Argonne NATIONAL LABORATORY

Member of the US Nuclear Data Program

Consistency of Configuration Assignment in ENSDF

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Nuclear Physics

Introduction

ENSDF General Policies

For each level:

1. **E(lev)**: Excitation energy (relative to the ground state).
2. **J^{Π}**: Spin and parity with arguments supporting the assignment.
3. **$T_{1/2}$ or Γ**: Half-life or total width in center of mass.
4. **Decay branching** for the ground state and isomers (an isomer is recently redefined as a nuclear level with $T_{1/2} \geq 100$ ns (earlier it was ≥ 0.1 s) or one for which a separate decay data set is given in ENSDF).
5. **Q**,μ: Static electric and magnetic moments.
6. **XREF Flags** to indicate in which reaction and/or decay data sets the level is seen.
7. **Configuration assignments** (*e.g.*, Nilsson orbitals in deformed nuclei, shell-model assignments in spherical nuclei).
8. **Band assignments** and possibly band parameters (*e.g.*, rotational bands in deformed regions).
9. Isomer and isotope shifts (usually only a literature reference is given).
10. Charge distribution of ground states (usually only a literature reference is given).
11. Deformation parameters.
12. **B(E2)↑,B(M1)↑**,...: Electric or magnetic excitation probabilities when the level half-life or the ground-state branching is not known.

- useful when applying systemics arguments for Jπ assignment
- important in nuclear structure studies & applications

Introduction – cont.

IAEA
International Atomic Energy Agency

INDC(NDS)-0733
Distr. Web G,ND

INDC International Nuclear Data Committee

Summary Report of an IAEA Technical Meeting

Co-ordination of the International Network of Nuclear Structure and Decay Data Evaluators

Lawrence Berkeley National Laboratory, Berkeley, USA

22 – 26 May 2017

IAEA
International Atomic Energy Agency

INDC(NDS)-0783
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Summary Report of an IAEA Technical Meeting

Co-ordination of the International Network of Nuclear Structure and Decay Data Evaluators

IAEA Headquarters, Vienna, Austria

8 – 12 April 2019

40	ANL, ANU	Policy implementation	Recommend suitable standard(s) for band configurations - need to agree upon the adoption of a particular nomenclature.

⇒ recommendations at the 2019 NSDD meeting

⇒ S. Basunia (LBNL) presentation at the 2024 NSDD meeting

⇒ we **MUST** provide **CONF** at minimum for the ground state and isomers when Jπ are given
⇒ still not implemented by many evaluators nor enforced by various reviewers

⇒ **Myth:** CONF not given since the authors did not give it … BUT …

- evaluators are experts in the region they evaluate – in most cases the assignment is straight forward; there could be complications, e.g. region of shape coexistence
- most of the evaluators are located at the NP research facilities – interactions with the NS experimentalists and/or theorists would be beneficial

Example – 1: an odd-odd nucleus

E(level)[†]	J^{π}[‡]	$T_{1/2}$	XREF	Comments
0[@]	2^+	45.4 ms *11*	ABCDEF	$\%\beta^-$=100; $\%\beta^-$n=30 *5*; $\%\beta^-$2n=1.27 *25*; $\%\beta^-\alpha=5.5\times10^{-5}$ *2* (1983De23)

μ=+2.069 *2*
Q=+0.15 *4*
J^{π}: spin measured by LASER spectroscopy (1978Hu12), parity from shell calculations (1983Wi08).
$T_{1/2}$: weighted average of 48 ms *2* (1984La03), 50 ms *4* (1999Dl01,2001Pe14 – previous value 48 ms *5* (1997Ta22)), 54 ms *12* and 52.2 ms *36* (1974Ro31 – from β and neutron counting, respectively), 50 ms *3* (1981ThZV – mass spectrometry – their previous value 55 ms *3* (1969Kl08,1972Kl04)), and 44.1 ms *8* – β(t) (2017Ha23). Other: 38.5 ms *66* (2008ReZZ,1995ReZZ).
μ: from 2000Ke09. Other value: +2.083 *10* (1978Hu12, 2019StZV). N. Stone recommends the 2000Ke09 value by email (dated Mar 8, 2022), upon a private communication, was missed during the work of 2019StZV.
Q: value from 2002Pr12 (Coulomb excitation) – spectroscopic quadrupole moment deduced by the evaluators from reported intrinsic quadrupole moment of 51 fm² *15*. Others: +0.14 *1* (1998KeZY (β-NMR) – value estimated from Figure 3 by the evaluators), 1998KeZY notes that the measured value is about 0.24 barn higher than

