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Nuclear structure of ^{127}Te studied with (n,γ) and $(\vec{d},p)$ reactions and interpreted with IBFM and QPM

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Abstract

The nuclear structure of ^{127}Te has been investigated with the $^{126}\text{Te}(n,\gamma\gamma)^{127}\text{Te}$ reaction using thermal neutrons and with the $^{126}\text{Te}(\vec{d},p)^{127}\text{Te}$ reaction at $E_d = 20$ MeV. About 190 levels were identified in a region to 4.1 MeV excitation energy, in most cases including spin, parity and γ-decay. The γ-decay scheme after neutron capture is essentially complete containing about 100% of the population of the $11/2^-$ isomer and of the ground state. The thermal neutron capture cross section and isomer production of the $11/2^-$ state at 88.3 keV were determined to be 0.44(6) b and 0.069(10) b, respectively. The neutron binding energy was determined to be 6287.6(1) keV. A significant number of the (d,p) angular distributions of cross section and asymmetry are anomalous with respect to

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the distorted-wave Born-approximation calculations and could be accounted for by inelastic multi-step mechanisms. The observed strong correlation of the (d, p) and primary (n, γ) strengths gives evidence for the direct neutron capture process which is mainly responsible for the primary population of 16 levels. The experimental level scheme is compared with predictions of the interacting boson–fermion model and of the quasiparticle phonon model.

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Keywords: NUCLEAR REACTIONS: ^{126}Te(n, γ), $E =$ thermal; measured E_γ, I_γ, $\gamma\gamma$-coincidence; ^{126}Te(d, p), $E = 20$ MeV, polarized d; measured particle spectra, $\sigma(\theta)$, asymmetry. ^{127}Te deduced levels, J^π, γ-branching ratios, cross sections, binding energy, DWBA, CCBA spectroscopic factors. IBFM and QPM calculation and comparison. Direct neutron capture. Enriched targets; Ge detectors; Q3D magnetic spectrograph

1. Introduction

The long chain of available Te isotopes provides a nice possibility for the detailed study of the properties of nuclei undergoing a transition from an almost closed shell structure (^{131}Te, $N = 79$) to structures that have increased deformation near mid-shell (^{119}Te, $N = 67$). Systematic changes in the level energies and gamma decay modes have been interpreted [1] as a smooth admixture of O(6) to the dominant U(5) structure in the frame of the interacting boson model. It has been also possible in past to analyze the energy spectra and spectroscopic factors of the odd-A Te nuclides by quasiparticle-phonon coupling [2]. The nuclides near the $A \cong 130$ mass region have been the focus of calculations [3] using the U(6/20) supersymmetry. The recognition of different structures in the odd-mass Te nuclei and its extension to the higher energies may help to assess the validity of various nuclear structure models. However, it requires almost complete experimental data including spins, parities, electromagnetic properties and spectroscopic strengths.

The present work is a part of our joint project in which detailed and systematic investigations of the Te nuclides have been carried out using light particle induced transfer and thermal neutron capture reactions: ^{119}Te [4], ^{121}Te [1], ^{122}Te [5], ^{123}Te [6], ^{124}Te [7,8], ^{125}Te [9], ^{126}Te [10,11], ^{129}Te [12] and ^{131}Te [13]. In the present work we have studied the structure of the ^{127}Te nucleus with (d, p) and (n, γ) reactions. The application of polarized deuterons allowed to avoid many ambiguities of the previous spin-parity determination. The measurement of $\gamma\gamma$-coincidences enabled us to place most of transitions in the decay scheme. Thus a reliable set of data can be obtained for the comparison with different theoretical predictions. As in the case of our previous and current studies we use also the interacting boson–fermion model (IBFM-1) [14] and for the description of the high-lying states the quasiparticle phonon model (QPM) [15].

In earlier investigations compiled in Ref. [16] the energy levels have been studied by means of stripping [17,18] and pick-up [19] reactions and several beta decay works.