Adopted Levels, Gammas

S(n)=22420 *50*; S(p)=2741 *11*; Q(α)=−8934 *21* 2017Wa10

The β^+ decay of ^{20}Mg populates ^{20}Na*(984) for 69.7 % *12* of the decays (1995Pi03). The remaining 30.3% of decays populate ^{20}Na levels that proton decay to states in ^{19}Ne.

The A=20 T=2 mass multiplet is analyzed via the IMME in (1974Ce05, 1974Ro17, 1976Mi01, 1976Tr03, 1979Mo02, 1981Ay01, 1984An18, 2007Ga38, 2012Fo13, 2014Ga20).

For theoretical analysis of the level properties see:

Shell Model: 1980Wi18, 1987Po01, 1990Br26, 1997Ot01, 1999Si13, 2012Po15, 2014To04, 2014Yu02, 2015La10, 2016Ba59. 2017Dr03;

Hartree-Fock-Bogoliubov: 1996Gr21, 1997Te19, 2000St04, 2001La06, 2008Sc02, 2012Li11, 2014Ga13;

Cluster model: 1996Ch04, 1998De43, 1999Sh32, 2002Gu10, 2005Ma98, 2006Ma17, 2007Ma54;

Mean Field: 1996Re03, 1996Re10, 1997Ot01, 1997Pa38, 1998La02, 2003Bh06, 2003Jh01, 2005Ch71, 2006Sa29, 2008Sc02, 2011Ro50;

Other: 1978Gu10, 1984Ha14, 2001Pi11, 2002Mi14, 2002Ro32, 2002Sc48, 2006Zh19, 2007Wa30, 2010Zh45, 2011Eb04, 2011Gu03, 2011Ya01, 2013Bh09, 2013Eb02, 2013Ho01, 2013Sc14, 2015Si12, 2015Wu07, 2016Fo20, 2016Ja03, 2016Ro17, 2018Fo04.

^{20}Mg Levels

Cross Reference (XREF) Flags

A	^{2}H(^{20}Mg,d)	F	^{12}C(^{20}Mg,^{20}Mg)	K	Ni(^{20}Ne,^{20}Mg)
B	^{3}He(^{20}Ne,^{20}Mg)	G	^{20}Ne(^{3}He,3n)	L	Ni(^{24}Mg,^{20}Mg)
C	^{9}Be(^{22}Mg,^{20}Mgγ)	H	^{24}Mg(α,^{8}He)	M	Ni(^{36}Ar,^{20}Mg)
D	^{9}Be(^{24}Mg,^{20}Mg)	I	^{27}Al(^{20}Ne,^{20}Mg)	N	^{208}Pb(^{20}Mg,^{20}Mg′)
E	^{9}Be(^{28}Si,^{20}Mg)	J	Si(p,^{20}Mg)		

E(level)	J$^\pi$	T$_{1/2}$	XREF	Comments
0	0$^+$	90.4 ms *7*	ABCDEFGHIJKLMN	%β^+p=30.3 *12* (1995Pi03) T$_{1/2}$: From weighted average of the following values. T$_{1/2}$=85 ms *15* (1964Fl03) from Ni(^{20}Mg,^{20}Mg), T$_{1/2}$=95 ms *+80−50* (1979Mo02,1981Ay01) from ^{20}Ne(^{3}He,3n), T$_{1/2}$=82 ms *4* (1992Go10) from Ni(^{36}Ar,^{20}Mg), T$_{1/2}$=114 ms *17* (1992Ku24) from ^{9}Be(^{24}Mg,^{20}Mg), T$_{1/2}$=95 ms *3* (1995Pi03) from Ni(^{24}Mg,^{20}Mg), T$_{1/2}$=91.4 ms *10* (2016Lu13) from Si(p,^{20}Mg), and. T$_{1/2}$=90.0 ms *6* (2017Su05) from ^{9}Be(^{28}Si,^{20}Mg). T$_{1/2}$: The results of 1964Fl03, 1979Mo02 and 1992Ku24 are found to have little impact on the average.
1598 *10*	2$^+$		A C N	T=2 J$^\pi$: From ^{20}Mg angular distribution in ^{208}Pb(^{20}Mg,^{20}Mg′).
3.70×10^3 *20*	(2$^+$,4$^+$)	0.47 MeV *6*	A	E(level): From E$_x$=3.70$^{+2}_{-20}$ MeV. J$^\pi$: From Shell Model expectations of J$^\pi$=4$^+_1$ and 2$^+_2$ states in this region.
5.37×10^3 *2*			A	

