Beta-decay of ^{97}Ag: Evidence for the Gamow-Teller Resonance near ^{100}Sn

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Abstract. The ^{97}Ag $\rightarrow$ ^{97}Pd β-decay was investigated by using a total absorption spectrometer and an array of 6 Euroball-Cluster Ge detectors. A total of 603 γ-rays de-exciting 151 levels in ^{97}Pd have been assigned. The Gamow-Teller β-decay strength distributions from the experiment and a shell-model calculation are compared, revealing a dominant resonance around a ^{97}Pd excitation energy of 4 MeV with a width of about 1.5 MeV. An experimental quenching factor of about 4.9(7) for the total Gamow-Teller strength was obtained, which is close to the predicted theoretical hindrance factor.

Introduction

The problem of missing strength in Gamow-Teller (GT) β-decay has attracted considerable experimental and theoretical interest in recent years, especially concerning the region near the double-magic nucleus ^{100}Sn (see *e.g.* [1]). As part of an ongoing research program on β-decay near ^{100}Sn, we investigated ^{97}Ag. On the basis of an extreme single-particle model, one expects this decay to be dominated by the "core decay", *i.e.* to mainly populate, after breaking a $\pi g^2_{9/2}$ pair, *3qp* states ($\pi g^{-2}_{9/2} \nu g_{7/2}$) in ^{97}Pd at excitation energies around 4 MeV.

As complementary spectroscopic tools, we used a total absorption spectrometer (TAS) [2] and a cube-like array of 6 Euroball-Cluster Ge detectors (Cluster Cube) [3]. The "double strategy" of combining high- and low-resolution studies can serve to map the GT strength distribution even at high excitation energies of the daughter nucleus, which indeed represents a challenge in studying nuclei far from stability.

Experimental Techniques

The TAS is a highly efficient NaI detector which allows to measure the β-intensity distribution rather than the individual γ-rays. The Cluster Cube represents a compromise between high resolution and high efficiency. It surrounds the source with a solid angle of ~65% of 4π *sr* , the total efficiency for 1.33 MeV γ-rays being ~19%. For this γ-ray energy, the actual energy resolution of an individual capsule is ~2.6 keV.

The experiment was performed at the GSI on-line mass separator equipped with a FEBIAD ion source [4]. ^{97}Ag was produced by fusion-evaporation reactions induced by a ^{40}Ca beam from the UNILAC on an isotopically enriched ^{60}Ni target. The mass-separated A = 97 beam was implanted into a tape. After a selected collection period, which was optimized for the half-life of ^{97}Ag and thus suppressed longer-lived activity such as the isobaric contaminant ^{97}Pd, the resulting radioactive source was periodically transported to the center of either spectrometer.

Experimental Results

Based on the preliminary analysis of the Cluster Cube data, we have placed a total of 603 γ rays (578 new) depopulating 151 (132 new) levels in the β-decay scheme of ^{97}Ag. This scheme was applied for de-convoluting the TAS data with a so-called "peel-off" method [5]. From the preliminary evaluation of the TAS data, a Q_{EC} value of 6.93(10) MeV was determined in agreement with a systematic estimate of 7.0(5) MeV [6]. The β-intensity distributions obtained from de-convoluting the TAS spectra and

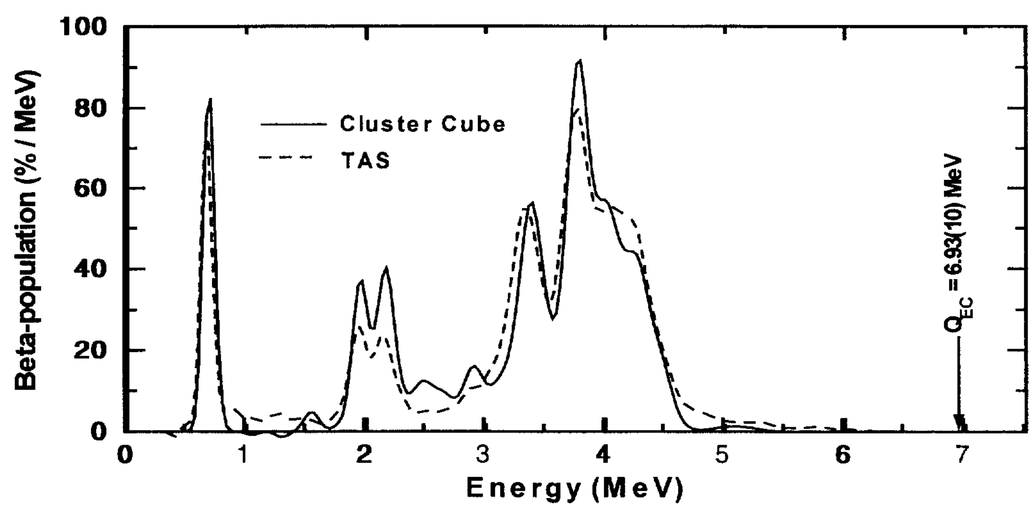

Figure 1. Beta-intensity distributions obtained from the TAS data (dashed line) and from the Cluster Cube data (solid line). The latter result was adapted to the TAS data by smoothing procedure.

from the γ-intensity balances based on the Cluster Cube data agree with respect to the overall shape which is dominated by a resonance between ~3 MeV and ~4.5 MeV (see Fig. 1). However, the Cluster Cube data show a little more β-feeding in the energy region below 4 MeV than the TAS data, while missing some β-feeding above that energy. According to the Cluster Cube data, the states above 4 MeV receive ~21% of the total decay intensity, compared to a value of ~26% from the TAS data. This ~5% difference can be interpreted by assuming that the Cluster Cube measurement has still missed some weak γ-rays emitted from high-lying ^{97}Pd levels.

