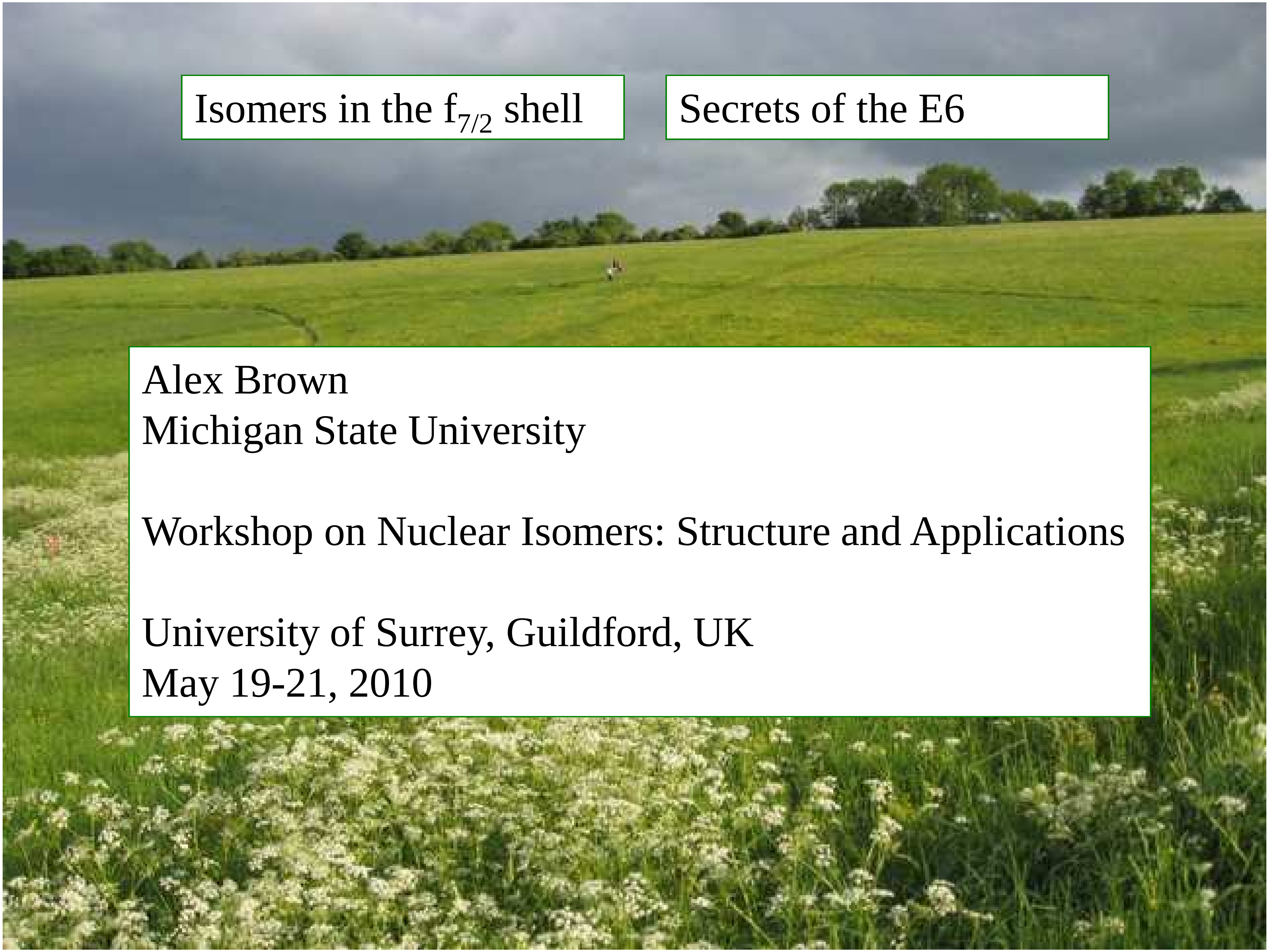

Isomers in the $f_{7/2}$ shell

Secrets of the E6

Alex Brown
Michigan State University

