^{90}Zr(d,p) 1976Bl11,2013Sh02

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 114, 1293 (2013)	1-Sep-2013

Other measurements: 1974Za03, 1963Co10 (E=15 MeV), 2012ShZZ.

2013Sh02: E(d)=15 MeV from Yale WNSL tandem accelerator; >98% ^{90}Zr self-supporting target; Enge split-pole spectrometer with position-sensitive gas-filled ionization chamber at focal plane and plastic scin behind it; measured E(p) (FWHM ≈ 45 keV), $\sigma(\theta)$ (18 °, 34 °, 42 °): deduced E(level), L-transfer, spectroscopic factors (C^{2}S); DWBA analysis. See 2012ShZZ for additional details of results from this experiment.

2012ShZZ: Submission to XUNDL database by authors of 2013Sh02,

1976Bl11: E=15.89 MeV. 97.65% enriched target. Magnetic spectrometer, semi, FWHM=7 keV *9* 9 keV. θ=5° to 100° in 5° steps.

1972Gr12: E=7.5 MeV. 98.6% enriched target; multi-gap spectrograph; measured $\sigma(\theta)$, θ(lab)≈10°−170°; DWBA analysis.

1970Bi03: E=33.3 MeV; θ(lab)≈12.5° to≈45°; broad-range spectrograph with photographic emulsions preceded by Al absorber (3° acceptance angle); 25 keV resolution; DWBA analysis.

Theory (incomplete list): 1987Ro20.

Centroids of single-particle strength are At E=1534 *4*, 2646 *4* and 126 *4* for L=0, L=2 (J=3/2) and L=2 (J=5/2), respectively 2013Sh02.

Cross sections (dσ/dΩ mb/sr) at 15 MeV (2012ShZZ).
(Uncertainties quoted for cross sections are purely statistical.
There exists an additional systematic uncertainty of ≈7%.)
Some of these data were reported by 2013Sh02 also.

Level	7°	18°	34°	42°
0	2.881 *48*	9.354 *57*	1.898 *10*	1.050 *11*
1212 *1*	16.95 *12*	0.857 *17*	2.632 *12*	1.326 *9*
1476 *2*	0.122 *13*	0.197 *9*	0.057 *2*	0.050 *2*
1877 *5*	0.027 *8*	0.033 *6*	0.080 *3*	0.055 *2*
2048 *1*	2.565 *46*	5.286 *43*	1.244 *8*	1.311 *9*
2131 *5*	0.047 *12*	0.047 *8*	0.049 *3*	0.056 *3*
2171 *2*	0.191 *21*	0.220 *16*	0.445 *8*	0.484 *8*
2203 *2*	0.284 *23*	0.319 *17*	0.616 *9*	0.429 *8*
2333 *5*	0.038 *11*	0.023 *6*	0.061 *3*	0.064 *3*
2354 *4*	0.031 *6*	0.020 *2*	0.008 *2*	
2559 *2*	4.826 *63*	0.450 *14*	0.941 *7*	0.588 *6*
2625 *3*	0.072 *12*	0.023 *5*	0.017 *2*	0.010 *1*
2690 *3*	0.060 *11*	0.038 *6*	0.017 *2*	0.013 *2*
2813 *2*	0.208 *15*	0.297 *11*	0.155 *3*	0.092 *3*
2875 *1*	0.338 *18*	0.577 *15*	0.245 *4*	0.146 *3*
2928 *8*	0.017 *8*	0.051 *6*	0.015 *2*	
3087 *1*	0.705 *26*	1.261 *22*	0.337 *5*	0.341 *5*
3291 *1*	0.886 *30*	1.625 *29*	0.446 *6*	0.418 *6*
3330 *2*	0.180 *18*	0.103 *12*	0.055 *3*	0.044 *4*
3475 *1*	0.407 *21*	0.522 *16*	0.553 *7*	0.462 *6*
3558 *3*	0.085 *13*	0.100 *31*	0.075 *23*	
3631 *3*	0.078 *16*	0.082 *10*	0.028 *3*	
3682 *1*	0.721 *35*	1.132 *23*	0.408 *6*	
3751 *3*	0.104 *16*	0.246 *13*	0.059 *3*	
3850 *1*	0.263 *21*	0.484 *15*	0.218 *5*	0.124 *4*
3917 *3*	0.084 *17*	0.208 *11*	0.224 *5*	0.175 *4*
3992 *2*	0.122 *10*	0.020 *16*	0.019 *4*	
4018 *11*	0.025 *14*	0.061 *14*	0.046 *3*	

