Outline: K-isomers in ^{180}Ta

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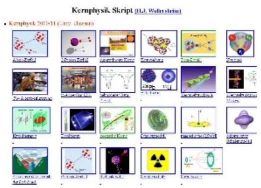
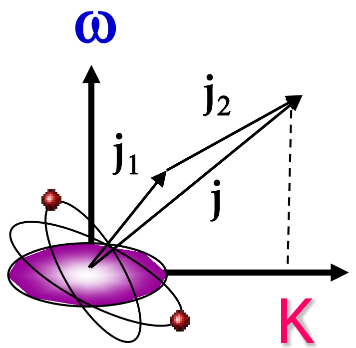
web-page: https://web-docs.gsi.de/~wolle/ and click on



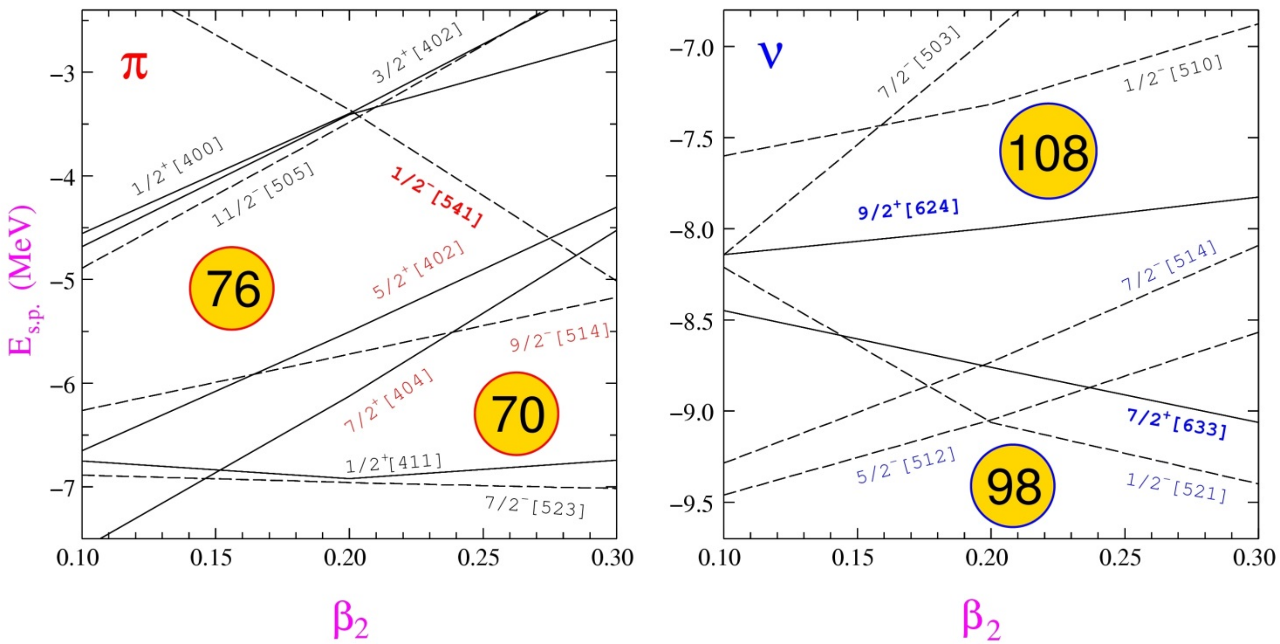
1. K-selection rule
2. Coulomb activation of ^{180}Ta
3. excitation and decay of K=1 band in ^{180}Ta
4. investigation of the K=16 isomer in ^{178}Hf
5. deuteron and ^{208}Pb inelastic scattering, laser spectroscopy

K-isomers: Where to find them?

- Deformed nuclei with axially-symmetric shape



Mass 180 region : Yb (Z=70) **- *Ir*** (Z=77)