Workshop on Nuclear Isomers: Structure and Applications

University of Surrey, Guildford, UK
May 19-21, 2010

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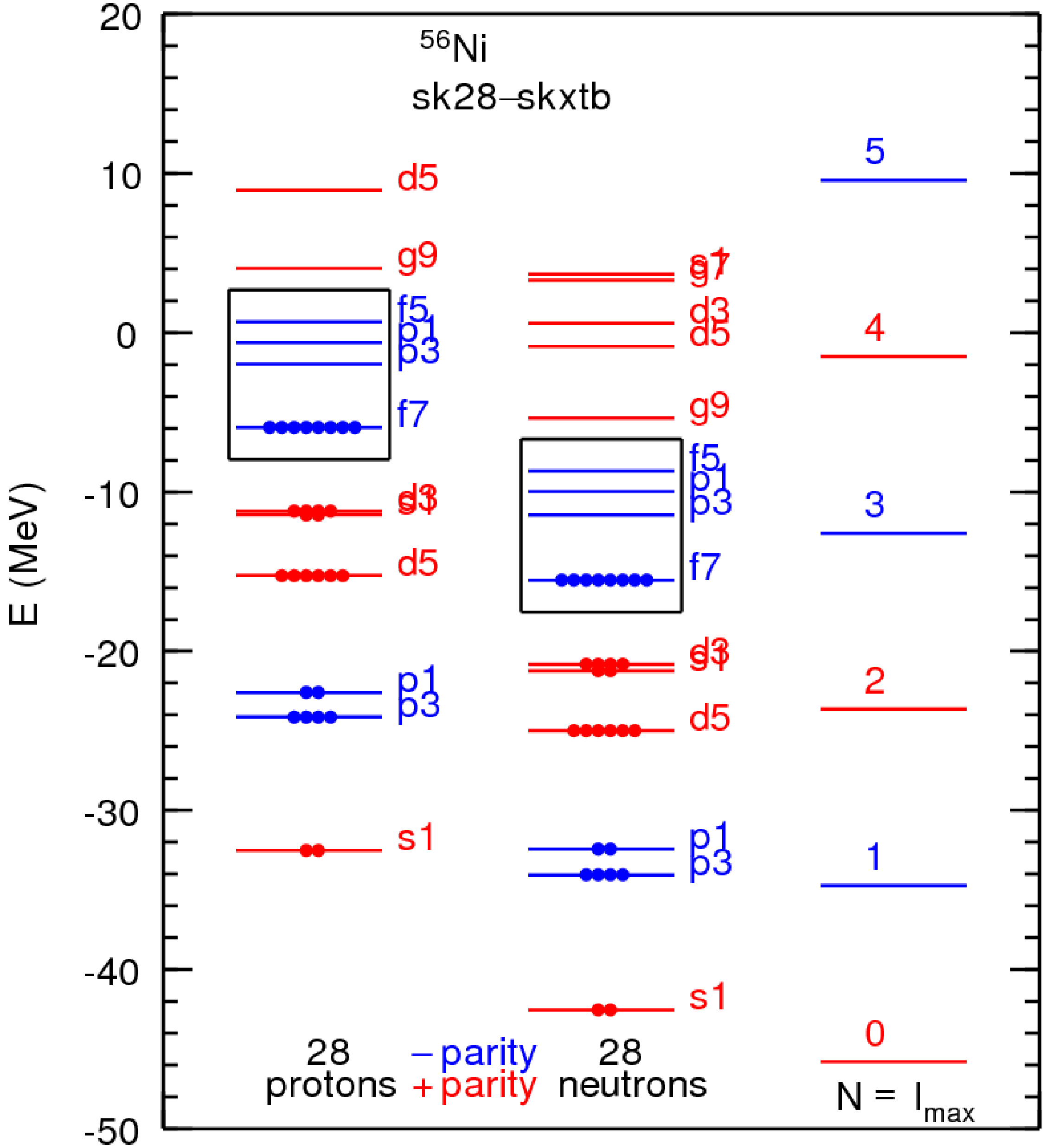
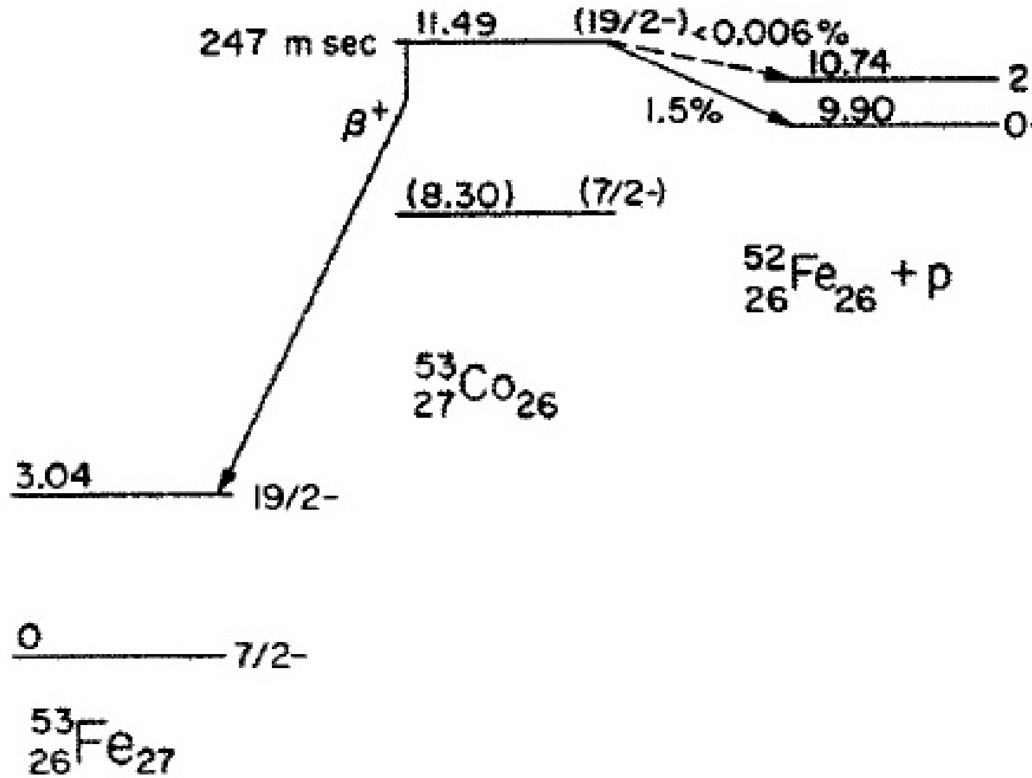