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^{90}Zr(d,p) 1976Bl11,2013Sh02 (continued)

^{91}Zr Levels

E(level)[†]	L[‡]	S[#]	Comments
0	2	0.75[@]	C^2S=1.05 (2013Sh02).
1206 *4*	0	0.66	other E: 1212 (2013Sh02), 1204 (1972Gr12), 1201 (1970Bi03), 1210 (1963Co10). C^2S=0.83 (2013Sh02).
1471 *4*	2	0.028[@]	other E: 1476 (2013Sh02), 1468 (1972Gr12), 1459 (1970Bi03), 1480 (1963Co10). C^2S=0.018 (2013Sh02).
1885 *4*	4	0.082	other E: 1877 (2013Sh02), 1883 (1972Gr12), 1871 (1970Bi03), 1890 (1963Co10). C^2S=0.078 (2013Sh02).
2044 *4*	2	0.56	other E: 2048 (2013Sh02), 2040 (1972Gr12), 2031 (1970Bi03), 2060 (1963Co10). C^2S=0.63 (2013Sh02).
2132 *4*			other E: 2131 (2013Sh02), 2127 (1972Gr12), 2133 In table 6 of 1976Bl11. weakly-populated with inconclusive $\sigma(\theta)$ In (d,p) and absent In (α,^{3}He), so 2013Sh02 suggest that level May Be populated via an indirect process.
2171 *4*	5	0.28	other E: 2171 (2013Sh02), 2167 (1972Gr12), 2157 (1970Bi03). C^2S=0.40 (2013Sh02).
2201 *4*	4	0.44	other E: 2203 (2013Sh02), 2195 (1972Gr12), 2186 (1970Bi03), 2210 (1963Co10). C^2S=0.34 (2013Sh02).
2259 *4*			
2322 *4*	5	0.040	other E: 2333 (2013Sh02), 2321 (1972Gr12), 2309 (1970Bi03). C^2S=0.048 (2013Sh02).
2359 *4*	1		other E: 2354 (2013Sh02), 2353 (1972Gr12), 2350 (1963Co10). L: from 2013Sh02; C^2S=0.004, 0.002.
2368 *4*			
2535 *6*	(2)	0.04	
2557 *6*	0	0.22	other E: 2559 (2013Sh02), 2554 (1972Gr12), 2541 (1970Bi03), 2580 (1963Co10). C^2S=0.24 (2013Sh02).
2577 *6*			
2642 *6*	1	0.009	other E: 2625 (2013Sh02), 2640 (1972Gr12). C^2S=0.006, 0.003 (2013Sh02). S: 0.004 if J^π=3/2$^-$.
2695 *6*	(1)		other E: 2690 (2013Sh02), 2693 (1972Gr12), 2681 (1970Bi03). L: 1 from 2013Sh02 but (3) from 1976Bl11, (2) from 1972Gr12. C^2S=0.005, 0.003 (2013Sh02).
2776 *6*	(3)		
2812 *6*	(2)	0.10	other E: 2813 (2013Sh02), 2807 (1972Gr12), 2792 (1970Bi03). L: 2 from 2013Sh02 and 1972Gr12 but L=3 from 1976Bl11. C^2S=0.11 (2013Sh02) if J^π=3/2$^+$.
2833 *6*			
2874 *6*	2	0.06	other E: 2875 (2013Sh02), 2869 (1972Gr12), 2853 (1970Bi03). 2880 (1963Co10). C^2S=0.21 (2013Sh02).
2905 *6*			other E: 2902 (1970Bi03).
2934 *6*	2		other E: 2928 *8* (2013Sh02), 2926 (1972Gr12). L: from 2013Sh02; L=(3) from 1972Gr12. C^2S=0.018 (2013Sh02) if J^π=3/2$^+$.
3008 *6*	3	0.009	other E: 2992 (1970Bi03), 3007 (1972Gr12). S: 0.005 if J^π=7/2$^-$.
3034 *6*			
3053 *6*			
3085 *6*	2	0.12	other E: 3087(2013Sh02), 3081 (1972Gr12), 3068 (1970Bi03). C^2S=0.12 (2013Sh02).
3107 *6*			other E: 3110 (1963Co10).
3237 *6*			
3292 *6*	2	0.16	other E: 3291 (2013Sh02), 3284 (1972Gr12), 3270 (1970Bi03), other E: 3300 (1963Co10). C^2S=0.15 (2013Sh02).