Adopted Levels, Gammas (continued)

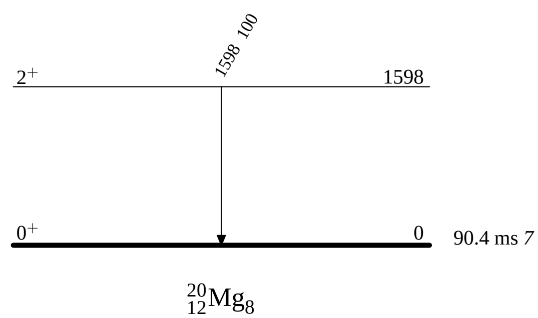
$\gamma(^{20}Mg)$

E_i(level)	J^π_i	E_γ	I_γ	E_f	J^π_f
1598	2^+	1598 *10*	100	0	0^+

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



^{2}H(^{20}Mg,d) 2019Ra06

2019Ra06: XUNDL dataset compiled by TUNL, 2019.

Radioactive ^{20}Mg ions were produced in the bombardment of a SiC target by 480 MeV protons at TRIUMF; the ^{20}Mg nucleons were collected and reaccelerated to 8.5 MeV/nucleon using the ISAC-II Linac before finally impinging on a windowless solid deuterium target that was formed on a 4.5 μm thick cryogrenically cooled silver target.

The incident ^{20}Mg ions were identified using an ionization chamber positioned upstream of the target, while scattered deutrons and residual beam ions were detected using position sensitive annular ΔE-E arrays that covered θ=30.1°−56.2° and θ=1.9°−6.1°, respectively. The ^{20}Mg excitation energies were deduced from kinematic analysis of the scattered deutrons. The observed spectrum was corrected for reaction yields associated with the Au backing target and with breakup into the four-body ^{18}Ne+p+p+d phase space.

Evidence for four states is observed, including previously unreported groups at E_x≈3.7 MeV and 5.37 MeV. The angular distribution of ^{20}Mg(1.65 MeV) confirms $J^\pi=2^+$ and indicates the quadrupole deformation parameter β_n=0.46 *21*. The analysis of the 3.7 MeV group is centered on discussion related to predicted $J^\pi=4^+_1$ and 2^+_2 states that are expected near this region. The angular distribution is not consistent with L=2 or L=4, which may suggest this group represents a $J^\pi=2^+_2+4^+_1$ doublet. The angular distribution of the E_x≈5.37 MeV group is not analyzed.

^{20}Mg Levels

E(level)	J^π	Γ (MeV)	Comments
0	0^+		
1.65×10^3 *10*	2^+		E(level): From $E_x=1.65^{+2}_{-10}$ MeV. β_n=0.46 *21* (2019Ra06).
3.70×10^3 *20*	(2^+,4^+)	0.47 MeV *6*	E(level): From $E_x=3.70^{+2}_{-20}$ MeV. J^π: From Shell Model expectations of $J^\pi=4^+_1$ and 2^+_2 states in this region.
5.37×10^3 *2*			

^{3}He(^{20}Ne,^{20}Mg) **2012Wa15**

The authors measured protons from ^{20}Mg β-delayed proton decay with the aim of adding understanding to the known ^{20}Na*(2647) resonance and its participation in the astrophysically important ^{19}Ne(p,γ) reaction.

A beam of ^{20}Mg ions, produced by ^{3}He(^{20}Ne,^{20}Mg) reactions at the Texas A&M MARS facility, was implanted at the mid-thickness of a 45 μm segmented Si strip detector (24×24 strips). The detector was sandwiched between two thicker Si detectors. Events within the strip detector were rejected if either of the thicker detectors was correlated in time. Hence the array was sensitive to the low-energy light particles from decay in the strip detector.

The emphasis of the measurement was a search for evidence of ^{20}Na*(2647) decay to ^{19}Ne$_{g.s.}$ with E_p=434 keV, as a result the full dataset is not analyzed.

^{20}Mg Levels

E(level)
0

^{9}Be(^{22}Mg,^{20}Mgγ) 2007Ga38

2007Ga38: Two-neutron removal from ^{22}Mg was studied.

