Status of AME & NuBase

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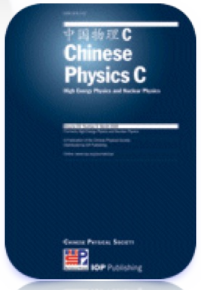
AME2020 & NUBASE2020 - March 2021

coordinated by M. Wang (AME) and F.G. Kondev (NuBase)



The NUBASE2020 evaluation of nuclear physics properties**

F.G. Kondev [1,*], M. Wang (王猛)[2,3,*], W.J. Huang (黄文嘉)[2,4,5,6], S. Naimi[7], G. Audi (欧乔治)[6]

IOP science

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The AME2020 atomic mass evaluation **

(I). Evaluation of input data, and adjustment procedures

W.J. Huang (黄文嘉)[1,2,3,4] Meng Wang (王猛)[1,5,*] F.G. Kondev[6] G. Audi (欧乔治)[3] S. Naimi[7]

The AME2020 atomic mass evaluation **

(II). Tables, graphs and references

Meng Wang (王猛)[1,2,*] W.J. Huang(黄文嘉)[1,3,4,5] F.G. Kondev[6] G. Audi (欧乔治)[5] S. Naimi[7]

Where to find the data

pdf & ascii: https://www.anl.gov/phy/atomic-mass-data-resources (ANL)
https://www-nds.iaea.org/amdc/ (IAEA)
http://amdc.impcas.ac.cn (IMP)

JAVA-AME
J. Chen

stand-alone & www

JANIS
NUBASE1997-2020
Nicolas Soppera

NUBASE2020
Marco Varpelli

Incorporated into LiveChart & standalone app

Table of Atomic Mass Evaluation

Atomic Mass Table
+NUBASE

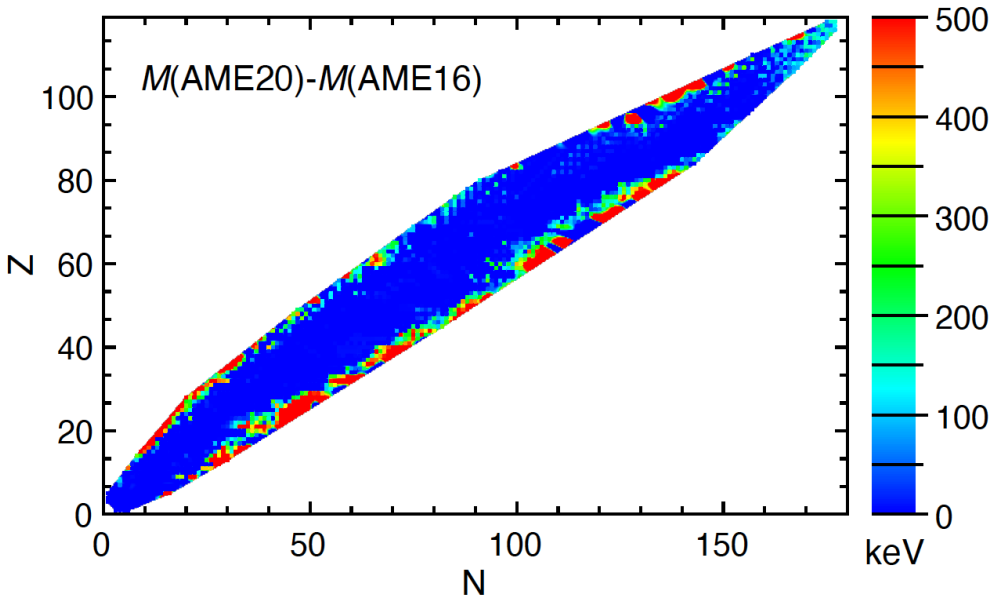
References ◉ AME2020 ○ AME2016 ○ AME2012