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^{90}Zr(d,p) 1976Bl11,2013Sh02 (continued)

^{91}Zr Levels (continued)

E(level)†	L‡	S#	Comments
3334 *6*	0	0.010	other E: 3330 (2013Sh02), 3332 (1972Gr12). C^2S=0.010 (2013Sh02).
3459 *6*	5	0.025	
3470 *6*	4	0.30	other E: 3475 (2013Sh02), 3462 (1972Gr12), 3444 (1970Bi03). 3490 for multiplet (1963Co10).
3477 *6*	2	0.023	C^2S=0.28 (2013Sh02).
3556 *8*	4	0.09	other E: 3558 (2013Sh02), 3546 (1972Gr12), 3533 (1970Bi03). C^2S=0.072 (2013Sh02).
3636 *8*	2	0.010	other E: 3631 (2013Sh02), 3627 (1972Gr12), 3610 (1970Bi03). C^2S=0.007 (2013Sh02) if $J^\pi=3/2^+$.
3673 *8*			other E: 3661 (1970Bi03).
3683 *8*	2	0.11	other E: 3682 (2013Sh02), 3675 (1972Gr12). 3700, presumably for multiplet (1963Co10). C^2S=0.10 (2013Sh02).
3749 *8*	2	0.015	other E: 3751 (2013Sh02), 3739 (1972Gr12), 3721 (1970Bi03). C^2S=0.022 (2013Sh02) if $J^\pi=3/2^+$.
3774 *8*			
3818 *8*	(4)	0.023	
3850 *8*	2	0.046	other E: 3850 (2013Sh02), 3841 (1972Gr12), 3824 (1970Bi03). 3890 for multiplet with L=3 not adopted (1963Co10). C^2S=0.019 (2013Sh02).
3898 *8*	4	0.066	E=3917, L=4, C^2S=0.21 (2013Sh02); May be for a multiplet.
3908 *8*	5	0.062	other E: 3903 (1972Gr12), 3880 (1970Bi03). see comment on 3898 level.
3926 *8*	2	0.012	see comment on 3898 level.
3985 *8*	2	0.010	other E: 3992 (2013Sh02), 3977 (1972Gr12). C^2S=0.010 (2013Sh02) if $J^\pi=3/2^+$.
4006 *8*	4	0.040	other E: 4018 (2013Sh02). C^2S=0.036 (2013Sh02).
4038 *8*	(2)		
4067 *8*	5	0.013	
4112 *8*	4	0.034	other E: 4106 (1972Gr12). 4120 for multiplet (1963Co10). other L: 2 from 1972Gr12.
4145 *8*	(2)		
4165 *8*	2,3		other E: 4157 (1972Gr12).
4194 *8*	2,3		other E: 4178 (1972Gr12).
4262 *8*	(1)		other E: 4264 (1972Gr12). 4290 for L=(3) multiplet (1963Co10).
4272 *8*	4	0.046	
4327 *8*	1	0.013	other E: 4318 (1972Gr12). S: 0.006 if $J^\pi=3/2^-$.
4350 *8*	2	0.014	other E: 4343 (1972Gr12).
4383 *8*	4	0.016	
4401 *8*	2	0.006	other E: 4396 (1972Gr12).
4415 *8*	5	0.017	
4470 *8*	2	0.012	other E: 4465 (1972Gr12).
4511 *8*			other E: 4504 (1972Gr12).
4535 *8*	2	0.013	other E: 4528 (1972Gr12). 4520 for multiplet (1963Co10).
4582 *8*	2,3		other E: 4577 (1972Gr12). L: (1) from 1972Gr12.
4611 *8*			
4656 *8*	0,1		other E: 4644 (1972Gr12). L: 1 from 1972Gr12.
4679 *8*	0,1		other E: 4668 (1972Gr12). 4680 for multiplet (1963Co10). L: 1 from 1972Gr12.
4709 *8*			other E: 4699 (1972Gr12).
4735 *8*	(3)		other E: 4730 (1972Gr12). L: inconsistent with adopted J^π.
4780 *8*			

