COMMENTS

Comments are short papers which criticize or correct papers of other authors previously published in the **Physical Review**. *Each Comment should state clearly to which paper it refers and must be accompanied by a brief abstract. The same publication schedule as for regular articles is followed, and page proofs are sent to authors.*

Reply to "Comment on 'Shadow model for sub-barrier fusion applied to light systems'"

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(Received 11 June 1993)

This is a reply to the "Comment on 'Shadow model for sub-barrier fusion applied to light systems'." We confirm the results of our paper. The claimed demonstration of the disagreement between the cross section derived from the "shadow" model and the low energy laboratory data is meaningless because it is based on a comparison which is incorrect.

PACS number(s): 25.70.Jj, 95.30.Cq, 97.10.Cv

In a recent paper [1] we suggested determining the parameters that appear in the "shadow" model [2] by fitting the experimental values of the fusion cross section. Then we suggested using the values of the fusion cross section extrapolated at lower energies to obtain the cross section factor. In the "Comment on 'Shadow model for sub-barrier..." [3] the authors claim that the assumed energy dependence of the fusion cross section for the ^{3}He(^{3}He,2p)^{4}He reaction given in Ref. [1] is wrong. To prove their claim they plot the function $S(E) = \sigma(E)E \exp(2\pi\eta)$ as deduced from the six parameters given in Ref. [1] and compare its behavior with the Krauss *et al.* data [4]. As a consequence of this comparison, the authors conclude that the "shadow" model is not useful for extrapolating measured cross section to astrophysically relevant energies. We reject both the claim and the conclusion of the authors, since they fail when comparing the behavior of the function fitted with a set of data (those of Dwarakanath and Winkler, and Dwarakanath [5]) as clearly stated in Ref. [1], with a different set of data (those of Krauss *et al.* [4]). In Fig. 1 we show the behavior of $S(E)$ obtained by using the "shadow" model when the parameters are determined by the fit to the Krauss *et al.* data [4]. In Figs. 2 and 3 the same comparison is shown for the reactions ^{3}He(^{4}He,γ)^{7}Be [6], ^{7}Be(p,γ)^{8}B [7].

Therefore we conclude that the argument about the disagreement between data and behavior of the shadow model $S(E)$, which the authors use as a main proof for invalidating the extrapolation at low energies, should be firmly rejected.

A quite different story is the author's firm statement about the "unphysical behavior" of the shadow model $S(E)$ as the energy decreases below the range of the existing experimental data. To corroborate their statement the authors quote the article on the microscopic calculation for the low energy ^{3}He(^{3}He,2p)^{4}He reaction (Typel *et al.* [8]), which lead to $S(0) = 5.3$ MeV b, showing that $S(E)$ is a slow varying function of energy as usually assumed in the astrophysical reaction rates calculations. In the above cited article the authors account for the laboratory increasing of $S(E)$ due to the electron screening through the factor $\exp(\pi\eta U_e/E)$, where U_e is the screening potential, and they predict behavior of the measured $S(E)$ at low energies. Now, besides the unavoidable uncertainties of the microscopic calculations even if they are based on firm grounds, it seems quite firmly established that the theoretical calculated U_e's cannot account the experimental increase of $S(E)$, as discussed in Bracci *et al.* [9]. This is also evident in measurements of Engstler *et al.* [10,11], where the authors need U_e's significantly

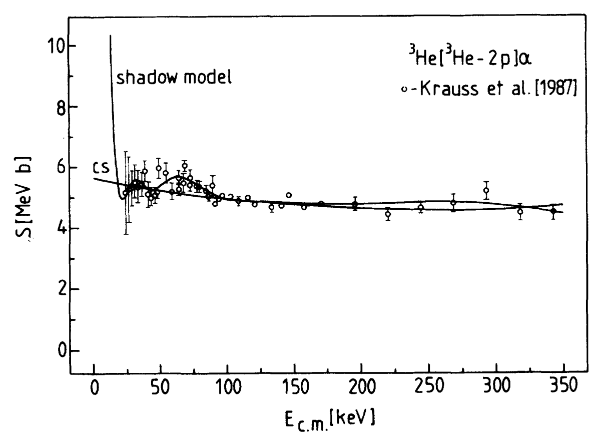

FIG. 1. $S(E)$ function for the reaction ^{3}He(^{3}He,2p)^{4}He. Experimental data are from Ref. [4]. The shadow model line is the energy dependence predicted by the "shadow" model by using the experimental data of Ref. [4]. The cs line is the energy dependence predicted by the classical $S(E)$ function obtained by using a polynomial fit to the data [4].

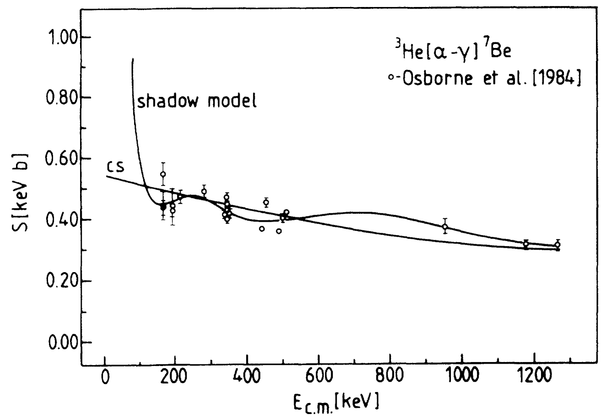

FIG. 2. Same as Fig. 1 for the reaction ^{3}He(^{4}He,γ)^{7}Be [6].

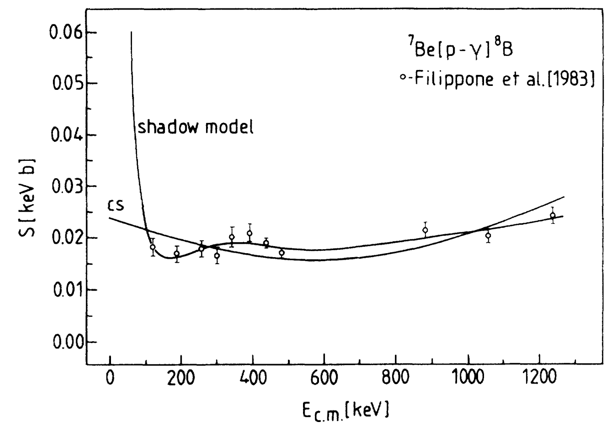

FIG. 3. Same as Fig. 1 for the reaction ^{7}Be(p,γ)^{8}B [7].

larger than those given by the Coulomb model to explain the large increase of $S(E)$ at low energies for examined reactions. All these considerations induce the thought that the experimental data tend to indicate a real increase or an oscillating behavior of $S(E)$ at low energies.

Finally we remark that the energy dependence of fusion cross section is obtained by performing a phenomenological analysis which considers the experimental data of a large number of reactions at energies below the Coulomb barrier (about 100 reactions with $3 \leq A_1 + A_2 \leq 194$) [1,2,12,13] so that the energy dependence of the fusion cross section in the "shadow" model is not simply assumed as claimed by the authors of the Comment [3].

Thanks are due to L. Paterno' for stimulating discussions.

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