First g Factor Measurement of the 2_1^+ State of ^{42}Ca ◇

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The surprising result of the measurement of the $g(2_1^+)$ factor for ^{44}Ca, $g = +0.17(3)$, by its striking deviation from a full fp shell model calculation, $g_{SM} = -0.4$, can only be explained by incorporating strong particle-hole excitations of the ^{40}Ca core [1]. Besides ^{44}Ca as the $f_{7/2}$ midshell isotope with an expected maximum collectivity, the lighter ^{42}Ca has been chosen in order to examine a subtle change in collective contributions to the wave function due to the reduced number of $f_{7/2}$ neutrons. In the present work the $g(2_1^+)$ factor of ^{42}Ca has been determined and the $B(E2)$ value was deduced from a new lifetime measurement.

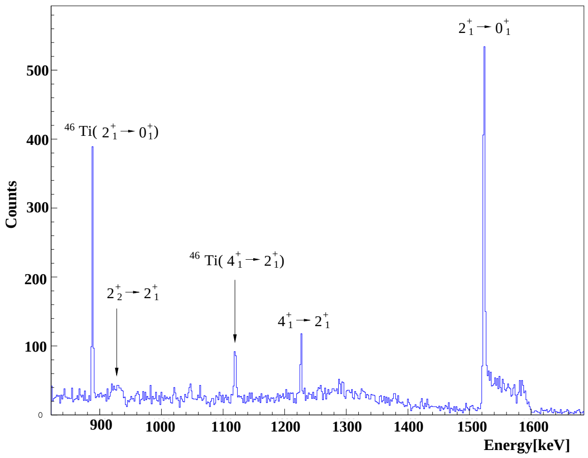

Fig. 1: γ -coincidence spectrum observed for ^{42}Ca with the 0° Ge detector. γ transitions of ^{46}Ti result from an α-transfer reaction.

Two different multilayer targets, consisting of C-Gd-Ta-Cu with slightly different layer thicknesses, were bombarded with an isotopically pure ^{42}Ca beam with intensities of 0.5 enA. The beam was provided in his natural abundance (0.6%) by the ion source of the Cologne tandem accelerator and accelerated to an energy of 95 MeV. After Coulomb excitation and precession of the ions in the target, the de-excitation γ rays were detected with 12.7 cm x 12.7 cm NaI(Tl) scintillators and a Ge detector in coincidence with the forward scattered ions, either carbon or 2α particles, in the latter case resulting from an α-transfer reaction. The γ lines emitted from the ^{46}Ti nucleus did not interfere with the $(2_1^+ \to 0_1^+)$ line of ^{42}Ca (see Fig. 1). The pronounced lineshapes of the γ lines from the 2_1^+ and 2_2^+ states detected in the 0° Ge detector were analyzed to determine the nuclear lifetimes.

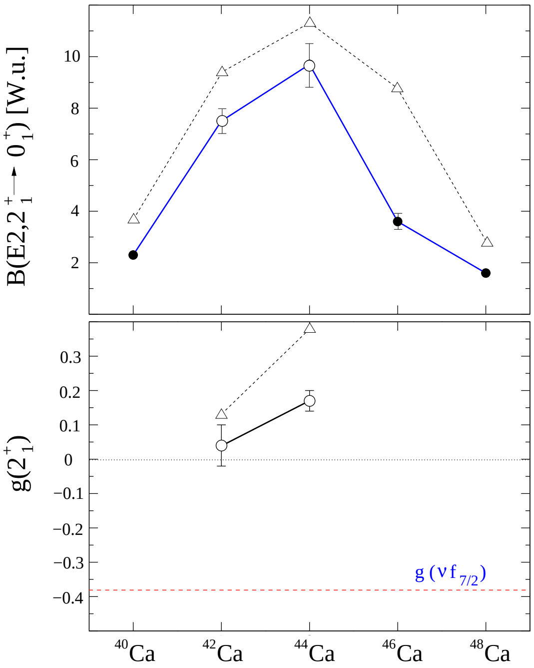

Fig. 2: Summary of $B(E2)'s$ and known $g(2_1^+)$ factors for all even-even Ca isotopes. Open circles refer to present data and [1]. Dashed lines connect results from LSSM. The Schmidt-value for $f_{7/2}$ neutrons with $g_S^{eff} = 0.7 \cdot g_S^{free}$ is also marked.

A very small g factor was obtained for ^{42}Ca(2_1^+), $g = +0.04(6)$. The lifetime of the 2_1^+ state, $\tau = 1.52(10)$ ps, is significantly larger than the adopted value quoted in the literature, $\tau = 1.18(3)$ ps. A 5% feeding from higher states (mainly from the 4_1^+ state) was included in the analysis. In contrast the lifetime of the ^{42}Ca(2_2^+) state, $\tau = 0.23(7)$, agrees very well with the literature value, $\tau = 0.20(6)$. The g factors of ^{42,44}Ca(2_1^+) were compared with results from large scale shell model calculations (LSSM) assuming a model space which includes sd shell orbits in addition to the fp shell [2]. In order to explain $g(2_1^+)$ of ^{42}Ca a large number t of particle-hole excitations are needed. The results of such calculations with t = 12 for the $B(E2)'s$ and g factors are displayed in Fig. 2. Evidently, the calculations describe very well the trends of the experimental data; shortcomings in the agreement with the absolute values are attributed to the truncation of the model space. However, the most striking result of the present work is the fact that the structure of the Ca nuclei requires large configuration mixing.

References

[1] S. Schielke et al., to be published

[2] E. Caurier et al., Phys. Lett. **B522** (2001) 240

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