Measurement of ^{208}Pb(^{48}Ti,n)^{255}Rf excitation function

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Świątecki, Siwek-Wilczyńska, and Wilczyński [1] have created a model that reproduces much of the cold fusion cross section data to within a factor of two. This model referred to as the *Fusion by Diffusion* model treats the heavy element formation probability (cross section) as the product of three factors: 1) the probability for *sticking* (the cross section for projectile and target to overcome the Coulomb barrier and form a composite system), 2) the probability for this composite system to *diffuse* into a compound nucleus, and 3) the *survival* probability for this compound nucleus (CN) (the probability that the CN de-excites via emission of a single neutron, rather than fissions). The cross section predictions are summarized in Fig. 1. Points placed directly above each other are cross sections of elements formed by using projectiles differing by two neutrons. The circled pair represents the predicted cross sections for ^{48}Ti and ^{50}Ti beams on a ^{208}Pb target. This projectile pair is particularly interesting for two reasons: a) the largest difference in 1n cross sections and b) a large difference in the predicted shapes of the excitation functions.

To test the *Fusion by Diffusion* theory, we measured the ^{208}Pb(^{48}Ti,n)^{255}Rf excitation function by using the Berkeley Gas-filled Separator at the Lawrence Berkeley Laboratory 88-Inch Cyclotron. The ^{208}Pb(^{50}Ti,n)^{257}Rf excitation function has previously been studied by Hessberger [2,3]. In this experiment, we ran a total of 5 projectile-center-of-target-lab-frame beam energies: 223.8, 228.8, 232.8, 238.8, and 243.8 MeV. We measured $1.77^{+0.7}_{@0.39}$ s for the ^{255}Rf half-life, which agrees well with the known literature value of 1.64 ± 0.11 s [2]. The maximum cross section of $309^{+166}_{@114}$ pb is measured at 228.8 MeV, which is comparable to the predicted 255 pb. Excitation functions are shown in Figure 2, accompanied with the theoretical predictions. The shape of ^{208}Pb(^{50}Ti,n)^{257}Rf excitation function is predicted to be Gaussian-like, while ^{208}Pb(^{48}Ti,n)^{255}Rf is predicted to be asymmetric. *Fusion by Diffusion* predicts the ^{208}Pb(^{48}Ti,n)^{255}Rf cross section to be a factor of 80 smaller than ^{208}Pb(^{50}Ti,n)^{257}Rf. We have experimentally determined that this ratio is ~ 50. The results reported here are preliminary, and they so far reflect the predicted shapes. The high energy side of each excitation function is truncated by second-chance fission. Measuring the centroid shifts may give accurate corrections to fission saddle point masses. Due to low statistics and poor energy resolution further studies are needed. An experiment is planned with thin ^{208}Pb targets, (~100μg/cm^2), to reduce energy loss within the target thus improving the energy resolution, and a longer irradiation time for improvement of statistics.

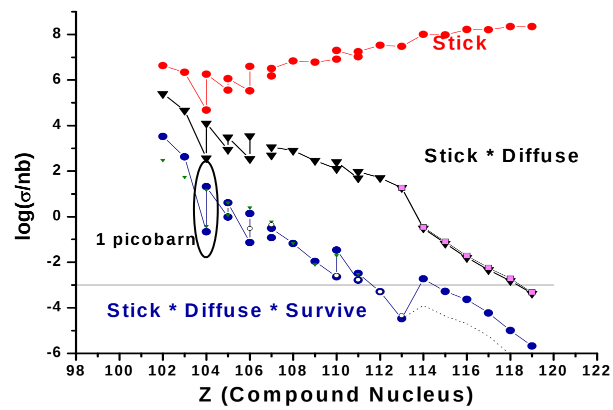

FIG. 1. Predicted cross sections in cold fusion reactions utilizing ^{208}Pb and ^{209}Bi targets.

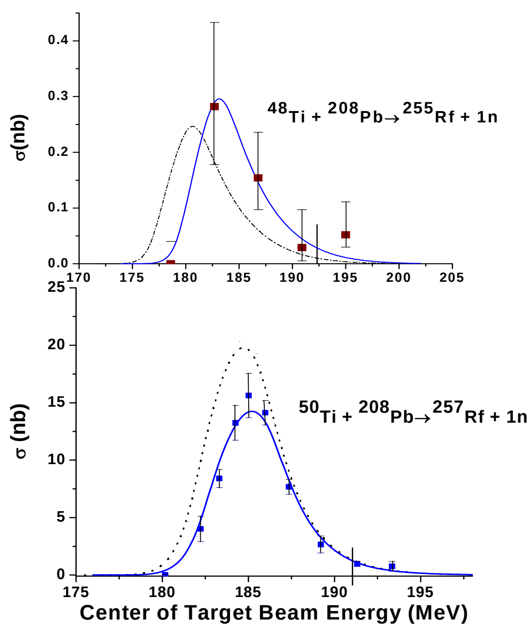

FIG. 2. Measured excitation functions for the ^{208}Pb(^{48}Ti,n)^{255}Rf reaction (top) and ^{208}Pb(^{50}Ti,n)^{257}Rf (bottom).Also shown with the dotted lines are the predictions of Fusion by Diffusion theory for these reactions.

REFERENCES

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