

<sup>90</sup>Zr(p,p),(p,p'),(p,p'γ) IAR 1968Li11

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

Others: 1966Mo02, 1967FiZX, 1968Th07, 1969Gr25, 1969Jo20, 1969Wi15, 1970Li07, 1971Kr21, 1971Ri11, 1973Gr08, 1974Gr33, 1977Fe12, 1996KiZT.  
 S(p)=5154 3 (2012Wa38).  
 (p,p): 1968Li11 (E(p)=6.1-9.5 MeV), 1968Th07 (E(p)≈5.7-6.9 MeV), 1969Sc22, 1971Ri11 (E(p)=5.1-6.1 MeV).  
 (p,p'): 1968Li11, 1969Jo20, 1970Li07.  
 (p,p'γ): 1968Li11.  
 (p,polarized p): 1966Mo02 (E(p)=6.6-7.1 MeV), 1967FiZX (E(p)=6.65-6.95 MeV), 1996KiZT (E(p)=5.80-6.05 MeV).  
 (pol p,p): 1969Wi15 (E(p)=6.4-8.85 MeV), 1971Kr21 (E(p)≈4.55-4.9 MeV), 1973Gr08 (E(p)≈4.7-5.1 MeV).  
 (pol p,p'): 1969Gr25 (E(p)=8.25-8.7 MeV, 6 angles, σ(θ), A(θ)), 1977Fe12 (E(p)=6-8 MeV, σ(θ), A(θ)).  
 (pol P,P'γ): 1974Gr33 (E(p)≈7.65 MeV).

<sup>91</sup>Nb Levels

Theoretical studies: 1972Co21, 1972Sp02, 1974Al20, 1977Fe12.

E(level) <sup>†</sup>	J <sup>π</sup>	T <sub>1/2</sub> <sup>‡</sup>	Comments
S(p)+4664 6	5/2 <sup>+</sup>	24 keV 2	E(level): unweighted average of S(p)+4655 (1973Gr08), S(p)+4675 (1971Kr21), S(p)+4662 (1969Sc22). T <sub>1/2</sub> from 1973Gr08. Other Γ: 22 keV 3 (1969Sc22), 17 keV (1971Kr21). Γ <sub>p0</sub> =4.0 5 keV (1969Sc22), 3.1 keV (1971Kr21), 3.8 5 keV (1973Gr08). J <sup>π</sup> : from σ(θ,E) and A(θ,E) (1973Gr08). Analog of <sup>91</sup> Zr g.s.
S(p)+5850 <sup>#</sup> 4	1/2 <sup>+</sup>	83 keV 4	J <sup>π</sup> : from (p,p) (1968Th07). T <sub>1/2</sub> : average of 88 4 keV (1968Th07) and 77 4 keV (1971Ri11). 1971Ri11 also studied the fine structure of this resonance (E(p)=5814-6053; θ(lab)=90°, 125°, 165°; 700-eV steps). Γ <sub>p</sub> =33 2 keV (1971Ri11), 44 3 keV (1968Th07). Analog of 1205 level in <sup>91</sup> Zr.
S(p)+6150 5	5/2 <sup>+</sup>	5.6 keV 10	E(level),T <sub>1/2</sub> : from (p,p') (1970Li07); supersedes data from 1968Li11. J <sup>π</sup> : deduced from proton σ(θ) (1968Li11). Γ <sub>p1</sub> =1.0 5 keV (1970Li07). Analog of 1466 level in <sup>91</sup> Zr.
S(p)+6389 10			Weak resonance in elastic channel only; no level is known in <sup>91</sup> Zr for which this could be the analog.
S(p)+6576 5			Analog of 7/2 <sup>+</sup> 1882 level in <sup>91</sup> Zr.
S(p)+6714 3	3/2 <sup>+</sup>	42 keV 3	E(level): one discrepant datum (S(p)+6676 7) from 1968Li11 omitted from average. Other E: S(p)+6712 5 (1968Th07), S(p)+6710 (1966Mo02), S(p)+6735 (1969Wi15 and 1977Fe12). J <sup>π</sup> : from σ(θ,E) and polarization (1966Mo02,1969Wi15). T <sub>1/2</sub> : from 1968Th07. Others: Γ=54 keV (1966Mo02), Γ=54 2 keV (1968Li11), 60 keV (1969Wi15), 53 keV (1977Fe12). Γ <sub>p</sub> =18 keV (1966Mo02), 16 2 keV (1968Th07). Γ <sub>p0</sub> =18 keV (1969Wi15). Analog of 3/2 <sup>+</sup> 2042 level in <sup>91</sup> Zr.
S(p)+6799 7			Analog of (9/2) <sup>+</sup> 2131 level in <sup>91</sup> Zr.
S(p)+6877 5		28 keV 2	E(level): S(p)+6880 10 (1969Jo20). Analog of 7/2 <sup>+</sup> 2201 level in <sup>91</sup> Zr.
S(p)+6925 5			Other E: 6920 10 (1969Jo20). Energy consistent with analog of (13/2) <sup>-</sup> 2260 level in <sup>91</sup> Zr.
S(p)+7050 5			Other E: 7050 10 (1969Jo20).
S(p)+7207 3	1/2 <sup>+</sup>	63 keV 5	Possible analog of 2367 level in <sup>91</sup> Zr. J <sup>π</sup> : deduced from proton σ(θ) (1968Li11). Γ <sub>p0</sub> =17 3 keV, Γ <sub>p1</sub> =26 7 keV (1968Li11).

