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Short Note

Investigation of the Kr + Au System at 22 MeV/u

D. Dalili, M. Berlanger, S. Leray, R. Lucas, C. Mazur, C. Ngô, M. Ribrag, and T. Suomijarvi
Service de Physique Nucléaire – Métrologie Fondamentale, CEN Saclay, F-91191 Gif-sur-Yvette Cedex, France

C. Cerruti, S. Chiodelli, A. Demeyer, and D. Guinet
IPN Lyon, Université Claude Bernard Lyon I, F-69622 Villeurbanne Cedex, France

A. Genoux Lubin, C. Lebrun, J.F. Lecolley, F. Lefebvres, and M. Louvel
Laboratoire de Physique Corpusculaire LA34, Université de Caen, F-14032 Caen Cedex, France

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Abstract: We have measured the mass, the atomic number and the kinetic energy of the fragments emitted between 6° and 21° in the 22 MeV/u ^{84}Kr + ^{197}Au reaction. As in the case of a similar experiment at 35 MeV/u we found products with a velocity substantially smaller than the one of the projectile.

Heavy ion reactions in the bombarding energy range between ~ 20 and 50 MeV/u allow to investigate the transition between the low energy domain dominated by the mean field, and the high energy one, dominated by the nucleon-nucleon interaction. Recent experiments performed with projectiles in this energy region have already shown that the bombarding energy is not the only important parameter, and that the size of the projectile plays also an important role in the mechanisms which are observed. This is the case for linear momentum transfer experiments using a 44 MeV/u Ar beam [1] or for reactions induced by 35 MeV/u Kr projectiles on a Au target [2,3]. In this last experiment it was shown the existence of events with an atomic number distribution centered around 24 units and a FWHM of about 8 units, which have a kinetic energy (< 15-18 MeV/u) much smaller than the one of the incident krypton projectile (35 MeV/u). Such a component is quite unexpected from an extrapolation of our knowledge on the low energy domain. It could come from a cold fracture of one of the two nuclei, which would behave in this case like crystals, or from a dissipative interaction between the participant and the spectator zones associated to the projectile, leading to a hot system which fissions. These unexpected events are quite apparent beyond the grazing angle but they also exist forwards it, although they represent there only a small fraction of the differential cross section [3]. Since such a mechanism should also be dependent upon the bombarding energy of the projectile, it is interesting to investigate a lower bombarding energy. In order to answer this question we have bombarded a 300 μg/cm^2 self-supporting Au target with the 22 MeV/u Kr beam accelerated at GANIL. The fragments emitted during the reaction have been detected between 6° and 12° using a time of flight telescope made of the following parts : a carbon foil, associated with channel plates, located at 24 cm of the target gives a first timing signal. A large area parallel plate detector located at 350 cm from the target gives a second timing signal allowing in this way the time of flight of the particle to be measured. This parallel plate counter was located at the entrance of a large area position sensitive ionization chamber, similar to those developed at GSI [4], which provides us with a two-dimensional localization of the fragment, and with a E-ΔE identification (it consists of 3 ΔE and one E). This detector was operated under a pressure of 150 torrs of CF_4. The mass, the atomic number, the energy and the direction of the particle can be measured with the above set-up.

For the present system the grazing of the projectile is 10°. Consequently we cover a detection region wich is forwards but also backwards off the grazing angle. In Fig. 1 we show the velocity spectra of the products for different laboratory

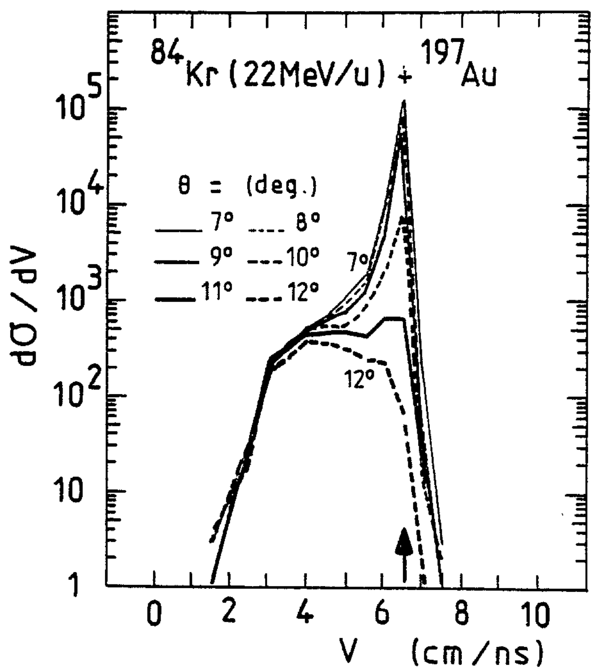

Fig. 1 - Velocity spectra of the products for different laboratory angles Δθ = ± 0.5°.