^{56}Ni
sk28–skxtb
E (MeV)
20
10
0
-10
-20
-30
-40
-50
d5
g9
f5
p1
p3
f7
d3
s1
d5
p1
p3
s1
s1
g7
d3
d5
g9
f5
p1
p3
f7
d3
s1
d5
p1
p3
s1
5
4
3
2
1
0
28
protons
– parity
+ parity
28
neutrons
N = l_{max}

1970 first proton decay from an isomer - in ^{53}Co



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Alex Brown, May 19, 2010

Volume 33B, number 4 PHYSICS LETTERS 26 October 1970

$^{53}Co^m$: A PROTON-UNSTABLE ISOMER†

K. P. JACKSON *, C. U. CARDINAL **, H. C. EVANS ‡ and N. A. JELLEY
Nuclear Physics Laboratory, University of Oxford, England

J. CERNY ‡‡
Nuclear Physics Laboratory, University of Oxford, England: and
Lawrence Radiation Laboratory and Department of Chemistry,
University of California, Berkeley, California 94720, USA.

Received 23 September 1970

A 1.53 ± 0.04 MeV proton activity with a 245 ± 20 ms half-life has been observed in the reaction of ^{16}O on ^{40}Ca. The most plausible origin of this activity is the proton radioactivity of $^{53}Co^m$, although the decay of this isomer by beta-delayed proton emission remains a possibility.

Volume 33B, number 4 PHYSICS LETTERS 26 October 1970

CONFIRMED PROTON RADIOACTIVITY‡ OF $^{53}Co^m$

J. CERNY, J. E. ESTERL, R. A. GOUGH* and R. G. SEXTRO
Department of Chemistry and Lawrence Radiation Laboratory
University of California, Berkeley, California 94720, USA

Received 23 September 1970

Proton-induced reactions on ^{54}Fe produce a proton activity [1.57 ± 0.03 MeV; 242 ± 15 ms] with a threshold of 26.3 ± 0.4 MeV which can only arise from $^{53}Co^m$. Failure to detect positron-proton coincidences in the decay of this isomer establishes its *direct* proton radioactivity.

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1.E.4

Nuclear Physics **A188** (1972) 666—672; © *North-Holland Publishing Co., Amsterdam*

FURTHER RESULTS ON THE PROTON RADIOACTIVITY OF ^{53m}Co

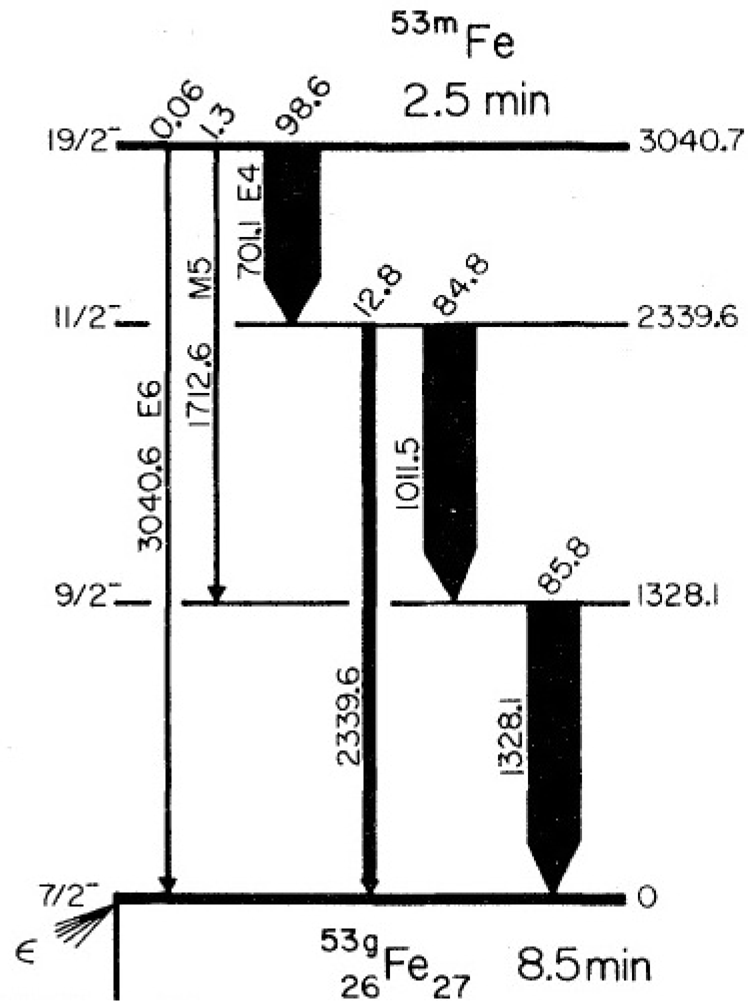
JOSEPH CERNY, R. A. GOUGH †, R. G. SEXTRO and JOHN E. ESTERL ††

Department of Chemistry and Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720 †††

Received 7 March 1972

Abstract: Additional studies on the proton radioactivity of the 247±12 msec isomer ^{53m}Co lead to an improved estimate of ≈ 17 sec for its partial half-life for emission of 1.59±0.03 MeV protons to the ^{52}Fe ground state. An upper limit of 1/250 for the ratio of direct proton decay to the ^{52}Fe*(2$^+$, 0.84 MeV) state relative to decay to the ^{52}Fe(g.s.) can be set.

