

# Identification of isomers in the $N = Z + 1$ nucleus $^{95}\text{Ag}$

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For decades, spin-gap isomers have been predicted by shell-model studies for nuclei close to  $^{100}\text{Sn}$  [1]. These isomers are based on the attractive  $g_{9/2}$  proton –  $g_{9/2}$  neutron residual interaction for holes in the upper part of the  $g_{9/2}$  subshell lowering the excitation energy of certain stretched high-spin configurations dramatically, so that the depopulation of these levels via  $\beta$  decay can compete with the slow electromagnetic decay via a high multipole  $\gamma$ -ray transition. Such a spin-gap isomer has been identified, for example, in  $^{95}\text{Pd}$  via  $\beta$ -delayed proton and  $\gamma$  rays [2,3]. Applying this scenario to other nuclei in this mass region, high-spin isomers such as a  $23/2^+$  M3 isomer in  $^{95}\text{Ag}$  or a  $16^+$  E6 isomer in  $^{96}\text{Cd}$  were predicted [1] but not yet identified experimentally. Previous attempts to identify the decay of the predicted isomer in  $^{95}\text{Ag}$  concentrated on the measurement of  $\beta$ -delayed protons and  $\beta$ -delayed  $\gamma$  rays [4], however, without success. The electromagnetic decay was also searched for, but hampered by the low detection efficiency for  $\gamma$  rays. By using a composite Ge-detector array with high granularity, another search for an isomeric  $\gamma$  decay in  $^{95}\text{Ag}$  was carried out.

The  $^{95}\text{Ag}$  nuclei of interest were produced via the  $^{58}\text{Ni}(^{40}\text{Ca}, p2n)$  reaction using a  $^{40}\text{Ca}$  beam of 3.94 A MeV and 80 particle-nA, provided by the GSI UNILAC accelerator. The beam was impinged on a 2.8 mg/cm<sup>2</sup> thick  $^{58}\text{Ni}$  foil. The reaction products were stopped in a hot carbon catcher inside a FEBIAD-B2C ion source. The  $A=95$  recoils were separated from the other reaction products by the GSI on-line mass separator. A beam intensity of about 28 ions/s was obtained. For the detection of  $\gamma$  rays, an array of 13 Ge crystals was used in close geometry around the deposition point of the mass-separated beam on a tape inside a plastic beam pipe. Positrons were measured with a plastic scintillator having an efficiency of about 85%. The decay of the activity was measured during deposition (grow-in method) for about 7.5 h, corresponding to 5645 4.8-s cycles. In the off-line analysis,  $\beta$ - $\gamma$ - $\gamma$  matrices with different dispersion were sorted, and the known  $\beta$ -delayed  $\gamma$  rays from the  $^{95}\text{Ag} \rightarrow ^{95}\text{Pd}$  decay [4], such as the 1262 keV line, were observed. The high  $\beta$ -detection efficiency allowed also for the sorting of  $\gamma$ - $\gamma$  coincidence events in anti-coincidence with positrons. In this matrix, three distinct  $\gamma$ -decay sequences have been found and assigned to the decay of three isomers in  $^{95}\text{Ag}$ , as shown in Fig. 1. The assignment of  $\gamma$  rays depopulating the  $23/2^+$  isomer at 2531 keV in  $^{95}\text{Ag}$  is supported also by a recent paper [5] where three  $\gamma$  rays (164, 937 and 1117 keV) in  $^{95}\text{Ag}$  were observed in-beam for the first time.

Spin and parity assignments to the states in  $^{95}\text{Ag}$  are based on predictions by the shell model such as  $9/2^+$ ,  $1/2^-$  and  $23/2^+$  for the ground state, the 344 keV and the 2531 keV isomers, respectively, on experimental level energy systematics of  $N=48$  isotones and on the observed decay pattern.

Shell-model calculations have been performed in the minimum model space ( $p_{1/2}$ ,  $g_{9/2}$ ) for both protons and neutron using an empirical interaction. The level energies of the  $1/2^-$  and  $23/2^+$  isomers are well reproduced, and a  $37/2^+$  state is predicted as candidate for a high-lying E4 spin-gap isomer if the  $33/2^+$  and  $37/2^+$  levels are swapped (see right side of Fig. 1). Inspection of the  $37/2^+$  wave function reveals a close relation to isomers in neighboring nuclei, namely coupling of a  $g_{9/2}$  proton to the  $14^+$  isomer of  $^{94}\text{Pd}$ .

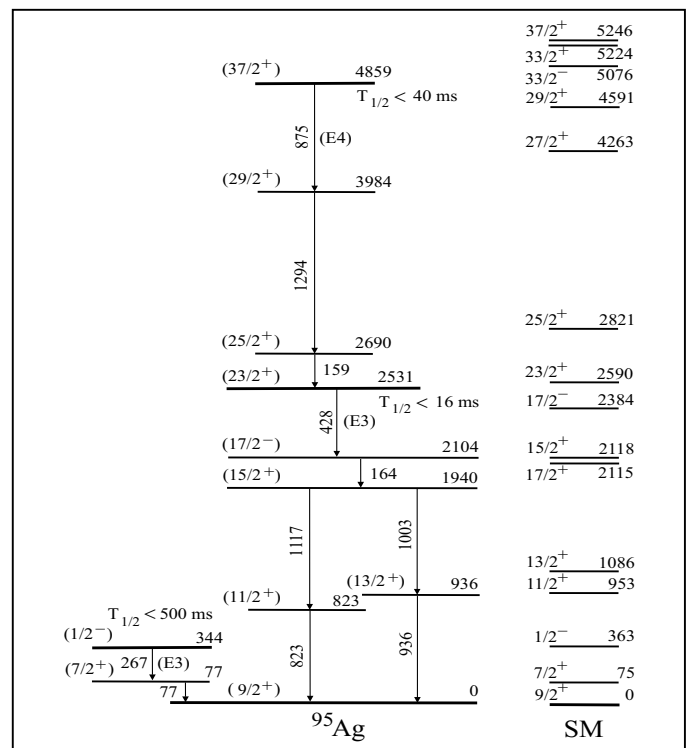


Figure 1: Experimental decay scheme of isomers in  $^{95}\text{Ag}$  compared to empirical shell-model calculations.

In summary, the long-standing search for the predicted  $23/2^+$  spin-gap isomer in  $^{95}\text{Ag}$  has been successfully carried out at the GSI on-line mass separator. Sufficient yield and stable experimental conditions were obtained to perform detailed spectroscopic investigations. The results have been published recently [6].

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