Transition State Rates and Mass Asymmetric Fission Barriers of Compound Nuclei ^{90,94,98}Mo

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The emission of complex fragments (or mass-asymmetric fission) can be treated in an analogous fashion to mass-symmetric fission by introducing the ridge line of conditional saddle points. Each mass or charge emission can be associated with a conditional saddle (or barrier) with the constraint of a fixed mass asymmetry. The locus of all such conditional saddles define the ridge line in the potential energy surface of a nucleus. This ridge line controls the emission of complex fragments, and can be measured with techniques similar to those used to determine fission barriers. In this work, we measured the excitation functions for complex fragments with atomic number Z=5-25 emitted from the compound nuclei ^{90,94,98}Mo produced in the reactions ^{78,82,86}Kr + ^{12}C. Mass-asymmetric fission barriers (or the ridge line) for the compound nuclei ^{90}Mo, ^{94}Mo, and ^{98}Mo (see fig. 1) were extracted by fitting the measured excitation functions with a transition state formalism.

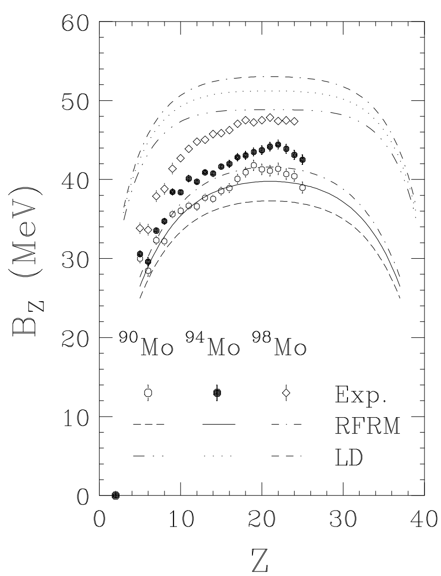

FIG. 1. The shell corrected mass-asymmetric fission barriers (B_Z) for compound nuclei ^{90}Mo, ^{94}Mo, and ^{98}Mo are compared with the Rotating Finite Range Model and the Rotating Liquid Drop Model calculations.

With the shell correction, the measured barriers are several MeV higher on average than the predictions of the Rotating Finite Range Model, and substantially lower than that predicted by the Rotating Liquid Drop Model. A stronger N/Z dependence of the experimental conditional barriers is observed than predicted by either model. These results suggest the need for refinements of the parameters in both models, if not modifications of the models themselves.

As for the symmetric fission, the rate for mass-asymmetric fission has been calculated successfully by the means of the transition-state method. However, the claims for the failure of the transition state method to account for the observed prescission particle emission (n, p, α, γ) prompted an attempt to justify the validity of the transition-state method and/or to identify regimes in which deviations might be expected. In this work we compared the experimental emission rates of complex fragments with the transition state predictions, and searched for E and Z dependent deviations that would indicate the existence of a transient effect which has been advocated as an explanation for the alleged large number of prescission particle emission observed in the fission of many systems.

In fig. 2, we show that, over ninety excitation functions measured for complex fragments emission from five different nuclei (^{75}Br, ^{90}Mo, ^{94}Mo, ^{94}Mo, and ^{110,112}In), can be scaled, as expected from the transition state theory, onto a single universal straight line which has a slope near unity and passes closely through zero. This is strong evidence for the validity of the transition state formalism and allows us to assign an upper limit for the transient time of 1×10^{-20} seconds.

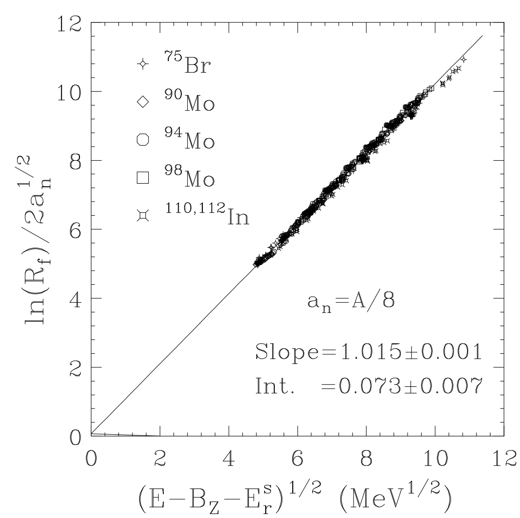

FIG. 2. The logarithm of the reduced mass-asymmetric fission rate R_f divided by $2{a_n}^{1/2}$ versus the square root of the intrinsic excitation energy for five different compound nuclei. The solid lines are the linear fits to all of the data. The error bars are smaller than the size of symbols.