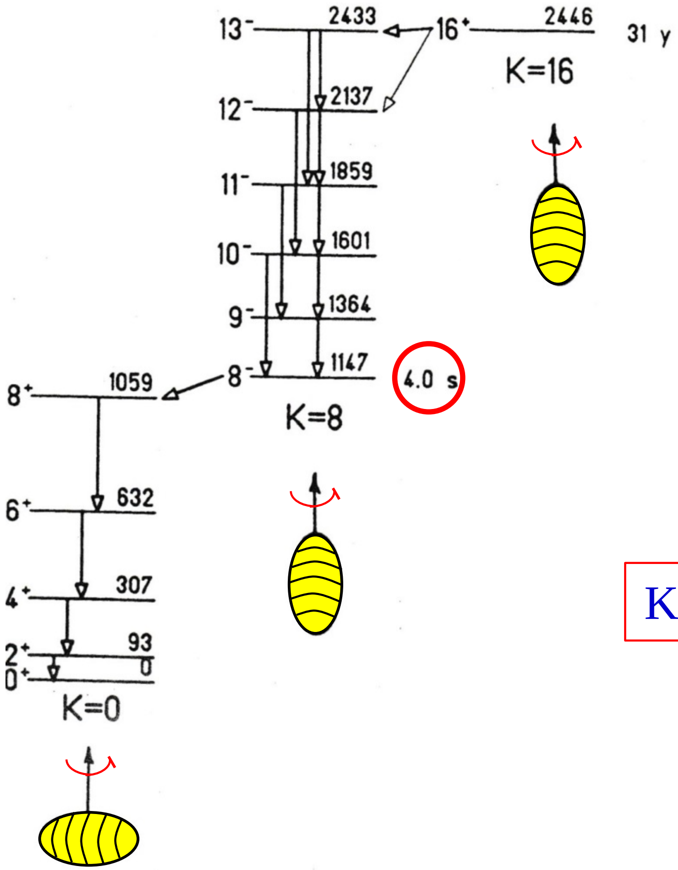


- High-K orbitals near the Fermi surface

π: 7/2[404], 9/2[514], 5/2[402]

ν: 7/2[514], 9/2[624], 5/2[512], 7/2[633]

