First g Factor and Lifetime Measurements of the 2_1^+ State of Radioactive Self-Conjugate ^{44}Ti ◇

S. Schielke [a], K.-H. Speidel [a], O. Kenn [a], J. Leske [a], N. Gemein [a], M. Offer [a], Y.Y. Sharon [b], L. Zamick [b], J. Gerber [c], and P. Maier-Komor
[a] Institut für Strahlen- und Kernphysik, Univ. Bonn, Nußallee 14-16, D-53115 Bonn
[b] Department of Physics and Astronomy, Rutgers University, New Brunswick, New Jersey 08903, USA
[c] Institut de Recherches Subatomique, F-67037 Strasbourg, France

Magnetic moments and lifetimes of nuclear states are sensitive to the detailed composition of the nuclear wave function. Hence measurements of g factors enable one to determine the relative proton and neutron contributions because magnitude and sign of the spin g factors of protons and neutrons are different. In default of a radioctive beam an alternative technique was applied in order to measure $g(2_1^+)$ of $N = Z$ ^{44}Ti ($T_{1/2} = 60$a). This application incorporates the merits of the inverse kinematics, forward focussing of the particles and high ion velocities, but is based on a particle transfer reaction to stable beam nuclei. In former measurements with projectile Coulomb excitation using carbon targets, α transfer was found to be a particularly strong reaction channel. In the transfer mechanism state selectivity by populating predominantly the 2_1^+ state occurs and feeding from higher states is negligible. This feature ensures a clean measurement of the precession. In this way $g(2_1^+)$ values were measured for radioactive ^{62}Zn obtained in α transfer to a ^{58}Ni beam [1] and also for ^{68}Ge using a ^{64}Zn beam [2].

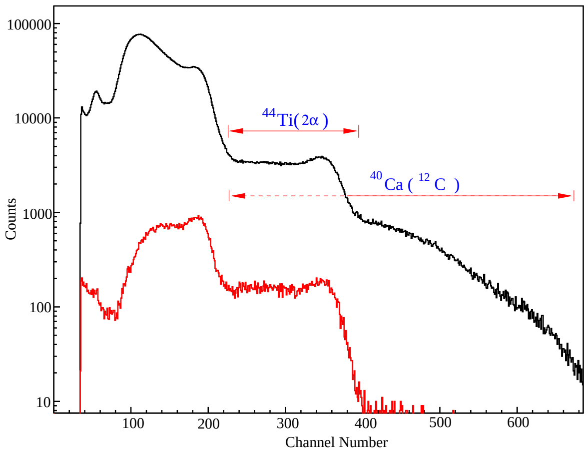

Fig. 1: Particle spectrum observed in coincidence with all γ-rays (upper spectrum). Lower spectrum refers to a gate on the ^{44}Ti ($2_1^+ \to 0_1^+$) γ transition only. Gates for γ-coincidence spectra are indicated for ^{44}Ti and ^{40}Ca.

An isotopically pure ^{40}Ca beam was provided by the ion source of the Cologne tandem accelerator and accelerated to an energy of 95 MeV, whereby beam intensities of 2-3 nA were achieved. For Coulomb excitation and precession a multilayered target was used consisting of C-Gd-Ta-Cu. De-excitation γ-rays were measured with four 12.7 cm x 12.7 cm NaI(Tl) scintillators in coincidence with forward scattered and kinematically focussed ions, either carbon ions or 2α particles from the decay of ^{8}Be. A Ge detector with relative efficiency of 40% placed at 0° served as a monitor for contaminant lines and to measure nuclear lifetimes via the Doppler-Shift-Attenuation-Method. Besides Coulomb excitation of the 3^- and 5^- states of ^{40}Ca, strong α transfer occurred in the reaction $^{12}C(^{40}Ca,^{8}Be)^{44}Ti$. The $^{44}Ti(2_1^+)$ state at 1083 keV was strongly populated and only weak excitations of the 4_1^+, 2_2^+ and 3_1^- were also observed (see Fig. 2). The γ-anisotropy and the precession have been measured for the ($2_1^+ \to 0_1^+$) transition.

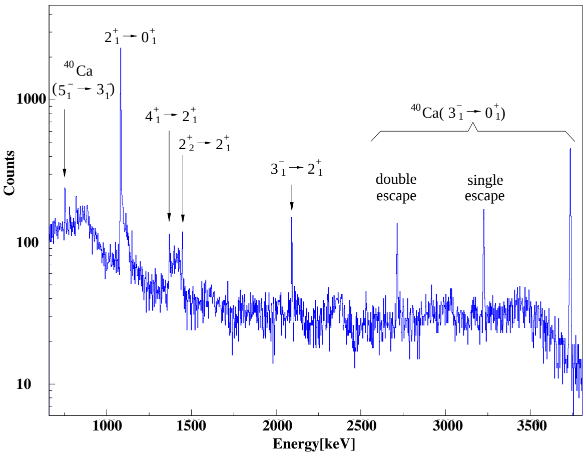

Fig. 2: γ-coincidence spectrum observed with the 0° Ge detector with the particle gate on ^{44}Ti events (see. Fig. 1)

The deduced g factor of the 2_1^+ state is $g = +0.52(15)$. In addition, the lifetimes of the 2_1^+, $\tau = 3.97(28)$ ps, and the 4_1^+, $\tau = 0.65(6)$ ps, were redetermined with higher precision. The $g(2_1^+)$ and the $B(E2)$ values, $B(E2; 0_1^+ \to 2_1^+)$ $= 0.069(6)$ e^2b^2 and $B(E2; 2_1^+ \to 4_1^+) = 0.047(4)$ e^2b^2, deduced from the lifetimes have been interpreted within the framework of the nuclear shell model. A full fp shell calculation with the FPD6 effective NN interaction yields the best agreement for many of the low-lying level properties. The calculated $B(E2; 0_1^+ \to 2_1^+)$ and $g(2_1^+)$ agree within 2% with the experimental data whereas the $B(E2; 2_1^+ \to 4_1^+)$ is underestimated by 27%. Furthermore, one derives from the experimental $B(E2; 0_1^+ \to 2_1^+)$ a quadrupole moment $Q(2_1^+) = -0.235$ eb close to the calculated value $Q(2_1^+) = -0.218$ eb.

References

[1] O. Kenn *et al.*, Phys. Rev. **C65** (2002) 034308
[2] K.-H. Speidel *et al.* to be published

◇ work supported by the DFG