Nuclide ? 177lu Get ☑ rounded

177Lu71 (AME+NUBASE2020) --- rounded

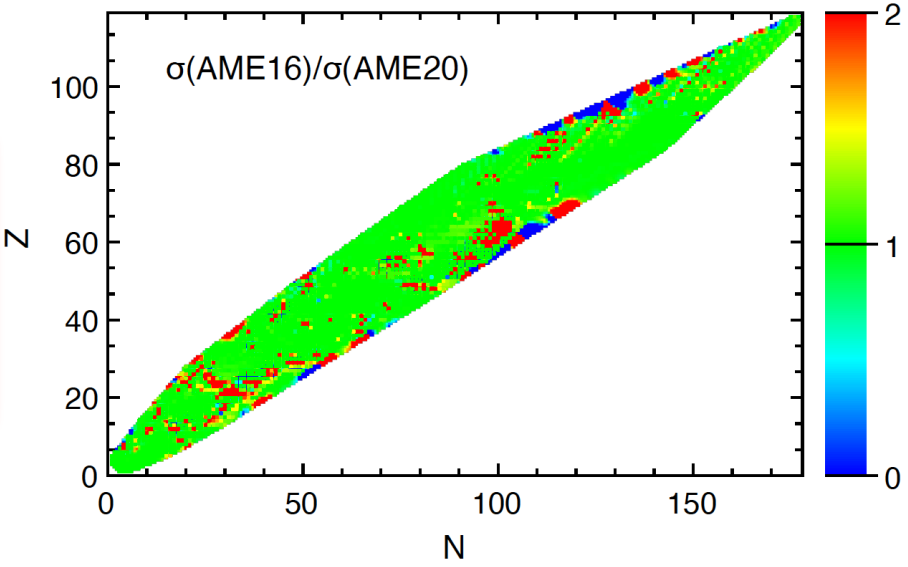
```
   Q(b-) = 496.8 +/- 0.8
   Q(ec) = -1397.5 +/- 1.2
 **Q(b+) = -2419.5 +/- 1.2 (see note)
    S(n) = 7072.89 +/- 0.16
    S(p) = 6181.6 +/- 1.2
    Q(a) = 1447 +/- 5
   S(2n) = 13360.86 +/- 0.22
   S(2p) = 14650 +/- 50
   Q(ep) = -10300 +/- 100
  Q(b-n) = -5878.8 +/- 0.9
  Q(2b) = -669 +/- 3
    mass = 176943763.6 +/- 1.3
                 (micro-u)
  B.E./A = 8053.450(check) +/- 0.007
M Excess = -52383.9 +/- 1.2
   Q(4b) = -6115 +/- 28
  Q(d,a) = 13022.5 +/- 1.2
  Q(p,a) = 9424.7 +/- 1.2
  Q(n,a) = 7130 +/- 40
  Energy = 0.0
     JPI = 7/2+*
   T1/2 = 6.6443 d 0.0009
DecayMode = B-=100

prev=177Yb    Q(b-)=1397.5 +/- 1.2
              Q(ec)=-3420# +/- 200#
next=177Hf    Q(b-)=-1166 +/- 3
              Q(ec)=-496.8 +/- 0.8


**:here Q(b+)=Q(ec)-2*510.999 keV
   Q(b+)=Q(ec) defined in AME and ENSDF
```

AME2020 vs AME2016



- **777** new experimental data
  - **477** mass spectrometry
  - **300** decay energies
- masses for **74** nuclei measured for the first time
- significant impact at the neutron- and proton-rich sides
- impact in the region of heavy nuclei

- improved mass uncertainties for **857** nuclides
- worsen mass uncertainty for **313** nuclei – mostly derived from TMS (extrapolation), but some are for measured masses – *e.g.* ^{167}Lu (30 vs 37 keV)



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The NUBASE2020 evaluation of nuclear physics properties**

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complete, up-to-date & reliable information about the basic NP properties

What is included in NuBase?

- masses & Ex for isomers ($T_{1/2}$>100 ns) and their method of deduction
- $T_{1/2}$, Jπ, decay modes and BR for both ground states (**3558**) and isomers (**1983**)
- properties of **205** Isobar Analog States (IAS)

