

# Scaling laws and transient times in $^3\text{He}$ induced nuclear fission \*

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It is well known from early studies that fission excitation functions vary dramatically from nucleus to nucleus over the periodic table [1–3]. Some differences can be understood in terms of a changing liquid-drop fission barrier with the fissility parameter, others are due to strong shell effects which occur e.g. in the neighborhood of the double magic numbers  $Z=82$  and  $N=126$ . Further effects may be associated with pairing and the angular momentum dependence of the fission barrier.

Fission rates have been successfully calculated most often with the transition state method introduced by Wigner [4] which has then been applied to fission by Bohr and Wheeler [5]. However, recent measurements of an enhancement of precission emission of neutrons and  $\gamma$ -rays in relatively heavy fissioning systems claim the failure of the transition state method. The alleged failure has been attributed to the transient time necessary for the so-called slow fission mode to attain its stationary decay rate. Since these methods are indirect and are fraught with difficulties, we have experimentally investigated the fission probability to search for possible deviations from the predicted transition state rates. Therefore, we have measured  $^3\text{He}$  induced fission cross sections of three compound nuclei using two large area PPACs which allowed for the detection of both fission fragments in coincidence; the results are shown in Fig. 1 [6].

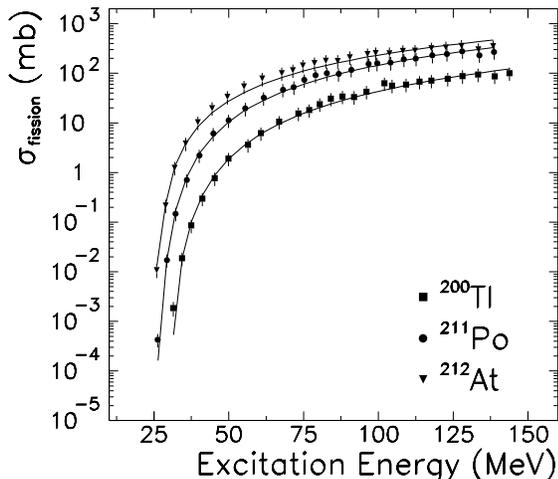


FIG. 1. Excitation function for fission of several compound nuclei formed in  $^3\text{He}$  induced reactions. The different symbols correspond to the experimental data points. The solid line shows the results of a fit to the data.

Recently, we have introduced a method to analyze fission excitation functions [6,7]: it has been shown that this analysis allows the scaling of different excitation func-

tions according to the transition state predictions, once the shell effects are taken into account. As we show in Fig. 2, no deviations from the straight line, which would indicate a failure of the transition state method, are observable. Furthermore, this method allows one to determine the effective fission barrier, the shell effect, and  $a_f/a_n$ .

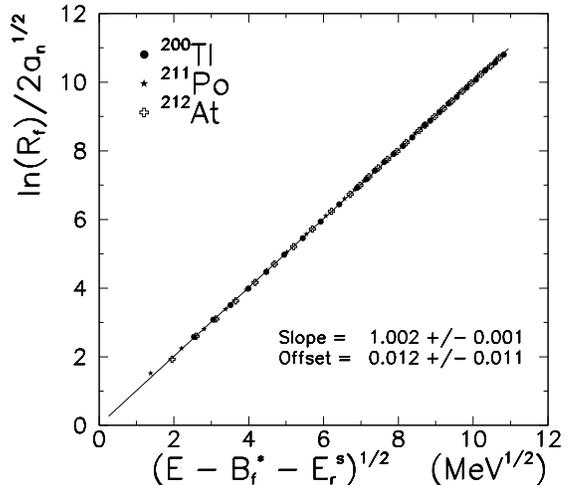


FIG. 2. The scaled fission excitation functions vs the square root of the intrinsic excitation energy over the saddle for fission of several compound nuclei. The straight line represents a fit to the whole data set.

The excitation energy covered by our experiment (25–145 MeV) corresponds to compound nucleus life times between  $10^{-18}$  and  $10^{-22}$  seconds, and is therefore sensitive to delay times in the first chance fission probability. We have assumed a step function for the transient time effect and calculated accordingly the resulting fission width. Modest fission transient times would show up as significant deviations from the straight line presented in Fig. 2. This allows us to determine an upper limit for the transient time of no longer than  $10^{-20}$  seconds. Since the experimental fission rates are well described by the transition state method, it seems likely that most precission emission occurs during the descent from saddle to scission.

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