Multiphonon and Quasiparticle States in ^{126}Te ◇

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In recent years an increase of spectroscopic studies on the even tellurium isotopes (Z=52) could be observed. One reason may be that there exists no common theoretical framework to describe all features of these nuclei, which are close to the proton shell closure at Z=50.

While the lighter ones may be successfully interpreted in terms of the Interacting Boson Model [1,2] the nucleus ^{126}Te would require an unusual high anharmonic U(5) version of it [3]. On the other hand some properties of the ^{124}Te isotope are better described by the Quasiparticle Phonon Model (QPM) [4].

In order to extend the structure information obtained from the (d,p) and (d,^{3}He) measurements [5], the (d,d') reaction ($E_d = 24\,$MeV) at laboratory angles of 25°, 35°, 45°, 60° and 70° was measured and evaluated. A remarkable problem was that none of the two strongest lines in the energy range between 2.5 MeV and 2.9 MeV could be identified with any known level from [6]. To overcome this situation it was necessary to introduce new levels using the γ-transitions from [7,8] and the Ritz principle. Further information was provided by a (γ, γ') reaction [9] which was performed in spring 1995 at the injector of the S-DALINAC in Darmstadt. All together yield an experimental level scheme of ^{126}Te consisting of 103 levels and 140 γ-transitions. Among them 27 new levels (6 uncertain) could be established and 37 transitions (7 speculative) could be assigned for the first time.

This level scheme was compared with a theoretical one, calculated with the QPM. The results for the low-lying states up to 2.6 MeV excitation energy are shown in figure 1. On the right-hand side the levels are denoted in terms of RPA phonons. These are divided into two classes of different collectivity. Important members of the first class are the 2_1^+ and 3_1^- phonons. Their wave functions are built up by many two-quasiparticle components, i.e. these phonons are really collective. The other class consists of phonons which are dominated only by a single two-quasiparticle component. Examples for the latter are the neutron dominated 2_3^+ and 5_1^- states and the proton dominated 6_2^+ state. It is worth mentioning that up to 2.55 MeV for each theoretical level a corresponding experimental one can be found.

At higher excitation energies a two-phonon quintet of quadrupole-octupole coupled states with $J^\pi = 1^-, 2^-, 3^-, 4^-, 5^-$ is expected. In the (γ, γ') measurements [9] three states with $J = 1$ are found: 2812 keV, 2898 keV and 2974 keV. The last of them was found to be excited very strongly in the (d,d') reaction, indicating natural parity. Keeping in mind that the QPM calculations only yield one state with $J^\pi = 1^-$ in this energy range, namely the quadrupole-octupole coupled two-phonon state, the only possible conclusion is that the 2974 keV level is the $|2_1^+ \otimes 3_1^- |1^-\rangle$ state. Using an earlier spin assignment [10] of a state at 2863 keV, comparing its (d,d') intensity with that of the 2974 keV state and performing a coupled channel calculation with a standard set of optical model parameters [11] leads to the result that this level can be interpreted as $|2_1^+ \otimes 3_1^- |3^-\rangle$ state.

One of the other $J = 1$ states from (γ, γ') can be considered to result from the coupling $|2_1^+ \otimes 2_2^+ |1^+\rangle$ of the collective 2_1^+ phonon with the isovector 2_2^+ phonon [9]. Some evidence for the corresponding $|2_1^+ \otimes 2_2^+ |4^+\rangle$ state exists in our (d,d') data.

More detailed information about the data analysis and the development of the nuclear structure interpretation concerning the even tellurium isotope ^{126}Te can be found in [12].

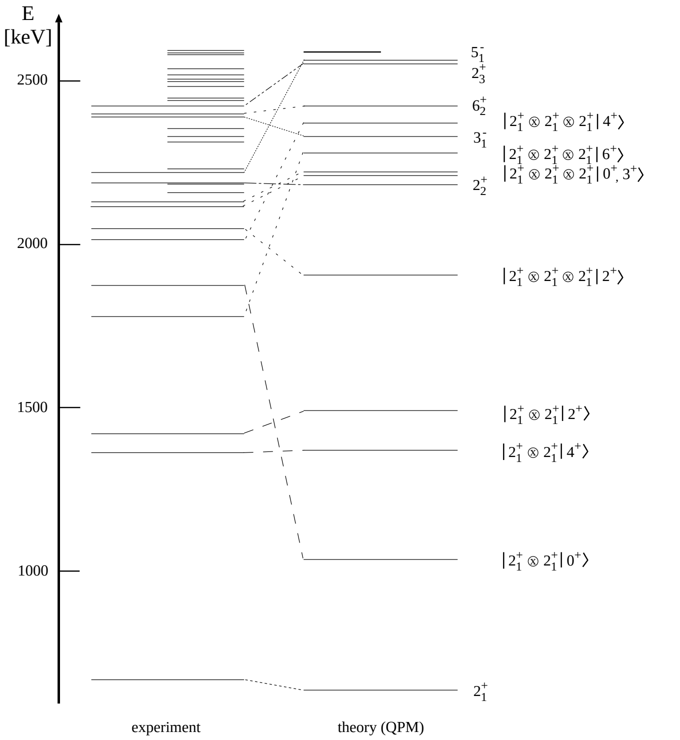

Fig. 1: Comparison of the experimental level scheme of ^{126}Te with a theoretical one, calculated with the QPM.

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