First Measurements of g Factors of the 2_1^+ States in ^{36,38}Ar and their Shell Model Interpretation

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The *Ar* isotopes lie in a mass region where the nuclear structure exhibits subtle effects. In fact, in self-conjugate ^{36}Ar (N=Z=18) protons and neutrons are occupying the same orbitals providing information on proton-neutron pairing correlations and isospin symmetry effects. ^{38}Ar is characterized by the $N = 20$ shell closure with two proton holes in the ^{40}Ca core. ^{40}Ar has two valence neutrons in the $f_{7/2}$ orbital, beyond the magic shell gap. Hence, all three isotopes exhibit characteristic changes in the nuclear structure with neutron number which has to be explained in a consistent way within the framework of the spherical shell model.

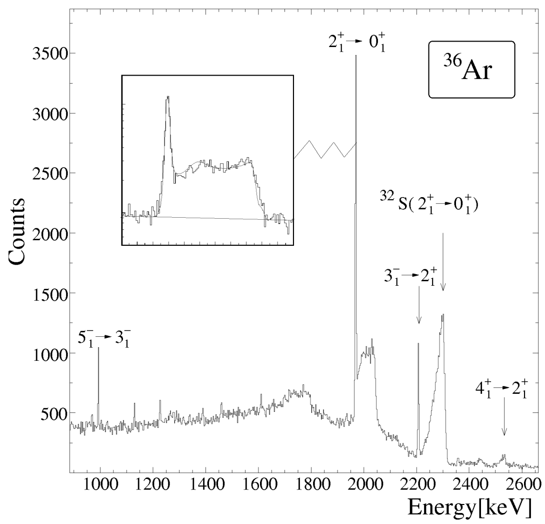

Fig. 1: Coincident γ spectrum of a Ge detector at 0° for ^{36}Ar and ^{32}S

Measurements were performed for ^{36,38}Ar essentially populating the first 2^+ states. The g factors were determined for the first time and the nuclear lifetimes have been remeasured. The nuclei and the states in question were produced in α-transfer reactions to sulphur projectiles from the Cologne and Munich tandem accelerators. Isotopically pure ^{32}S and ^{34}S beams were accelerated to 65 and 67 MeV, respectively. The α transfer was accomplished with natural carbon which was part of a multi-layered target consisting of Gd for spin precessions in the transient field. The technique used has been described elsewhere [1]. The de-excitation γ rays were measured in coincidence with the two α particles from the decay of ^{8}Be. The excited *Ar* nuclei were moving in the beam direction through the magnetized Gd layer and were stopped in a copper backing of the target. In case of ^{32}S beams also Coulomb excitation of the 2_1^+ state at 2.230 MeV occurred. Hence the known g factor of this state has been remeasured.

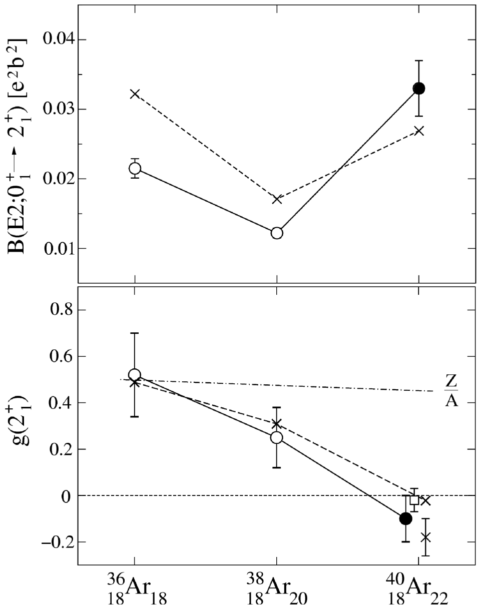

Fig. 2: Experimental g factors and B($E2$)'s compared to results from shell model calculations

As the corresponding carbon ions were well resolved from the α particles of the transfer reaction, both ^{36}Ar and ^{32}S could be measured simultaneously. This procedure, however, was not applicable to ^{34}S and ^{38}Ar as the $(2_1^+ \to 0_1^+)$ γ lines could not be resolved by the NaI(Tl) scintillators which were used for γ detection. In this case, the carbon recoils were stopped in a front-layer of the particle detector which otherwise was transparent for the α particles. A typical coincidence spectrum of a Ge detector at 0° for ^{36}Ar is shown in Fig. 1. Also displayed is a fit to the Doppler-broadened lineshape of the $(2_1^+ \to 0_1^+)$ transition for determining the nuclear lifetime. Results of the g factors and B($E2$)'s deduced from the lifetimes including known data for ^{40}Ar [2,3] are shown in Fig. 2. The data are compared with results from shell model calculations. Evidently, the characteristic differences in the data are very well explained.

References

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