Eur. Phys. J. A **3**, 209–211 (1998)

**THE EUROPEAN PHYSICAL JOURNAL A**


*Short note*

# Spectroscopy of neutron deficient $^{108}$Te

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Received: 7 September 1998
Communicated by B. Herskind

**Abstract.** The neutron deficient nucleus $^{108}$Te was studied in the $^{54}$Fe($^{58}$Ni,$2p2n$) reaction. A detector system consisting of 4 Euroball cluster detectors, a charged-particle detector ball and a 16 element neutron multiplicity filter was used to detect the emitted particles and $\gamma$ rays. A new, significantly extended level scheme was constructed on the basis of $\gamma\gamma$-coincidence relations. Spin values for the states were determined from angular distribution ratios. The experimental results are discussed in terms of the shell model.

**PACS.** 21.10.Hw Spin, parity, and isobaric spin – 23.20.Lv Gamma transitions and level energies – 27.60.+j $90 \leq A \leq 149$

The structure of the neutron deficient $^{108}$Te nucleus has been reinvestigated using high efficiency Euroball cluster detectors in a pre-Euroball experiment at the Niels Bohr Institute.

A 3.0 mg/cm$^2$ thick $^{54}$Fe target, isotopically enriched to 99.9% and backed by a 21.8 mg/cm$^2$ Au foil, was bombarded by a beam of 261 MeV $^{58}$Ni ions. The emitted $\gamma$ rays were detected by 4 cluster detectors[1] mounted in the upstream direction in a closely packed geometry having a common focus at 21 cm from the center of each cluster. The target position was moved 10 cm out of the focus of the cluster detectors upstream the beam line to increase the $\gamma$-ray detection efficiency. The photo peak efficiency of the setup was estimated by using the GEANT code[2] to be ∼8% at 1.3 MeV. For the selection of different reaction channels the detector array was equipped with a $4\pi$ charged particle detector system comprising 31 thin Si-detectors[3,4] and a neutron multiplicity filter consisting of 16 liquid scintillators[5,6] covering a solid angle of $1.4\pi$ in the downstream direction. The setup was triggered if at least one cluster segment fired and a neutron was detected in one of the scintillators.

A total of about $2.5\times10^9$ coincidence events were collected and sorted into $\gamma\gamma$-coincidence matrices by gating on different numbers of detected charged particles and neutrons. The $^{108}$Te nucleus was produced by evaporation of one $\alpha$-particle or two protons and two neutrons from the compound nucleus $^{112}$Xe. In the $1\alpha$-gated matrix only the strongest $\gamma$ rays of $^{108}$Te could be observed because of the high background. Therefore, only proton and neutron gated matrices were used. To improve statistics the $2p2n$-, $1p2n$-, $2n$- and $2p1n$-gated matrices were summed. Gamma-rays were assigned to $^{108}$Te on the basis of their coincidence relations with the previously known transitions[7]. Typical gated spectra obtained from the summed $\gamma\gamma$-coincidence matrix are shown in Fig. 1.

The multipolarities of the transitions were deduced from the angular distribution ratios $R_1 = I_\gamma(135^o)/I_\gamma(120^o)$ and $R_2 = I_\gamma(135^o)/I_\gamma(100^o)$ determined from particle gated $\gamma$-ray spectra, sorted for the three different rings of cluster crystals being at approximately the same

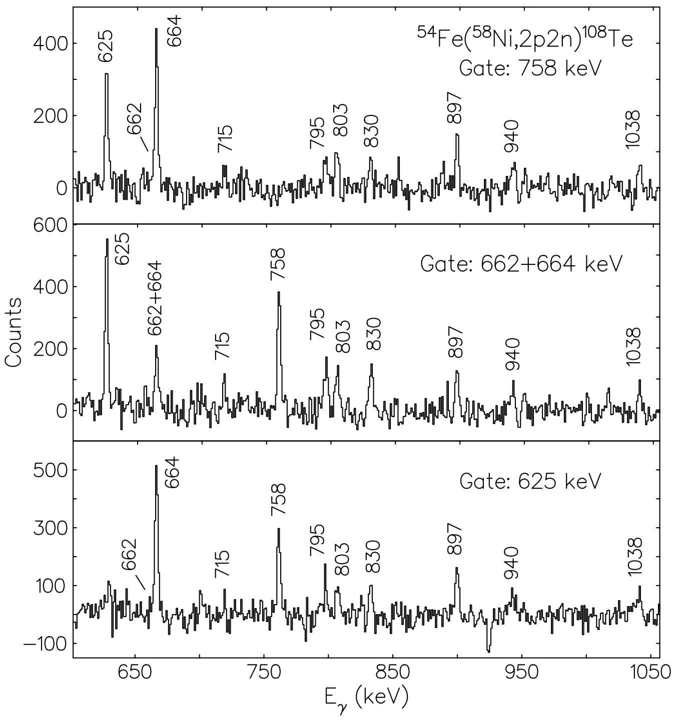


**Fig. 1.** Background subtracted $\gamma\gamma$-coincidence spectra of $^{108}$Te with gates on the 625, 664 and 758 keV $\gamma$ rays in the sum matrix