Isomerism

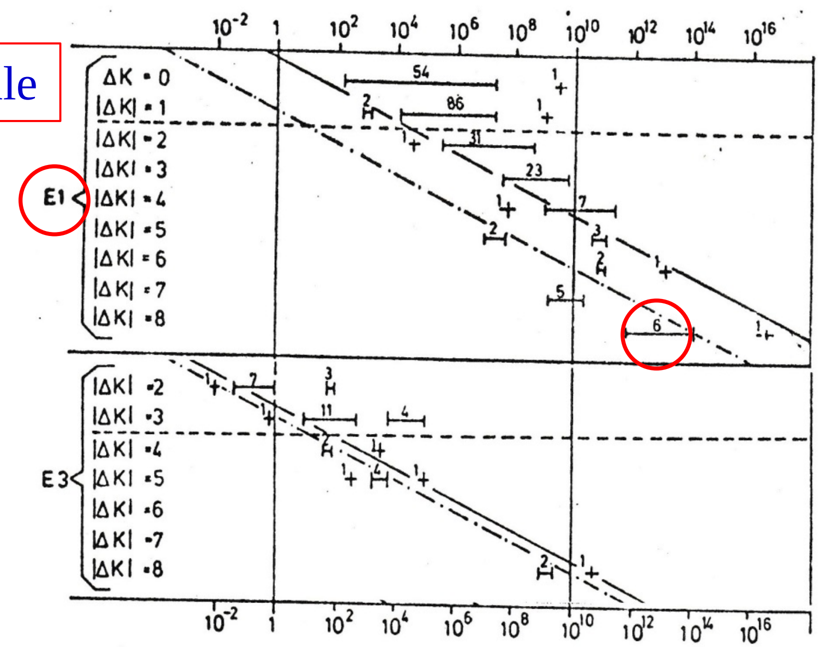


$H = 10^9$

$H = 2 \cdot 10^{13}$

$$H = \frac{t_{1/2}(experiment)}{t_{1/2}(Weisskopf\ estimate)}$$

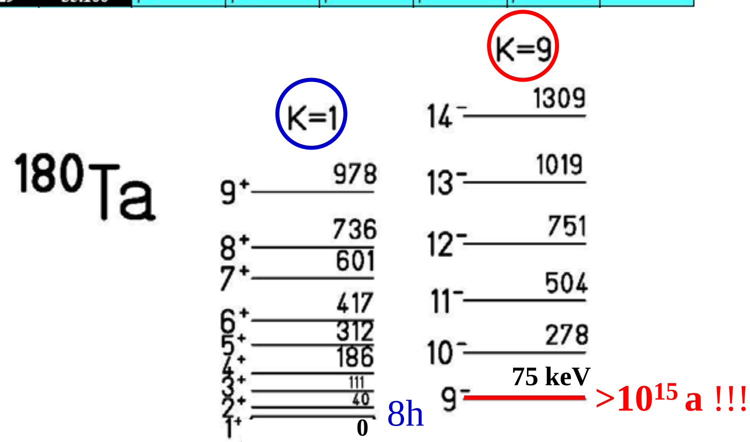
K-selection rule

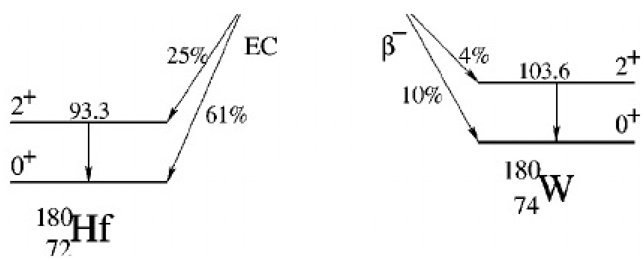


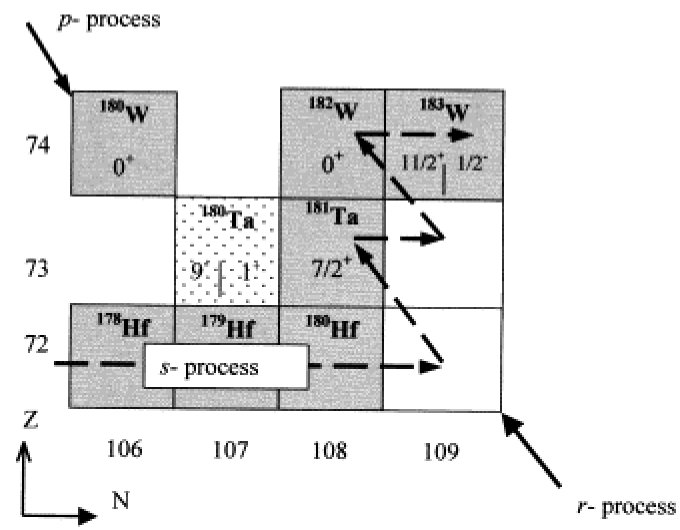
Helmer & Reich; Nucl. Phys. A114 (1968), 649

K-isomers in ^{180}Ta

W176 2.5 h 0+ EC	W177 135 m (1/2-) EC	W178 21.6 d 0+ EC	W179 37.05 m (7/2)- * EC	W180 0+ * 0.13	W181 121.2 d 9/2+ EC	W182 0+ 26.3	W183 1.1E+17 y 1/2- * 14.3	W184 3E+17 y 0+ 30.67	W185 75.1 d 3/2- * β-	W186 0+ 28.6	W187 23.72 h 3/2- β-	W188 69.4 d 0+ β-	W189 11.5 m (3/2-) β-	W190 30.0 m 0+ β-
Ta175 10.5 h 7/2+ EC	Ta176 8.09 h (1)- * EC	Ta177 56.56 h 7/2+ EC	Ta178 9.31 m 1+ * EC	Ta179 1.82 y 7/2+ * EC	Ta180 8.152 h 1+ EC,β- * 0.012	Ta181 7/2+ 99.988	Ta182 114.43 d 3- * β-	Ta183 5.1 d 7/2+ β-	Ta184 8.7 h (5-) β-	Ta185 49.4 m (7/2+) β-	Ta186 10.5 m 2,3 β-	Ta187	Ta188	116
Hf174 2.0E15 y 0+ α 0.162	Hf175 70 d 5/2- EC	Hf176 0+ 5.206	Hf177 7/2- * 18.606	Hf178 0+ * 27.297	Hf179 9/2+ * 13.629	Hf180 0+ * 35.100	Hf181 42.39 d 1/2- β-	Hf182 9E6 y 0+ * β-	Hf183 1.067 h (3/2-) β-	Hf184 4.12 h 0+ β-	Hf185 3.5 m β-	Hf186 0+		

