Microscopic Calculations of the ^{123}Sb(p,t)^{121}Sb Reaction Cross Sections

P. Guazzoni [a], V. Yu. Ponomarev [b], L. Zetta [c], G. Graw, R. Hertenberger, G. Staudt [d], and M. Jaskola [e]

[a] Dipartimento di Fisica dell'Universita' and I.N.F.N,I-20133 Milano, Italy
[b] Bogoliubov Laboratory of Theoretical Physics, Joint Institute of Nuclear Research, Dubna, Russia
[c] Dipartimento di Fisica dell'Universita' and I.N.F.N,I-20133 Milano, Italy
[d] Physikalisches Institut der Universität, D-72076 Tübingen, Germany
[e] Soltan Institute for Nuclear Studies, Swierk, Poland

To contribute to a better understanding of the ^{121}Sb nucleus from the ^{123}Sb(p,t)^{121}Sb reaction induced by 26 MeV protons and measured up to an excitation energy of about 3 MeV, we have supplemented the (p,t) data with microscopic calculations of the reaction cross sections within the QPM [1,2,3].

On the first stage calculations have been done for the neighboring even-even ^{120}Sn nucleus to fix the model parameters. Excited states in ^{120}Sn have been described by a wave function which includes one- and two-phonon configurations. Strength parameters of multipole residual interaction have been adjusted to reproduce the properties of low-lying collective states. On a good level a one-to-one correspondence has been established up to about 3 MeV between calculated excited states of different multipolarities in ^{120}Sn and levels observed in ^{122}Sn(p,t)^{120}Sn reaction measured at the same incident energy and in the same experimental conditions.

On the second stage of our calculations we have considered ground and excited states in ^{121}Sb with a total spin J and projection M which we describe by a wave function:

$$\Psi^{\nu}(JM) = \Bigg\{ C^{\nu}(J)\ \alpha^{+}_{JM} \ + \sum_{j\beta_1} S^{\nu}_{j\beta_1}(J)\ [\alpha^{+}_{j} Q^{+}_{\beta_1}]_{JM} + \sum_{j\beta_1\beta_2 l} \frac{D^{\nu}_{j\beta_1\beta_2}(J)\ [\alpha^{+}_{j}[Q^{+}_{\beta_1} Q^{+}_{\beta_2}]_{l}]_{JM}}{\sqrt{1+\delta_{\beta_1\beta_2}}} \ |^{120}\ \mathrm{Sn}\rangle_{g.s.} \quad (1)$$

where α^{+}_{jm} is an operator of a quasiparticle (qp) creation on an average field level with quantum numbers $jm \equiv (n,l,j,m)$ and Q^{+}_{β} is a phonon (ph) creation operator with $\beta \equiv (\lambda,\mu,i)$. Square brackets in Eq. (1) denote momentum coupling, i.e. $[\alpha^{+}_{j} Q^{+}_{\beta}]_{JM} = \sum_{m\mu} C^{JM}_{jm\lambda\mu} \alpha^{+}_{jm} Q^{+}_{\lambda\mu i}$, etc. with Clebsh-Gordon coefficients C. In actual calculation we have used several lowest RPA solutions for each multipolarity $\lambda = 0-7$ corresponding to natural parity excitations of the core ^{120}Sn nucleus. In the present calculation all [qp $\times$ 1ph] configurations up to 4.0 MeV and [qp $\times$ 2ph] ones up to 5.75 MeV which do not violate Pauli principle have been accounted for.

Calculations have been performed for excited states in ^{121}Sb with J^{π} ranging from $1/2^{\pm}$ to $19/2^{\pm}$ up to an excitation energy of 3.5 MeV. Since we consider their excitation in (p,t) reaction from the $7/2^{+}$ ground state of ^{123}Sb, only $[1g_{7/2} \times Q^{+}_{\lambda i}]_{J^{\pi}}$ configurations are responsible for their excitation. All other configuration have excitation matrix elements a few orders of magnitude smaller than the above mentioned ones. The only exception is the excitation of $7/2^{+}$ states for which we have a very large matrix element of excitation of the qp-configuration which corresponds to the excitation of the 0^{+} ground state of ^{120}Sn in ^{122}Sn(p,t)^{120}Sn reaction.

The results of calculation of the ^{123}Sb(p,t)^{121}Sb reaction cross sections, as a function of excitation energy of ^{121}Sb, in fig. 1c are compared to experimental data in fig. 1a In the middle part of this figure we present the results of simplified calculations in which the unpaired quasiparticle is considered as a pure spectator. In the last calculations all multiplets $[\alpha^{+}_{j} Q^{+}_{\lambda}]_{J}$ with $|j-\lambda| \leq J \leq (j+\lambda)$ are energy degenerated and only the states with the maximum possible value of J are seen in fig. 1b because of their largest excitation probability.

References

[1] V. G. Soloviev, Theory of Complex Nuclei, Pergamon, Oxford, 1976
[2] A. I. Vdovin *et al.*, Sov. J. Part. Nucl. **16** (1985) 105
[3] S. Gales *et al.*, Phys. Rep. **166** (1988) 125

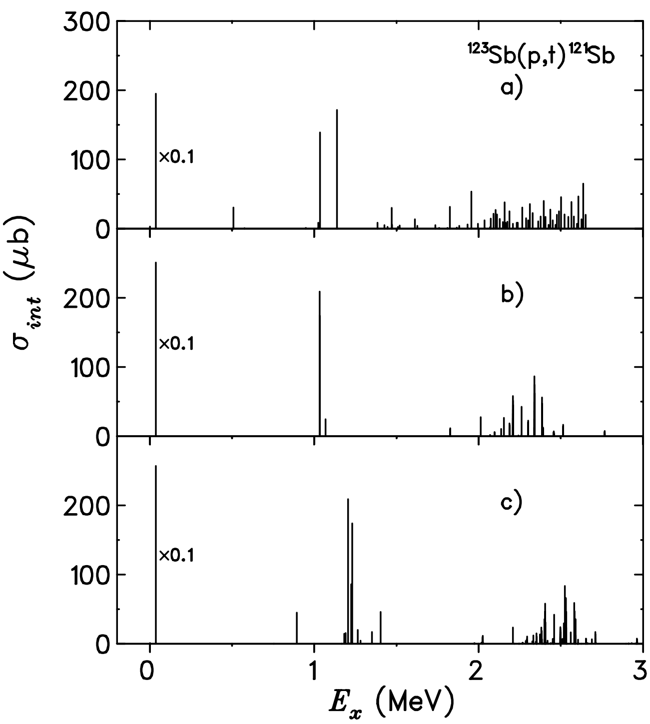

Fig. 1: reaction cross sections, as a function of excitation energy of ^{121}Sb, see text