Continued on next page (footnotes at end of table)

$^{90}\text{Zr}(\text{p,p}),(\text{p,p}'),(\text{p,p}'\gamma)$  IAR **1968Li11** (continued) $^{91}\text{Nb}$  Levels (continued)

E(level) <sup>†</sup>	J <sup>π</sup>	T <sub>1/2</sub> <sup>‡</sup>	Comments
S(p)+7279 7			Analog of 1/2 <sup>+</sup> 2558 level in $^{91}\text{Zr}$ . Other E: S(p)+7260 10 (1969Jo20).
S(p)+7330 10			Possible analog of (3/2) <sup>-</sup> 2580 level in $^{91}\text{Zr}$ . E(level): from 1969Jo20.
S(p)+7440 5			Possible analog of (3/2) <sup>-</sup> 2640 level in $^{91}\text{Zr}$ . Other E: S(p)+7460 10 (1969Jo20).
S(p)+7503 5			Possible analog of (5/2) <sup>-</sup> 2775 level in $^{91}\text{Zr}$ . Datum from (p,p <sub>3</sub> ) channel in (1968Li11); S(p)+7530 from (p,p <sub>1</sub> ) channel is rejected because resonance is not visible in σ(θ,E). Other E: S(p)+7490 10 (1969Jo20).
S(p)+7557 4	3/2 <sup>+</sup>	40 keV 5	Analog of 3/2 <sup>+</sup> ,5/2 <sup>+</sup> 2826 level in $^{91}\text{Zr}$ . J <sup>π</sup> : from polarization data of 1969Wi15. Other E: S(p)+7586 (1969Wi15), S(p)+7576 (1977Fe12). Other Γ: 20 keV (1969Wi15), 36 keV (1977Fe12). Γ <sub>p0</sub> =2 keV (1969Wi15). Analog of 3/2 <sup>+</sup> 2871 level in $^{91}\text{Zr}$ .
S(p)+7645 5			E(level): from 1969Jo20.
S(p)+7680 10			
S(p)+7748 4	3/2 <sup>+</sup>	47 keV 2	Other E: S(p)+7764 (1969Wi15), S(p)+7774 (1977Fe12). Other Γ: 35 keV (1969Wi15), 48 keV (1977Fe12). J <sup>π</sup> : from proton σ(θ,E) and polarization (1969Wi15). Γ <sub>p0</sub> =8 keV (1969Wi15).
S(p)+7967 6	3/2 <sup>+</sup>	30 keV	Analog of 3/2 <sup>+</sup> 3083 level in $^{91}\text{Zr}$ . J <sup>π</sup> : from proton σ(θ,E) (1969Wi15). T <sub>1/2</sub> : from 1969Wi15. Other Γ: 56.5 keV (1968Li11) at E=S(p)+7988. E(level): from table vi of 1968Li11; E=S(p)+7988 from table V. Other E: S(p)+8001 (1969Wi15). Γ <sub>p0</sub> =6 keV (1969Wi15). Analog of 3/2 <sup>+</sup> 3290 level in $^{91}\text{Zr}$ .
S(p)+8116 5			
S(p)+8151 5		28 keV 2	
S(p)+8348 4	3/2 <sup>+</sup>	48 keV 5	E(level): one discrepant datum (S(p)+8216 10) (1968Li11) omitted from average. Other E: S(p)+8377 (1969Wi15), S(p)+8362 (1969Gr25). J <sup>π</sup> : from proton σ(θ,E) (1969Wi15). Other Γ: 67 keV 8 (1968Li11), 25 keV (1969Wi15), 50 keV (1969Gr25). Γ <sub>p0</sub> =5 keV (1969Wi15). Analog of 3/2 <sup>+</sup> 3681 level in $^{91}\text{Zr}$ .
S(p)+8476 10			
S(p)+8687 7			
S(p)+8798 7			
S(p)+8972 4			
S(p)+9152 7			
S(p)+9215 10			

<sup>†</sup> E(res) in c.m. system; S(p)=5154 3 (2012Wa38). If not indicated otherwise, data are from 1968Li11; weighted averages are shown for resonances which were observed for more than one final state. Additionally, all resonance energies from 1968Li11 have been reduced by 60 keV based on the note in 1970Li07 that a recalibration of the accelerator common to both studies resulted in a 60 keV energy shift; this calibration error may also explain why resonance energies for the (p,p' $\gamma$ ) study in fig. 10 of 1968Li11 are 60 keV lower than values indicated elsewhere in 1968Li11. Uncertainties for the 1968Li11 data should be considered as statistical only, especially so since the precise nature of the calibration error is not known. Except for data from 1968Th07 and 1971Ri11, it is assumed that authors' resonance energies have been corrected for beam energy loss in the target.

<sup>‡</sup> From 1968Li11, except as noted.

<sup>#</sup> Weighted average of S(p)+5844 5 (1968Th07, 18 keV target thickness) and S(p)+5852 3 (1971Ri11); the latter was calculated by the evaluator from E(p)(lab)=5925 at resonance, assuming energy scale had not been corrected for beam energy loss in the 15

---

${}^{90}\text{Zr}(\text{p,p}),(\text{p,p}'),(\text{p,p}'\gamma)$  IAR [1968Li11](#) (continued)

${}^{91}\text{Nb}$  Levels (continued)

keV thick target (an earlier study by different authors from the same laboratory ([1968Th07](#)) quotes  $E(\text{p})(\text{lab})$  without correction for energy loss in target).