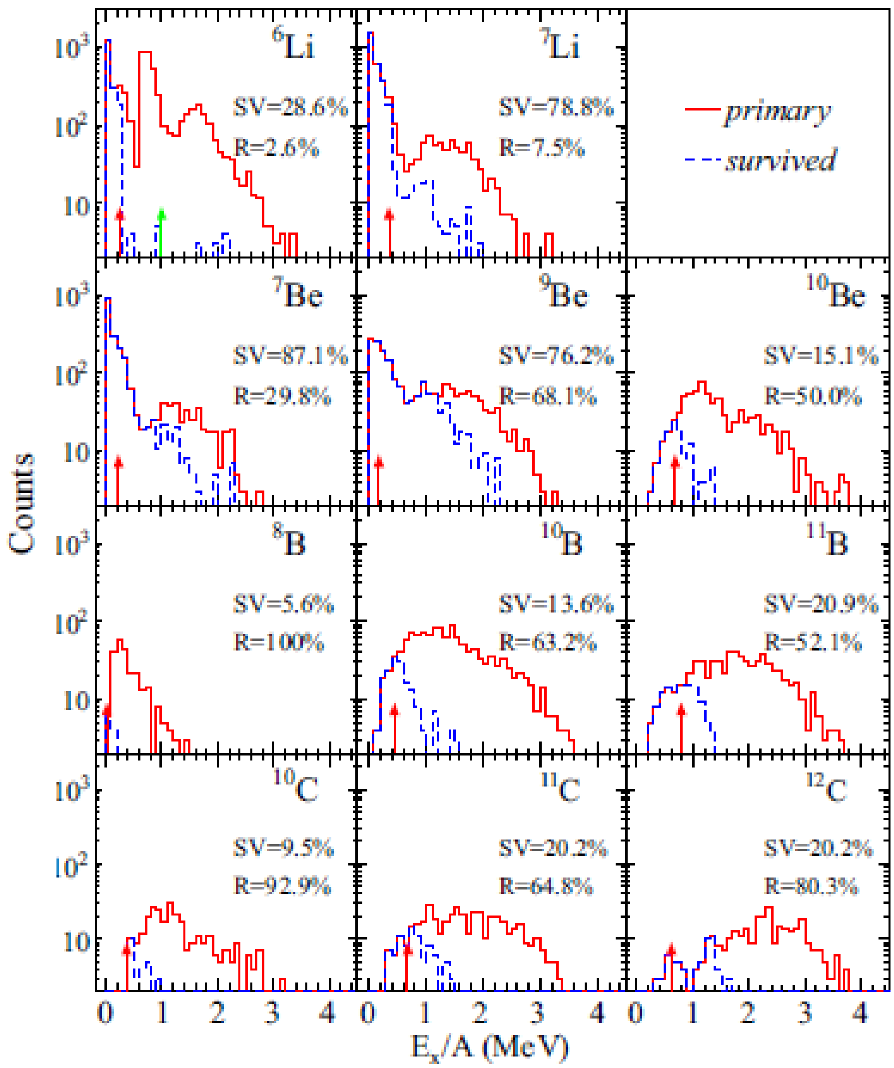

FIG. 2. Excitation energy distributions of each fragment emitted at θ ≥ 20o and with kinetic energies above experimental energy thresholds. Red solid and blue dashed histograms represent those for the excited primary and survived secondary fragments, respectively. The particle decay thresholds are also shown on the X axis by red arrows. SV is given as the ratio of the number of the survived fragments to the total number of the primary fragments for each isotope. R is defined as the ratio between yields with $E_x > E_{pth}$ and the whole, where *E*pth is the particle decay energy threshold.

histograms. The yields at $\theta \geq 20^o$ are improved significantly for the most of isotopes, but becomes worse at smaller angles, where the PLF component is dominant. We are now currently investing what is the cause of this. A part of this study has been published in Ref. [2].

[1] N. Ikeno, A. Ono, Y. Nara, and A. Ohnishi, Phys. Rev. C **93**, 044612 (2016).

[2] G. Tian *et al.*, Phys. Rev. C **97**, 034610 (2018).

[3] A. Ono and H. Horiuchi, Phys. Rev. C **53**, 2958 (1996).

[4] J. Dudouet *et al.*, Phys. Rev. C **88**, 024606 (2013).