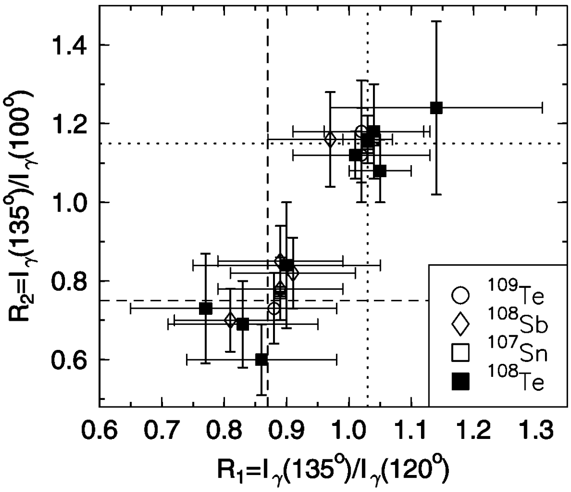


**Fig. 2.** Two-dimensional plot of the angular distribution ratios. The two kinds of dashed lines indicate the weighted average values for dipole and quadrupole transitions obtained from ratios of $\gamma$ rays with known multipolarities

angle relative to the beam direction. The intensity ratios of transitions of the $^{108}$Te were compared to those of $\gamma$ rays with known multipolarities in $^{107}$Sn, $^{108}$Sb and $^{109}$Te. The obtained values formed two groups with $R_1 \approx 0.87$, $R_2 \approx 0.75$ and $R_1 \approx 1.03$, $R_2 \approx 1.15$, with a relative error of 10% for the stronger transitions. The first group corresponds to stretched dipoles and the second one to stretched quadrupoles. Even in the case of weak transitions definite conclusions could be drawn from the two-dimensional plot of the $R_1$ and $R_2$ ratios as shown in Fig. 2. Thus, the 625, 664, 758, 803, 897 keV $\gamma$ rays are stretched quadrupoles and the 662, 830, 940, 1038 keV $\gamma$ rays are stretched dipole transitions.

The level scheme of $^{108}$Te was extended up to 5 MeV excitation energy, shown in Fig. 3, on the basis of coincidence relations, as well as energy and intensity balances. The order of the $\gamma$ rays in a cascade was determined by their relative intensities. The locations of the known transitions in the level scheme are in agreement with the previous results[7].

The $^{108}$Te nucleus has one proton and three neutron pairs outside the $^{100}$Sn core. From the systematics of heavier Te nuclei the lowest lying states are expected to have vibrational character, while in the wave function of the higher lying states the weight of broken pair components is expected to increase with increasing excitation energy. Thus, the $2_1^+$ and $4_1^+$ states are expected to be mainly the one and two phonon states, respectively. In the $6_1^+$ state significant broken proton and neutron $[g_{7/2}]^2_{6^+}$ and $[g_{7/2}d_{5/2}]_{6^+}$ components must also be present. To generate higher spin an additional pair of nucleons has to be broken. The $8_1^+$ state is expected to arise from the $6_1^+$ state coupled to the collective $2^+$ excitation created from mixing of different broken pair configurations. The odd spin states are expected to have two broken neutron pairs, as well as one broken neutron and one broken proton pair

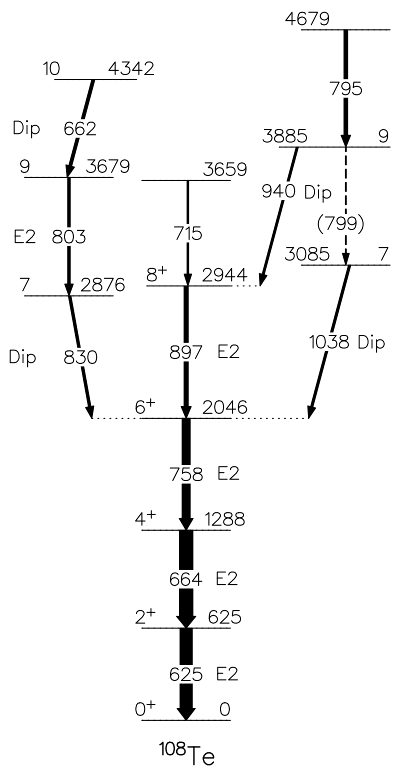


**Fig. 3.** Proposed experimental level scheme of $^{108}_{52}$Te$_{56}$. The multipolarities of the transitions are also given. *Dip* marks dipole transitions

configurations. The 830 keV and the 1038 keV branches might be based on a mixed proton–neutron broken pair configuration, and on the $g^3_{7/2}d_{5/2}$ two broken neutron pair configuration, respectively. The 830 keV branch has lower energy, because of the strong proton–neutron interaction between the active nucleons.

This work was supported by the Swedish and Danish Natural Science Research Councils, and by the Hungarian Found for Scientific Research (OTKA contract No. 20655).

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