1975 first E6 decay - from an isomer ^{53}Fe



Alex Brown, May 19, 2010

PHYSICAL REVIEW C VOLUME 11, NUMBER 3 MARCH 1975

Decays of the $f_{7/2}$ isomers $^{53}Fe^{g}$ and $^{53}Fe^{m}$

J. N. Black* and Wm. C. McHarris†
Department of Chemistry,‡ Cyclotron Laboratory,§ and Department of Physics, Michigan State University, East Lansing, Michigan 48824

W. H. Kelly and B. H. Wildenthal
Cyclotron Laboratory§ and Department of Physics, Michigan State University, East Lansing, Michigan 48824

(Received 25 July 1974)

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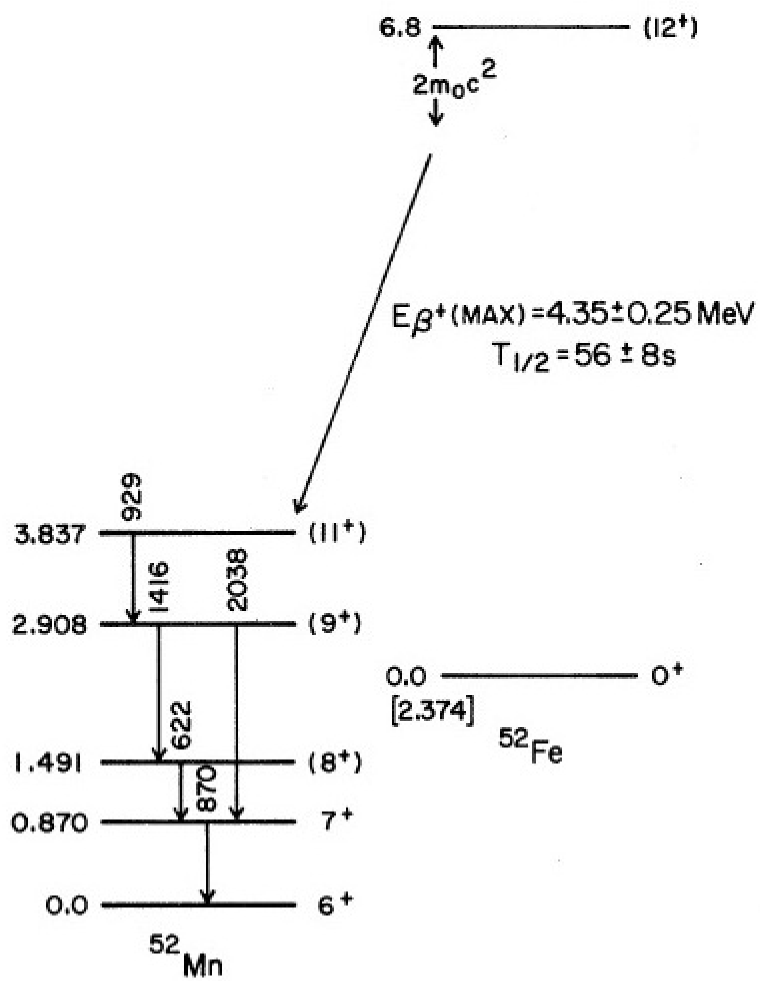
Alex Brown, May 19, 2010