^{162}Eu	−58722.9	1.3				∼10 s		1$^+$#	07 17Wu04	T	1987	β^-=100		
^{162}Eu^m	−58565.0	1.3	158.0	1.7	MD	15.0 s	0.5	(6$^+$)	07 18Ha19	TJ	2016	β^-=100		
^{162}Gd	−64281	4				8.4 m	0.2	0$^+$	07		1967	β^-=100		
^{162}Tb	−65879.5	2.0				7.60 m	0.15	(1$^-$)	16		1965	β^-=100		
^{162}Tb^m	−65594.0	2.5	286	3		10# m		4$^-$#	20Or03	EJ	2020	β^- ?; IT ?		
^{162}Dy	−68181.2	0.7				STABLE		0$^+$	07		1934	IS=25.475 36		
^{162}Dy^m	−65993.1	0.8	2188.1	0.3		8.3 μs	0.3	8$^+$	11Sw02	ETD	2011	IT=100		
^{162}Ho	−66041	3				15.0 m	1.0	1$^+$*	07		1957	β^+=100		
^{162}Ho^m	−65935	3	105.87	0.06		67.0 m	0.7	6$^-$*	07		1961	IT=62;β^+=38		
^{162}Er	−66334.2	0.8				STABLE	>140Ty	0$^+$	07 56Po16	T	1938	IS=0.139 5;α ?;2β^+ ?		*
^{162}Er^m	−64308.2	0.8	2026.01	0.13		88 ns	16	7(−)	07 12Sw01	TJ	1974	IT=100		
^{162}Tm	−61477	26				21.70 m	0.19	1$^-$*	07		1963	β^+=100		
^{162}Tm^m	−61350	50	130	40		24.3 s	1.7	5$^+$	07 74De47	EDJ	1974	IT=81 4;β^+=19 4		*
^{162}Yb	−59821	15				18.87 m	0.19	0$^+$	07		1963	β^+=100		
^{162}Lu	−52830	80			*	1.37 m	0.02	1$^-$*	07		1978	β^+=100		
^{162}Lu^m	−52710#	220#	120#	200#	*	1.5 m		4$^-$#	07		1980	β^+≈100;IT ?		
^{162}Lu^n	−52530#	220#	300#	200#	EU	1.9 m		9$^-$#	07		1980	β^+ ?;IT ?		*
^{162}Hf	−49168	9				39.4 s	0.9	0$^+$	07		1982	β^+=99.992 1;α=0.008 1		
^{162}Ta	−39780	60			*	3.57 s	0.12	3$^-$#	16		1985	β^+=99.926 10;α=0.074 10		
^{162}Ta^m	−39660#	80#	120#	50#	*	5# s		7$^+$#				β^+ ?;IT ?;α ?		
^{162}W	−33999	18				1.19 s	0.12	0$^+$	16		1973	β^+ ?;α=45.2 16		
^{162}Re	−22450#	200#				107 ms	13	(2)$^-$	07		1979	α=94 6;β^+ ?		
^{162}Re^m	−22280#	200#	175	9	AD	77 ms	9	(9)$^+$	07		1979	α=91 5;β^+ ?		
^{162}Os	−14500#	300#				2.1 ms	0.1	0$^+$	07		1989	α=100		
*^{162}Sm^m	T : other 17Pa25=1.7(0.2)													**
*^{162}Eu	T : 17Wu04=11.8(1.4) 87Gr12=10.6(1.0) but values include both gs and isomer													**
*^{162}Eu	J : from 18Ha19; conf p5/2[413]n7/2[633],K=1+													**
*^{162}Er	T : the lower limit is for α decay													**
*^{162}Tm^m	E : from 66.90+x keV; x<125 keV from 74De47													**
*^{162}Lu^n	I : existence is tentative and needs confirmation													**

