Shell Model Calculations of ^{89}Zr

A. Vitturi [a], J. N. Gu [b], P. Guazzoni [c], L. Zetta [c], Y. Eisermann, G. Graw, R. Hertenberger, G. Staudt [d], and M. Jaskola [e]

[c] Dipartimento di Fisica dell'Universita' and I.N.F.N,I-20133 Milano, Italy
[a] Dipartimento di Scienze Fisiche dell'Universita' and I.N.F.N I-35100 Padova, Italy
[d] Physikalisches Institut der Universität, D-72076 Tübingen, Germany
[e] Soltan Institute for Nuclear Studies, Swierk, Poland

The structure of low-lying levels of ^{89}Zr has been studied in the framework of the shell model with the code OXBASH [1]. The calculations have been performed using the residual interaction PMM90, introduced by B.A.Brown [1].

For its relevance in connection with the (p,t) reaction, in addition to the energy spectra we have also calculated the two-neutron parentage amplitudes with respect to the ground state in ^{91}Zr($5/2^+$). From the shell model calculations the wave function for this state is given by the coupling of the extra neutron in the $d_{5/2}$ orbital with the ^{90}Zr ground state, namely about 80% of $\nu(1p(d_{5/2}))$ nature with respect to the N=50, Z=40 core, and 20% corresponding to two-particle-two-hole proton excitation, namely of π(2p-2h)ν(1p) nature. The former component is expected to populate, via (p,t) reactions, components in ^{89}Zr of ν(1h) and ν(1p-2h) nature, while the latter leads to π(2p-2h)ν(1h) and π(2p-2h)ν(1p-2h) components. Note that for the PPS in the low-energy part of the spectrum (E $\leq$ 3 MeV) the relevant components involve neutron holes just in the $g_{9/2}$ orbital, since the presence of two holes in the (pf)states gives rise to much higher energies. In the case of negative parity states, one hole has to come necessarily from the (pf)orbitals. In addition, for these states, one can estimate that π(2p-2h)ν(1p-2h) components are much higher in energy and normally have negligible amplitudes for the lowest states.

Among the positive parity states, the first two $9/2^+$ levels have both as major component of the state corresponding, for the neutron part, to a single hole in the $1g_{9/2}$ orbital, with prevalent (close to 80% of probability) proton closure for the ground state, while for the excited state with π(2p-2h) nature. As a consequence the ground state has large two-particle parentage amplitudes associated with the transfer of one neutron of the pair in the $d_{5/2}$ shell and of the second neutron in $g_{9/2}$ shell, with all possible momentum transfer, while for the ${9/2^+}_2$ state the corresponding parentage amplitudes are smaller, although appreciable, with consistency with the experimental data. Using the two-particle parentage amplitudes, the DWBA calculations for the angular distributions of the G.S. $9/2^+$ and of the 1512 keV $(9/2)^+$ state of the ^{89}Zr are shown in fig. 1. The good agreement obtained between experimental and theoretical data for the 1512 keV state allows to remove the uncertainty on spin assignment reported in [2].

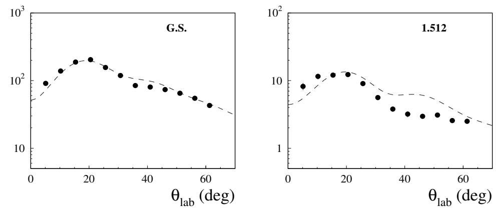

Fig. 1: DWBA calculations with the two-particle parentage amplitudes

The calculated level energies are shown in fig. 2 in comparison with the experimental values. The overall agreement is reasonable.

References

[1] B. A. Brown *et al.*, MSU-NSCL Report No 524, (1985).
[2] B. Singh, Nucl. Data Sheets **85** (1998) 1

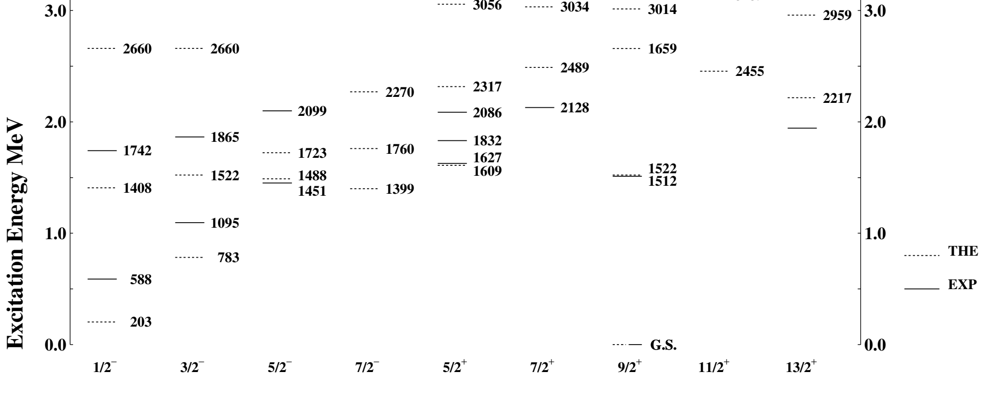

Fig. 2: calculated level energies in comparison with the experimental values