Nuclear structure studies on 38K

Hasper, Hendrik

INTRODUCTION AND SUMMARY

The nucleus ^{38}K, having one neutron and one proton hole coupled to the "inert" ^{40}Ca core, has been the subject of recent interest, both experimental and theoretical. The results of several theoretical calculations have emphasized the inadequacy of the shell model to explain the structure of this nucleus if the configuration is limited to the s-d shell. The problem has been treated for two different types of interactions, i.e. the phenomenological modified surface-delta interaction, and the realistic Tabakin interaction.

At the start of this investigation, only the spin-parity assignments of the ground state (3^+) and the first and third excited states (0^+ and 1^+) were known, and tentative assignments had been made for the second and fourth excited states (1^+ and 2^+).

Chapter 1 of this dissertation (published earlier in the Physical Review (Ha 72)) describes a study of 14 levels of ^{38}K up to 3.7 MeV by means of (α-γ) angular correlations following the excitation of the levels by the $^{40}Ca(d,\alpha)^{38}K$, with the alpha particle detected by an annular detector close to 180^o. A selection rule prohibits the population of the m = 0 magnetic substates for final states with natural parity. This rule is applied, with allowance for the solid angle subtended by the annular particle detector, for the determination of the parities of several states.

Chapter 2 (also published previously in the Physical

Review (Ha 73)) describes the determination of excitation energies and mean lives of levels in ^{38}K up to 3.85 MeV. The lifetimes were measured using the Doppler-shift attenuation method. Lifetimes or lifetime limits of 13 levels were measured. Several spin-parity restrictions derived in chapter 1 were made stricter on the basis of these results.

In chapter 3 the results are presented of a comparison between average yields to levels in ^{38}K populated in the ^{40}Ca(d,α) reaction, and Hauser-Feshbach calculations. Fluctuation analysis was also carried out on the yield curves. This provided an objective basis for the assignment of errors to the average yields. The conclusion is reached that this type of comparison can be a useful supplementary tool in spin-parity assignment.

The results of shell-model calculations for even-parity states in nuclei with mass number A = 35 through 39 and for odd-parity states in nuclei with mass number A = 36 through 39 are presented in chapter 4. For the positive-parity states two different residual interactions were used: the MSDI and the MSDI + TENSOR interaction. For positive-parity states three model spaces were tried: the $(1d_{5/2}, 2s_{1/2}, 1d_{3/2})$ configuration, the $(2s_{1/2}, 1d_{3/2}, 1f_{7/2})$ configuration and a truncated $(2s_{1/2}, 1d_{3/2}, 1f_{7/2}, 2p_{3/2})$ configuration. Only this last model space was used for calculations of negative-parity states. Calculated and experimental level schemes are compared. Lifetimes, branchings and log ft values are calculated and compared with experimental data for some positive-parity states in ^{38}K.

The conclusion is justified that the addition of a tensor force brings about a significant improvement in the calculations. Further it is clear that the extension of the configuration to the fp shell explains a number of "intruder" states for A as low as 36.

REFERENCES

Ha 72 H. Hasper, Ph.B. Smith and P.J.M. Smulders, Phys. Rev. C5 (1972) 1261.

Ha 73 H. Hasper, Ph.B. Smith, Phys. Rev. C8 (1973) 2240.