^{140}Ce(α,6nγ),^{141}Pr(p,4nγ) 1980Mu10,1975Yo01

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1980Mu10 (also 1979Mu03): ^{140}Ce(α,6nγ) E=85 MeV α beam was produced from the Julich isochronous cyclotron JULIC. Target was about 10 mg/cm^2 thick CeO_2 (99.7% enriched in ^{140}Ce) deposited onto a 3 μm mylar foil. γ rays were detected with Ge(Li) detectors. Measured Eγ, Iγ, γγ-coin, γ(θ), γ(t). Deduced levels, J, π, $T_{1/2}$, configurations. Systematics of neighbouring nuclei. Comparisons with the triaxial rotor-plus-particle model calculations.

1975Yo01: ^{141}Pr(p,4nγ) E=44 MeV proton beam was produced from the INS synchrocyclotron. Target was oxide powders of ^{141}Pr, with a thickness of 35 mg/cm^2 on a 4 μm thick Mylar film. γ rays were detected with a Ge(Li) detector (FWHM=2.7 keV at 1332 keV) and electrons were detected with a multigap reaction conversion electron spectrometer (M-Race). Measured Eγ, Iγ, γ(θ), γ(t), E(ce), I(ce). Deduced levels, J, π, $T_{1/2}$, γ-ray multipolarities. Systematics of neighbouring nuclei.

Other: 1973VaYZ (E(α)=104 MeV).

^{138}Nd Levels

E(level)†	J^π@	$T_{1/2}$#	Comments
0.0	0^+		
520.2 *3*	2^+	≤3 ns	
1013.0 *4*	2^+&		
1248.5 *4*	4^+	≤3 ns	
1450.1 *5*	3^+&		
1988.5 *5*	5^-	≤3 ns	
2132.2 *5*	6^+	≤3 ns	
2220.3 *5*	5	≤3 ns	
2318.8 *5*	7^-	≈250 ps	$T_{1/2}$: from 1973VaYZ.
2689.3 *5*	7	≤3 ns	
3105.1 *6*	8^+	≤3 ns	
3171.7 *7*	10^+	0.41 μs *5*	Configuration=$(\nu\ h_{11/2})^{-2}_{10+}$. $T_{1/2}$: from 1975Yo01, using γ(t) following timing with beam pulses.
3244.7 *6*	(9)	≤3 ns	
3697.6 *7*	(10)	≤3 ns	
3818.1 *7*	$12^{(+)}$	≤3 ns	
4199.8 *7*	(12)	≤3 ns	
4970.4 *9*	(13)	≤3 ns	
4991.4 *8*	(14)	≤3 ns	
5026.0 *9*	(13)	≤3 ns	J^π: (14^+) in Adopted Levels.
5348.8‡ *9*	(14)	≤3 ns	
5837.9 *9*		≤3 ns	
6309.8‡ *10*	(15)	≤3 ns	
6539.7‡ *10*	(16)	≤3 ns	
6824.4 *10*	(17)	≤3 ns	
7016.2‡ *11*	(18)	≤3 ns	
7327.8‡ *11*	(19)	≤3 ns	

† From a least-squares fit to γ-ray energies.
‡ Level not included in Adopted Levels.
# Experimental limit from (α,6nγ) (1980Mu10), unless otherwise noted.
@ From 1980Mu10 based on deduced γ-ray multipolarities, unless otherwise noted. Please refer to Adopted Levels for adopted assignments.
& From 1975Yo01 based on anisotropy.

^{140}Ce(α,6nγ),^{141}Pr(p,4nγ) 1980Mu10,1975Yo01 (continued)

γ(^{138}Nd)

