$$D(B)dB = \frac{1}{\sqrt{2\pi}\sigma_B} \exp\Big[-\frac{(B-B_0)^2}{2\sigma_B^2}\Big] \quad (1)$$

where the two parameters, the mean barrier B_0 and the distribution width σ_B, to be determined individually for each reaction.

III. THE FUSION CROSS SECTION

The energy dependence of the fusion cross section is obtained by folding the barrier distribution [9, 10] provided by Eq.(1), with the classical expression for the fusion cross section given by

$$\begin{aligned} \sigma_f(B) &= \pi R_B^2 \Big[1 - \frac{B}{E}\Big] && \text{for } B \le E \\ &= 0 && \text{for } B \ge E \quad (2) \end{aligned}$$

where R_B denotes the relative distance corresponding to the position of the barrier approximately, which yields

$$\begin{aligned} \sigma_{fus}(E) &= \int_0^\infty \sigma_f(B)D(B)dB \\ &= \int_0^{B_0} \sigma_f(B)D(B)dB + \int_{B_0}^{E} \sigma_f(B)D(B)dB \quad (3) \\ &= \pi R_B^2 \frac{\sigma_B}{E\sqrt{2\pi}} \Big[\xi\sqrt{\pi}\Big\{\mathrm{erf}\xi + \mathrm{erf}\xi_0\Big\} + e^{-\xi^2} + e^{-\xi_0^2}\Big] \end{aligned}$$

where

$$\begin{aligned} \xi &= \frac{E - B_0}{\sigma_B\sqrt{2}} \\ \xi_0 &= \frac{B_0}{\sigma_B\sqrt{2}} \quad (4) \end{aligned}$$

and erfξ is the Gaussian error integral of argument ξ. The parameters B_0 and σ_B along with R_B is to be determined by fitting Eq.(3) along with Eq.(4) to a given fusion excitation function. In the derivation of formula Eq.(3), the quantum effect of sub-barrier tunneling is not accounted for explicitly. However, the influence of the tunneling on shape of a given fusion excitation function is effectively included in the width parameter σ_B.

The fusion cross section formula of the Eq.(3) obtained by using the diffused-barrier, is a very elegant parametrization of the cross section for a process of overcoming the potential-energy barrier. Hence, it can be successfully used for analysis and predictions of the fusion excitation functions of light, medium and moderately heavy systems, especially in the range of near-barrier energies. The term 'capture' is used to refer the process of overcoming the interaction barrier in a nucleus-nucleus collision, followed by formation of a composite system. In general, the composite system undergoes fusion only in a fraction f of the capture events. For light and medium systems, $f \approx 1$, and almost all the 'capture' events lead to fusion resulting fusion cross sections to be practically identical with the capture cross sections. However, for very heavy systems, only a small fraction ($f < 1$) of 'capture' events ultimately lead to fusion while for the remaining part of the events, the system re-separates prior to equilibration and clear distinction between fusion and capture cross sections then becomes necessary. Therefore, for very heavy systems, when the overcoming the barrier does not guarantee fusion, predictions based on Eq.(3) give the capture cross section.

IV. CALCULATION AND RESULTS

The near-barrier (above barrier) fusion excitation functions of medium and heavy nucleus-nucleus systems have been analyzed using a simple diffused barrier formula (given by Eq.(1)) derived by folding the Gaussian barrier distribution with the classical expression for the fusion cross section for a fixed barrier. The same set of target-projectile combinations have been selected for which heavy ion sub-barrier fusion has been recently [11] studied. The values of mean barrier height B_0, width σ_B and the effective radius R_B have been obtained using the least-square fit method. These values are listed in Table-I and arranged in order of the increasing value of the Coulomb parameter $z = Z_1Z_2/(A_1^{1/3} + A_2^{1/3})$. Since the number of data points for ^{48}Ca+^{124}Sn is too low compared to other systems, the error bars for B_0 (111.93±0.44), σ_B (1.28±0.83) and R_B (8.24±0.09) are rather large.

TABLE I: The values of the mean barrier height B_0, the width of the barrier height distribution σ_B and the effective radius R_B, deduced from the analysis of the measured fusion excitation functions.

Reaction	z	Refs.	B_0 [MeV]	σ_B [MeV]	R_B [fm]
^{16}O+^{154}Sm	62.94	[12]	58.80	2.43	10.04
^{17}O+^{144}Sm	63.49	[12]	60.28	1.75	10.46
^{16}O+^{148}Sm	63.51	[12]	59.88	2.31	10.61
^{16}O+^{144}Sm	63.91	[12]	60.65	1.76	10.46
^{36}S+^{110}Pd	90.94	[13]	85.51	1.92	8.20
^{32}S+^{110}Pd	92.39	[13]	86.04	3.10	8.45
^{48}Ca+^{96}Zr	97.41	[14]	93.76	2.75	10.07
^{48}Ca+^{90}Zr	98.58	[14]	94.94	2.11	10.01
^{40}Ca+^{96}Zr	100.01	[15]	94.30	3.09	9.71
^{40}Ca+^{90}Zr	101.25	[15]	96.26	1.67	10.07
^{48}Ca+^{124}Sn	116.00	[16]	111.93	1.28	8.24
^{40}Ca+^{124}Sn	118.95	[17]	113.36	2.70	9.57

In Figs.-1 & 2, the measured fusion excitation functions represented by full circles are compared with the