MODELS OF ODD-A NUCLEI IN THE Ca-Ru REGION ACCORDING TO RESULTS FROM SOME ALPHA-PARTICLE-INDUCED REACTIONS

Mårten Brenner
Dept. phys., Abo Akademi, Abo, Finland

Recently the use of α-particles of energies below 50 MeV has revealed the existence of many new high-spin states in the study of odd nuclei in the Ca-Ru region. In the predominantly (α,xnγ) or (α,xpγ) reactions the spacings between or sequences of the populated levels, level spins and parities and E2/M1 mixing ratios of γ-radiation are determined from single and coincidence γ-ray spectra and from angular distribution and polarisation measurements of the emitted γ-radiation. Occasionally half-lifes of excited states have been determined by means of pulse techniques or Doppler-shift measurements. A better idea of the validity of different nuclear models in the studied region has been obtained from such data. Typically high-spin states of odd nuclei have revealed bands of a rotational character or coupling between a quasi-particle and a presumably vibrational core.

The results can be understood in terms of a core made up of an inert closed shell structure surrounded by a "softer" open proton and/or neutron shell. In odd nuclei one or more particles or holes are added to such a core. Inherently the nuclei ^{40,48}Ca, ^{56,66}Ni and ^{88}Sr may form closed shell structures, while the particles of the open shell as well as the extra core particles belong to the fp-major shell, the $g_{9/2}$ or higher orbitals. When considering holes the sd-shell may even be involved.

Above ^{40}Ca the observed high spin states give evidence of the existence of positive parity states forming K-rotational-like bands based on a 1 $d_{3/2}$-hole in the sd-shell. This is the case in ^{43}Ca, ^{43,45}Sc, ^{45}Ti and ^{49}V |1,2,3|. A similar band with a $f_{7/2}$-hole coupled to a rotating core

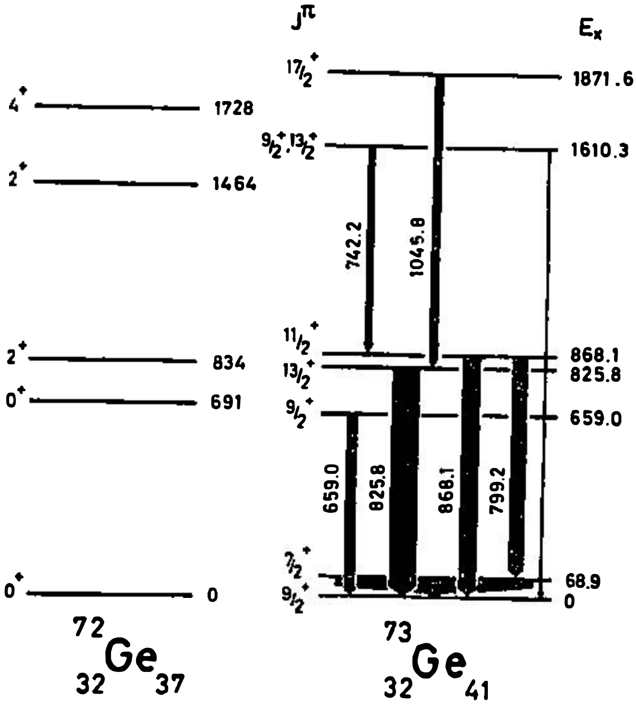

Fig. 1. Spacings and spins of levels in ^{73}Ge as compared with excited levels of a ^{72}Ge core.

is found in ^{53}Cr |3|. More rotational bands are proposed in this lower part of the region |4|.

Close above Ni the expected shell model with a particle and an inert core fails to give satisfactory explanation of the states in e.g. ^{59}Ni. Instead one particle coupled to the 2^+ excited state of the even-even A-1 nucleus seems to give the best description of states found in the nuclei of increasing Z from 28 upwards; in Zn, Ga and Ge |3|. Although no definite model exists for the 2^+ core excited state, a vibrational character is expected to describe it because of the level spacings of the 0_1^+, 2_1^+, 2_2^+ and 4_1^+ levels of the even-even core. This is illustrated by the level schemes of ^{72}Ge and ^{73}Ge in fig. 1, where the lower $13/2^+$ state in ^{73}Ge is described by a $g_{9/2}$ neutron coupled to the 2^+ excited state.

While in the upper part of the studied region the even-even Mo and Ru nuclei seem to exhibit ground-state quasi-rotational bands |5|, it is obvious that nuclei closer to the semi-magic ^{88}Sr are better described by the shell model. In the odd-even nuclei ^{91}Nb and ^{93}Tc the $(g_{9/2})^3$ and $(p_{1/2})(g_{9/2})^4$ proton configurations reproduce, with a few exceptions, all levels populated in the α-induced reactions |6|. Similarly the odd-odd nuclei ^{88}Y and ^{90}Y show quite pure states of e.g. the configuration $(\pi g_{9/2})^1(\nu g_{9/2})^{-1}$, as is demonstrated by the excellent agreement between theoretical and experimental M1-transition probabilities in ^{88}Y |7|. In the α-reaction studies ^{88}Sr thus seems to exhibit a more inert core than Ca and Ni. Moreover, vibrational states may be found in nuclei from Ni to Ge and nuclei of Zr, Mo and Ru. Simple arguments such as level spacings of typically vibrational character are not satisfactory to demonstrate the validity of a collective model. The rather complicated states of e.g. ^{96}Mo are examples of apparently collective structures which are not easily described by vibrational or rotational models. Rather complicated approaches are necessary to produce a satisfactory agreement between theory and experimental data for this nucleus |8|.

REFERENCES

|1| P.R. Maurenzig, in Proceedings of the Topical Conference on the Structure of $1f_{7/2}$ Nuclei, Legnaro, 1971, edited by R.A. Ricci, p. 469.

|2| N.G. Alenius, S.E. Arnell, Ö. Skeppsted, E. Wallander and Z.P. Sawa, Nuovo Cimento 9 (1972) 147.

|3| Z.P. Sawa, On Structures of Odd Mass Nuclei in the 1f2p Major Shell with Emphasis on Properties Associated with High Angular Momentum, thesis, Research

Institute for Physics, Stockholm (1973),

|4| Z.P. Sawa, K. Forssten, F. Ingebretsen and W. Walus, contribution to this conference.

|5| C.M. Lederer, J.M. Jaklevic and J.M. Hollander, Nucl. Phys. A169 (1971) 449.

|6| A. Nilsson, Experimental Studies of the Coupling of $g_{9/2}$ Nucleons in Nuclei Close to ^{88}Sr, In-Beam Gamma-Ray Spectroscopy on Medium-Weight Nuclei Excited by Alpha-Particle-Induced Reactions, thesis, Research Institute for Physics, Stockholm (1974).

|7| M. Brenner, K. Forssten, M. Ishihara, Ph. Monseu and A. Nilsson, USIP Report 74-17, University of Stockholm, Institute of Physics (1974).

|8| V. Paar, Joint Inst. for Nuclear Research, Dubna (USSR), Lab. of Theoretical Physics (1973).