Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen and Balraj Singh	NDS 199,1 (2025)	30-Sep-2024

Q(β^-)=13460 *7*; S(n)=2280 *4*; S(p)=20970 *40*; Q(α)=-1.586×10^4 *15* 2021Wa16

S(2n)=8058 *4*, S(2p)=40800 *270*, Q(β^-n)=7991 *8* (2021Wa16). Q(β^-2n)=3772 *4*, deduced by the evaluators from relevant masses in 2021Wa16.

Identification: 1984Gu19: In(p,X) E=10 GeV, measured γ, isotopic half-life.

Mass measurements: 2019As04, 2013Ch49, 2006Lu09, 2006Ga04, 1991Zh24, 1991Or01, 1987Gi05.

Other measurements:

2006Kh08: Cross section measurement in Si(^{33}Mg,X) E(^{33}Mg)=30-65 MeV/nucleon, deduced reduced strong absorption radius=1.260 fm^2 *19*. ^{33}Mg beam was obtained from fragmentation of ^{48}Ca beam with ^{181}Ta target at GANIL facility.

Nearly pure 2p-2h configuration deduced from g-factor, evidence for this nucleus being in the middle of the "island of inversion".

2007Yo06: ^{33}Mg and ^{31}Mg produced by bombarding a uranium-carbide target with 1.4 GeV proton beam at ISOLDE-CERN facility followed by laser ionization to select Mg isotopes The radioactive beam of Mg ions was accelerated to 40 keV, sent through a mass analyzer and then to a collinear laser spectroscopy arrangement for the measurement of spin and magnetic moment by laser spectrometry and nuclear magnetic resonance. Measurements are made relative to ^{31}Mg.

2010Ka05: C(^{33}Mg,^{32}Mg) E=898 MeV/nucleon at GSI. Measured the longitudinal-momentum distribution of one-neutron removal from ^{33}Mg in ground state and the one-neutron removal cross-section, 74 mb *4*.

2010Yo08: ^{33}Mg produced at ISOLDE-CERN by 1.4 GeV protons impinging on a thick uranium-carbide target. Measured hyperfine structure and nuclear gyromagnetic ratio by combining laser spectroscopy with nuclear magnetic resonance.

2010Yo01, 2010Tr03: comments on 2008Tr07 for ground state parity of ^{33}Mg.

2011Ne14: review and evaluation of available experimental work on ^{33}Mg.

2015Mo17: ^{9}Be(^{40}Ar,X) E=95 MeV/nucleon at RIKEN. Measured transverse momentum distributions.

Structure calculations:

2021In02: calculated deformation parameter.

2020Mi15, 2014Wa14: calculated ground-state energy, S(2n).

2016Ba59, 2013Sh05: calculated binding energy, charge radius, deformation parameters.

2015Pu01, 2014Ca21, 2011Ki12, 2011Ne14: calculated low-lying levels, J^π.

1994Po05: calculated levels, binding energies.

Additional information 1.

^{33}Mg Levels

Cross Reference (XREF) Flags

A	^{33}Na β^- decay (8.1 ms)	E	^{9}Be(^{36}Si,^{33}Mgγ)
B	^{34}Na β^-n decay (5.0 ms)	F	^{9}Be(^{46}Ar,^{33}Mgγ)
C	^{1}H(^{33}Mg,^{33}Mg$'\gamma$),(^{34}Mg,^{33}Mg$'\gamma$)	G	Coulomb excitation
D	^{9}Be(^{34}Mg,^{33}Mgγ),(^{34}Al,^{33}Mgγ)		

E(level)[†]	J^π	$T_{1/2}$	XREF	Comments
0.0[#]	3/2$^-$	90.3 ms *10*	ABCDEFG	%β^-=100; %β^-n=15 *2*; %β^-2n=? μ=-0.7455 *5* (2007Yo06,2019StZV) Q=+0.13 *9* (2019Yo06,2021StZZ) Theoretical $T_{1/2}$=167.6 ms, %β^-n=38, %β^-2n=0 (2019Mo01). Theoretical $T_{1/2}$=30.6 ms, %β^-n=4.68, 6.23; %β^-2n=0.49, 0.60 (2021Mi17, two values for different fission barriers). J^π: spin from hyperfine and NMR measurements of 2007Yo06. Parity is from measured negative β-asymmetry in NMR experiment (2010Yo08). Negative parity is also supported by the comparison of experimental magnetic moment of -0.7456 *5* (2007Yo06) and theoretical prediction of -0.88 for 3/2$^-$ member of 1/2[330] configuration with β_2=0.25, -0.39 for 3/2[321] configuration and +0.91 for

