HIGH RESOLUTION MEASUREMENT OF THE ^{116}Sn$(p,t)^{114}$Sn REACTION AT 26 MeV*

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Angular distributions of tritons from the ^{116}Sn$\,(p,t)^{114}$Sn reaction induced by 26 MeV protons have been measured up to an excitation energy of $\sim$ 4.1 MeV using the Q3D spectrometer. The DWBA analysis of the angular distributions allowed to confirm previous spin and parity values and to propose new assignments for a large number of states. Shell model calculations are in progress.

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1. Introduction

The study of the ^{116}Sn$(p,t)^{114}$Sn reaction was performed to improve the experimental information on ^{114}Sn via accurate measurement of the differential cross sections for about 60 transitions to the residual nucleus up to an excitation energy of $\sim$ 4.1 MeV, allowing to confirm and identify spin and parity for many levels.

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The ^{114}Sn level structure was investigated by means of γ-spectroscopy using ^{100}Mo(^{18}O$, 4n\gamma$)^{114}Sn, ^{112}Cd($\alpha, 2n\gamma$)^{114}Sn and $(n, n'\gamma)$ reactions; β^- and β^+ decay; inelastic scattering of protons, deuterons and α-particles; Coulomb excitation; one- and two-nucleon transfer reactions. The experimental results are summarized in the NDS compilation [1], where a more complete collection of references can be found.

2. Experimental results and DWBA analysis

The experiment was performed using the 26 MeV proton beam from the Munich HVEC MP Tandem, the Q3D magnetic spectrograph and the light ion focal plane detector with cathode periodic readout [2]. A ^{116}Sn isotopic enriched (96.8%) target with a thickness of 100 μg/cm^2 on a carbon backing of 5.6 μg/cm^2 was used.

High resolution energy spectra with an energy resolution of about 8 keV FWHM in the detection of the outgoing particles were obtained. The uncertainty on our quoted energies is estimated to be 3 keV.

The cross section angular distributions were measured in two different magnetic field settings of the spectrograph, in order to reach an excitation energy of the ^{114}Sn residual nucleus of $\sim$ 4150 keV. Absolute cross sections are estimated with a systematic uncertainty of $\sim$ 15%.

In Table I all information on previous experiments available in literature [1] and the results of present transfer reaction experiment are summarized.

Starting from a 0^+ initial state and assuming that the neutrons are transferred in a relative $L = 0$ state with total spin $S = 0$, only natural parity states in the final nucleus will be populated in a one-step transfer process, with a unique L transfer. In this case the determination of the L transfer directly gives both spin and parity of the observed level.

For the transitions populating the ^{114}Sn states, DWBA analyses have been carried out assuming a semimicroscopic dineutron cluster pickup mechanism. The calculations have been done in finite range approximation, using the computer code TWOFNR [3], and a proton-dineutron interaction potential of Gaussian form:

$$V(r_{p2n}) = V_0 \exp - \left(\frac{r_{p2n}}{\xi}\right)^2 \quad \text{with} \quad \xi = 2\,\text{fm}.$$

The parameters for the proton entrance channel, deduced from a systematic survey of elastic scattering by Perey [4] and for the triton exit channel by Fleming *et al.* [5] have been slightly adjusted for optimized agreement with the experimental angular distributions.

TABLE I

^{114}Sn level scheme (energies in keV).