A beam of ^{22}Mg, produced by fragmenting a ^{36}Ar beam on a thick ^{9}Be target, impinged in a 188 mg/cm^2 ^{9}Be foil at the S800 target position. The ^{20}Mg reaction products were detected in the focal plane of the spectrometer, while associated gamma-rays were detected using sixteen segmented HPGe detectors from the SeGa array that were positioned either at 37° or 90° with respect to the incident beam.

An Eγ= 1598 *10* transition was observed, which is associated with the first 2$^+$ state in ^{20}Mg. The Isobaric Mass Multiplet Equation (IMME) is discussed for the A=20 T=2 and Jpi=0$^+$ and 2$^+$ states.

^{20}Mg Levels

E(level)	J^π	Comments
0	0$^+$	
1598 *10*	2$^+$	T=2 E(level): mirror state of first 2$^+$ state at 1674 in ^{20}O.

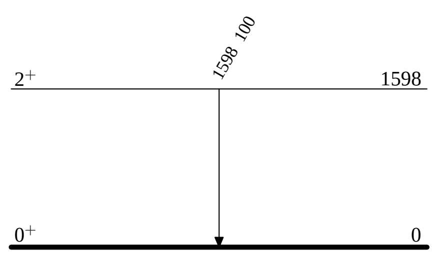
γ(^{20}Mg)

E_i(level)	J_i^π	E_γ	I_γ	E_f	J_f^π
1598	2$^+$	1598 *10*	100	0	0$^+$

^{9}Be(^{22}Mg,^{20}Mgγ) 2007Ga38

Level Scheme

Intensities: % photon branching from each level



$^{20}_{12}Mg_8$

^{9}Be(^{24}Mg,^{20}Mg) 1992Ku07,1992Ku24

1992Ku07,1992Ku24: States in ^{20}Na were studied by analyzing the β^+ decay of ^{20}Mg. A beam of ^{20}Mg ions was produced by fragmenting a 100 MeV/nucleon ^{24}Mg beam in a thick Be target. The ^{20}Mg beam was magnetically purified and stopped in the center of a stack of Si detectors. Each time a ^{20}Mg implantation was detected the beam was stopped for a 200 ms period so the decay could be measured.

Decay to various ^{20}Na states was observed with a lifetime $T_{1/2}$=114 ms *17*. 85% of detected events were connected with ^{20}Na decay, which implies %β^+p=15%.

2015Gl03: A beam of ^{20}Mg ions was produced by fragmenting a 170 MeV/nucleon ^{24}Mg beam on a ^{9}Be target at the A1900/NSCL fragment separator. In this study, the mass of the lowest T=2 state of ^{20}Na was measured in the Jπ=0^+ to 0^+ superallowed β decay of ^{20}Mg. The beam was implanted in a 25 mm thick plastic scintillator that was surrounded by 16 elements of the SeGA germanium detector array. The β-γ coincident events were analyzed. Their results validate the IMME without the need for additional terms.

2017Wr02: XUNDL dataset compiled by TUNL, 2017.

A beam of ^{20}Mg ions was produced by fragmenting a ^{24}Mg beam on a ^{9}Be target using the NSCL/A1900 fragment separator. The beam was implanted ≈10 mm deep into a 25 mm thick plastic scintillator that was surrounded by the SeGA germanium array. The SeGA was configured with two coaxial rings of eight γ-ray detectors. The β-γ coincidences were analyzed. Using the $\Gamma_{\gamma0}/\Gamma$=(80 *15*)% branching ratio, the β-p feeding of (0.0156 *38*)% was deduced for populating ^{19}Ne(4034); the ^{20}Na levels feeding ^{19}Ne*(4034) are not determined.

Finally, the authors suggest a new experimental configutation that would measure β-p-α coincidences and would have a sensitivity for improving on the $\Gamma_\alpha/\Gamma \leq 5\times10^{-5}$ limit with a 10% accuracy.

2018Gl01: XUNDL dataset compiled by TUNL, 2018.

A cocktail beam including a ^{20}Mg ion component, produced at the MSU/A1900 fragment separator, was implanted into a 26.7 mm thick plastic scintillator that was surrounded by the SeGA array, which was configured as two rings of eight HPGe detectors. The β-γ coincidence events were analyzed with an exclusive focus on primary transitions from ^{20}Na*(2647).

