PREEQUILIBRIUM EMISSION OBSERVED IN THE CORRELATION BETWEEN LIGHT PARTICLES AND EVAPORATION RESIDUES FOR THE ^{84}Kr + ^{27}Al SYSTEM

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Evaporation residues (ER) of Z = 34–42 were measured in coincidence with emitted protons (p), deuterons (d), tritons (t), and alpha particles (α) for the reaction ^{84}Kr + ^{27}Al at a ^{84}Kr bombarding energy of 1260 MeV. The experiment was carried out using the large detector array HILI described elsewhere[4] and used in previous measurements of similar reactions with compound nuclei A~100.[5,6,7] . It is enough to mention in this report that the detector covered the angular range of 3.0° to 25°, that the ER were detected in an ionization chamber, and the coincident nucleons by an hodoscope array of plastic scintillators placed behind the ionization chamber. The beam of Kr was extracted form the Texas A&M University super-conducting cyclotron. Timing between the cyclotron's rf and the hodoscopes was used to separate the Z = 1 particles by time of flight.

A detailed study of the light particle spectra and ER indicates a strong preequilibrium component in the emission of p's and α's but not for d's and t's. From the ER spectra measured with HILI, the experimental centroids (in MeV) were extracted and are plotted in Fig. 1 as a function of the Z of the fragments from Z = 34 to 42. The solid points are the experimental centroids corresponding to the inclusive measurements (singles). The open squares correspond to the centroids for the multiplicity condition $m \geq 1$ and the open circles are those for $m \geq 2$ (m is the charged particle (p,d,t and α) multiplicity measured by the HILI). The main observation to point out from Fig. 1 is the large difference in the slope of the centroid vs. Z plots when changing from singles and $m \geq 1$ to $m \geq 2$. A qualitative explanation of this effect is that in the spectra for Z around and below the beam (Z = 36), the contribution from projectile-like reactions is reduced drastically for $m \geq 2$. The small circle-dashed line and the thick-dashed line drawn in Fig. 1 corresponds to the centroids calculated (using the code LILITA[8]) assuming a complete fusion (CF) reaction. As can be seen the experimental centroids are higher than the calculations for all Z values below Z = 37, consistent with current incomplete fusion (IF) systematics. However, when the comparisons are done for the $m \geq 2$ case (which selects preferentially the ER components in the energy spectra), one can see that most of the experimental centroids are much lower than the CF prediction for $m \geq 2$ (thin dashed line in Fig. 1).

The apparent agreement seen for the centroids below Z = 37 (for singles and $m \geq 1$) with the IF systematics is due to the fact that deep inelastic and quasi-elastic components are included. To account for the data in Fig. 1, the best assumption is that of energetic forward center of mass angular emission (preequilibrium) of p and α after full momentum transfer . This description differs substantially from the one expected from the usual incomplete fusion mechanism. The final comparison should be seen in Fig. 1 where we show the

results for the centroids (thick solid line) for the preequilibrium calculations (Preq) and m ≥ 2 and as can be seen the trend of the data vs. Z is perfectly well reproduced .

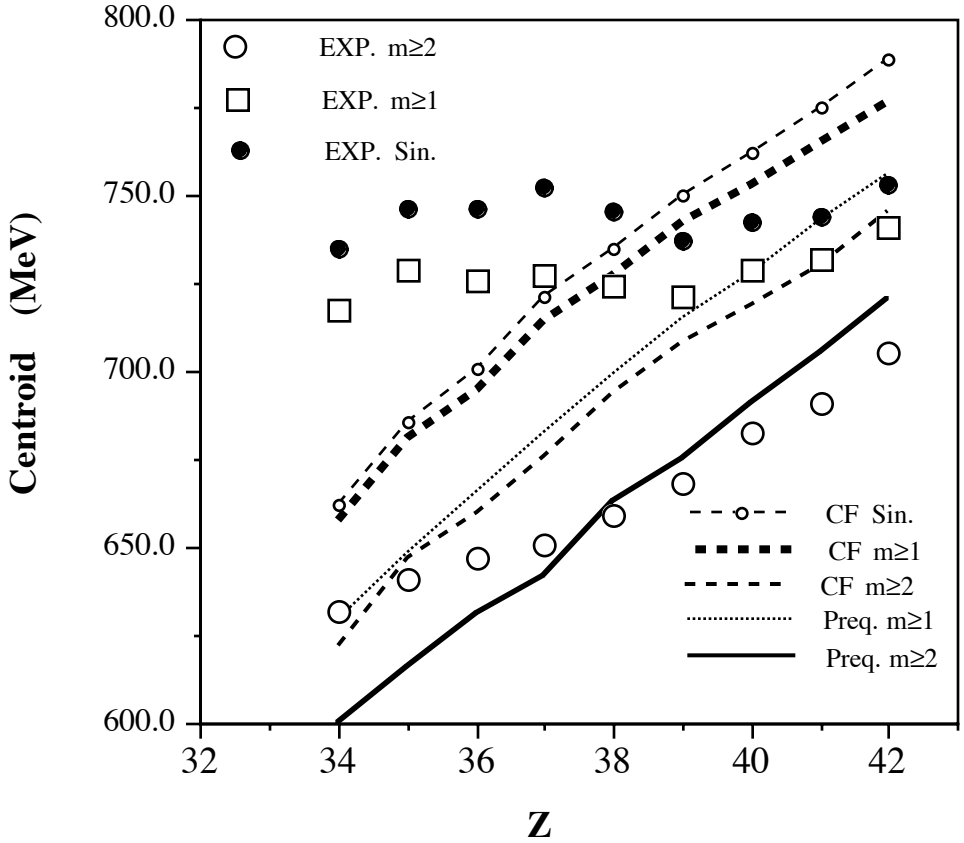

Fig. 1. Experimental centroids of the energy spectra (solid circles, squares and open circles) of ER of the $^{84}Kr + ^{27}Al$ at ^{84}Kr = 1260 MeV. The various curves are calculations described in the text. m refers to the light charged particle multiplicity measured in the detector.

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[4] D. Shapira et al. Nucl. Instrum. Methods Phys. Res. A **301**,76 (1991).
[5] J. Gomez del Campo, et al. Phys. Rev. C **53**,222 (1996).
[6] J. Gomez del Campo, et al. Rev. Mex. Fis. **42-1**,101(1996).
[7] D. Shapira et al. Phys Rev C **55**, 2448 (1997).
[8] J. Gomez del Campo and R.G. Stokstad , ORNL TM-7295 (1981).