QPM Calculations of ^{119}In

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

[a] Bogoliubov Laboratory of Theoretical Physics, JINR - Dubna, Russia

[b] Dipartimento di Fisica dell'Universita' and I.N.F.N,I-20133 Milano, Italy

[c] Soltan Institute for Nuclear Studies, Swierk, Poland

To contribute to a better understanding of the structure of ^{119}In, from the ^{122}Sn$(\vec{p},\alpha)^{119}$In reaction, induced by 26 MeV polarized protons and measured up to $\sim$ 2.6 MeV of excitation energy, the experimental $(\vec{p},\alpha)$ data have been supplemented with microscopic calculations of the ^{119}In energy spectrum in the framework of Quasiparticle Phonon Model (QPM), which accounts for the interaction between simple and complex configurations.

The spectrum of excited states in ^{119}In has been calculated within the Quasiparticle-Phonon Model (QPM). The ground and excited states of ^{119}In have been described by wave functions of the form:

$$\Psi^\nu(JM) = \Bigg\{ C^\nu(J)\ \alpha^+_{JM} \ + \ \sum_{j\lambda i} S^\nu_{j\lambda i}(J)\ [\alpha^+_j Q^+_{\lambda i}]_{JM} + \sum_{j\beta_1\beta_2 l} \frac{D^\nu_{j\beta_1\beta_2}(J)\ [\alpha^+_j[Q^+_{\beta_1}Q^+_{\beta_2}]_l]_{JM}}{\sqrt{1+\delta_{\beta_1\beta_2}}} \Bigg\} |^{118}\ \mathrm{Cd}\rangle_{g.s.} \quad (1)$$

where α^+_{jm} is a quasiparticle (qp) creation operator, Q^+_β is a phonon (ph) creation operator, and $|^{118}\ \mathrm{Cd}\rangle_{g.s.}$ is the ground state wave function of the neighboring even-even core. Square brackets in Eq. (1) denote angular momentum coupling, i.e. $[\alpha^+_j Q^+_\beta]_{JM} = \sum_{m\mu} C^{JM}_{jm\lambda\mu} \alpha^+_{jm} Q^+_{\lambda\mu i}$, etc. where $\mathrm{C}^{JM}_{jm\lambda\mu}$ are the Clebsch-Gordan coefficients. Quasiparticles with shell quantum numbers $jm \equiv (n,l,j,m)$ have half-odd-integral angular momenta. The index β of the phonon operator means a combination of (λ,μ,i) where i is used to distinguish between one-phonon states of the same multipolarity λ, but with different excitation energies. In the QPM, phonons are composed of different two-quasiparticle configurations:

$$Q^+_{\lambda\mu i} = \frac{1}{2}\sum_{j\,j'}^{N,Z} \Big\{ \psi^{\lambda i}_{jj'}[\alpha^+_{jm}\alpha^+_{j'm'}]_{\lambda\mu} + (-1)^{\lambda-\mu}\phi^{\lambda i}_{jj'}[\alpha_{jm}\alpha_{j'm'}]_{\lambda-\mu} \Big\} \quad (2)$$

where $\psi^{\lambda i}_{jj'}$ and $\phi^{\lambda i}_{jj'}$ are the forward and backward amplitudes.

In the actual calculations we have used several of the lowest QRPA states for each multipolarity $\lambda = 2-7$ corresponding to natural parity excitations of the ^{118}Cd core nucleus. Calculations in ^{119}In up to 3 MeV excitation energy have been performed in practically complete basis which includes [qp $\times$ 1ph] configurations up to 4.0 MeV, and [qp $\times$ 2ph] configurations up to 6.00 MeV, not violating the Pauli principle. Coefficients C, S, and D in Eq. (1), and energy eigenvalues, are obtained by diagonalizing the model Hamiltonian on the set of wave functions (1). The index ν is used to distinguish between different excited states with the same J^π. For more details of the QPM application to the description of excited states in odd-mass nuclei, we refer to [1,2,3].

An advantage of the QPM calculations in comparison with the shell-model ones is that within the QPM, it is possible to carry out the calculations employing rather complete single-particle basis. In the present calculations single-particles levels of the Woods-Saxon potential (for neutrons and protons) from $1s_{1/2}$ to narrow quasi-bound levels in the continuum are used. The summations in Eq. (1,2) are taken over all these levels j. Thus, no additional effective charges are needed to reproduce the collectivity of the lowest vibrational states. The shell-model calculations employ only several single-particle levels near the Fermi surface and realistic calculations for medium-heavy nuclei with open shell, like ^{119}In, become very complex.

In figure the spectrum from the QPM calculations (b) is shown, compared with the experimental $(\vec{p},\alpha)$ data (a) and Nuclear Data Sheets [4].

Calculations of the cross sections for the ^{122}Sn$(\vec{p},\alpha)^{119}$In reaction using the internal microscopic structure of any excited state of ^{119}In from QPM are in progress.

References

[1] A. I. Vdovin, V. V. Voronov, V. G. Soloviev, and Ch. Stoyanov, Sov. J. Part. Nucl. **16** (1985) 105

[2] S. Gales, Ch. Stoyanov, and A. I. Vdovin, Phys. Rep. **166** (1998) 125

[3] J. Bryssinck, L. Govor, V. Yu. Ponomarev, F. Bauwens, O. Beck, D. Belic, P. von Brentano, D. De Frenne, C. Fransen, R.-D. Herzberg, E. Jacobs, U. Kneissl, H. Maser, A. Nord, N. Pietralla, H.H. Pitz, and V. Werner, Phys. Rev. **C62** (2000) 14309

[4] S. Ohya and K. Kitao, Nuclear Data Sheets **89** (2000) 345

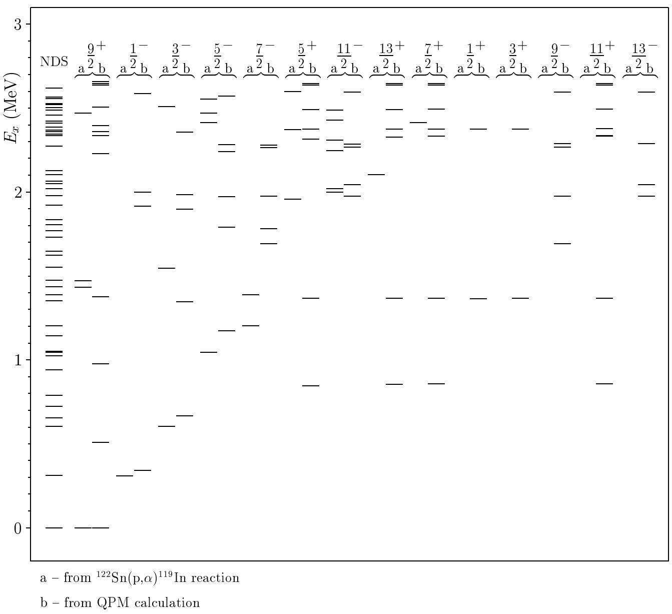

Fig. 1: QPM energy spectrum of ^{119}In.