^{20}Mg Levels

E(level)	$T_{1/2}$	Comments
0	114 ms *17*	$T_{1/2}$: From (1992Ku07).

^{9}Be(^{28}Si,^{20}Mg) 2016Li45,2017Su05

2016LI45,2017SU05: XUNDL dataset compiled by TUNL, 2017.

A beam of ≈0.59 ^{20}Mg/s was produced by fragmenting a 75 MeV/A ^{28}Si beam on a 1.5 mm thick ^{9}Be target at the Heavy Ion Research Facility of Lanzhou. The beam was magnetically purified before being implanted into a telescope of position sensitive Si detectors that measured the decay energies. A set of five clover segmented HPGe surrounded the telescope to detect the β-delayed γ-ray emissions.

The analysis was limited to events within the first 450 ms after implantation of a ^{20}Mg ion. About 10 peaks in the decay energy spectrum were easily attributed to β-delayed proton groups. The decay paths and branching ratios were interpreted using p+γ coincidences for γ-rays from ^{19}Ne*(238,275,1508,1536). The ^{20}Mg half-life, T=90.0 ms *6*, was deduced from analysis of the two strongest delayed proton groups E_p=(768,1589) keV.

^{20}Mg Levels

E(level)	$T_{1/2}$	Comments
0	90.0 ms *6*	$T_{1/2}$: From (2017Su05).

$^{12}C(^{20}Mg,^{20}Mg)$ **1996Ch24,1998Su07**

1996Ch24,1997Su04,1998Su07: The ineraction cross section of A=20 nuclides on a ^{12}C target was measured at E≈950 MeV/nucleon. The beams were produced by fragmenting 1050 MeV/nucleon ^{36}Ar and ^{40}Ar beams on thick ^{nat}Be targets. The interaction cross sections were determined by measuring the transmission of beam particles through the GSI/FRS fragment separator with a reaction target placed at the F2 midstage of the device.

A Glauber model analysis of the ^{20}Mg σ_{int}=1150 mb *16* cross section suggests $R^{matter}_{r.m.s.}$=2.88 fm *4* or 2.91 fm *5*, depending on the theoretical assumptions (1998Su07). The charge changing cross sections to Na, Ne, F, O, N and C isotopes are found as σ=5 mb *8*, 123 mb *9*, 29 mb *9*, 127 mb *7*, 46 mb *5* and 146 mb *7*, respectively (1996Ch24). The overall analysis suggests $R^{matter}_{r.m.s.}$=2.90 fm *6* with a thin proton skin with thickness=0.50 fm *28*.

See theoretical analysis in (1997Ki22,1997Kn04,1997Su04,2001Oz04,2011Al11, 2017Ah08,2019Ra09).

^{20}Mg Levels

E(level)	Comments
0	A Glauber model analysis of interaction cross sections for 950 MeV/nucleon A=20 isotopes suggests ^{20}Mg has a $R^{matter}_{r.m.s.}$=2.90 fm *6* and a thin proton skin with thickness=0.50 fm *28*.

^{20}Ne(^{3}He,3n) 1979Mo02,1981Ay01

1979Mo02,1980MOZM,1981Ay01: Decay of the ^{20}Mg nucleus was studied by producing ^{20}Mg nuclei using the the ^{20}Ne(^{3}He,3n) reaction. Decay from ^{20}Mg to ^{20}Na*(6570), followed by proton decay to ^{19}Ne*(0, 238) was observed and used to determine the mass excess of the first T=2 member of the A=20 multiplet in ^{20}Na. The corresponding β^{+} delayed proton groups were found to have energies of E_p=4.16 MeV *5* and 3.95 MeV *6*. Coefficients of the IMME were analyzed.

The decay half-life $T_{1/2}$=95 ms *+80−50* was deduced.

^{20}Mg Levels

E(level)	$T_{1/2}$
0	95 ms *+80−50*

^{24}Mg(α,^{8}He) 1974Ro17

1974Ro17: The mass of ^{20}Mg was measured by characterizing the ^{24}Mg(α,^{8}He) reaction at E(α)=156 MeV. The ^{8}He ejectiles were momentum analyzed using a low dispersion double focusing magnetic analyzer consisting of a dipole followed by a quadrupole doublet. At θ_{lab}=2° ^{8}He corresponding to ^{20}Mg production were observed with $\sigma\approx$7 nb/sr. The mass excess deduced was 17.74 MeV *21*, with most uncertainty attributed to target thickness and other systematic issues. An IMME comparison of the A=20 T=2 (isospin) multiplet is given. Measurements providing improved ^{8}He mass values, such as (1974Ce05), had an impact on the ^{20}Mg mass and improved the IMME comparison.