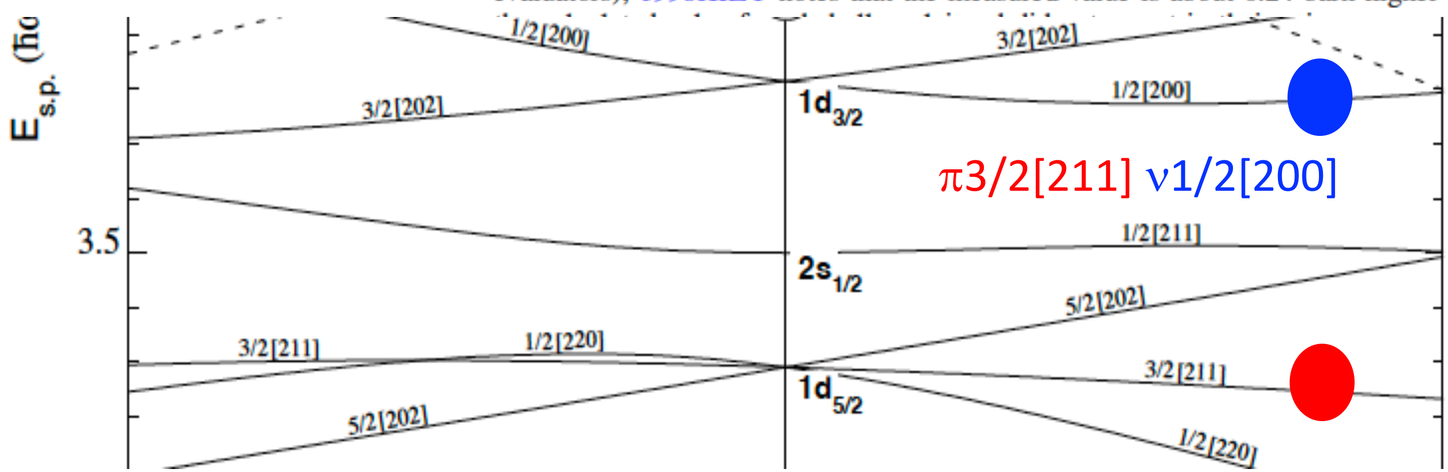
$$Q=\frac{3K^2-I(I+1)}{(I+1)(2I+3)}Q_0$$

$$\beta_2\approx-7\sqrt{\frac{\pi}{80}}+\sqrt{\frac{49\pi}{80}+\frac{7\pi Q_0}{6Zr_0^2A^{2/3}}}$$

$$\beta_2\approx0.4(1)$$

$$\mu=g_RI+\frac{K^2}{I+1}(g_K-g_R)$$

$g_R=0.7\times Z/A$



π3/2[211] ν1/2[200]