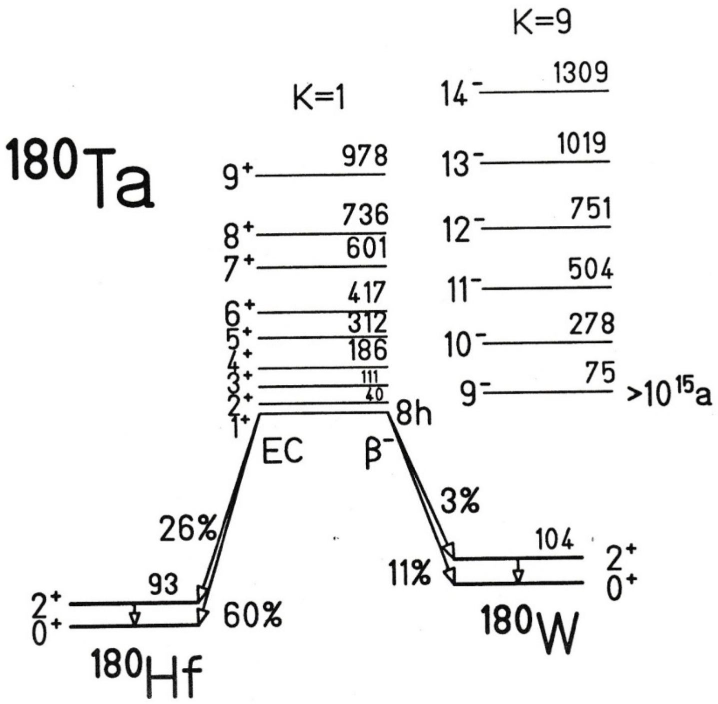




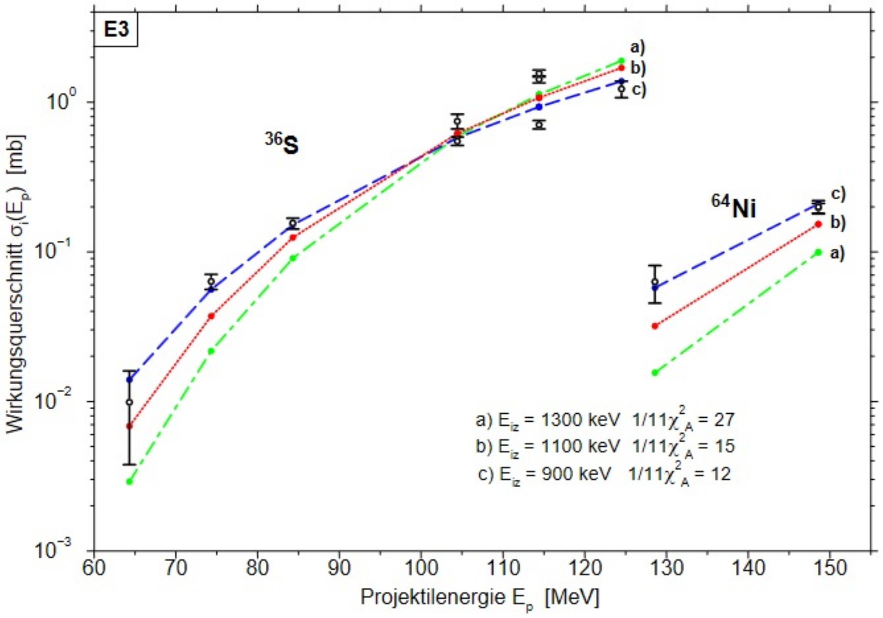


The rarest natural isotope: abundance of 0.012%

Coulomb activation of ^{180}Ta



excitation function



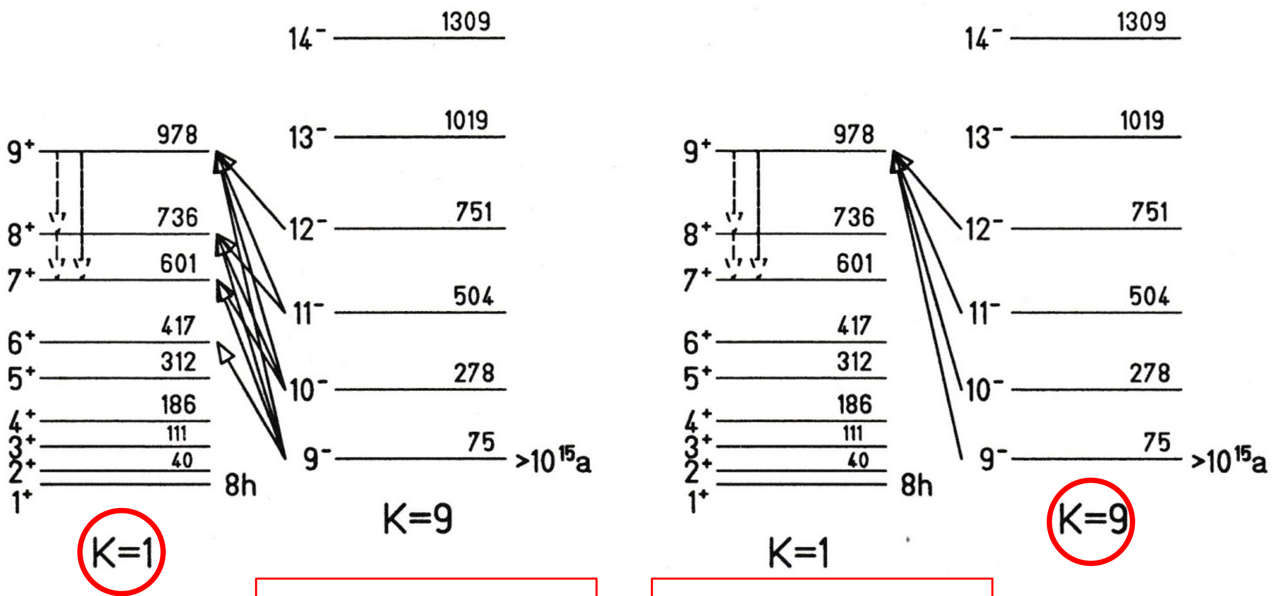
The curves are calculated with the Coulomb excitation code COULEX