1976Tr03: The mass of ^{20}Mg was measured at E(α)=126.9 MeV using an ENGE spectrometer a θ_{lab}=5°. The ^{8}He recoils were observed with $\sigma\approx$3 nb/sr. The mass excess 17.57 MeV *3* was deduced, and A=20 T=2 multiplet states are compared.

^{20}Mg Levels

E(level)
0

^{27}Al(^{20}Ne,^{20}Mg) 1964Ma44

1964MA44: Al, Ni and Cu targets were bombarded with E=80 to 200 MeV ^{20}Ne beams with the aim of producing ^{20}Na activity, via p-n exchange reactions. The decay radiations and associated lifetimes of the produced activities were measured and analyzed. In the case of ^{20}Ne of the ^{27}Al target, the apparent lifetimes the strongest ^{20}Na radiations was observed to be longer than expected; the author assumed that ^{20}Mg was being formed, which then decayed to ^{20}Na and caused the apparent increase in ^{20}Na lifetime. The lifetime $T_{1/2}$=620 ms *60* was deduced from the analysis. This compares very poorly with the present value of T≈90 ms.

A private communication with (1974Ro17) indicates the evidence for ^{20}Mg production was traced to a spurious instrumental effect.

^{20}Mg Levels

E(level)	$T_{1/2}$
0?	620 ms *60*

Si(p,^{20}Mg) 2014Ga20

2014Ga20: The mass of ^{20}Mg was measured using a Penning trap. Beams of ^{20,21}Mg ions were produced via 480 MeV proton spallation on a SiC target and separately transported to the TRIUMF/TITAN system. The cyclotron frequency was determined relative to a ^{23}Na reference. The mass excess of 17477.7 keV *18* was deduced, which compares relatively poorly with the value given in AME2012 (17559 keV *27*). In addition, the IMME parameters were discussed.

2016Lu13: XUNDL dataset compiled by TUNL, 2017.

A pulsed beam of 30 keV ^{20}Mg ions was produced at the CERN/ISOLDE facility using standard spallation techniques. The beam was magnetically purified, for mass separation, and implanted in a 24.5 μg/cm^2 carbon foil. The foil was surrounded by an array of four position sensitive ΔE-E Si detector telescopes that were placed at $\theta\approx\pm45°$ and $\pm135°$ in the horizontal plane. The 5 cm $\times$ 5 cm ΔE detectors each covered about 5.2% of 4π. A thick position sensitive E detector covered the region below the implantation foil while the target apparatus occupied the space above. In addition, a set of four clover segmented HPGe detectors were positioned downstream of the target, to measure decay γ rays.

The decay paths and branching intensities are determined from analysis of the p+γ coincidences for proton decays to ^{19}Ne*(0,235,275,1508,1536). The ^{20}Na energies are deduced using the measured γ ray and proton energies and the known S_p=2190.1 keV *11*. The ^{20}Mg half-life, T=91.4 ms *10*, was deduced from analysis of the delayed proton events.

^{20}Mg Levels

E(level)	$T_{1/2}$	Comments
0	91.4 ms *10*	The cyclotron frequency was determined relative to a ^{23}Na reference, and the mass excess of 17477.7 keV *18* was deduced. $T_{1/2}$: From (2016Lu13).

Ni(^{20}Ne,^{20}Mg) 1964Fl03

1964FL03: An E_p=5 MeV β^+ delayed proton emitter was observed following E(^{20}Ne)=140 MeV bombardment of a 10 μm ^{nat}Ni target. Analysis of the $T_{1/2}$=85 ms *15* lifetime suggested this could be the first observation of ^{20}Mg. The nuclei ^{17}Ne and ^{20,21}Mg were listed as potential candidates of nuclei that could produce such radiations; the observed lifetime is in good acreement with the presently accepted ^{20}Mg value.