1975 beta isomer in ^{52}Fe



^{52}Fe(6.8 MeV) β-Decaying Isomeric State*

D. F. Geesaman, R. Malmin, R. L. McGrath, and J. W. Noé
Department of Physics, State University of New York, Stony Brook, New York 11974

and

J. Cerny
Lawrence Berkeley Laboratory and Department of Chemistry, University of California, Berkeley, California 94720

(Received 26 August 1974)

An isomeric state in ^{52}Fe has been located at $E_x = 6.83 \pm 0.25$ MeV with the reaction ^{40}Ca(^{14}N, pn)^{52}Fe. The state decays by positron emission to the (11$^+$) 3.837-MeV state of ^{52}Mn with $T_{1/2} = 56 \pm 8$ sec. The probable spin and parity of the isomer is 12$^+$.

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Alex Brown, May 19, 2010

1979 search for E4 gamma in ^{52}Fe – not found

PHYSICAL REVIEW C VOLUME 19, NUMBER 5 MAY 1979

Yrast states in ^{52}Fe, ^{52}Mn and the decay of ^{52}Fe^{m}

D. F. Geesaman,* R. L. McGrath, J. W. Noé, and R. E. Malmin†
Department of Physics, State University of New York, Stony Brook, New York 11794
(Received 5 December 1978)

