EXPERIMENTAL INDICATIONS OF DEFORMATIONS IN ODD NEUTRON NUCLEI AROUND A = 75

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The existence of sizeable collective effects in the N $\approx$ 42 nuclei has been predicted from the systematics of energy states |1|. However, the validity of a strong coupling model in this mass region could not be hitherto ascertained because of the scarcity of appropriate experimental data. This note reports some new results from "in-beam" gamma-ray spectroscopy on ^{73}Ge, ^{77}Se, ^{77}Kr and ^{79}Kr. Together with other recent studies of ^{75}Se |2| and ^{77}Kr |3| the data clearly indicate the presence of bands, in support of the supposition above. A possible generic similarity between these states and the well-known deformed particle-hole states in lighter nuclei is discussed.

Excited states in ^{73}Ge, ^{77}Se, ^{77}Kr and ^{79}Kr were populated from the corresponding (α,xn), n = 1,2,3 compound reactions at E_α = 14, 28 and 43 MeV. The α-beams from the 80 and the 225 cm Stockholm cyclotrons were used. Gamma-gamma coincidences were detected in two Ge(Li) detectors and recorded event by event on magnetic tapes through two 4096 channel ADC´s. The spectra generated by off-line playback of the tapes give clear indications of bands, i.e. regularly spaced levels interconnected through gamma-ray cascades (fig. 1). Spin-parity assign-

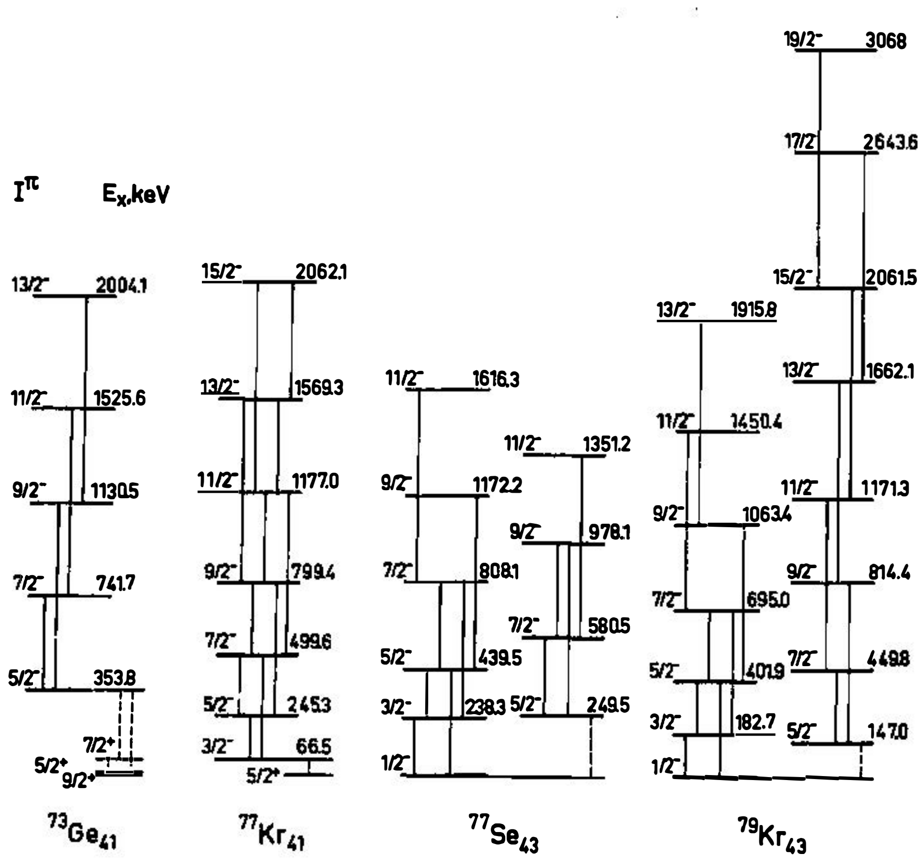

Fig.1. The energy states which constitute the proposed rotational bands in ^{73}Ge, ^{77}Kr and ^{77}Se, ^{79}Kr, i.e. the N=41 and N=43 isotones. Only the band transitions detected in the γ-γ coincidence measurement are shown in the figure.

ments for the proposed band heads in ^{73}Ge, ^{77}Se and ^{79}Kr are previously known (|4,5,6| respectively). The $3/2^-$ assignment for the band head at 66.5 keV in ^{77}Kr is suggested from a recent ^{77}Rb(β^+) decay study |3|. The suggested spin values for the band members are supported by the measurements of:

a) The yield of transitions in ^{73}Ge, ^{77}Se and ^{79}Kr, populated in (α,n) reactions at E_α = 14 and 12 MeV.
b) The angular distributions of transitions in ^{73}Ge and ^{77}Kr, populated in the reactions $^{70}Zn(\alpha,n)$ and $^{76}Se(\alpha,3n)$ at E_α = 14 and 43 MeV, respectively.