Nilsson model

$g_K(\pi3/2[211])=1.68$

$g_K(\nu1/2[200])=-1.92$

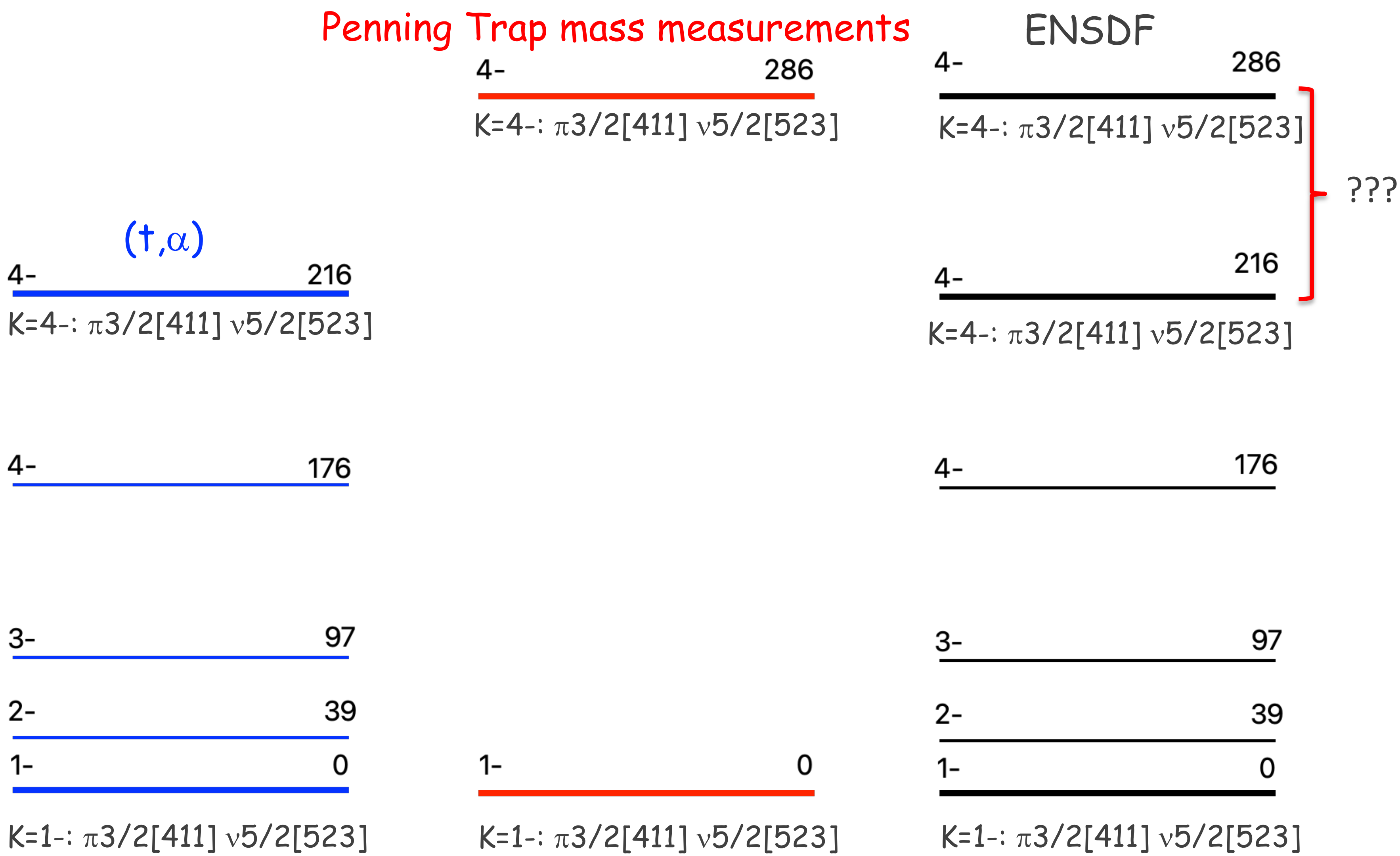
$g_K(\nu1/2[211])=0.71$

$\mu\,(\pi3/2[211]\nu1/2[411])\sim+4$

$\mu\,(\pi3/2[211]\nu1/2[400])\sim+2$

CONF: π3/2[211] ν1/2[400]

Example - 2



Penning Trap mass measurements
ENSDF
(t,α)
4- 286
K=4-: π3/2[411] ν5/2[523]
4- 286
K=4-: π3/2[411] ν5/2[523]
???
4- 216
K=4-: π3/2[411] ν5/2[523]
4- 216
K=4-: π3/2[411] ν5/2[523]
4- 176
4- 176
3- 97
3- 97
2- 39
2- 39
1- 0
1- 0
1- 0
K=1-: π3/2[411] ν5/2[523]
K=1-: π3/2[411] ν5/2[523]
K=1-: π3/2[411] ν5/2[523]

Spherical nuclei: shell-model notation

- use only the valence particles (holes)
- the spin and parity balance
- close relation between CONF and MOMM1 (g-factors, g_K-g_R, ...)