E_γ[‡]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[†]	α[&]	Comments
66.6 *3*	49 *17*	3171.7	10+	3105.1	8+	E2	10.0	α(K)=3.44; α(L)=5.06; α(M)=1.15; α(N+..)=0.306 Mult.: A_2=+0.04 *7*, A_4=+0.03 *11* (1980Mu10); α(exp)=7.4 *34* (Iγ balance); level scheme.
191.8 *3*	72 *13*	7016.2	(18)	6824.4	(17)	D+Q		Mult.: A_2=−0.36 *10*, A_4=+0.05 *15* (1980Mu10).
229.9 *3*	67 *12*	6539.7	(16)	6309.8	(15)	D+Q		Mult.: A_2=−0.42 *10*, A_4=−0.02 *15* (1980Mu10).
x276.6 *3*	25 *6*					D+Q		Mult.: A_2=−0.26 *12*, A_4=−0.12 *18* (1980Mu10).
284.7 *3*	79 *12*	6824.4	(17)	6539.7	(16)	D+Q		Mult.: A_2=−0.23 *7*, A_4=+0.03 *11* (1980Mu10).
311.6 *3*	90 *30*	7327.8	(19)	7016.2	(18)	D+Q		Mult.: A_2=−0.39 *7*, A_4=+0.04 *11* (1980Mu10).
322.4 *5*	36 *5*	5348.8	(14)	5026.0	(13)	D+Q		Mult.: A_2=−0.57 *11*, A_4=+0.05 *16* (1980Mu10).
330.3 *3*	300 *36*	2318.8	7−	1988.5	5−	E2	0.0391	α(K)=0.0313; α(L)=0.00613; α(M)=0.00133; α(N+..)=0.00036 Additional information 6. Mult.: α(K)exp=0.035 *3*, A_2=+0.23 *5*, A_4=−0.05 *8* (1975Yo01); A_2=+0.17 *10*, A_4=+0.015 (1980Mu10).
370.6 *3*	30 *20*	2689.3	7	2318.8	7−			
378.7 *5*	31 *5*	5348.8	(14)	4970.4	(13)	D+Q		Mult.: A_2=−0.41 *13*, A_4=−0.07 *19* (1980Mu10).
437.3[#] *5*		1450.1	3+	1013.0	2+			
452.9 *3*	157 *16*	3697.6	(10)	3244.7	(9)	D(+Q)		Mult.: A_2=−0.24 *4*, A_4=+0.02 *6*.
469.0 *3*	71 *11*	2689.3	7	2220.3	5	Q		Mult.: A_2=+0.26 *10*, A_4=+0.10 *15* (1980Mu10).
492.8[#] *5*		1013.0	2+	520.2	2+			
502.2 *3*	161 *16*	4199.8	(12)	3697.6	(10)	E2	0.0118	α(K)=0.0097; α(L)=0.00157 Mult.: A_2=+0.26 *6*, A_4=−0.07 *9* (1980Mu10).
520.1 *3*	1000 *80*	520.2	2+	0.0	0+	E2	0.0107	α(K)=0.0088; α(L)=0.00142 Additional information 1. Mult.: A_2=+0.15 *1*, A_4=+0.01 *5* (1975Yo01); A_2=+0.16 *2*, A_4=+0.02 *3* (1980Mu10).
555.4 *3*	150 *23*	3244.7	(9)	2689.3	7	E2	0.0090	α=0.0090; α(K)=0.00743; α(L)=0.00117 Mult.: A_2=+0.33 *7*, A_4=−0.02 *11* (1980Mu10).
x555.9 *3*	125 *38*					(Q)		Mult.: A_2=+0.13, A_4=−0.03 *14* (1980Mu10).
557.2 *3*	242 *36*	2689.3	7	2132.2	6+	D(+Q)		Mult.: A_2=−0.16 *6*, A_4=+0.01 *9* (1980Mu10).
646.4 *3*	196 *20*	3818.1	12(+)	3171.7	10+	E2	0.00612	α=0.00612; α(K)=0.00510; α(L)=0.00077 Mult.: A_2=+0.31 *5*, A_4=−0.05 *8* (1980Mu10).
x676.7 *3*	93 *12*					D+Q		Mult.: A_2=−0.92 *10*, A_4=+0.13 *15* (1980Mu10).
728.3 *3*	1017 *82*	1248.5	4+	520.2	2+	E2	0.00459	α=0.00459; α(K)=0.00384; α(L)=0.00056 Additional information 2. Mult.: α(K)exp=0.0028 *3*, A_2=+0.19 *5*, A_4=−0.01 *7* (1975Yo01); A_2=+0.16 *2*, A_4=+0.01 *3* (1980Mu10).
740.0 *3*	288 *29*	1988.5	5−	1248.5	4+	E1	0.00170	α=0.00170; α(K)=0.00145; α(L)=0.00019 Additional information 3. Mult.: α(K)exp=0.0016 *3*, A_2=−0.05 *6*, A_4=−0.03 *11* (1975Yo01); A_2=−0.21 *6*, A_4=+0.02 *9* (1980Mu10).
791.6 *3*	105 *11*	4991.4	(14)	4199.8	(12)	E2	0.00378	α=0.00378; α(K)=0.00317; α(L)=0.00046 Mult.: A_2=+0.36 *15*, A_4=−0.03 *12* (1980Mu10); RUL.
846.5 *3*	87 *9*	5837.9		4991.4	(14)	(Q)		Mult.: A_2=+0.42 *10*; A_4=+0.17 *15* (1980Mu10).
883.7 *3*	641 *51*	2132.2	6+	1248.5	4+	E2	0.00295	α=0.00295; α(K)=0.00248; α(L)=0.00035 Additional information 4. Mult.: α(K)exp=0.0021 *4*, A_2=+0.21 *11*, A_4=−0.07 *14* (1975Yo01); A_2=+0.11 *2*, A_4=+0.03 *3* (1980Mu10).
x917.9 *3*	36 *7*					(Q)		Mult.: A_2=+0.36 *15*, A_4=+0.12 *23* (1980Mu10).
929.6[#] *5*		1450.1	3+	520.2	2+			Iγ(437.3γ)/Iγ(929.6γ)=5/3 (1975Yo01).