Adopted [1]		Pres. experim.		Adopted [1]		Pres. experim.	
$E_{\rm exc}$	J^π	$E_{\rm exc}$	J^π	$E_{\rm exc}$	J^π	$E_{\rm exc}$	J^π
0	0^+	0.0	0^+	3451.7		3452	0^+
1299.92	2^+	1300	2^+	3471.4	6^+	3473	6^+
1953.2	0^+	1954	0^+	3478.9	(2^+)	3477	2^+
2156.2	0^+	2154	0^+			3486	5^-
2187.5	4^+	2188	4^+	3510.5	9^-		
2239.0	2^+					3515	3^-+9^-
2274.7	3^-	2274	3^-	3514.19	$2^+,3^+$		
2421.2	0^+	2417	0^+	3525.1	3^-	3526	3^-
2454.3	2^+	2451	2^+	3548	0^+	3549	0^+
		2510	3^-	3561.2	2^+		
2514.7	$3^+,4^+$					3561	2^++7^-
2576?	2^+	2576	2^+	3566.4	(7^-)		
2614.3	4^+	2613	4^+			3587	4^+
2765.6	4^+	2765	4^+	3658.7		3654	4^+
2815.1	5^-	2816	5^-			3680	4^+
2859.9	4^+	2860	4^+	3690		3696	2^+
2905.1	4^+			3717.5			
		2906	3^-	3722	2^+	3727	2^+
2915.7	2^+	2916	2^+	3740.0		3740	0^+
2943.5	2^+	2943	2^+	3759	0^+	3765	0^+
3025	$2,3^+$			3781.9	2^+		
3027	0^+	3028	0^+			3786	4^+
3028.1	$2,3^+$					3800	2^+
3087.4	7^-	3088	7^-	3870.7	8^+		
3149.8	6^+	3149	6^+			3871	5^-
3186.1	2^+	3186	2^+	3872	2^+	3876	2^+
3188.4	6^+	3190	6^+	3928			
3190.3	$(8)^-$					3939	3^-
3204	0^+			3956	2^+		
3207.8	4^+	3206	4^+			3971	2^+
3211.8	(1,2)			3971.4	8^-		
		3225	3^-	3976			
3225.9	$2^+,3^+$					3988	3^-
3242.0	5^-			3991.4	$2^+,3^+,4^+$		
		3242	5^-+6^+			4000	4^+
3244.1	$(4,5,6)^-$			4029.8			
3308.4	0^+	3309	0^+	4046.8	(5^-)	4044	5^-
3325.5	2^+	3325	2^+			4057	6^+
3357.2	4^+	3358	4^+	4088.9	$(8)^+$		
3363.1	$4^-,5^-,6^-$	3363	5^-			4095	2^+
3397.2	(4^-)	3397	6^+	4119	4^+	4118	4^+
3422.7	0^+	3422	0^+	4136		4136	4^+
3448.4		3448	4^+	4139.4	10^+		

