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LETTER TO THE EDITOR

A note on the systematic features of the low-lying levels of even–even nuclei near the closed shell $Z = 50$

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Abstract. It has been suggested that particle–hole symmetry may be responsible for level energy systematics in the $Z \simeq 50$ region but the measured quadrupole moments do not have a similar simple explanation.

In recent articles Sakai (1972, 1973) has suggested that there may exist a high degree of particle and hole symmetry in the excitation of the even–even nuclei in the region of the closed proton shell at $Z = 50$. Certainly, as Sakai points out, if the energies of the low-lying levels are plotted as a function of neutron number there seems to be a very striking correspondence between isotone pairs with $Z = 50-z$ and $Z = 50+z$; ie between Cd and Te, Pd and Xe, etc (see figure 1). Sakai has suggested that this may imply that proton holes inside the closed shell play a similar role to protons outside the closed shell in their interaction with the collective core. He argues that the correspondence arises especially in the $Z \simeq 50$ region because of the similarity of the $g_{9/2}$ hole and $g_{7/2}$ particle wavefunctions.

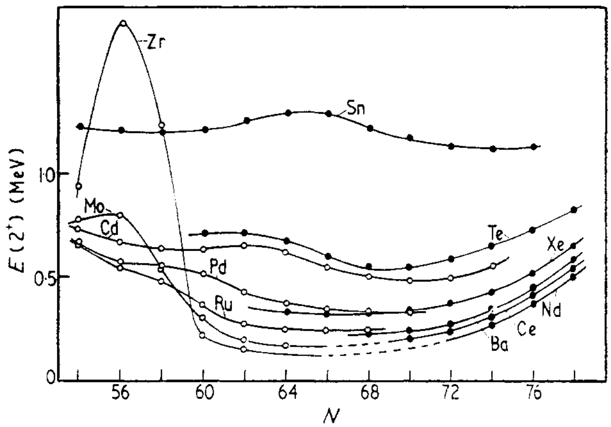

Figure 1. Energies of the first excited 2^+ states plotted as a function of neutron number; this figure is taken from Sakai (1972).

The model in which extra-core particles or holes are coupled to a vibrational core has been used by Alaga and co-workers (Alaga *et al* 1967) to decribe nuclei in this region and especially in an effort to understand the measured static quadrupole moments of the first excited 2^+ states. In this model the core is effectively polarized by the extra-core particles and the sign of the resultant quadrupole moment is thus determined by the single particle motion.

We now consider the isotopes of Cd ($Z = 48$) and Te ($Z = 52$). If we restrict the two proton holes in Cd to $g_{9/2}$ states the sign of the quadrupole moment is determined by the sign of the moment due to the coupling of two $g_{9/2}$ holes to spin two. This is negative and in fact all of the measured moments in the Cd isotopes given in the compilation of Christy and Häusser (1972) are negative. However, a similar treatment of Te involving only $g_{7/2}$ extra-core particles gives a positive moment. Some of the Te data given in the Christy and Häusser compilation have been recently amended and the present position regarding the measured moments is shown in table 1. The moments

Table 1. Quadrupole moments (in eb) of the first 2^+ states in Te isotopes measured by Coulomb excitation. Two alternative values of the quadrupole moment are normally quoted for each measurement due to the uncertainty in the relative phases of certain E2 matrix elements required in the analysis of the Coulomb excitation experiments. There is circumstantial theoretical and experimental evidence in favour of the results given in the left-hand column but this need not be assumed in the present discussion.

Isotope	Quadrupole moment		Reference
^{122}Te	$-0{\cdot}50 \pm 0{\cdot}22$		Stelson (1968)†
^{124}Te	$-0{\cdot}50 \pm 0{\cdot}10$	$-0{\cdot}27 \pm 0{\cdot}10$	Kleinfeld *et al* (1973)
^{126}Te	$-0{\cdot}40 \pm 0{\cdot}10$	$-0{\cdot}24 \pm 0{\cdot}08$	Stokstad and Hall (1967)
	$-0{\cdot}20 \pm 0{\cdot}09$	$0{\cdot}00 \pm 0{\cdot}09$	Kleinfeld *et al* (1973)
^{128}Te	$-0{\cdot}27 \pm 0{\cdot}13$	$-0{\cdot}11 \pm 0{\cdot}10$	Stokstad and Hall (1967)
	$-0{\cdot}07 \pm 0{\cdot}09$	$+0{\cdot}12 \pm 0{\cdot}09$	Kleinfeld *et al* (1973)
^{130}Te	$-0{\cdot}19 \pm 0{\cdot}15$	$-0{\cdot}12 \pm 0{\cdot}15$	Christy *et al* (1970)

†Private communication to de Boer J and Eichler J *Adv. nucl. Phys.* **1** 1–65.

of the heavier isotopes are probably small due to the proximity of the $N = 82$ neutron shell closure. It seems clear however that at least the moments of the lighter Te isotopes are negative, ie opposite in sign to the moment which would be induced by a simple $(g_{7/2})^2$ cluster. Lopac (1970) has shown that negative moments for Te can be reproduced by the Alaga model when higher orbitals are included since these can give rise to negative contributions to the quadrupole moment which outweigh the effect of the $g_{7/2}$ state.

If the proposed particle–hole symmetry is indeed largely responsible for the level energy systematics we may conclude that the quadrupole moment and the level energy have a very different sensitivity to the details of the nuclear wavefunction.

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