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THE BETA-DECAY STRENGTH FUNCTIONS OF ^{100}Ag AND ^{104}In

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The study of the beta strength in the ^{100}Sn region has been continued by using a total absorption gamma-ray spectrometer (TAGS) on the GSI on-line mass separator. The beta-decay by neutron-deficient isotopes near the doubly-magic nucleus ^{100}Sn is dominated by the Gamow-Teller (GT) transformation of a $g_{9/2}$ proton into a $g_{7/2}$ neutron . Whenever strong beta transitions are observed in this region of the nuclear chart, they have to be associated with these two l = 4 orbits. Therefore, such data represent a firm basis for testing nuclear models. Previous studies were focused on even-even nuclides [1], that decay to a few well-resolved 1^+ levels. The excitation energies of these levels are usually below 2 MeV so that high-resolution spectroscopy can be applied. For the odd-odd and odd-mass parent nuclei near ^{100}Sn, the predominant feeding of high-lying levels is expected to be a general decay feature. However, at these energies the level density is high, and gamma transitions deexciting these levels have statistical character. Therefore, discrete-level spectroscopy is not suitable for a quantitative determination of the strength distribution, and 4π-counter technique is necessary [2].

The neutron-deficient isotopes ^{100}Ag ($t_{1/2}$ = 2.0 m, $I^\pi = 5^+$) and ^{104}In($t_{1/2}$ = 1.8 m, $I^\pi = 6^+$) were produced in the fusion-evaporation reaction between a 5 MeV/u ^{58}Ni beam and an enriched ^{50}Cr target. The mass-separated atoms were implanted into a tape and driven periodically from the separator to the TAGS detection system operating in the air. The source composition was determined by using germanium detectors for gamma-ray measurements during the collection of the sources and after their removal from the TAGS set-up.

The TAGS, which was built at PNPI, was an improved version of the spectrometer used earlier in experiments at the IRIS facility of PNPI [3]. The TAGS consists mainly of a NaI

cylinder of 20 cm diameter and 20 cm length housing the radiactive sample in a hole. Thin Si(Li) detector, mounted close to the sample, was used to detect β-rays and thus to separate the branches of positron decay and electron capture. The performance of TAGS was similar to that used at PNPI except that a BGO detector was installed in the hole of the NaI detector. The response function of the spectrometer has been found using a set of radiactive samples as well as a special simulation computer code. Starting from the known low energy decay scheme, we have constructed the high-spin level deexcitation in a recurcive way in order to reproduce the experimental γ-spectra produced in positron decay, as well as the electron capture spectra. The γ-γ-coincidence data between the total absorption spectrum and the small BGO detector were also taken into account.

The beta strength functions corresponding to the measured beta feeding distributions in ^{100}Ag and ^{104}In decay are plotted in Fig.1. The decay energies Q_{EC} = 7.07(8) MeV for ^{100}Ag and Q_{EC} = 7.91(14) MeV for ^{104}In were used [4]. The experimental values of B(GT)$_{exp}$ in units of $(g_A^2/4\pi)$, obtained by summing the beta strength distributions, amount to 1.2(2) and 1.90(35) for ^{100}Ag and ^{104}In, correspondingly. Part of the beta strength is expected to be missed in the experiment due to the energy decay window and the limited experimental sensitivity. The missed strength for the decay of ^{100}Ag, estimated using a Breit-Wigner fit to the strength distribution, is about 20%, thus the total B(GT) value may increase to a value of 1.44(20). The strength distribution for the decay of ^{104}In is complicated, and we have not succeeded to fit it on the basis of simple approximation. A two Breit-Wigner peak fit allows to estimate the missed strength to be less than 10%. Anyway, the main source of errors of the B(GT) for ^{104}In is due to the experimental uncertainties occuring on the high-energy slope of the resonant structure and to the uncertainty of the Q_{EC} value. Two basic channels are expected in the beta decay of neutron-deficient odd-odd nuclei near ^{100}Sn. Both of them represent $\pi g_{9/2} - \nu g_{7/2}$ transformations and populate 2-quasi particle $\{\nu g_{7/2}, \nu d_{5/2}\}$ states and 4-quasi particle $\{(\pi g_{9/2}, \nu g_{7/2})1^+ \times (\pi g_{9/2}), \nu d_{5/2})\}$ states, respectively. The latter decay mode corresponds to the decay of the even-even core of the initial odd-odd nuclei to a 1^+ excitation. These decay properties have been unambiguously established for the first time in our measurements with TAGS. One can see from the Fig.1 that the most of the beta strength is located in a wide peak at the excitation energy typical for $4qp$ states. The small peak that is visible in the strength function of ^{100}Ag could be attributed to $2qp$ states.