A full account of the data reduction which yielded information on a member of states associated with other degrees of freedom as well will be given elsewhere.

Two of the proposed spin assignments are in conflict with presently available interpretations of β-decay data. Firstly, the 581 keV state in ^{77}Se was previously assigned $5/2^+$ from its decay mode and from the log ft-value of 8.6 in the study of $^{77}Br(\beta^+)$ |5|,whereas $7/2^-$ is proposed here. Secondly, the 183 keV state in ^{79}Kr was previously assumed to have positive parity |7|. This was based on the observation of a weak 52.33 keV line in the singles gamma-ray spectrum, interpreted as a transition to the $7/2^+$ isomeric state at 129.7 keV. However, the lifetime of the 183 keV state of $\leq$0.6 ns |6| does not favour the positive parity assignment.

From the measured moment of the $5/2^-$ state at 250 keV in ^{77}Se, as well as the enhanced B(E2)↑-values of 47 W.u. for the $3/2^-$ 238 keV and 43 W.u. for the $5/2^-$ 440 keV states, Engels |8| has proposed the existence of rotational bands built on the $1/2^-$|301| and the $5/2^-$|303| Nilsson orbitals, with band heads at the ground and the 256 keV states respectively.

The rotational parameters $\hbar^2/2\mathcal{J}$ of all six bands proposed here are all within the range

$$23 < \frac{\hbar^2}{2\mathcal{J}} < 40 \text{ keV} .$$

The energies versus proposed spins for ^{79}Kr are shown in fig. 2. Furthermore, the rotational parameter for the recently proposed $K^\pi = 5/2^-$ band with $I \leq 15/2^-$ in ^{75}Se is

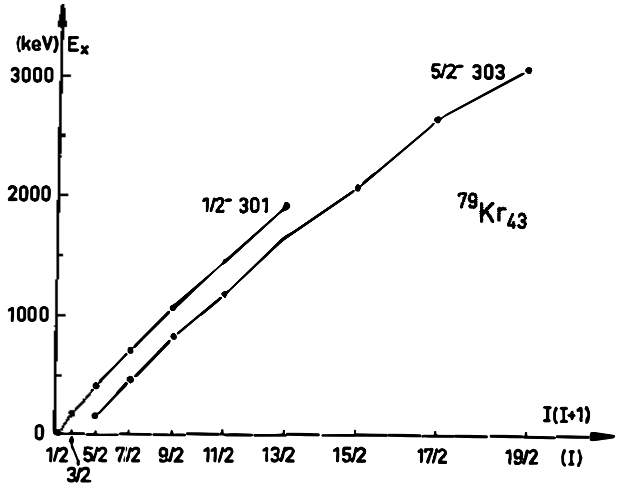

Fig.2. Plot of the state excitation energies in ^{79}Kr as a function of I(I+1). One observes that the effect of the Coriolis interaction is present in the $K=5/2^-$ band, while the $1/2^-$ band is associated with a negligible decoupling factor.

32 keV |2|. In ^{72}Se, the $K^\pi = 0^+$ band ($I^\pi \leq 12^+$) based on the 990 keV state, the rotational parameter is 26 keV. This mutual consistency indicates that we encounter a similar degree of deformation for these states in this mass region.

It is a well known fact that in the oxygen and calcium regions, deformed states can be made by the excitation of particles from the even-even cores. This gives rise to rotational state bands in the presence of spherical shell model states |11,12|. Recently, also the 2p-1h state bands with $K^\pi = 7/2^-$ have been suggested in the ^{53}Cr |13| and ^{55}Fe |14| isotones, with the band heads located at 1.536 and 1.408 MeV excitation, respectively. The corresponding even particle - odd hole $K^\pi = 3/2^+$ band heads in the calcium region appear at lower excitation energy, i.e. below 0.5 MeV. This difference in energy is explained by a consideration of balance of pairing energies associated with the promotion of a single nucleon from the core to the valence orbital. This energy is greater for the $1f_{7/2}$ nucleons than for those in the adjacent orbitals.

A similar gain of pairing energy occurs for the $1g_{9/2}$ orbital. Accordingly, one finds an appreciable lowering of the corresponding particle-hole states and the formation of low-lying rotational state bands in lighter $1g_{9/2}$-nuclei. The distinguished candidates for showing this property are indeed ^{73}Ge, ^{75}Se, ^{77}Se and ^{79}Kr. In the zeroth order approximation, the first three have one and the two last have three valence neutrons in the $1g_{9/2}$ orbital. The available data from (d,p) and (p,d) investigations, at least for the 375 keV $5/2^-$ band head in ^{73}Ge, clearly indicate its mainly hole structure |4|, in support of the explanation above.

In conclusion, in the vicinity of closed shells one may quite generally encounter deformations and associated rotational bands due to holes in the cores. However, the oxygen and the calcium regions provide the clearest examples for light spherical nuclei, because of favourable pairing energy conditions. The results from N=41 and 43 nuclei presented here are in full accordance with the above suggestion.

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