

¹⁹F(α ,n),(α ,n γ) 1967Wa13,1976Ma23,1982Ve05

Type	Author	History	Citation	Literature Cutoff Date
Full Evaluation	M. Shamsuzzoha Basunia		NDS 127, 69(2015)	1-Apr-2015

Other references: 1966Su07, 1967KaZW, 1967Po14, 1968BI03, 1968Pa11, 1969Jo10, 1969Wa17, 1971Go10, 1972Sn01, 1973An01, 1973Fr18, 1973Ha55, 1975Sp02, 1976Be06, 1976Fr19, 1977Ba77, 1977Ha11, 1977Og03, 1977Ra01, 1980Fi07, 1987Ne04, 2003Ge08.

1967Wa13: The ¹⁹F targets were in the form of CaF₂ evaporated onto nickel backings. Projectile: α , E=4 to 7 MeV; Detector: one Ge(Li) and two NaI(Tl) detectors. Measured: E γ , I γ , $\gamma\gamma$ coincidence, γ -ray angular distribution.

1976Ma23: Target ⁶LiF (thickness \approx 1 mg/cm²) evaporated onto 0.25 mm gold. Projectile: α , E=8.1- and 9.1-MeV. Detectors: γ -ray angular distribution and linear polarization were measured by an escape-suppressed spectrometer positioned at five angles 0°, 30°, 45°, 60°, and 90° with respect to beam direction and a three-crystal Ge(Li) Compton polarimeter at 270°. Also measured E γ , I γ , deduced level energies, mixing ratios, mean lifetime, and excited level energies.

1982Ve05: CaF₂ target evaporated onto a 50 μ m Ni foil. Projectile: α , E=5 MeV. Two Ge(Li) detectors. Measured E γ , I γ , $\gamma\gamma$ coincidence. Deduced isoscalar E2 strength.

