Resonance function for line shape analysis

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Abstract

A comparison of two expressions for the Breit-Wigner resonance function is given to facilitate line shape analyses of neutron resonances.

1 Resonance functions

The following single Breit-Wigner resonance function was used in Ref. [1] for the line shape analysis of neutron resonances:

$$\sigma(E_{\rm rel}) \sim \frac{\Gamma(E_{\rm rel})\Gamma_r}{\{E_r + \Delta E(E_{\rm rel}) - E_{\rm rel}\}^2 + \{\Gamma(E_{\rm rel})/2\}^2}. \tag{1}$$

The shift function $\Delta E(E_{\rm rel})$ and the level width $\Gamma(E_{\rm rel})$, which depend on the relative energy $E_{\rm rel}$, are given by using the penetration P and shift S factors [2] by the relations:

$$\Delta E(E_{\rm rel}) = \Gamma_r \times \{S(E_r) - S(E_{\rm rel})\}/\{2P(E_r)\}, \tag{2}$$

$$\Gamma(E_{\rm rel}) = \Gamma_r \times P(E_{\rm rel})/P(E_r). \tag{3}$$

Here the dependence on the angular momenta l for some quantities (e.g., P and S) is implicit.

In a recent paper [3], Riisager has shown the line shape function for a resonance populated by a Gamow-Teller β decay as [Eq.(5)]

$$\rho(E) = \frac{P(E)\gamma^2}{(E_0 + \Delta - E)^2 + [P(E)\gamma^2]^2}, \tag{4}$$

where $\Delta = -[S(E) - S(E_0)]\gamma^2$. This expression is also consistent to those in Refs. [4, 5].

It is noted that with the following substitutions, Eqs.(1)−(3) are recovered from Eq.(4) apart from a trivial constant factor:

$$\Gamma = 2P\gamma^2, \tag{5}$$

$$E_{\rm rel} = E, \tag{6}$$

$$E_r = E_0. \tag{7}$$

Table 1: Expressions for $A_l^2 z^l$ and $A_l^2 S_l z^l$ which characterise positive energy neutron wave functions. $z = \rho^2$. There is conviction that the expressions of $A_l^2 S_l z^l$ for l=2 and 3 in Table.A.1 of Ref. [2] must be corrected as given here.

l	$A_l^2 z^l$	$A_l^2 S_l z^l$
0	1	0
1	$1+z$	-1
2	$9+3z+z^2$	$-3(6+z)$
3	$225+45z+6z^2+z^3$	$-3(225+30z+2z^2)$

2 Penetration and shift factors

The penetration and shift factors may be calculated using the following formulae [2]:

$$P_l = \frac{\rho z^l}{A_l^2 z^l}, \tag{8}$$

$$S_l = \frac{A_l^2 S_l z^l}{A_l^2 z^l}. \tag{9}$$

Here $\rho = kr$, $z = \rho^2$, and $A = \sqrt{F^2 + G^2}$, with F and G the Coulomb wave functions. The expressions of $A_l^2 z^l$ and $A_l^2 S_l z^l$ for various values of l are given in Table 1.

3 Miscellaneous

There is conviction that the expression of v_2' [Eq.(5.8) of chapter 8] in Ref. [6] must be corrected as below:

$$v_2' = \left(1 - \frac{6}{x^2}\right)^2 + \left(\frac{6}{x^3} - \frac{3}{x}\right)^2. \tag{10}$$

References

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