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$^{140}Ce(\alpha,6n\gamma),^{141}Pr(p,4n\gamma)$ 1980Mu10,1975Yo01 (continued)

$\gamma(^{138}Nd)$ (continued)

E_γ ‡	I_γ ‡	E_i(level)	J_i^π	E_f	J_f^π	Mult.†	α&	Comments
961.0 *3*	89 *18*	6309.8	(15)	5348.8	(14)	D+Q		Mult.: A_2=−0.63 *10*, A_4=+0.09 *15* (1980Mu10).
971.7@ *3*	152 *41*	2220.3	5	1248.5	4^+			Additional information 5. Mult.: M1(+E2) from reanalysis of ce data of α(K)exp=0.0018 *6* for the 971.8γ in 1975Yo01 (1980Mu10). A Dipole value was adopted.
972.9@ *3*	4.1×10^2 *11*	3105.1	8^+	2132.2	6^+	E2	0.00239	α=0.00239; α(K)=0.00202; α(L)=0.00028 Additional information 7. Mult.: α(K)exp=0.0018 *6*, A_2=−0.02 *12*, A_4=−0.03 *18* (1975Yo01); A_2=−0.01 *6*, A_4=+0.01 *9* (1980Mu10).
1013.3# *5*		1013.0	2^+	0.0	0^+			Iγ(492.8γ)/Iγ(1013.3γ)=11/4 (1975Yo01).
1152.7 *5*	93 *14*	4970.4	(13)	3818.1	$12^{(+)}$	D+Q		Mult.: A_2=−0.79 *11*, A_4=−0.04 *16* (1980Mu10).
1207.6 *5*	122 *18*	5026.0	(13)	3818.1	$12^{(+)}$	Q		Mult.: A_2=+0.19 *11*, A_4=−0.10 *16* (1980Mu10).

† From α(K)exp, normalized to α(K)(E2)=0.0087 for 520γ (1975Yo01), $\gamma(\theta)$ (1980Mu10) and RUL.

‡ From 1980Mu10, unless noted otherwise. Intensities are for transitions observed in $^{140}Ce(\alpha,6n\gamma)$ and relative to Iγ(520.1γ)=1000 *80*.

\# Observed only in (p,4nγ) (1975Yo01).

@ Unresolved doublet in 1980Mu10. 1975Yo01 observed a line at 971.8, with α(K)exp=0.0018 *6*, but not recognized it as a doublet and assigned it as a transition from the 3105, 8^+ level.

& Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

^{x} γ ray not placed in level scheme.

^{140}Ce(α,6nγ),^{141}Pr(p,4nγ) 1980Mu10,1975Yo01

Level Scheme

Intensities: Relative I_γ