red curve: single step E2 E* = 1.1 MeV B(E2) = 0.3 W.u. final spin 9^-

blue curve: single step E3 E* = 1.1 MeV B(E3) = 3.3 W.u. final spin 9^+

green curve: single step E3 E* = 1.2 MeV B(E3) = 4.0 W.u. final spin 9^+

2-band K-mixing model



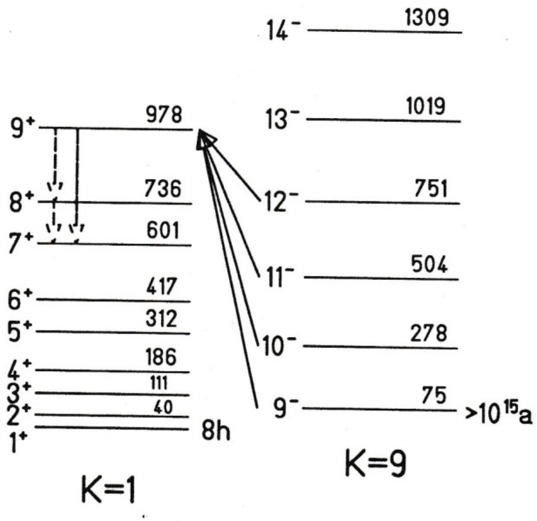
+ small K=1 admixture

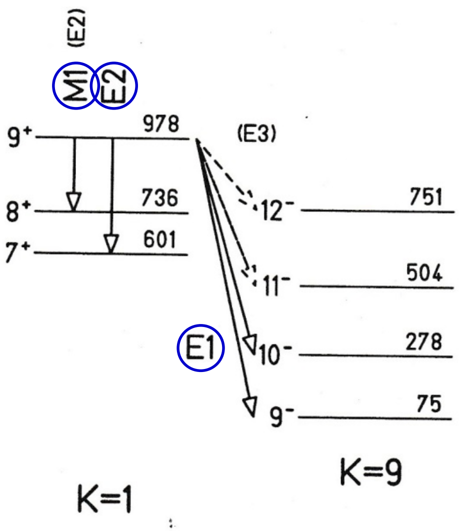
+ small K=9 admixture

rigid rotor model:

$$\left\langle I_f \,\|M(E3)\|\, I_i \right\rangle = \sqrt{2I_i + 1} \cdot \left(I_i 3 K 0 | I_f K \right) \cdot M_{30}$$

Excitation and decay of the K=1 band





decay probabilities:

$$(1+\alpha_T)\ \delta^2_{9^+\rightarrow 8^+}(M1) = 1.48 * 10^{11}\ (s^{-1})$$

$$(1+\alpha_T)\ \delta^2_{9^+\rightarrow 8^+}(E2) = 1.00 * 10^{9}\ (s^{-1})$$

$$(1+\alpha_T)\ \delta^2_{9^+\rightarrow 7^+}(E2) = 1.54 * 10^{11}\ (s^{-1})$$

$$(1+\alpha_T)\ \delta^2_{9^+\rightarrow 9^-}(E3) = 7.35 * 10^{5}\ (s^{-1})$$

$$(1+\alpha_T)\ \delta^2_{9^+\rightarrow 9^-}(E1) = 1.17 * 10^{17} B(E1; 9^+ \rightarrow 9^-)\ (s^{-1})$$

interband / intra-band	$B(E1; 9^+ \rightarrow 9^-)$	
10.	$2.6 * 10^{-5}\ (e^2b)$	
1.0	$2.6 * 10^{-6}\ (e^2b)$	$1.3 \cdot 10^{-4}$ W.u.
0.1	$2.6 * 10^{-7}\ (e^2b)$	