²²Na Levels

E(level) [†]	J π [‡]	T _{1/2}	Comments
0.0	3 ⁺		
583.05 10	1 ⁺	243 ns 2	T _{1/2} : From 1966Su07. Other value: 266 ns 10 (1958Te15).
657.00 14	0 ⁺	19.6 ps 7	T _{1/2} : Weighted average of 20.3 ps 7 (1987Ne04), 18.8 ps 8 (1980Fi07), Other value: 14 ps 2 (1967KaZW).
890.89 20	4 ⁺	10.0 ps 3	T _{1/2} : Weighted average of 11 ps 3 (1967KaZW), 7.5 ps 12 (1968BI03), 8.5 ps 12 (1968Pa11), 11.2 ps 21 (1972Sn01), 10.2 ps 5 (1973Ha55), 11.4 ps 12 (1973Ha55), 9.6 ps 6 (1977Og03), 10.7 ps 4 (1977Ra01), 9.8 ps 3 (1980Fi07), 9.8 ps 4 (1977Ba77), and 10.0 ps 5 (1969Jo10).
1528.1 3	5 ⁺	3.42 ps 24	T _{1/2} : Weighted average of 3.3 ps 11 (1967KaZW), 2.6 ps 6 (1967Wa13), 2.4 ps 4 (1968Pa11), 3.5 ps 4 (1973Ha55), 3.1 ps 6 (1972Sn01), 3.26 ps 24 (1973An01), 4.0 ps 8 (1976Ma23), 4.1 ps 5 (1977Og03), 3.72 ps 19 (1977Ra01), 3.5 ps 5 (1969Jo10), 3.4 ps 2 (1977Ba77) and 3.0 ps 10 (1973Ha55).
1936.9 2	1 ⁺	20 fs 3	T _{1/2} : From 1967Wa13.
1951.8 3	2 ⁺ #		
1983.5 5	3 ⁺	1.47 ps 15	T _{1/2} : Weighted average of 1.2 ps 3 (1967Wa13), 1.21 ps 24 (1968Pa11), 1.66 ps 28 (1976Ma23), 1.66 ps 21 (1973An01), 1.73 ps 14 (1977Ra01), and 1.45 ps 28 (1973Ha55).
2211.4 3	1 ⁻	14.9 ps 6	T _{1/2} : Weighted average of 15.5 ps 10 (1973An01), 15.3 ps 7 (1973Ha55), 13.7 ps 12 (1977Og03), 14.1 ps 15 (1973Ha55), and 14.7 ps 6 (1977Ra01), 14.4 ps 7 (1969Jo10), 15.2 ps 6 (1976Be06). Other value: 8.3 ps 14 (1968BI03).
2571.5 3	2 ⁻ #	5.0 ps 6	T _{1/2} : Weighted average of 3.1 ps 7 (1968BI03), 4.0 ps 6 (1968Pa11), 6.1 ps 6 (1973Ha55), and 5.6 ps 4 (1977Ra01).
2968.6 6	3 ⁺ #	42 fs 9	T _{1/2} : From 1968Pa11.
3059.4 6	2 ⁺ #	28 fs 7	T _{1/2} : From 1968Pa11.
3519.1	(3 ⁻)#	465 fs 76	T _{1/2} : Weighted average of 444 fs 110 (1973Ha55) and 485 fs 105 (1976Ma23). Other: >416 fs (1978Bi11).
3706.7 4	6 ⁺	59 fs 12	T _{1/2} : Weighted average of 36 fs 12 (1969Wa17), 53 fs 14 (1973Ha55), 90 fs 17 (1973An01), 55 fs 28 (1973Ha55) and 76 fs 14 (1976Ma23).
3941.9 9		<15 fs	T _{1/2} : From 1976Ma23.
4071.4 6	4 ⁺		E(level): From 1975Sp02.
4296.2 4		3.5 ps +8-2	T _{1/2} : From 1976Ma23.
4319.0 5		30 fs 8	T _{1/2} : From 1976Ma23.
4360.0 4	2 ⁺ #	<7 fs	T _{1/2} : From 1976Ma23.
4468.7 4	(4 ⁻)	100 fs 38	T _{1/2} : From 1972Sn01. Other value: 180 fs 42 (1976Ma23 – unreliable result).
4523.9 5	(7 ⁺ ,5 ⁺)#	38 fs 14	T _{1/2} : From 1976Ma23. Other value: 80 fs 31 (1973Fr18).
4583 2		<69 ps	T _{1/2} : From 1968Pa11.

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$^{19}\text{F}(\alpha,n),(\alpha,n\gamma)$ **1967Wa13,1976Ma23,1982Ve05 (continued)**

^{22}Na Levels (continued)

E(level) [†]	J ^π [‡]	T _{1/2}	Comments
4622 2		<69 ps	T _{1/2} : From 1968Pa11.
4710.0 4	5 ⁺	37 fs 14	T _{1/2} : Weighted average of 35 fs 14 (1976Ma23) and 55 fs 40 (1972Sn01).
5062.5 4	2 ⁺	<14 fs	T _{1/2} : From 1976Ma23.
5100.4 13	4 ⁺	38 fs 12	T _{1/2} : From 1976Ma23.
5130 7		<69 fs	E(level),T _{1/2} : Level energy from Adopted Levels. Half life From 1968Pa11.

[†] Excited level energies up to 3059 keV are from 1967Wa13, energies above this level are from 1976Ma23, except otherwise noted.

[‡] From γ -ray placement and multiplicity, except otherwise noted.

From Adopted Levels.