^{20}Mg Levels

E(level)	$T_{1/2}$
0	85 ms *15*

Ni(^{24}Mg,^{20}Mg) 1995Pi03

1995Pi05: States in ^{20}Na were studied by analyzing the β^+ decay of ^{20}Mg. A beam of ^{20}Mg ions was produced by fragmenting a 95 MeV/nucleon ^{24}Mg beam in $^{nat.}$Ni target. The ^{20}Mg beam was purified in the LISE3 spectrometer and implanted near the middle of a 300 μm thick Si Strip detector. The strip detector was surrounded by two 500 μm segmented Si β-ray detectors and three 70% HPGe detectors. Hence the delayed proton energy in the implantation detector could be correlated with β particles and delayed γ-rays. The coincidence data were analyzed to deduce the decay branches. The %β^+p=30.3 % *12* was deduced.

The half-life of ^{20}Mg was determined by analyzing the rate of two delayed protons, E_p=802 and 1675 keV. $T_{1/2}$=95 ms *3* is deduced and compared with prior results; the measurement (1992Go10) is suggested as having systematic errors.

^{20}Mg Levels

E(level)	$T_{1/2}$	Comments
0	95 ms *3*	%β^+p=30.3 *12* (1995Pi03)

$Ni(^{36}Ar,^{20}Mg)$ 1992Go10

1992Go10: The decay of ^{20}Mg was measured in a study aimed at resolving details of the $^{20}Na^{*}(2645)$ state, which would decay by ≈450 keV proton emission. The ^{20}Mg ions were produced by fragmenting an 80 MeV/nucleon ^{36}Ar beam on a ^{nat}Ni target; the beam was then magnetically purified and implanted in a 50 μm Si detector that was part of a Si detector telescope constructed to be sensitive to low-energy β-delayed proton decays. Implantation of a ^{20}Mg ion in the telescope resulted in the beam being halted so the decay could be studied. By analyzing the rate of β-delayed α particles from the ^{20}Na daughter, one finds the β-delayed proton rate of (100-74(*7*))=26 % *7*, by comparing with the total number of implanted ^{20}Mg.

The ^{20}Mg lifetime was measured as $T_{1/2}$=82 ms *4*.

^{20}Mg Levels

E(level)	$T_{1/2}$
0	82 ms *4*

^{208}Pb(^{20}Mg,^{20}Mg′) 2008Iw04

2008Iw04: The Coulomb excitation of ^{20}Mg was studied. A beam of 58 MeV/nucleon ^{20}Mg ions, produced by fragmentation of a 135 MeV/nucleon ^{24}Mg beam on a Ni target, impinged on a 226 μg/cm^2 target. A set of PPACs determined the incident angle and event-by-event position on target, while the scattered ^{20}Mg ions were detected in an array of position sensitive ΔE-E Si strip detectors. An array of 68 NaI(Tl) scintillators surrounded the target.

A de-excitation γ-ray transition corresponding to E_γ=1.61 MeV *6* was observed in the Doppler corrected NaI energy spectrum. The angular distribution of associated ^{20}Mg scattered particles is consistent with l=2. There was no evidence of any other transitions populated in the inelastic scattering. The cross sections were measured on both Pb and ^{nat}C targets so the nuclear and Coulomb components could be analyzed.

^{20}Mg Levels

E(level)	J^π	L	σ (mb)	Comments
0	0^+			
1610 *60*	2^+	2	105 *10*	B(E2)↑=0.0177 *32* J^π: From $\sigma(\theta)$ distribution and DWBA analysis. β_2=0.44 *4*. Proton matrix element (M_p)=13.3 fm^2 *12*; M_p/M_n=2.51 *25*. σ (mb): The cross sections on Pb and ^{nat}C targets were measured as σ(Pb)=105 mb *10* and σ(^{nat}C)=20 mb *2*.

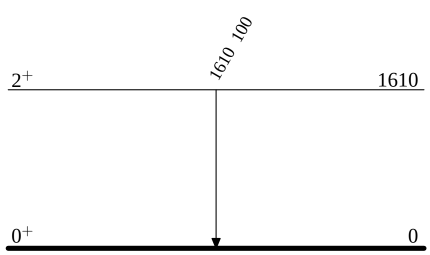
γ(^{20}Mg)

E_i(level)	J^π_i	E_γ	I_γ	E_f	J^π_f
1610	2^+	1610 *60*	100	0	0^+

^{208}Pb(^{20}Mg,^{20}Mg′) 2008Iw04

Level Scheme

Intensities: % photon branching from each level



$^{20}_{12}Mg_8$

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