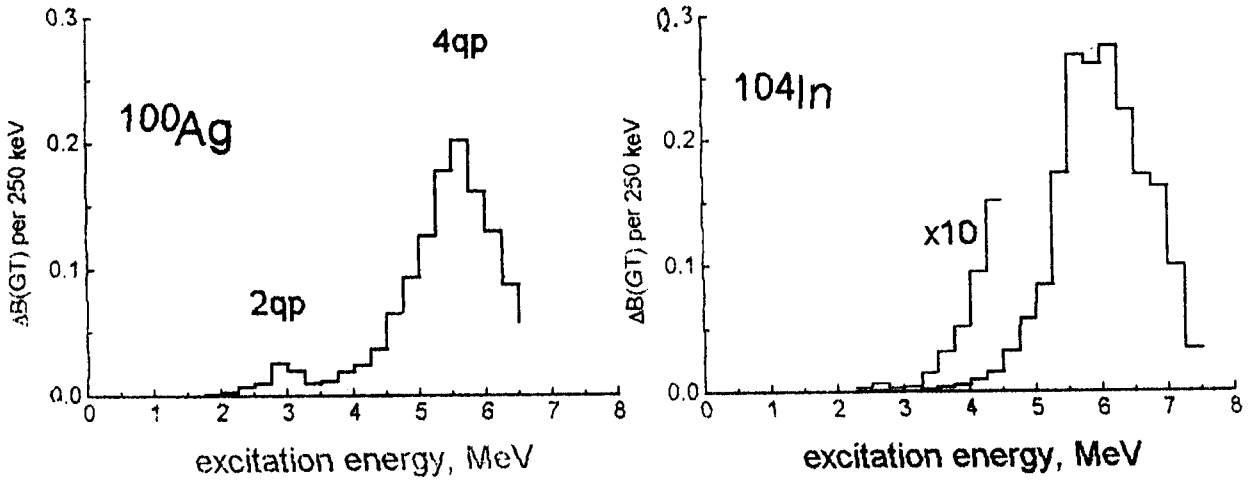

Fig.1. The beta strength distributions measured for ^{100}Ag and ^{104}In

It is customary to refer the total beta strength found in an experiment B_{exp}, to a reference strength, B_{ref}, deduced from the simple shell model. For the nuclei under consideration, $B_{ref} = 16/9 \cdot z \cdot (1 - n/8)$, where z is the number of protons in the $g_{9/2}$ orbit and n is the number of neutrons in the $g_{7/2}$ orbit. We use here $z = Z - 40, n = 0$. Another characteristic is the energy of 1^+ excitation in daughter nucleus,E_{GT}, given by the peak position in the experimental beta-strength function with respect to Q_{EC}. The hindrance factors B_{ref}/B_{exp} and energies (Q_{EC}-E_{GT}) obtained in this work are shown in Fig.2. Both odd-odd studied nuclei have the same value of the neutron-proton difference (N-Z). As this difference is important for the charge exchange excitation, it is interesting to compare this values with those for neighboring even-even nuclei with the same (N-Z), namely ^{94}Ru,^{98}Pd,^{102}Cd, and ^{106}Sn. This comparison is also shown in Fig.2. For these nuclei the B_{exp} values displayed result from summing the B_{GT} values obtained for discrete levels, while the energies shown represent weighted average energies. The hindrance factors vary slightly along the (N-Z)=6 chain in contrast with a predicted strong mass dependence in the hindrance factors for the same isotopes with N=50 [5]. Evidently, the obtained weak mass dependence in hindrance factors for the nuclei under consideration may be due to the constant value of (N-Z). One can see the smooth behavior of the average beta strength energies ($Q_{EC}-E_{GT}$) along the (N-Z)=6 chain. The dependence of ($Q_{EC}-E_{GT}$) upon z can be fitted with a single straight line dependence, in spite of the large variations of the E_{GT} values. The slope of this dependence is about 0.22 MeV/z, which can be compared with the slope for the Coulomb energy being 0.27 MeV/z [6].

