On the Question of Electron Bridge for the 3.5-eV Isomer of ^{229}Th

In Ref. [1], the observation of complex radiation from solid samples containing ^{233}U has been reported. It was interpreted as being due to deexcitation of the (3.5 ± 1)-eV isomeric level of the daughter ^{229}Th decaying to the ground state, which is accompanied by a redshifted component of similar intensity due to an inelastic electron bridge mechanism. We note that, from the calculation reported below and in Ref. [2], such an interpretation greatly underestimates the effect of the electron bridge.

In Table I we present the ratio R of the partial width of the isomeric decay via the electron bridge mechanism (with the emission of the redshifted photons) to the width of the direct radiative transition to the ground state. As is the case for internal conversion coefficients (ICC), this ratio is expected to be independent of the nuclear model, being fully determined by the atomic structure (e.g., Ref. [2]). R also manifests itself as the ratio of the intensities of the redshifted and the primordial nuclear lines. For this calculation we used the RAINE package [3]. Listed are the calculated energies of the redshifted photons. Starting from the electronic configuration $(7s)^2(6d_{3/2})^2$ of neutral thorium, we considered the chain of transitions $7s$-ns-$7p_{1/2}$ and $7s$-ns-$7p_{3/2}$. On the basis of Table I, two prominent peaks of approximately equal intensity are predicted for the nuclear transition energy of 3.5 eV, namely, with energies of 1.08 and 1.83 eV, instead of one peak at about 2.4 eV as reported in Ref. [1]. The anticipated intensity of the two peaks is 3 orders of magnitude higher than the intensity of the direct nuclear transition. This is in contrast with the statement and result [1] that the relative contribution of the bridge is close to unity. The probable reason for the latter erroneous statement is that it is based on the chain $6d_{3/2}$-nd-$7p_{1/2}$. Its probability is lower by 3 orders of magnitude indeed because of the very small localization probability of the $6d$ electrons in the vicinity of the nucleus, and, by consequence, small ICC in the $6d$ shell in comparison with the $7s$ shell [2].

Note that in such complex compounds as those used in experiment [1] the appearance of satellite lines may be due to hybridization of the atomic orbits belonging to different centers in a molecule [4].

In conclusion, the deexcitation of the isomer through the electron bridge mechanism is the prevailing channel. It can be suggested that the application of gaseous targets would provide more unambiguous information at the contemporary stage of investigation.

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TABLE I. The ratio R (see text) and the energies ω of the redshifted lines, corresponding to the decay of the $7p_{1/2}$ and $7p_{3/2}$ final states of the Th atom. R and ω are calculated for various energies of the ^{229m}Th isomer. Total intensity of the redshifted components is also listed.

Nuclear energy, eV	2.5 eV		3 eV		3.5 eV		4 eV		4.5 eV	
Final Atomic State	ω, eV	R	ω, eV	R	ω, eV	R	ω, eV	R	ω, eV	R
$7p_{1/2}$	0.84	8.35	1.33	60	1.83	783	2.33	508	2.84	84
$7p_{3/2}$	0.09	0.07	0.58	44	1.08	782	1.58	730	2.09	97
Total	$\cdots$	8.4	$\cdots$	104	$\cdots$	1565	$\cdots$	1238	$\cdots$	181

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