$\gamma(^{22}\text{Na})$

E _i (level)	J _i ^π	E _{γ} [†]	I _{γ} [†]	E _f	J _f ^π	Mult. [†]	δ [†]	Comments
583.05	1 ⁺	583.04 10		0.0	3 ⁺			
657.00	0 ⁺	73.9 1	100	583.05	1 ⁺			
890.89	4 ⁺	890.87 20	100	0.0	3 ⁺	M1+E2	+3.2 3	δ : Weighted average of +3.1 3 (1968Wa04), +3.7 4 (1976Ma23), +3.2 7 (1970Ba47), and +2.6 5 (1967Po14).
1528.1	5 ⁺	637.50 20	4.7 13	890.89	4 ⁺	M1+E2	+2.11 15	δ : Weighted average of +2.00 15 (1968Wa04), +2.4 3 (1976Ma23) and +2.5 5 (1977Ha11); Other: +1.18 15 (1967Po14).
1936.9	1 ⁺	1528.1 ^{&} 2 1280.5 10	100.0 13 100	0.0 657.00	3 ⁺ 0 ⁺	E2 M1		
1951.8	2 ⁺	1294.8 ^a	0.29 [‡] 5	657.00	0 ⁺			I _{γ} : From 1982Ve05.
1983.5	3 ⁺	1368.7 3 1092.6	100 [‡] 1.3 2	583.05 890.89	1 ⁺ 4 ⁺	M1(+E2)	-0.04 6	δ : From 1968Wa04.
2211.4	1 ⁻	1400.4 5 1983.5 1554.4 3 2211.3	100.0 [#] 3 1.9 [#] 3 100.0 [#] 5 1.5 2	583.05 0.0 657.00 0.0	1 ⁺ 3 ⁺ 0 ⁺ 3 ⁺	E2(+M3) E1	-0.02 2	δ : Average of -0.04 4 (1976Ma23) and -0.01 2 (1975Sp02). Mult.: From 1967Po14, 1973Ha55. I _{γ} : From 1976Fr19. Other value: 1.7 5 (1975Sp02).
2571.5	2 ⁻	360.1 1914.4 1988.8 4 2571.4	1.6 5 2.6 7 29 3 100 3	2211.4 657.00 583.05 0.0	1 ⁻ 0 ⁺ 1 ⁺ 3 ⁺	E1 E1		I _{γ} : Weighted average of 3.2 13 (1973Ha55) and 1.4 4 (1975Sp02). I _{γ} : Weighted average of 2.4 7 (1973Ha55) and 3.4 14 (1975Sp02). I _{γ} : Weighted average of 28 3 (1973Ha55) and 32 4 (1975Sp02). δ : -0.05 6 in 1976Ma23, 0.00 10 in 1968Pa11. I _{γ} : From 1973Ha55. δ : -0.02 3 in 1968Pa11.
2968.6	3 ⁺	1016.8 5	100	1951.8	2 ⁺	M1(+E2)	-0.02 3	δ : From 1968Wa04.
3059.4	2 ⁺	1107.6 5	100 1	1951.8	2 ⁺	M1(+E2)	+0.01 5	δ : Weighted average of +0.05 15 (1968Wa04) and +0.01 5 (1976Ma23).
3519.1	(3 ⁻)	2476.2 948.0 ^a 2 1307.7 1566.8 ^a 2	3 1 11.4 8 46 2 100 6	583.05 2571.5 2211.4 1951.8	1 ⁺ 2 ⁻ 1 ⁻ 2 ⁺	M1+E2 M1+E2 E2(+M3) E1(+M2)	+0.13 7 +2.1 3 -0.1 1 -0.014 16	δ : From 1976Ma23. δ : From 1976Ma23. δ : From 1976Ma23. δ : From 1976Ma23.