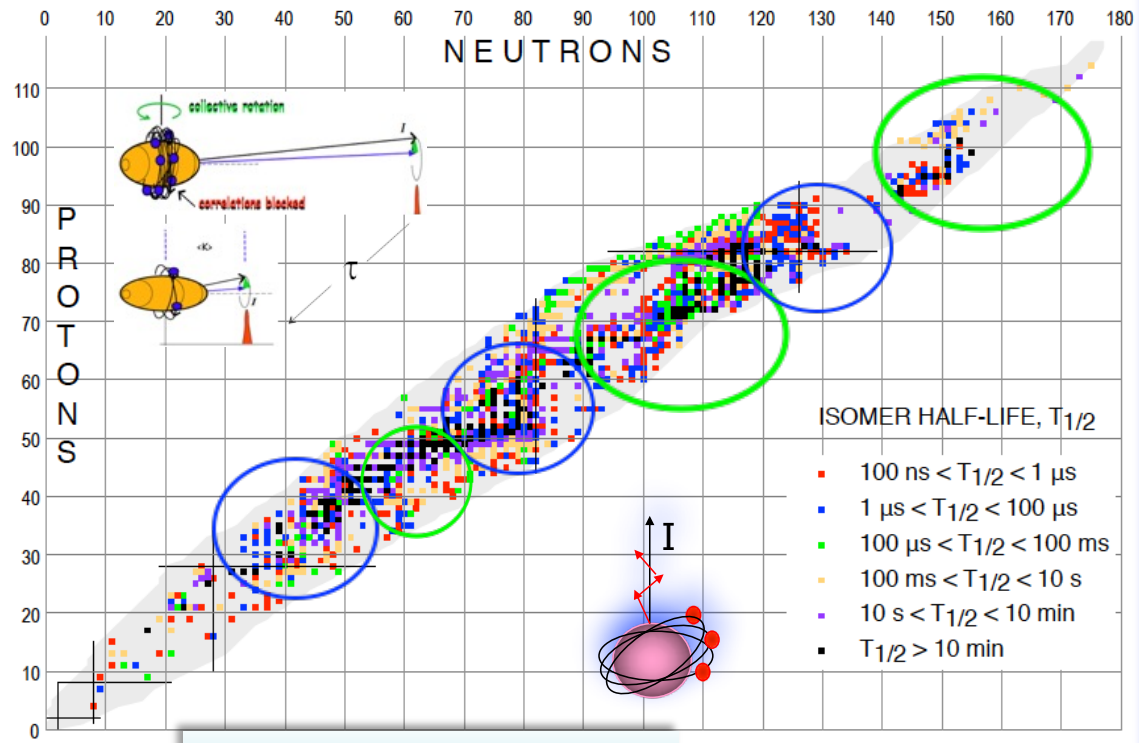
integral part of AME

- need to assign a mass measurement result to a specific nuclear state (ground or isomer)
- cases where the experimental Δm/m is insufficient to resolve ground state from isomers
- cases where excitation energy of the isomer is used to determine the ground state mass

NUBASE2020 - Isomers

Deformed nuclei
K-isomers (high-J)
Spin-traps Isomers (odd-odd)

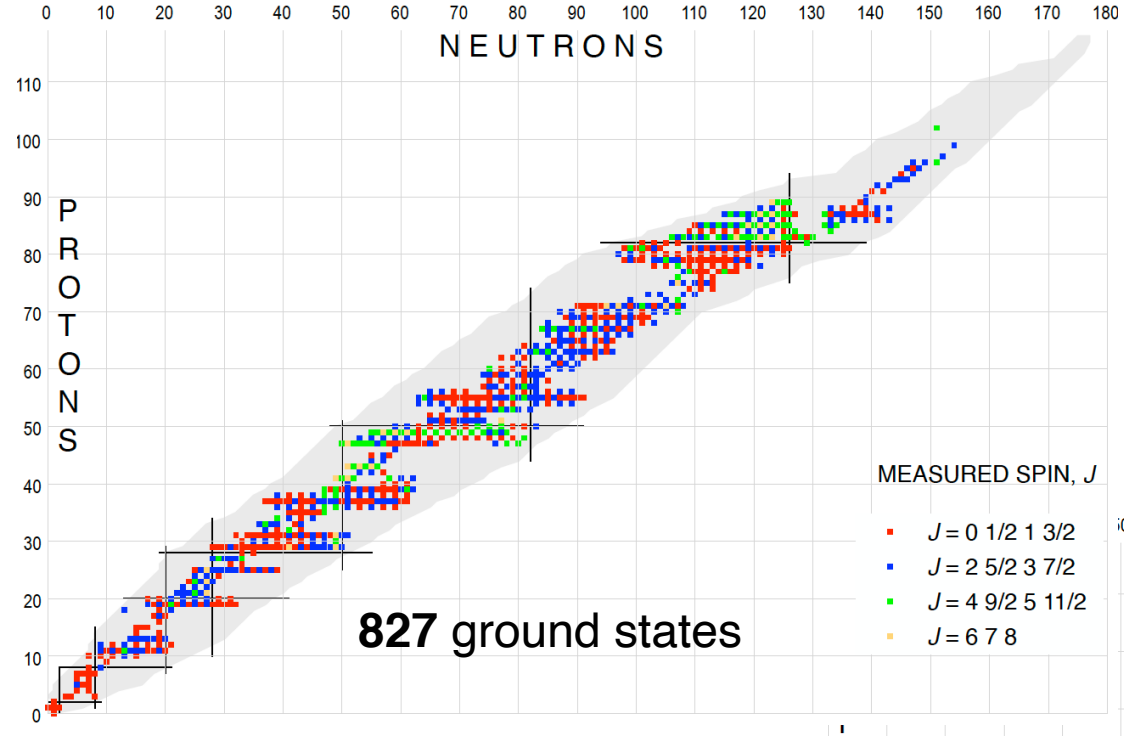
1983 isomers with $T_{1/2} > 100$ ns



Spherical Nuclei
Spin-trap Isomers (high-J)
Seniority Isomers

- Excitation energy (E_x) & $T_{1/2}$
  - E_x=160#(40#) keV in NuBase, but +X(+Y, …) in ENSDF
  - $T_{1/2}$ - "#" from systematics – Trend in Neighboring Nuclei (TNN) - e.g. $T_{1/2}(^{233}Th^m)$=2# s – from the known BE3 for $^{235}U^m$ - the same configuration change
- not clear which state is the ground state or the isomer
  - '*' in col [59:59] – $\Delta E_x > E_x/2$
  - '&' in col [60:60]
- previous assignments in doubt
  - EU in col [61:62] – **11** cases, *e.g.* $^{138}Pm^m$ (10 s) – gs in ENSDF
  - RN in col [61:62] – **9** cases, *e.g.* $^{181}Pb^m$
- uncertainties are symmetrized – $X(+\Delta X_1 - \Delta X_2)$ to $Y(\Delta Y)$

