Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen	NDS 178, 41 (2021).	12-Nov-2021

Q(β^-)=11981 *6*; S(n)=4173 *5*; S(p)=14100 *70*; Q(α)=-1.233×10^4 *18* 2021Wa16
Q(β^-n)=4575 *6*, S(2n)=10608 *7*, S(2p)=32350 *260* (2021Wa16).

1985Gu14: ^{64}Mn formed in fragmentation of ^{86}Kr beam at 33 MeV/nucleon with Ti and Ta targets, identification by time-of-flight method using ΔE-E detectors at GANIL.

1994Se12 and 1990Tu01: Th(p,F) E=800 MeV reaction followed by time-of-flight detection of fission fragments to identify ^{64}Mn and measured its mass using Time-of-Flight Isochronous (TOFI) spectrometer at the Los Alamos Meson Physics Facility (LAMPF).

1998Am04: ^{64}Mn formed in fragmentation of ^{86}Kr beam, fragment mass separator. Measured $T_{1/2}$ at GSI.

1998Gr14: ^{64}Mn formed in fragmentation of ^{86}Kr beam at 60.3 MeV/nucleon with Ni target. Measured Eγ, Iγ, γ(t), (fragment)γ coin, $T_{1/2}$ at GANIL.

2002MaZN (thesis): ^{64}Mn obtained from fragmentation of ^{86}Kr beam at 57.8 MeV/nucleon with a ^{9}Be target, LISE2000 spectrometer at GANIL facility. Measured half-life from timing of β measurement.

2011Da08: ^{64}Mn produced in the fragmentation of 57.8 MeV/nucleon ^{86}Kr beam impinged on 50 mg/cm^2 thick tantalum target using LISE-2000 spectrometer at GANIL facility. Detector system included a three-element Si-detector telescope containing a double-sided silicon-strip detector (DSSSD) backed by a Si(Li) detector and surrounded by four clover type EXOGAM Ge detectors. Product identified by mass, atomic number, charge, energy loss and time of flight. Measured half-life.

2012Na15: measured precise mass excess using RILIS facility and ISOLTRAP mass spectrometer at CERN facility.

2015He28: measurement of spin, static magnetic dipole moment and electric quadrupole moment of the g.s. ^{64}Mn beam produced in U(p,X) reaction at E(p)=1.4 GeV at CERN-ISOLDE facility using a RILIS ion source. Measured hyperfine structure using collinear laser spectroscopy (COLLAPS) technique. Deduced hyperfine constants for 3d^{5}4s^2 6S$_{5/2}$ -> 3d^{5}4s4p 6P$_{3/2}$ ground state atomic transition with wave number=35689.980 cm^{-1}, spin, magnetic dipole moment and electric quadrupole moment of the ground state of ^{64}Mn. The magnetic dipole moment of ^{55}Mn, μ=+3.46871790 *9* was used as a standard reference for the other Mn isotopes. (Note: 2015He28 quote μ=+3.4687179 *9* for ^{55}Mn in their Table I). Comparison with large-scale shell-model calculations using GXPF1A and LNPS effective interactions, and with previous experimental results. The spin and moments for the (4$^+$) isomer in ^{64}Mn could not be measured in 2015He28 because of its short half-life of 0.44 ms.

2016He14: E=1.4 GeV proton beam was produced from the ISOLDE facility at CERN. Target was a thick uranium carbide. Recoiling ions were ionized using the resonance ionization laser ion source (RILIS), mass-separated, cooled and bunched in the gas-filled RFQ ISCOOL, re-accelerated and guided to the laser spectroscopy beam line COLLAPS. Measured hyperfine spectra using collinear laser spectroscopy on atomic and ionic transitions, respectively. Deduced changes in mean-square charge radii relative to ^{55}Mn. Comparisons with theoretical calculations. Systematics of neighboring nuclei.

Theory references for structure and other topics: four primary references in the NSR database at www.nndc.bnl.gov.

Additional information 1.