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$^{19}\text{F}(\alpha, n), (\alpha, n\gamma)$ **1967Wa13, 1976Ma23, 1982Ve05 (continued)** $\gamma(^{22}\text{Na})$ (continued)

$E_i(\text{level})$	J_i^π	E_γ^\dagger	I_γ^\dagger	E_f	J_f^π	Mult. [†]	δ^\dagger	Comments
3519.1	(3 ⁻)	2628.0	14 4	890.89	4 ⁺			
		3518.8	28 6	0.0	3 ⁺	E1+M2	-0.19 3	δ : From 1976Ma23.
3706.7	6 ⁺	2176.5 10	39 9	1528.1	5 ⁺	M1(+E2)	+6 3	E_γ, δ : E_γ from 1975Sp02; $A_2=+0.65$ 15, $A_4=+0.92$ 21 (1975Sp02), mixing ratio from +5.7 +20-38 (1977Ha11); Other values: +3.7 +12-34 (1975Sp02), <+18 or >-15 (1976Ma23). I_γ : Weighted average of 54 15 (1969Wa17) and 33 9 (1973Fr18).
		2815.8 3	100 ^a 9	890.89	4 ⁺	E2(+M3)	-0.0 1	E_γ, δ : From 1976Ma23.
3941.9		1990.0	7 1	1951.8	2 ⁺			
		3284.9 ^a 9	100 1	657.00	0 ⁺			
4071.4	4 ⁺	2088.2 5	100	1983.5	3 ⁺	M1(+E2)	0.00 7	E_γ, δ : From 1975Sp02, $A_2=-0.26$ 10, $A_4=+0.14$ 16 (1975Sp02).
4296.2		1724.7 ^a 2	100	2571.5	2 ⁻			
4360.0	2 ⁺	2408.1 3	100 5	1951.8	2 ⁺	M1(+E2)	+0.02 9	E_γ, δ : From 1976Ma23.
4468.7	(4 ⁻)	1897.2 ^a 3	100 [@] 6	2571.5	2 ⁻	(E2)		E_γ : Other: 1895.5 keV 6 (1975Sp02). Mult.: From 1975Sp02, $A_2=+0.56$ 26, $A_4=-0.11$ 31.
		2485.1	14 [@] 5	1983.5	3 ⁺			
		2940.4	21 [@] 5	1528.1	5 ⁺			
		3577.5	17 [@] 5	890.89	4 ⁺			
4523.9	(7 ⁺ , 5 ⁺)	2995.8 4		1528.1	5 ⁺	M1(+E2)		Mult.: From 1975Sp02, $A_2=+0.40$ 8, $A_4=-0.17$ 10.
4710.0	5 ⁺	638.6	83 6	4071.4	4 ⁺	M1(+E2)	-0.04 4	δ : From 1976Ma23.
		1741.3	10 2	2968.6	3 ⁺	E2		δ : -0.04 10 in 1976Ma23.
		2726.0 ^a 4	100 4	1983.5	3 ⁺	E2		δ : +0.06 6 in 1976Ma23.
5062.5	2 ⁺	3110.6 ^a 4	100	1951.8	2 ⁺	M1		δ : +0.04 8 in 1976Ma23.
5100.4	4 ⁺	1029.0	100 ^a 8	4071.4	4 ⁺	M1		δ : +0.00 9 in 1967Wa13.
		2039.1 ^a 3	49 ^a 5	3059.4	2 ⁺	E2		δ : +0.07 9 in 1967Wa13.
		3573.3 ^a 4	32 ^a 5	1528.1	5 ⁺			
		4209.1	40 ^a 13	890.89	4 ⁺	M1+E2	>1	
		5101.0 ^a 6	49 ^a 5	0.0	3 ⁺	M1+E2	>+8	

[†] From 1967Wa13, except as noted. γ rays without uncertainty are from level energy difference (recoil energy subtracted). γ -ray multipolarity from angular distribution and linear polarization (at 90°) measurements.

[‡] From 1982Ve05.

From 1975Sp02.

@ Branching in 1978En02.

& Weighted average of data from 1967Wa13 and 1976Ma23.

^a From 1976Ma23.

$^{19}\text{F}(\alpha,n)(\alpha,n\gamma)$ **1967Wa13,1976Ma23,1982Vc05**Level Scheme

Intensities: Relative photon branching from each level

