Comments

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Measurement of nuclear potentials from fusion excitation functions

J. R. Birkelund and J. R. Huizenga
Nuclear Structure Research Laboratory and Departments of Chemistry and Physics, University of Rochester, Rochester, New York 14627
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Difficulties associated with the determination of the nuclear potential at distances inside the fusion barrier radius are discussed. The critical distance model analysis of fusion excitation functions at high bombarding energies does not give a model independent measurement of the internuclear potential at small separations of interacting heavy nuclei.

Recently, Gomez del Campo and Satchler[1] have proposed the measurement of the internuclear potential at small separations in heavy ion reactions by use of a technique similar to that proposed by Bass.[2] The technique involves the measurement of the slope and intercept of the high energy part of the fusion excitation function, expressed as a function of the inverse of the center-of-mass frame translational energy ($1/E_{c.m.}$) of the target-projectile system. The technique leads to a value of the total internuclear potential and separation determined from the measured slope and intercept, which have been interpreted[1] as the critical values applicable to the Glas and Mosel[3] model of the fusion excitation function. Gomez del Campo and Satchler use a theoretical Coulomb potential to determine the nuclear potential at the critical radius. The technique is an extension of the procedure[4] often used for the determination of fusion barrier parameters in heavy ion reactions at low energy.

Although initially attractive, and apparently leading to measurements of the nuclear potential at small separations of the nuclear centers, the procedure suggested by Gomez del Campo and Satchler suffers from several experimental and conceptual problems which have been previously discussed.[5,6]

The most obvious difficulty is the problem of experimental errors. This is especially troublesome for systems at high energies, where the measurement of fusion cross sections is complicated by the presence of incomplete fusion reactions, which may yield fragments not easily distinguished from those produced by complete fusion reactions. This is illustrated in Fig. 1, where the excitation function for the reaction $^{27}Al+^{20}Ne$ is shown.[7–10] The analysis of this reaction by Gomez del Campo and Satchler is based on that of Van Sen *et al.*[7] and makes use of high energy excitation function data which have not been corrected for the presence of incomplete fusion reactions. The data shown by dots in Fig. 1 are those of Morgenstern *et al.*,[8] and have been corrected for incomplete momentum transfer components in the cross section. The points shown as squares in Fig. 1 are the data of Morgenstern *et al.* uncorrected for incomplete momentum transfer components of the cross section. Line *a* in the figure reproduces the critical parameters used by Gomez del Campo and Satchler. However, this line does not agree with the corrected excitation function data. Line *b* in the figure is drawn through the corrected data in Fig. 1, and leads to a critical radius of zero, and a critical potential of $-\infty$, which illustrates that the model dependent technique suggested by Gomez del Campo and Satchler fails to give a sensible value for the nuclear potential. It is important to observe that line *b* is unaltered even if the two highest energy points of Morgenstern *et al.* are not used.

The problem of the incomplete momentum transfer correction is present in almost all existing high energy heavy ion fusion data and, when the measurements are corrected, will lead at least to a reassessment of the Gomez del Campo and Satchler parameters, and to further difficulties such as

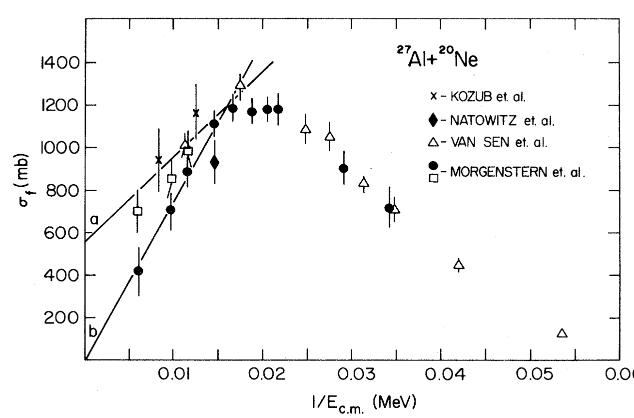

FIG. 1. Excitation function for fusion of $^{27}Al+^{20}Ne$, plotted as a function of $1/E_{c.m.}$. The data are from Refs. 7–10. The data from Morgenstern *et al.* are shown as dots when corrected for the presence of incomplete momentum transfer processes, and as squares when uncorrected. The solid lines *a* and *b* are described in the text.

those seen when the analysis is applied to line *b* in Fig. 1. See, for example, recent measurements[11] of the complete-fusion cross sections for the ^{26}Mg + ^{20}Ne reaction. In conclusion, it is not possible to obtain information about the nucleus-nucleus potential at close contact (large negative values of s) from fusion at high energies by utilizing the critical distance model of Glas and Mosel.

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