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COUPLED-CHANNEL ANALYSIS OF NEUTRON SCATTERING FROM ^{12}C BETWEEN 9 and 15 MeV

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A deformed and energy dependent phenomenological optical model potential and coupled-channel formalism for deformed nuclei have been used in the analysis of elastic and inelastic (Q = -4.439 MeV) scattering, and analyzing power for neutrons scattered from ^{12}C in the energy range of 9 to 15 MeV.

Measurements[1-3] of the angular distributions for the (n,n_0) and $(n,n')_{4.44}$ secondary neutrons and for the analyzing power $A(\Theta)$ of polarized neutrons scattered from these two levels were analyzed using deformed optical model potentials (DOMP). The coupled-channel (CC) calculations were done with the code ECIS using deformed central and spin orbit potentials. The main objectives of these calculations were, 1) to find an energy dependent DOMP (EDDOMP) that will give reasonable fits to the scattering and analyzing power data and 2) to investigate the importance of a rotation-vibration interaction at these energies by coupling the levels of the ground state (GS) rotational band $K = 0^+$ to those of the first octupole band $K = 3^-$.

There are two earlier CC analyses[2,3] of some of the data included in this work but both have their limitations. In Ref. 3 the authors did not obtain an EDDOMP from the analysis of their polarization measurements and scattering data[4]. Furthermore, the latter has recently been reanalyzed[5] and although systematic differences with the earlier data have not been found, there are changes in the values of the cross sections. In Ref. 2 the prescribed EDDOMP (set A & B) were obtained from a CC analysis that only included elastic and inelastic neutron scattering data. As a result these DOMP give poor fits to the analyzing power data of Ref. 3.

Starting from the DOMP given[2] by set B, a search procedure was done to optimize the fits to both the scattering and analyzing power angular distributions from the GS and 4.44 MeV level. The CC calculations shown in Fig. 1 include the GS(0^+), 4.439 MeV(2^+) and 14.08 MeV (4^+) levels of the GS band. The central potential (V_R and W_D) and the real spin orbit potential, V_{SO}, are deformed (see Table I for the values of the parameters). No improvement in the fits to the data was found by introducing an imaginary spin orbit potential.

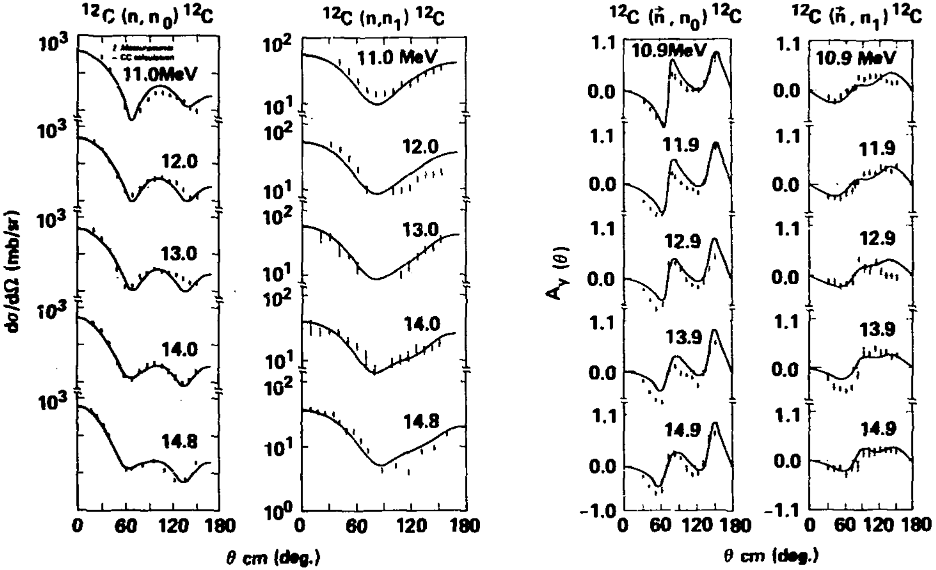

Fig. 1. Coupled-channel calculations carried out with the DOMP given in Table I. Measurements of the neutron elastic and inelastic (4.44 MeV level) differential cross sections[1,2] and respective analyzing power[3]. The fits to the 9 and 10 MeV data are not shown to avoid overcrowding the figures, but they are comparable in quality to the ones seen here.

TABLE I. Parameters for the DOMP used in the present calculations.

$V_R = 59.80 - 0.34E$ MeV $r_V = 1.06$ fm $a_R = 0.540$ fm

$W_V = 0$

$W_D = 0.66E - 4.60$ MeV $r_W = 1.25$ fm $a_W = 0.280$ fm

$V_{SO} = 9.67 - 0.38E$ MeV $r_{SO} = 0.86$ fm $a_{SO} = 0.360$ fm

$\beta_2 = 0.640$ $\beta_4 = 0.200$ $\beta_3 = 0.227$

A second calculation was done where the GS and 4.44 levels were coupled to each other and to the 9.64 MeV 3^- level (rotational-vibrational model). Starting from the DOMP given in Table I, the interband and intraband transitions potentials were calculated using the formalism derived by Meigooni *et al.*[6]. In these calculations only the central potential is deformed and a real, spherical V_{SO} is included only in the calculation of the intraband potentials (codes OCTOVIB and EXTERNAL written by A. S. Meigooni were used to calculate the potentials to be input into ECIS). The CC results showed that if only the 0^+-3^- interband coupling was included, the agreement with the data was comparable to that shown in Fig. 1, although sytematically worse. The fits were similar to those obtained with the 0^+-2^+-4^+ coupling with a spherical V_{SO}. However when the 2^+-3^- ($\lambda = 3,5$) couplings were also included the fits to the 2^+ inelastic scattering and $A(\theta)_y$ data deteriorated completely (the limited space of this presentation does not allow to show the results of these calculations). In order to reproduce the measurements the interband potential for the 2^+-3^- coupling has to be changed drastically from the values predicted[6] by the calculations. Since these changes affected also the values of the cross sections for the 3^- level and they could not be tested due to the lack of data for this level in this energy region, it was felt that we did not have enough information to have a meaningful interband calculation.

In summary, neutron scattering data from ^{12}C in the 9-15 MeV enegy range is well reproduced by CC calculations where the target is described by a pure rotational model. The complexities of the calculations required to couple the GS rotational band to the octupole band were not justified by the quality of the fits to the data. At this stage it is not clear if the rotational-vibrational description is needed at these energies, or if the approximations in the calculations of the potentials must be revised before proceding any further.

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