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OBSERVATION OF PHOTONUCLEAR REACTIONS ON ISOMERIC TARGETS: $^{178}Hf^{m_2}(\gamma, n)^{177}Hf^{m_2}$, $^{180}Ta^{m}(\gamma, 2n)^{178}Ta^{m,g}$ AND $^{180}Ta^{m}(\gamma, p)^{179}Hf^{m_2}$

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1 Introduction

Nuclear reactions with high-spin isomers are of interest for the investigation of nuclear structure effects. Special features are expected in the reaction cross-sections and angular distributions. Furthermore, high-spin levels may be excited with higher probability. Of special interest is the question of structure selectivity for the population of levels in the residual nucleus. This selectivity is well known for excited levels below ~3 MeV populated in β- and γ-decays. It is important to know whether an initial structure of the target nucleus influences the feeding intensities of the levels in the reaction product or if it is governed just by spin and excitation energy, in accordance with the statistical-model predictions.

Photonuclear reactions starting from a high-spin isomer can be important for the study of giant resonances built on quasiparticle states as well as for the study of the amount of K-mixing at high excitations energies. The interest in such reactions may also be motivated by the possible applications, e.g. the search for efficient ways of γ-laser pumping.

Some years ago the strong depopulation of the ^{180}Ta^{m} isomeric state (m) by the (γ,γ')-reaction was investigated [1]. After more detailed studies [2] the idea of strong K-mixing was introduced for the levels at an excitation energy $E^* \geq 2.8$ MeV which serve as intermediate states z for the $m \rightarrow z \rightarrow g$ (ground state) transitions. In Coulomb excitation the depopulation of ^{180}Ta^{m} was observed [3], however the measurements were disturbed by possible transfer reactions on ^{181}Ta.

Another program focuses on the study of the ^{178}Hf^{m_2} isomer, both with regard to aspects of nuclear structure and of nuclear-reaction mechanisms. This isomer is a four-quasiparticle, 16^+, long-lived (31 years) yrast trap. It can be considered as a unique object for reaction studies. The methods for production, chemical and mass-separation of the ^{178}Hf^{m_2} isomer were developed [4] and resulted in the production of as many as $2 \cdot 10^{15}$ atoms until now. Several nuclear reactions such as Coulomb excitation, (d,d'), (p,t) and (n,γ)-reactions using a ^{178}Hf^{m_2} target were successfully investigated. One can find the results in the original papers [5-7] and review talks [8-10]. Many problems are under continuous investigation and among them the problem of the levels population in products of nuclear reactions with exotic isomeric targets.

Let us assume that the reaction starts from an isomeric state and finally populates both isomeric and ground states in a residual nucleus. The measured ratio of the isomeric-to-ground state yields can throw some light on the feeding selectivity especially if the initial and final isomeric states have similar single-particle structure.

The yields of the exotic reactions: $^{178}Hf^{m_2}(\gamma,n)^{177}Hf^{m_2}$, $^{180}Ta^{m}(\gamma,2n)^{178}Ta^{m,g}$ and $^{180}Ta^{m}(\gamma,p)^{179}Hf^{m_2}$, as well as yields of many other photonuclear reactions on ground states of Ta and Hf nuclei were measured by the method of the γ-spectroscopy off-line after the targets activation by the bremsstrahlung radiation. The properties of the isomeric and ground states of the involved nuclei are presented in fig. 1. Their decay γ-lines are listed in table 1.

2 The $^{178}Hf^{m_2}(\gamma,n)^{177}Hf^{m_2}$ reaction

The single-particle structures of the target and product nuclei are attributed to the ($\pi 7/2^+$, $\pi 9/2^-$, $\nu 7/2^-$, $\nu 9/2^+$) and ($\pi 7/2^+$, $\pi 9/2^-$, $\nu 5/2^-$, $\nu 7/2^-$, $\nu 9/2^+$) configurations, respec-