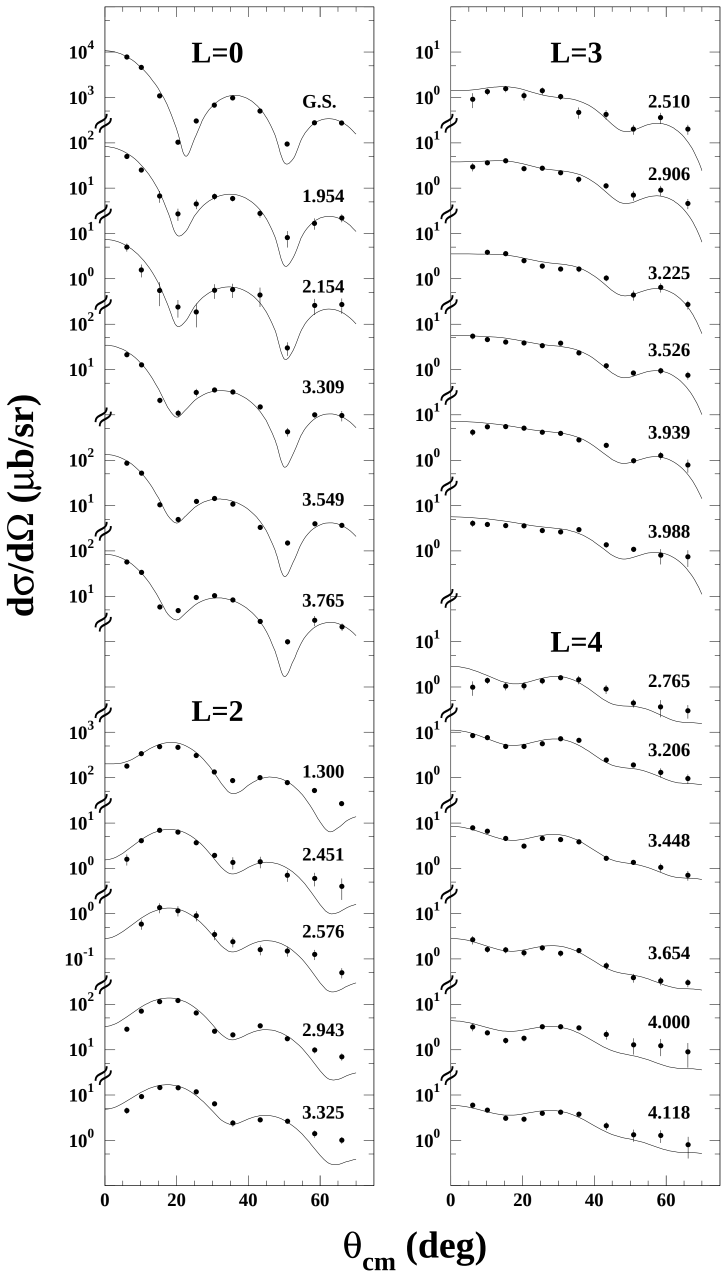

Fig. 1. Examples of comparison of experimental angular distributions with calculated ones for some L-transfers (energies in MeV).

Transferred L-values have been assigned by comparing the shapes of the experimental angular distributions with the calculated ones. Examples of typical analyses for different L-transfers are reported in Fig. 1. The clear structure of the angular distributions, allowing for an easy discrimination of different L-transfer, is well described by the DWBA calculations.

As Table I evidences, we have made spin-parity assignements for all the observed levels. In particular 15 levels have been observed for the first time and identified in J^π. Moreover, for levels reported in NDS [1], 32 confirmations and 6 new assignments of J^π have been made and 4 ambiguities have been removed. Three unresolved doublets have been observed, giving 3 confirmations, 2 new assignments and 1 ambiguity removed.

3. Shell model calculations

Along with the experimental work a shell-model description of the ^{114}Sn is in progress.

We assume that ^{100}Sn is a closed core and let the 14 valence neutrons occupy the five single-particle orbits in the 50–82 shell. As residual interaction between the valence neutrons a realistic effective interaction derived from the Bonn-A nucleon–nucleon potential, already used in a previous study of the light tin isotopes with $A \leq 105$ [6], is employed. This interaction, however, turns out to be not completely adequate when moving away from closed shell. A better agreement between theory and experiment is obtained by weakening the $J^\pi = 0^+$ matrix elements.

TABLE II

Experimental [1] and calculated yrast states of ^{114}Sn.

Experimental		Calculated	
J^π	$E_{\rm exc}$ (MeV)	J^π	$E_{\rm exc}$ (MeV)
0^+	0.0	0^+	0.0
2^+	1.300	2^+	1.755
4^+	2.188	4^+	2.224
3^+,4^+	2.515	3^+	2.419
5^-	2.815	5^-	2.756
7^-	3.087	7^-	3.031
6^+	3.150	8^-	3.091
$(8)^-$	3.190	6^+	3.226
9^-	3.511	9^-	3.484
8^+	3.871	8^+	3.990
10^+	4.139	10^+	3.998

Within the chosen model space the size of the energy matrices to be set up and diagonalized is very large and we have found it convenient to resort to some truncation method. To start with, we have carried out calculations within the framework of the broken-pair approximation [7] including up to two broken pairs. The comparison between the calculated excitation energies of the yrast states and the experimental ones is rather satisfactory, as reported in Table II.

The results presented here are to be considered preliminary. We are currently refining our calculations employing a better approximation scheme, the chain-calculation method, which we have already used in a previous study of ^{120}Sn [8]. A detailed comparison between theory and experiment will be performed upon completion of these calculations.

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