QPM Calculations of the Nucleus ^{119}Sb

V. Yu. Ponomarev [a], P. Guazzoni [b], L. Zetta [b], T. Faestermann, G. Graw, R. Hertenberger, H.-F. Wirth, and M. Jaskóla [c]

[a] Institut für Kernphysik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany
[b] Dipartimento di Fisica dell'Università, and I.N.F.N., Via Celoria 16, I-20133 Milano, Italy
[c] Soltan Institute for Nuclear Studies, Hoza Street 69, Warsaw, Poland

To better understand our ^{121}Sb(p,t)^{119}Sb reaction data [1], the (p,t) experiment has been supplemented with microscopic calculations of the integrated cross sections within the Quasiparticle-Phonon Model [2]. These microscopic calculations of the ^{121}Sb(p,t)^{119}Sb integrated cross sections have been performed since it is not possible to unequivocally identify the spin of most of the excited levels of ^{119}Sb from the analysis of the experimental angular distributions.

QPM calculations for the neighboring residual even-even nucleus ^{118}Sn have been performed with a wave function of excited states with multipolarity J, written as a combination of one- and two-phonon configurations. The properties of the phonon excitations have been obtained by solving quasiparticle RPA equations for different natural-parity multipolarities from 0^+ to 7^-. These equations yield the phonon energies and the internal fermion structure of each phonon. The strength of the residual interaction in the model Hamiltonian has been adjusted to the experimental properties of the collective 2_1^+ and 3_1^- levels.

Calculations for the odd-mass nucleus ^{119}Sb have been performed with a wave function containing quasiparticle-, [quasiparticle x one-phonon]-, and [quasiparticle x two-phonon]-configurations:

$$\Psi^\nu(JM) = \Bigg\{ C^\nu(J)\ \alpha^+_{JM} \ + \sum_{j\lambda i} S^\nu_{j\lambda i}(J)\ [\alpha^+_j Q^+_{\lambda i}]_{JM} + \sum_{j\lambda_1 i_1 \lambda_2 i_2 l} D^\nu_{j\lambda_1 i_1 \lambda_2 i_2}(J) \frac{[\alpha^+_j [Q^+_{\lambda_1 i_1} Q^+_{\lambda_2 i_2}]_l]_{JM}}{\sqrt{1+\delta_{\lambda_1 i_1, \lambda_2 i_2}}} \Bigg\} |^{118}\ \mathrm{Sn}\rangle_{g.s.} \quad (1)$$

where α^+_{jm} is a quasiparticle creation operator on a proton mean field level $jm = |nljm>$ and $Q^+_{\lambda\mu i}$ is a phonon excitation in the ^{118}Sn core. To obtain the coefficients C, S, and D in (1) we diagonalize the model Hamiltonian on the set of wave functions (1). This diagonalization performed for different J also yields eigen-energies of the excited states. The ^{121}Sb$(p,t)^{119}$Sb cross section to the final state $J\nu$ by momentum transfer L, has the form:

$$\frac{d\sigma}{d\Omega}(^{121}\mathrm{Sb}_{g.s.} \to ^{119}\mathrm{Sb}_{J\nu}) = \Bigg| C^\nu(J)\ \delta_{J,5/2^+}\ A_{g.s.} + \sum_i S^\nu_{jLi}(J)\ \delta_{j,5/2^+}\ A_{Li} \Bigg|^2 \quad (2)$$

where $J = 5/2^+$ is the ground state of ^{119}Sb. Since experimental conditions for the ^{120}Sn(p,t)^{118}Sn and ^{121}Sb(p,t)^{119}Sb reaction were very close, we have used in (2) the amplitudes A of excitations of one-phonon configurations in ^{118}Sn. The amplitude $A_{g.s.}$ corresponds to the transition between the ground states $^{120}\mathrm{Sn}_{g.s.} \to {}^{118}\mathrm{Sn}_{g.s.}$. In fact when the ^{119}Sb nucleus is excited, the same set of phonons of the core ^{118}Sn is involved and the unpaired proton of antimony does not influence the excitation process in a one step transfer. In Fig. 1 the experimental integrated cross sections of the ^{121}Sb(p,t)^{119}Sb reaction (top) is compared with the complete calculations (bottom) carried out with the wave functions (1) and with the simplified calculations (middle) in which the unpaired proton is considered as a pure spectator.

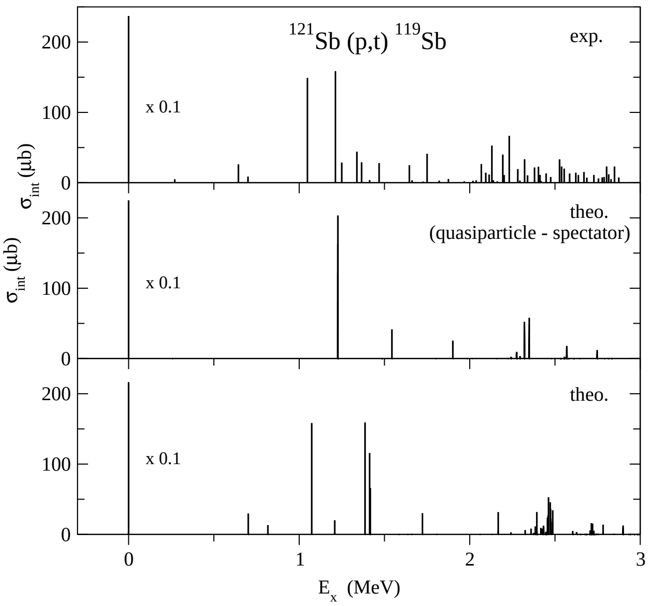

Fig. 1: Comparison between experimental and QPM integrated cross sections.

For that, we have switched off the term of the residual interaction in the model Hamiltonian which is responsible for mixing between simple and complex configurations. The spectator approach reproduces the general features of the experimental distribution, but is not able to describe the splitting of the multiplets. On the contrary, the realistic calculations performed with the wave function (1) reasonably well reproduce the fragmentation of the (p,t) cross section at higher excitation energy, as well as the absence of the (p,t) strength above 2.9 MeV. In the excitation energy region up to 2.597 MeV, besides the ground state, three $5/2^+$ states have been identified because of L=0 transfer. The theory also predicts the existence of only four $5/2^+$ states below 2.9 MeV. The agreement between experiment and theory for these states, both in position and integrated (p,t) cross sections, is very good.

References

[1] P. Guazzoni *et al.*, Annual report 2006, p. 12
[2] V. G. Soloviev, Theory of Complex Nuclei (Pergamon Oxford, 1976).