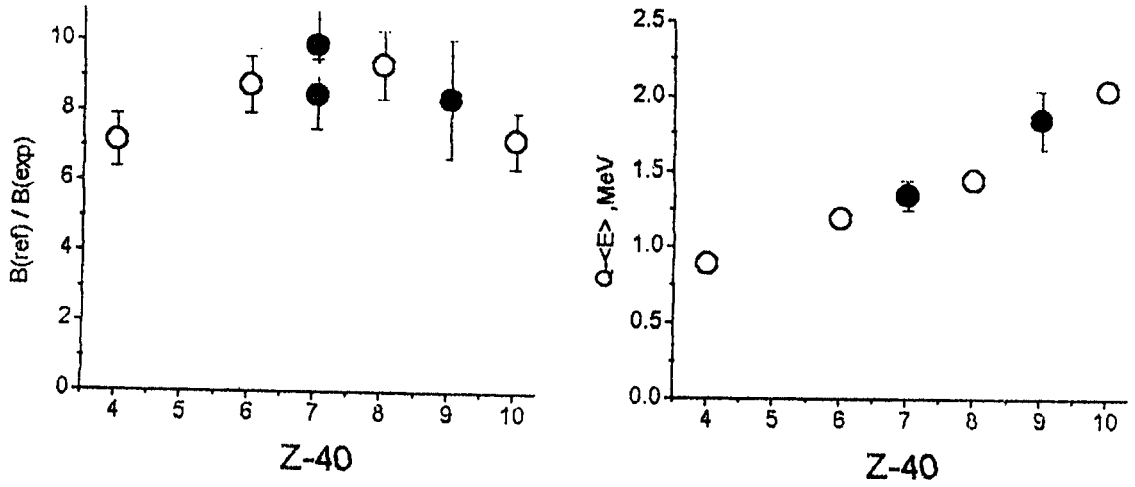

Fig.2. The hindrance factors B_{ref}/B_{exp} for nuclei with N-Z=6 (left panel), and the average weighted energies E_{GT} of GT resonance states in the respective daughter nuclei, ploted as the difference with respect to the relevant Q_{EC} values (right panel). The values for the odd-odd isotopes, obtained in this work by using total absorption gamma-ray spectrometry, and the values for the even-even isotopes are denoted by solid and open circles, respectively

The stength ratio of the transitions to $4qp$ and $2qp$ states, expected from the simple shell model considerations, is 15:1 for the ^{100}Ag decay and 40:1 for ^{104}In [5]. The observed ratios are about 16(5) for ^{100}Ag decay and larger than 600 for the ^{104}In decay. The core polarization should not affect the shell model prediction of this ratio much but may, according to [5], reduce them somewhat, Thus the agreement for the $4qp/2qp$ ratio in ^{100}Ag decay may be accidental but the strong suppression of transitions to $2qp$ for ^{104}In decay seems to be a puzzle.

The results obtained indicate that the studies of odd-odd nuclei in the ^{100}Sn-region performed with the total absorption technique may yield an important contribution to the understanding of the GT-strength quenching.

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THE MARBURG UNIVERSITY — PNPI OFF-LINE MASS SEPARATOR

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The goal of the Marburg University - PNPI joint programme is to investigate atomic and nuclear properties of longlived promethium isotopes. Previous optical experiments with isotope ^{147}Pm had unsatisfactory accuracy due to the Doppler broadening of spectral lines. Therefore most of the badly resolved hyperfine structures in the measured spectra are still unexplained [1]. The usage of mass separated beams of promethiums ions and Collinear Laser-Ion Beam Spectroscopy with a continuous wave dye laser give results free of Doppler broadening and thus provides very accurate hfs data [2]. A good knowledge of the promethium atomic properties, in particular, their hfs data, is necessary to extract information of nuclear momentums of shortlived promethiums isotopes.

Mass separator Mars-II of Marburg University was transported to Gatchina and installed in the IRIS experimental area. In 1995, the off-line mass separator was put into operation. It has 90 deg. sector magnet with a bending radius of 1 m, an ion energy is 20 keV [3] . Besides, the separator includes an ion source, electrostatic focusing lenses and collector chambers.