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Adopted Levels, Gammas (continued)

^{33}Mg Levels (continued)

E(level)†	Jπ	XREF	Comments
			3/2[202] (2010Ha07). Negative parity is suggested in reaction-spectroscopy work on the ground state of ^{33}Mg by 2010Ka05 who measured the longitudinal-momentum distribution from the one-neutron removal. The observed narrow distribution clearly supports significant occupancy in low angular momentum orbitals and could be explained with a large spectroscopic strength for the $2p_{3/2}$ orbital which thereby confirms that the island of inversion is well pronounced beyond N=20. However log *ft*=5.2 to $(5/2)^+$ g.s. in ^{33}Al seems at variance with negative parity. 2008Tr07 proposed $(3/2^+)$ from β-decay of ^{33}Mg and the allowed β transition to $(5/2)^+$ g.s. in ^{33}Al. The 1p-1h and 3p-3h mixed configuration for g.s. of ^{33}Mg proposed by 2008Tr07 is consistent with all experimental evidence, including the negative magnetic moment from 2007Yo06. Low log *ft* for first-forbidden value may be due to ^{33}Mg nuclide being near N=20 closed shell. Earlier assignments were proposed as $(3/2)^+$ from ^{33}Na decay (2001Nu02) and $(5/2^+)$ from Coulomb excitation measurements (2002Pr09). $7/2^-$ was assumed in shell-model calculations by 2002Mo29. From analysis of Coulomb dissociation experiment at intermediate incident energy in ^{12}C(^{33}Mg,^{32}Mg) reaction, 2016Da06 proposed combined multi-quasiparticle configuration for the g.s. of ^{33}Mg: ^{32}Mg(3.0 MeV,2^-; 3.5 MeV,1^-)$\otimes\nu s_{1/2}$ + ^{32}Mg(0,0^+)$\otimes\nu p_{3/2}$ + ^{32}Mg(2.5 MeV,2^+)$\otimes\nu p_{3/2}$. Evaluators note, however, that J^π assignments for the 2.5-, 3.0- and 3.5-MeV states in ^{32}Mg are not firm. $T_{1/2}$: weighted average of 93.9 ms *18* (2017Ha23), 89 ms *1* (2008Tr07), 93 ms *11* (2006AnZW), 90.5 ms *16* (2002Mo29), and 90 ms *20* (1984La03). Other: 63 ms *25* (1995ReZZ,2008ReZZ). %β^-n: weighted average of 14 *2* (2006AnZW), 25 *13* (1995ReZZ,2008ReZZ), and 17 *5* (1984La03,1984Gu19). Others: 19 *2* estimated from absolute intensities of 8 *1* and 11 *2* for 735γ and 2765γ to g.s., respectively, in ^{32}Al from ^{33}Mg β^-n decay as measured by 2008Tr07; and 5.2% *4* feeding of g.s. of ^{32}Al by direct β^-n feeding from ^{33}Mg as reported in 2006AnZW. μ: from g factor=−0.4971 *4* (2007Yo06), hyperfine structure and NMR measurements. Q: from β-asymmetry detected hyperfine structure measurement (2019Yo06). Matter radius (rms)=3.19 fm *3* (2011Ka01), deduced from the measured interaction cross section in C(^{33}Mg,X) and H(^{33}Mg,X) reactions at 900 MeV/nucleon with a $(CH_2)_n$ target, and using Glauber model analysis with Fermi densities. The ^{33}Mg secondary beam obtained from ^{9}Be(^{48}Ca,X) primary reaction. Experiment used fragment separator (FRS) at GSI.
484.1# *1*	$(5/2^-)$	A CDEFG	J^π: proposed by 2017Ri06 based on band assignments; from Coulomb excitation data, 2002Pr09 proposed that the 484γ was probably E2 and thus this level should have the same parity as the g.s., which also supported $(5/2^-)$ assignment. Others: 2001Nu02 in ^{33}Na β^- decay proposed $(3/2^-)$ on the basis of shell-model calculations; 2021Ba28 in ^{9}Be(^{34}Mg,^{33}Mgγ), however, proposed $(3/2^+,5/2^+)$ based on a tentative L=(2).
546.2 *1*	$(3/2^-)$	A C	XREF: C(561). This level is defined by the evaluators based on the revised placement of 546γ. See detailed comments at 546γ. J^π: 546γ-gated momentum distribution in (^{34}Mg,^{33}Mgγ) suggests $2p_{3/2}$ orbital for the removed neutron. Other: $(1/2)^+$ proposed by 2011Ne14 based on comparison of their proposed level scheme with theoretical calculations.
705.0 *1*	$(3/2,5/2^+)$	A D F	J^π: 21.0γ to $(5/2^-)$; 2001Nu02 proposed $(5/2^+)$ and 2011Ne14 proposed $(3/2^+)$, based on theoretical calculations. 2021Ba28 proposed $(3/2)^-$ based on assigned L=1 from measured momentum distribution in (^{34}Mg,^{33}Mg), but it is also stated that both p-wave (L=1) and d-wave (L=2) components are present, with L=2 attributed by 2021Ba28 most likely to the cross contamination from the 779-keV d-wave component, which the evaluators consider is a rather weak argument to rule out L=2 and adopt only L=1 for this level. The evaluators consider, as also stated in 2021Ba28, the shape is ambiguous with L=(1,2).
780# *6*	$(7/2^-)$	D F	J^π: proposed by 2017Ri06 based on band assignment. This assignment is supported by non-observation of any transition from this level in ^{33}Na β^- decay from the $(3/2^+)$ parent, which would require an unlikely 2nd-forbidden unique decay to this level. However, L=2