single-particle (hole)

$\pi(h_{9/2}^{+1})$ |p(h{-h/2}{++1}), e.g. $^{209}Bi_{83}$; Jπ=9/2-

$\nu(p_{1/2}^{-1})$ |n(p{-1/2}{+-1}), e.g. $^{207}Pb_{125}$; Jπ=1/2-

$\pi(h_{9/2}^{+1}) \otimes 2^+$ |p(h{-h/2}{++1})~#2{++}; Jπ=5/2- to 13/2-

two-particle (hole)

$\pi(h_{9/2}^{+1}) \otimes \nu(p_{1/2}^{-1})$ |p(h{-h/2}{++1})~#|n(p{-1/2}{+-1}); Jπ=4+ or 5+

$\pi(h_{9/2}^{+2})_{8^+}$ |p(h{-h/2}{++1}){-{8{++}}}; Jπ=8+

many-particle (hole)

$\pi(h_{9/2}^{+1}) \otimes \nu(p_{1/2}^{-1}, f_{5/2}^{-1})_{4^+}$ Jπ=1/2- to **17/2-**, odd-Z (N)

$\pi(h_{9/2}^{+2})_{8+} \otimes \nu(p_{1/2}^{-1}, f_{5/2}^{-1})_{4^+}$ Jπ=12+, even-even (or odd-odd)

Deformed nuclei: Nilsson-level labeling

one-quasiparticle states

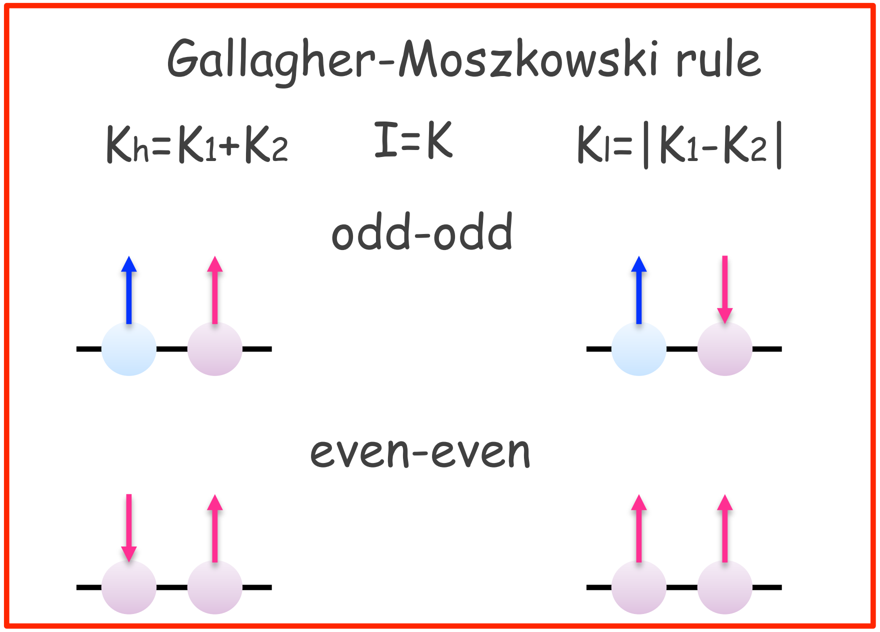
$K^{\pi} = 1/2^{-}, \pi 1/2^{-}[541]$

$K^{\pi} = 7/2^{+}, \nu 7/2^{+}[633]$

two-quasiparticle states

$K^{\pi} = 2^{-}, \pi 1/2^{-}[541] \otimes \nu 7/2^{+}[633]$

$K^{\pi} = 8^{-}, \pi^{2}(7/2^{+}[404], 9/2^{-}[514])$



multi-quasiparticle states

$K^{\pi} = 14^{+}, \pi^{2}(7/2^{+}[404], 9/2^{-}[514])_{8^{-}} \otimes \nu^{2}(5/2^{-}[512], 7/2^{+}[633])_{6^{-}}$

some time complicated band structures (very high spin) -> shell-model notation