Discussion and Conclusion

Using the Q_{EC} value obtained from the TAS data, the half-life value of 25.3(3) s determined from a previous work [7], and the β-intensity distributions deduced in this work, we have calculated the ^{97}Ag β-strength shown in Fig. 2. The global shapes of the distributions deduced from the TAS and Cluster Cube data, respectively, are in good agreement, showing a large GT resonance around 4 MeV with a width of about 1.5 MeV. However, as far as the total B(GT) values are concerned, we obtained a value of 2.14(38) from the Cluster Cube data in comparison to a value of 2.63(37) from the TAS data (We have excluded the B(GT)'s above 5.5 MeV due to large statistic uncertainties in the TAS result, as shown in Fig. 2). This discrepancy mainly results from the difference in the energy range above 4 MeV, where TAS yielded a summed

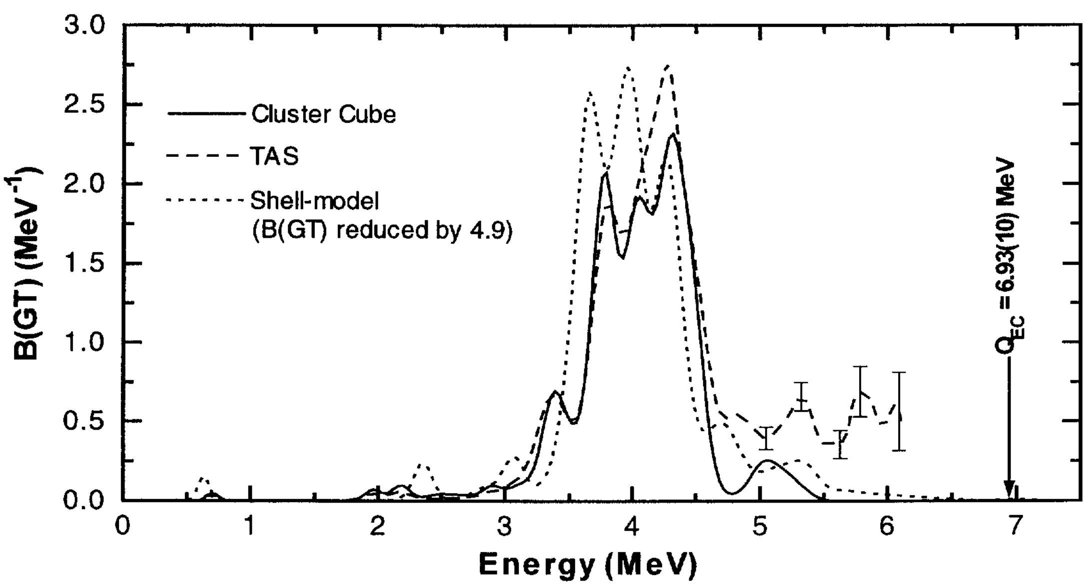

FIGURE 2. B(GT) distributions for the decay of ^{97}Ag from a shell-model calculation (dotted line) and from experiments performed with the TAS (dashed line) and the Cluster Cube (solid line). The B(GT) distribution from the shell-model calculation and the Cluster Cube measurement were adapted to the TAS data by a smoothing procedure. The error bars shown at the high-energy tail represent the statistic uncertainties of the TAS data in this region.

GT strength $\Sigma B(GT)$ of 1.65 compared to a value of 1.15 from the Cluster Cube data (excluding the B(GT)'s above 5.5 MeV). We conclude that, in comparison with the TAS data, the Cluster Cube data have missed 19(10)% of $\Sigma B(GT)$, which corresponds to the missing of ~5% of the β-feeding intensities above 4 MeV.

We have calculated the GT β-decay distribution of ^{97}Ag using the SNB model space, in which the interaction for protons is confined to the $1p_{1/2}$ and $0g_{9/2}$ orbits, and that for neutrons to the $0g_{7/2}$, $1d_{5/2}$, $1d_{3/2}$, $2s_{1/2}$ and $0h_{11/2}$ orbits [1]. As can be seen from Fig. 2, the shell-model calculation qualitatively reproduces the experimental results, especially concerning the centroid and width of the GT resonance. By comparing the $\Sigma B(GT)$ value deduced from the TAS data to the shell-model prediction, we obtained an experimental quenching factor of 4.9(7). This result is close to the value of 5.1±0.4 for ^{103}In [5], both experimental finding being in agreement with the hindrance factor of 4.4 expected from $0\hbar\omega$ excitations beyond the SNB space and from even higher-order configuration mixing (see refs. [5,8] for a detailed discussion). It is worth noting that ^{97}Ag and ^{103}In are the first two nuclei which are close enough to ^{100}Sn so that large space shell-model calculation can be performed and for which the complete GT resonance was observed experimentally.

Acknowledgments

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