^{64}Mn Levels

Cross Reference (XREF) Flags

A ^{64}Cr β^- decay (42.9 ms)
B ^{64}Mn IT decay (440 ms)

E(level)†	J$^\pi$	$T_{1/2}$	XREF	Comments
0.0	1$^{(+)}$	90 ms *4*	AB	%β^-=100; %β^-n=2.7 *6* (2012Pa39) μ=+2.085 *3* (2015He28,2019StZV) Q=+0.21 *11* (2015He28,2021StZZ) δ<r^2>(^{55}Mn,^{64}Mn)=+0.873 fm^2 *14*(stat) *76*(syst); isotopic shift $\delta\nu$(^{55}Mn,^{64}Mn)=+2566 MHz *6*(stat) *35*(syst) (2016He14, also 2015He10 and 2017Ne04; hyperfine spectra for atomic transitions using collinear laser spectroscopy). %β^-n=2.7 *6* in 2012Pa39, determined from the absolute intensity of the 995-keV γ ray (from ^{63}Fe β^- decay) as 43% *8* and the total number of ^{64}Mn decays. Other: 33% *2*

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{64}Mn Levels (continued)

E(level)†	J^π	$T_{1/2}$	XREF	Comments
				(2000HaZL, from β and n measurements). J^π: spin from hyperfine structure, collinear laser spectroscopy (2015He28), parity from possible allowed β feeding from 0^+ parent. $T_{1/2}$: weighted average of 90 ms *9* (2011Da08, also 2002MaZN, fitting of the implant-β correlated decay curve, including background rate, and half-lives of mother, daughter and grand-daughter activities, at GANIL); 91 ms *4* (2005GaZR, β-fragment correlation, at GANIL); 89 ms *4* (1999Ha05, β-fragment correlation at ISOLDE-CERN, also 2000HaZL). Others: 85 ms *5* (1999So20, β-fragment correlations, also 1999Le67, earlier conference reports from GANIL); 140 ms *30* (1998Am04, β-implant correlated decay curve at GSI, earlier value was 170 ms *20* in 1995AmZY). The value from 1998Am04 agrees within 1.5σ, but is much less precise, and it does not affect the adopted half-life. μ,Q: from hyperfine structure using collinear laser spectroscopy technique (2015He28, see also 2015He10 and 2017Ne04).
40.2 *3*	(2^-)		B	J^π: see comment for 175 level.
175.5 *4*	(4^+)	440 ms *49*	B	%IT=100 J^π: (M2)-(E1) cascade to $1^{(+)}$. $T_{1/2}$: weighted average of 400 μs *40* (2011Li50, decay curves for γ rays); 0.50 ms *5* (2005GaZR, γ(t)). Other: >100 μs (1998Gr14).
186.4 *3*	(2^+)		A	J^π: γ to 0^+; γ from (1^+); no β^- feeding from 0^+ parent.
1148.7 *4*	(1^+)		A	J^π: possible allowed β feeding from 0^+.

† From Eγ data.

$\gamma(^{64}Mn)$

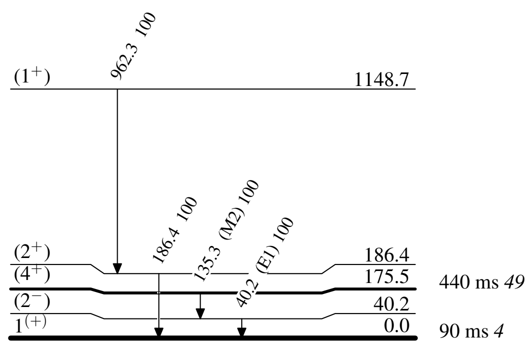
E_i(level)	J_i^π	E_γ	I_γ	E_f	J_f^π	Mult.†	α‡	Comments
40.2	(2^-)	40.2 *3*	100	0.0	$1^{(+)}$	(E1)	0.6 *4*	E_γ: from ^{64}Mn IT decay.
175.5	(4^+)	135.3 *3*	100	40.2	(2^-)	(M2)	0.11 *3*	B(M2)(W.u.)=8.8×10^{-5} *+11−9* E_γ: from ^{64}Mn IT decay.
186.4	(2^+)	186.4 *3*	100	0.0	$1^{(+)}$			E_γ: from ^{64}Cr β^- decay.
1148.7	(1^+)	962.3 *2*	100	186.4	(2^+)			E_γ: from ^{64}Cr β^- decay.

† From ce data and intensity balance in ^{64}Mn IT decay.
‡ 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.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



$^{64}_{25}Mn_{39}$