angles. The incidents velocity of the Kr beam is 6.5 cm/ns. Forwards the grazing angle we observe mainly products with a velocity close to the one of the beam. As we can see from Fig. 2, which shows the atomic number distribution for different detection angles (the mass distributions have a similar behaviour), these fast products correspond to atomic numbers close to the one of the projectile and most of them can be associated with the fragmentation of the projectile. However, even at forward angles we notice the existence of a tail extending at smaller velocities (Fig. 1) or lower atomic numbers (Fig. 2). As the detection angle goes backwards the grazing, the peak associated to fragmentation gradually disappears and is replaced by another one centered around 4 cm/ns, for the velocity spectrum, and around $Z \simeq 20$-25 for the atomic number spectrum. As far as the atomic number distribution is concerned the distribution around the mean value turns out to be rather large (FWHM ~ 19 units at 12°).
An interesting piece of information is displayed in Fig. 3 which shows the atomic number distributions for different bins of kinetic energy (these results correspond to the whole measured angular range : (6-12°). We observe that as the inelasticity increases, the distribution broadens and shifts towards smaller Z-values. This behaviour is quite different from the one observed at lower bombarding energies [5] where the atomic number

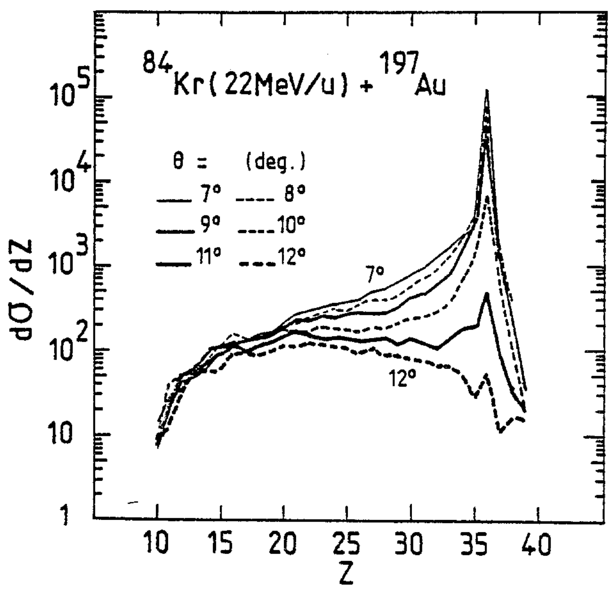

Fig. 2 - Atomic number distributions for different detection angles Δθ = ± 0.5°.

distribution either does not drift or drifts in the opposite direction. This is likely to indicate that we are already in a different regime of processes, similar to the case of ref.[1]. One possibility to understand the existence of such relaxed events would be to imagine that the reaction proceeds like in a participant spectator picture. The participants, which correspond to the common part of the projectile and the target get highly excited. Due to a reminiscence of the mean field we

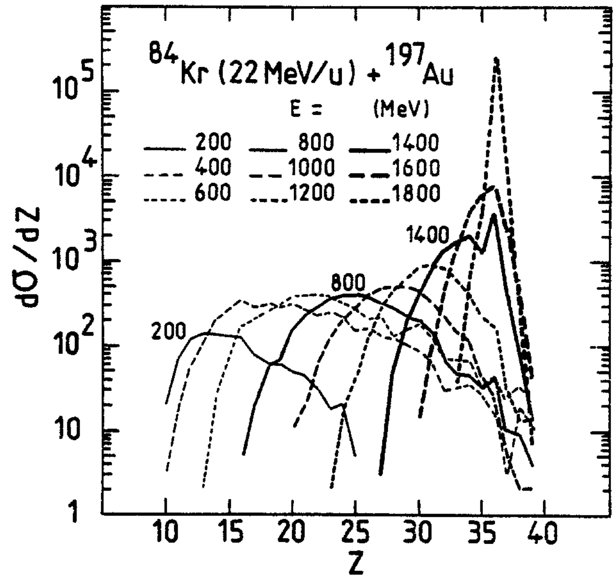

Fig. 3 - Atomic number distributions for different bins of kinetic energy ΔE = ± 100 MeV.

can imagine that they fuse with either projectile spectators, or the target ones. If the first possibility is achieved, we form an excited system which might split in two parts and we would detect one of them. Such an hypothesis, which has already been formulated in ref.[3], should of course be carefully checked in the future by coincidence experiments. Compared with experiments using heavy projectiles like Kr, or heavier [6], at lower bombarding energies (≤ 10-15 MeV/u), it is hard, from Fig. 3, to understand our results as coming from a deep inelastic process. However our observation might be connected to some extent to the three-body splitting observed at GSI [7] which seems to already occur around and above ~ 12 MeV/u.
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