Comment on "Temperature dependence of nuclear fission time in heavy-ion fusion-fission reactions"

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(Received 6 December 2017; published 6 August 2018)

We discuss several misleading statements made in the article by Eccles *et al.* [Phys. Rev. C **96**, 054611 (2017)]. In particular, contrary to what is claimed in that paper, the analysis of the borders of Kramers formula applicability as a function of temperature using the mean first-passage time formula was performed earlier in the paper by Gontchar *et al.* [Phys. Rev. C **82**, 064606 (2010)].

DOI: 10.1103/PhysRevC.98.029801

In Ref. [1] several misleading statements were formulated. Two of those concern Eq. (3) for the mean first-passage time from the potential minimum q_0 to the sink q_s. For convenience we rewrite this equation here:

$$\tau_{f1} = D\int_{q_0}^{q_s} \exp\left[\frac{U(y)}{T}\right]dy \int_{q_0}^{y} \exp\left[-\frac{U(z)}{T}\right]dz. \quad (1)$$

In this equation T is the nuclear temperature, $U(q)$ is the potential energy, and D is the (Stokes-Einstein) diffusion coefficient of the Brownian particle. Namely, it is said in Ref. [1] that Eq. (3) was used before in Ref. [2]. However, this is not true. Reference [2] contains a similar equation (unnumbered equations on page 255 of Ref. [2]) with a double integral for the mean saddle-to-scission time but not for the mean ground-state-to-scission time. On the other hand, an equation equivalent to Eq. (3) for the fission process was published in review [3] [Eq. (148)], to which the authors of [1] refer in another context. Moreover, using the mean first-passage time approach for the fission process was proposed even earlier in Ref. [4] [Eq. (15)].

In the same sentence of Ref. [1] concerning Eq. (3) it is stated that this equation was never used "to analyze the breakdown of Kramers formula as a function of temperature". In fact Ref. [5] is dedicated to this particular problem. In that work a formula slightly different from (1) is employed:

$$\tau_{f2} = D\int_{q_0}^{q_s} \exp\left[\frac{U(y)}{T}\right]dy \int_{-\infty}^{L} \exp\left[-\frac{U(z)}{T}\right]dz. \quad (2)$$

Here notations are adjusted to those of Ref. [1]. We call Eq. (2) the integral Kramers formula (or rate; see [5]). Since the potential in [1] has a reflecting boundary at $q = q_0$, for such a potential $-\infty$ as a lower limit of the second integral becomes q_0. The only difference between the integral Kramers formula from Eq. (1) is that the coupled double integral is replaced with the product of two independent integrals. However this difference is not significant: Eqs. (1) and (2) result in very close values for the mean first-passage times (or corresponding fission rates); this is illustrated by Table I. The values presented in Table I are obtained for the potential constructed of two smoothly joined parabolas with the stiffness C_0 at the potential minimum and C_L at the saddle point.

One more position in [1] does not reflect reality. In Fig. 4 the authors compare their theoretical fission times as function of temperature with what they call "the experimental data for the ^{224}Th system" of Ref. [6] (Ref. [27] of Ref. [1]). Seven points taken from [6] are shown there. However Ref. [6] contains the experimental γ-ray/fission multiplicities for five values of the compound nucleus excitation energy and does not contain the experimental fission times at all. The fission widths presented in Fig. 6 of Ref. [6] are the calculated quantities; they are not extracted from the experiment. Moreover these widths are calculated for seven values of the excitation energy which do not correspond to the beam energies used in the described experiment (see, e.g., Table I or Fig. 4 of Ref. [6]).

TABLE I. The relative difference between the times calculated through Eq. (1), τ_{f1}, and Eq. (2), τ_{f2}. The fission barrier height U_f = 4.58 MeV, which corresponds to Fig. 4 of Ref. [1].

U_f/T	C_0/C_L	$\tau_{f1}/\tau_{f2} - 1$
1.62	1.5	0.0249
	1.0	0.0144
	0.5	– 0.0053
3.43	1.5	0.0028
	1.0	0.0007
	0.5	– 0.0035

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