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Adopted Levels, Gammas (continued)

^{33}Mg Levels (continued)

E(level)†	J^{π}	XREF	Comments
			from 297γ-gated and 779γ-gated momentum distributions in (^{34}Mg,^{33}Mg) by 2021Ba28 suggesting $3/2^{+}$,$5/2^{+}$ is in disagreement. This level is strongly populated in both (^{46}Ar,^{33}Mgγ) (2017Ri06) and (^{34}Mg,^{33}Mg) (2021Ba28) but not seen in any other study. Further investigation is needed to resolve this discrepancy.
1242.4 *1*	($1/2^{-}$,$3/2^{-}$)	A DE	XREF: D(1258). J^{π}: 758.2γ to ($5/2^{-}$), 1242.8γ to $3/2^{-}$; (1/2,$3/2^{-}$) from measured momentum distribution in (^{34}Mg,^{33}Mgγ), with L=(0,1). Others: 2001Nu02 proposed ($1/2^{+}$) and 2011Ne14 proposed ($7/2^{-}$) based on theoretical calculations.
1850 *40*	(1/2,$3/2^{-}$)	D	J^{π}: from measured momentum distribution in (^{34}Mg,^{33}Mgγ), with L=(0,1).
3780‡		A	
4000‡		A	

† From a least-squares fit to γ-ray energies for levels connected with γ transitions.

‡ Decays to ^{32}Mg by neutron emission.

\# Band(A): Rotational band built on ν3/2[321]. Band assignment from 2017Ri06; see detailed comments in ^{9}Be(^{46}Ar,^{33}Mgγ).

γ(^{33}Mg)

E_i(level)	J^{π}_i	E_γ†	I_γ†	E_f	J^{π}_f	Mult.	Comments
484.1	($5/2^{-}$)	484.1 *1*	100	0.0	$3/2^{-}$	[E2]	E_γ: others: 483.6 *10* from (^{33}Mg,^{33}Mg′γ), 484 *6* from (^{34}Mg,^{33}Mgγ), 483 *4* from (^{46}Ar,^{33}Mgγ), and 485 *1* from Coulomb excitation.
546.2	($3/2^{-}$)	546.2 *1*	100	0.0	$3/2^{-}$		E_γ: other: 561 *17* from (^{33}Mg,^{33}Mg′γ). 2001Nu02 in ^{33}Na β^{-} decay considered different scenarios for the placement of 546γ and proposed placement from 705 level to a 159 level as the probable one, which is also adopted by 2021Ba28 in ^{9}Be(^{34}Mg,^{33}Mgγ) without further supporting evidence. However, this γ could also define a level of this energy, a possibility which 2001Nu02 considered less likely based on rather weak arguments. 2006El03 observed a 561 *17* γ in ^{1}H(^{34}Mg,^{33}Mgγ), which they suggested was most likely the same as 546.2γ in decay work, but no 704.9γ was seen in that study, which may imply that 546.2γ and 704.9γ de-excite different levels. Moreover, the non-observation of this 546γ and observations of 220γ and 703γ from 703 level by 2017Ri06 in ^{9}Be(^{46}Ar,^{33}Mgγ), and the observations of all those three transitions by 2021Ba28 with 546γ much stronger than 705γ further support that 546γ and 703γ deexcite different levels. Therefore a level at 546.2 keV has been defined and adopted by the evaluators for the placement of 546γ. A review of available experimental work by 2011Ne14 also suggests this placement.
705.0	(3/2,$5/2^{+}$)	221.0 *1*	40 *6*	484.1	($5/2^{-}$)		E_γ: others: 219 *8* from (^{34}Mg,^{33}Mgγ) and 220 *4* from (^{46}Ar,^{33}Mgγ). I_γ: weighted average of 38 *4* from ^{33}Na β^{-} decay and 62 *15* from (^{46}Ar,^{33}Mgγ).
		704.9 *1*	100 *9*	0.0	$3/2^{-}$		E_γ: others: 703 *8* from (^{34}Mg,^{33}Mgγ) and 703 *4* from (^{46}Ar,^{33}Mgγ). I_γ: others: 100 *29* from (^{34}Mg,^{33}Mgγ) and 100 *31* from (^{46}Ar,^{33}Mgγ).

