PHY 982 Homework 3

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1 Choice of beam energies and potentials

The ^{12}C(d, p)^{13}C reaction is discussed in this work. Two deuteron beam energies are used, one is 2.84 MeV near the Coulomb barrier around 2 MeV and another one is 4.51 MeV.

At both of the experimental energies chosen, the reaction is more accurately modeled as a compound reaction, as mentioned in [1]. Therefore our calculations using FRESCO may not yield satisfying agreement with experiment.

Optical potentials are needed that described the incoming and outgoing distorted waves. These are interactions between: ^{12}C, d [2]; ^{13}C, p [3]; and ^{12}C, p[4]. For the deuteron wavefunction, the binding for the proton and neutron was described by a simple gaussian potential

$$V_{np}(r) = -72.15e^{-(r/1.484)^2}. \tag{1}$$

scaled to reproduce a bound state at 2.2 MeV.

The neutron that is transferred in the reaction is expected to occupy a $1p_{\frac{1}{2}}$ orbit with an experimental single-particle binding energy of 4.946 MeV. The FRESCO calculation dynamically adjusts the Woods-Saxon depth for ^{13}C to reproduce this energy.

2 Results of DWBA post-form calculations

In a transfer reaction A(d,p)B showed in Fig. 1, by introduction the auxiliary potential $U_f(R_2)$, the transfer T-matrix has a formula [5]

$$T_{post} =< \phi_{nA}\chi_{pB}^{(-)} \left|V_{np}(r_1) + U_{pA}(r_p) - U_f(R_2)\right| \Psi_1^+(\vec{r}_1, \vec{R}_1) >, \tag{2}$$

where ϕ_{nA} and χ_{pB} are bound states wave-functions. Under DWBA approximation, it becomes

$$T_{post}^{DWBA} =< \phi_{nA}\chi_{pB}^{(-)} \left|V_{np}(r_1) + U_{pA}(r_p) - U_f(R_2)\right| \phi_{np}\chi_{dA} > . \tag{3}$$

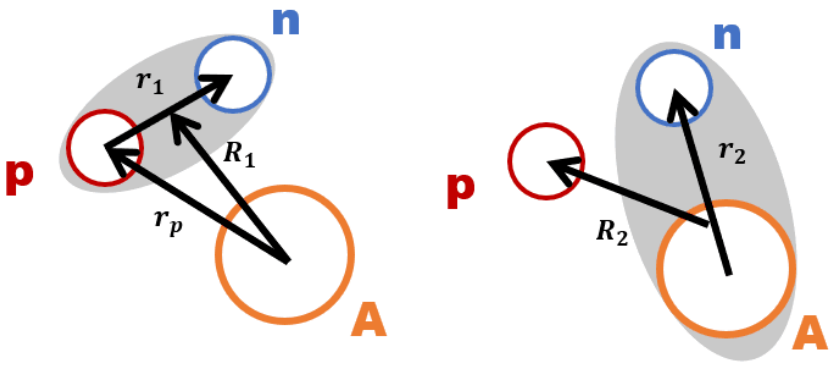

Figure 1: Coordinates used in one neutron transfer reaction.

Besides that, we still need information for the auxiliary potential $U_f(R_2)$. It's usually chosen as $U_{pB}(R_2)$ fitted from elastic scattering. We name $V_{np}(r_1)$ as binding potential and the rest two remnants.

Here are three different handling methods we used in our calculations.

1. Zero range approximation (ZRA): Remnants are neglected; $V_{np}(r_1)$ is considered as a local interaction with strength D_0. Correspondingly, the T-matrix becomes

$$T_{post}^{ZR-DWBA} = D_0 < \phi_{nA}(R_1)\chi_{pB}^{(-)}|\chi_{dA}(R_1) > \tag{4}$$

   It now relies on R_1 only which simplifies calculation.

2. First order DWBA without or with remnant: The former abandons the remnants but latter keeps, as well as the nonlocality of $V_{np}(r_1)$ is preserved in both.

The results together with experimental data are presented in figures (need to be supplemented). We can see ZRA gives result deviates most from experiment because it applies the roughest approximation. DWBA with or without remnants yield close results. This makes sense because U_{pA} and U_{pB} are so similar that they almost cancel each other in Eq. 3. But looking closer, we find the one with remnants is more contiguous to experiment.

3 Results of prior-form DWBA calculations

To be filled by Tong.

4 Extraction of spectroscopic factor

To be filled by Tong.

References

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