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^{90}Zr(d,p) 1976Bl11,2013Sh02 (continued)

^{91}Zr Levels (continued)

E(level)[†]	L[‡]	Comments
4808 *8*	(2)	other E: 4797 (1972Gr12). L: from 1972Gr12.
4833 *10*		other E: 4850 for L=3 multiplet (1963Co10).
4876 *10*		
4928 *10*		
4953 *10*	(3)	
4989 *10*		
5017 *10*		
5095 *10*	(1)	other E: 4990 for L=(2) multiplet (1963Co10).
5132 *10*		other E: 5130 for L=3 multiplet (1963Co10).
5158 *10*		
5176 *10*		
5217 *10*	(2)	
5254 *10*		
5312 *10*	(2)	
5357 *10*		
5382 *10*		
5426 *10*		
5450 *10*		
5472 *10*		
5496 *10*		
5530 *10*		
5550 *10*		
5598 *10*		
5645 *10*		
5674 *10*		
5716 *10*		
5744 *10*		
5781 *10*		
5804 *10*		
5843 *10*		
5877 *10*		
5894 *10*		
5933 *10*		
5954 *10*		
6003 *10*		
6027 *10*		
6081 *10*		
6103 *10*		
6156 *10*		
6179 *10*		
6210 *10*		
6262 *10*		
6297 *10*		
6352 *10*		
6390 *10*		
6431 *10*		
6457 *10*		

[†] From table 4 of 1976Bl11 for E<4810 keV. 1976Bl11 estimate ΔE=4 keV for the lower and ΔE=8 keV for the higher excited levels. Individual uncertainties have been assigned by the evaluator. Data from 1972Gr12 are typically lower by 1-10 keV. Above 4810 keV, data are from 1972Gr12, except as noted. Uncertainties from 2012ShZZ are given here In the table of cross sections; these are usually lower than the estimated uncertainty of ≈5 keV reported by 2013Sh02 and it seems possible that uncertainties given by 2012ShZZ are purely statistical and the ≈5 keV stated In 2013Sh02 is a systematic uncertainty.

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^{90}Zr(d,p) 1976Bl11,2013Sh02 (continued)

^{91}Zr Levels (continued)

‡ From DWBA (1976Bl11), except As noted; typically, these values agree well with those deduced by 2013Sh02. See 1976Bl11 for results of coupled-channel calculations. Above 4810, data are from 1972Gr12.

Spectroscopic factor S from DWBA (1976Bl11) assuming J=L−1/2. Values deduced assuming J=L+1/2 are given in comments when appropriate. 1972Gr12 give an independent set of S values. C^2S values from 2013Sh02 are given In comments.

@ If J=5/2.