NUBASE2020 - Directly measured spins



latest ND compilation of nuclear spins
A. MacDonald et al., NDS**114** (2013) 397

ENSDF: Jπ=(1/2-)

- weak experimental arguments
- systematics or theory

NuBase: Jπ=(1/2-)

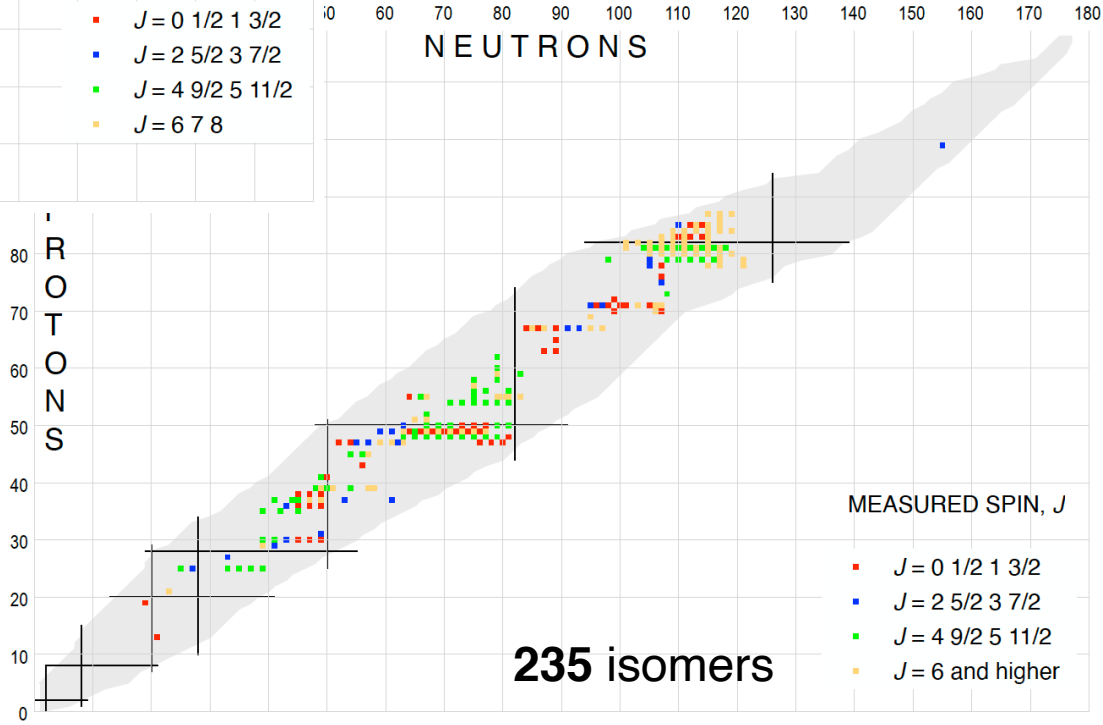
- weak experimental arguments

NuBase: Jπ=1/2-#

- systematics or theory

NuBase: Jπ=1/2-*

- directly measured spins – a wealth of new information using "in-source" (*e.g.* RILS at ISOLDE and TRILIS at TRIUMF) and "collinear" (*e.g.* CRIS at ISOLDE) laser spectroscopy
- parity from other spectroscopic data



Conclusions & Outlook

- the new AME2020 & NuBase2020 evaluations – complete, up-to-date & reliable information about the basic NP properties

https://www-nds.iaea.org/amdc/ (IAEA) http://amdc.impcas.ac.cn (IMP)

https://www.anl.gov/phy/atomic-mass-data-resources (ANL)

- if you spot a typo or error or if something is not clear please let us know: kondev@anl.gov (F.G. Kondev) and/or wangm@impcas.ac.cn (M. Wang)

future additions & improvements

- extension to other NP properties – nuclear structure, astrophysics & applications
- improving treatment of data correlations & extrapolations – important in the era of FRIB (astrophysics) and in studies of heavy and super-heavy nuclei

AME2024 & NUBASE2024