Coulomb excitation 2016Kl05,2015Kl01,2015Sa40

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2016Kl05 and 2015Sa40 are complied for XUNDL by B. Singh (McMaster) and respectively by J. Chen (NSCL, MSU).

2016Kl05,2015Kl01,2015Sa40 (interrelated, also contributing to ε decay): beam=^{140}Sm at E=2.85 MeV/nucleon, target=^{94}Mo with a thickness of 2 mg/cm^2. The secondary ^{140}Sm beam was produced in Ta(p,X),E(p)=1.4 GeV reaction at ISOLDE-CERN facility using RILIS laser ionization source for selection of samarium ions. The A=140 was selected using general purpose separator GPS, then cooled and trapped in REXTRAP and ionized to 34$^+$ charge state using EBIS charge breeder, and finally ^{140}Sm ions accelerated to 2.85 MeV/nucleon using the REX linear accelerator. Measured Eγ, Iγ, scattered ^{140}Sm and ^{94}Mo particles, (particle)γ-coin using MINIBALL HPGe detector array for γ detection and double-sided silicon strip detectors (DSSDs) for particles. Deduced E2 matrix elements for excitation of levels in ^{140}Sm using coupled-channel code GOSIA, measured γ-ray yields at different scattering angles were fitted to obtain E2 matrix elements. Two methods of normalization procedures were used: 1. Simultaneous fitting of γ-ray yields for ^{140}Sm projectile and ^{94}Mo target (871-keV transition from the first 2$^+$ state to g.s. in ^{94}Mo) using GOSIA2 code. 2. Fitting of the γ-ray yields for ^{140}Sm using the known lifetime of 9.1 ps *6* (2015Be25) and standard GOSIA code. Complete analysis of the first procedure of normalization to target excitation followed four steps using GOSIA and GOSIA2 codes, the former code employed when data for only ^{140}Sm were used.

2016Kl05 did comparison of deduced quadrupole moment of the first 2$^+$ state and reduced E2 matrix elements with several theoretical models such as geometric model of Davydov and Filippov, algebraic model (IBA, E(5) description), shell model, and beyond mean-field model (constrained Hartree-Fock-Bogoliubov theory with Gogny DIS interaction).

2015Kl01,2015Sa40: determined angular correlation coefficients for 459γ-531γ and 1068γ-531γ cascades.

^{140}Sm Levels

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$	Comments
0.0	0$^+$		
530.7 *1*	2$^+$	5.8 ps *5*	Q=−0.06 *+41−15* (2016Kl05) Q: average of +0.02 *+41−15* and −0.13 *+38−14* from two different methods. T$_{1/2}$: deduced by evaluator from B(E2)↓=0.23 *2* (2016Kl05).
990.4 *1*	2$^+$	7.7 ps *12*	J$^\pi$: from angular correlation coefficients for 459γ-531γ cascade. T$_{1/2}$: deduced by evaluator from B(E2)↓=0.35 *5* (2016Kl05).
1245.8 *1*	4$^+$	1.00 ps *7*	T$_{1/2}$: deduced by evaluator from B(E2)↓=0.30 *2* (2016Kl05).

† Rounded-off values from Adopted Levels, Gammas Dataset.

‡ From Adopted Levels, Gammas dataset.

γ(^{140}Sm)

E2 matrix elements are in eb units, B(E2) values in e^{2}b^2 units, and quadrupole moment Q in eb.

B(E2)(W.u.) are deduced by evaluator from averaged values of B(E2) determined by 2016Kl05.

E$_\gamma$[†]	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Mult.[#]	δ	α[@]	Comments
459.9 *1*	990.4	2$^+$	530.7	2$^+$	E2(+M1)	+8 *+22−4*	0.0162	B(E2)↓=0.35 *5* (2016Kl05); B(E2)(W.u.)=78 *11* B(E2) is the average of 0.35 *5* and 0.35 *+4−5* obtained using two different methods of normalization. I$_\gamma$: 47 *22* for 63°−71°, 150 *33* for 71°−82°, 306 *60* for 95°−112°, 300 *110* for 112°−125°. Mult.,δ: mostly pure ΔJ=0, E2 γ based on angular correlation coefficients: (98% *+2−4*)E2+(2% *+4−2*)M1 (2015Sa40). A$_2$=−0.15 *7*, A$_4$=+0.28 *8* for 460γ-531γ cascade

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Coulomb excitation 2016Kl05,2015Kl01,2015Sa40 (continued)

$\gamma(^{140}Sm)$ (continued)

E_γ [†]	I_γ [‡]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [#]	α [@]	Comments
								(2015Sa40,2015Kl01). E2 matrix element=1.33 *+8−9*; B(E2)=0.35 *5*, when normalized to Coulomb excitation yield for ^{94}Mo target. E2 matrix element=1.32 *+8−9*; B(E2)=0.35 *+4−5*, when normalized to the known lifetime of the first 2^+ state in ^{140}Sm.
530.7 *1*	1435×10^1 *17*	530.7	2^+	0.0	0^+	E2	0.01096	B(E2)↓=0.23 *2* (2016Kl05); B(E2)(W.u.)=51 *5* B(E2) is the average of 0.25 *+2−1* and 0.21 *+2−1* obtained using two different methods of normalization. I_γ: 10200 *140* for 63°−71°, 13840 *170* for 71°−82°, 13780 *170* for 95°−112°, 6860 *120* for 112°−125°. E2 matrix element=1.11 *3*; B(E2)=0.25 *+2−1*, when normalized to Coulomb excitation yield for ^{94}Mo target. E2 matrix element=1.02 *+4−3*; B(E2)=0.21 *+2−1*, when normalized to the known lifetime of the first 2^+ state in ^{140}Sm. E2 diagonal matrix element=+0.03 *+54−20*; Q(spectroscopic)=+0.02 *+41−15*, when normalized to Coulomb excitation yield for ^{94}Mo target. E2 diagonal matrix element=−0.17 *+51−19*; Q(spectroscopic)=−0.13 *+38−14*, when normalized to the known lifetime of the first 2^+ state in ^{140}Sm.
715.0 *1*	286 *31*	1245.8	4^+	530.7	2^+	E2	0.00524	B(E2)↓=0.30 *2* (2016Kl05); B(E2)(W.u.)=67 *5* B(E2) is the average of 0.30 *2* and 0.29 *2* obtained using two different methods of normalization. I_γ: 118 *18* for 63°−71°, 209 *24* for 71°−82°, 389 *34* for 95°−112°, 199 *23* for 112°−125°. E2 matrix element=1.63 *5*; B(E2)=0.30 *2*, when normalized to Coulomb excitation yield for ^{94}Mo target. E2 matrix element=1.61 *5*; B(E2)=0.29 *2*, when normalized to the known lifetime of the first 2^+ state in ^{140}Sm.
990 [&]		990.4	2^+	0.0	0^+			B(E2)↓<0.001 (2016Kl05) Transition was not observed in the present work, only an upper limit was used in the GOSIA analysis to deduce B(E2) value.

[†] Adopted values.
[‡] For a range of 82°−95° c.m. scattering angle. Values for other angular ranges are given under comments.
[#] As implied by Coulomb excitation; some values also implied from $\gamma\gamma(\theta)$ (2015Sa40, 2015Kl01).
[@] 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.
[&] Placement of transition in the level scheme is uncertain.

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Legend

Level Scheme

Intensities: Relative I_γ