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Adopted Levels, Gammas (continued)

$\gamma(^{33}Mg)$ (continued)

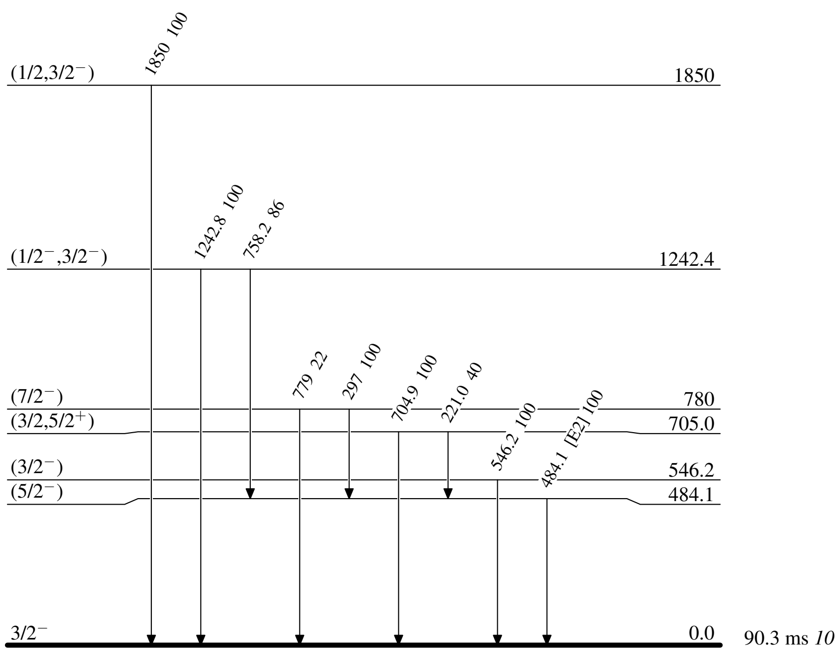
E_i(level)	J^π_i	E_γ†	I_γ†	E_f	J^π_f	Comments
780	(7/2⁻)	297 *4*	100 *5*	484.1	(5/2⁻)	E_γ: from (^{46}Ar,^{33}Mgγ). Other: 295 *7* from (^{34}Mg,^{33}Mgγ). I_γ: from (^{34}Mg,^{33}Mgγ). Other: 100 *27* from (^{46}Ar,^{33}Mgγ).
		779 *4*	22 *5*	0.0	3/2⁻	E_γ: from (^{46}Ar,^{33}Mgγ). Other: 779 *12* from (^{34}Mg,^{33}Mgγ). I_γ: weighted average of 21 *5* from (^{34}Mg,^{33}Mgγ) and 25 *8* from (^{46}Ar,^{33}Mgγ).
1242.4	(1/2⁻,3/2⁻)	758.2 *1*	86 *10*	484.1	(5/2⁻)	
		1242.8 *2*	100 *27*	0.0	3/2⁻	E_γ: other: 1258 *15* from (^{34}Mg,^{33}Mgγ).
1850	(1/2,3/2⁻)	1850 *40*	100	0.0	3/2⁻	E_γ,I_γ: from (^{34}Mg,^{33}Mgγ).

† From ^{33}Na β^- decay, unless otherwise noted.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



$^{33}_{12}Mg_{21}$

Adopted Levels, Gammas