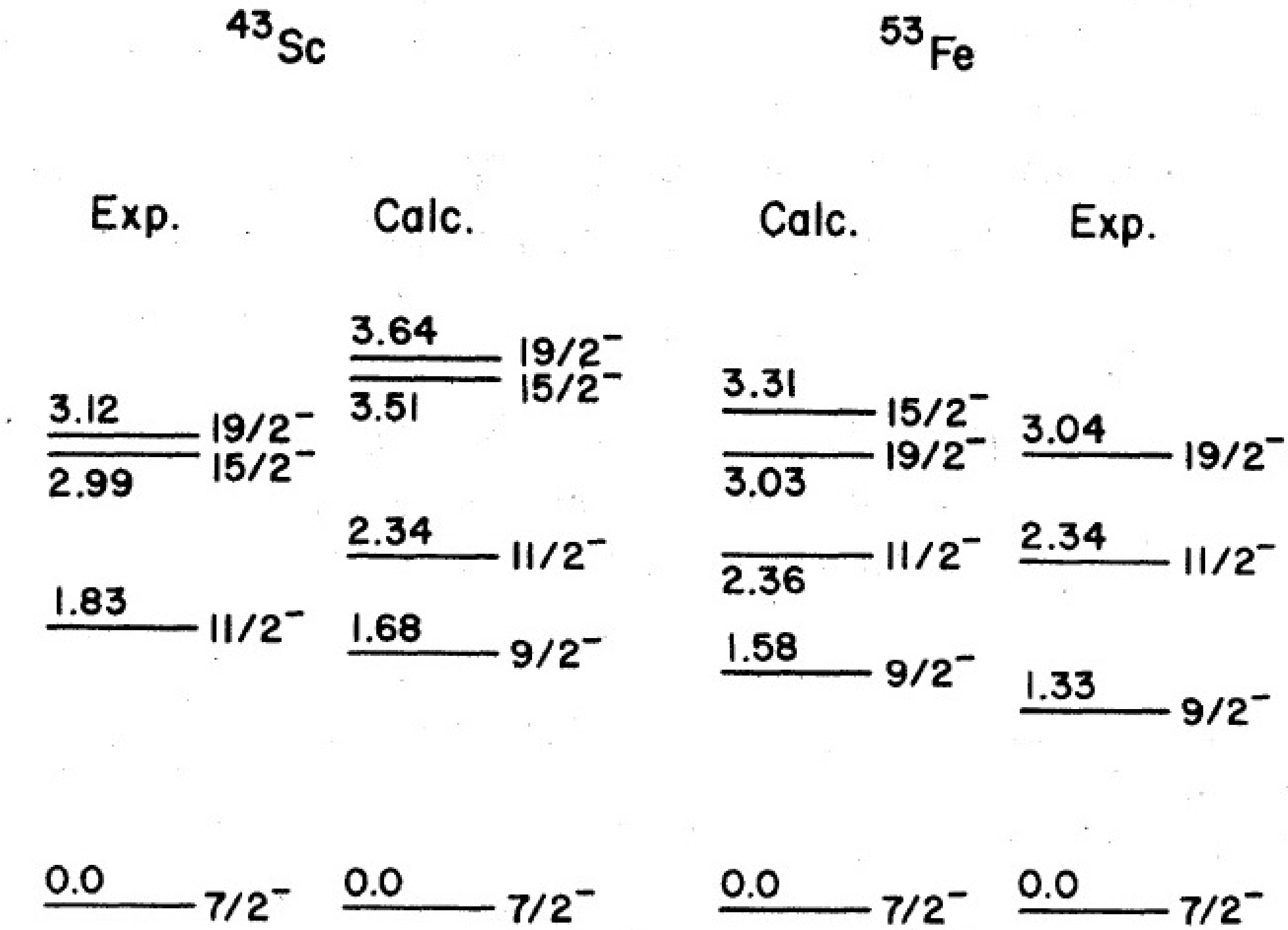


FIG. 10. Comparison of experimental and $(1f_{7/2})^{\pm 3}$ model level schemes of ^{43}Sc and ^{53}Fe. Effective interactions taken from ^{42}Sc and ^{54}Co spectra were used for ^{43}Sc and ^{53}Fe, respectively.

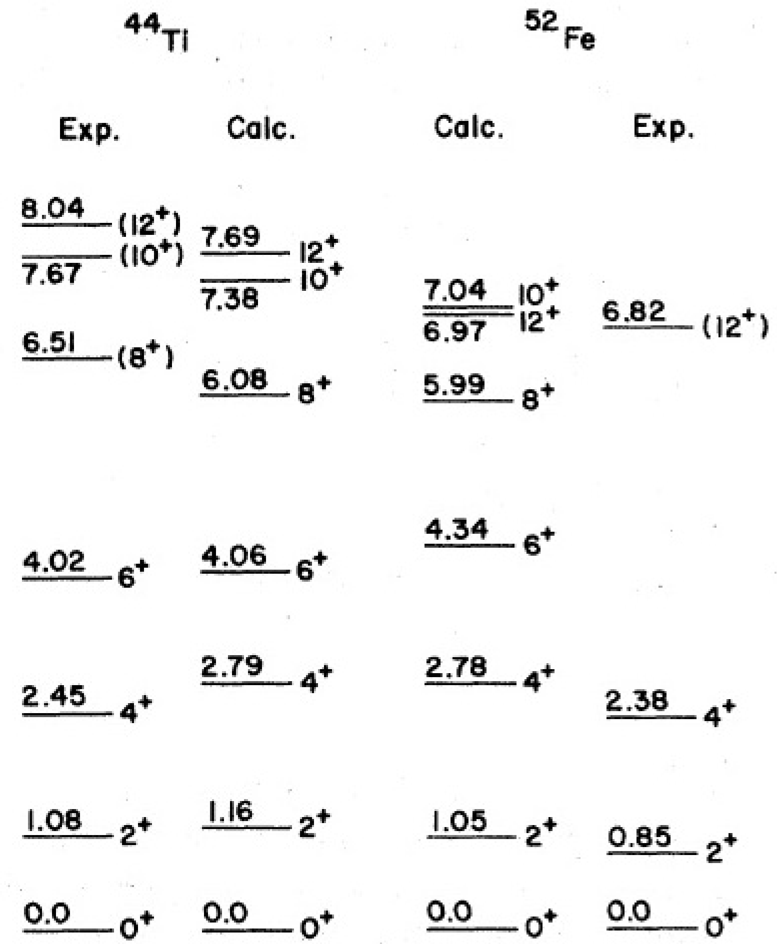
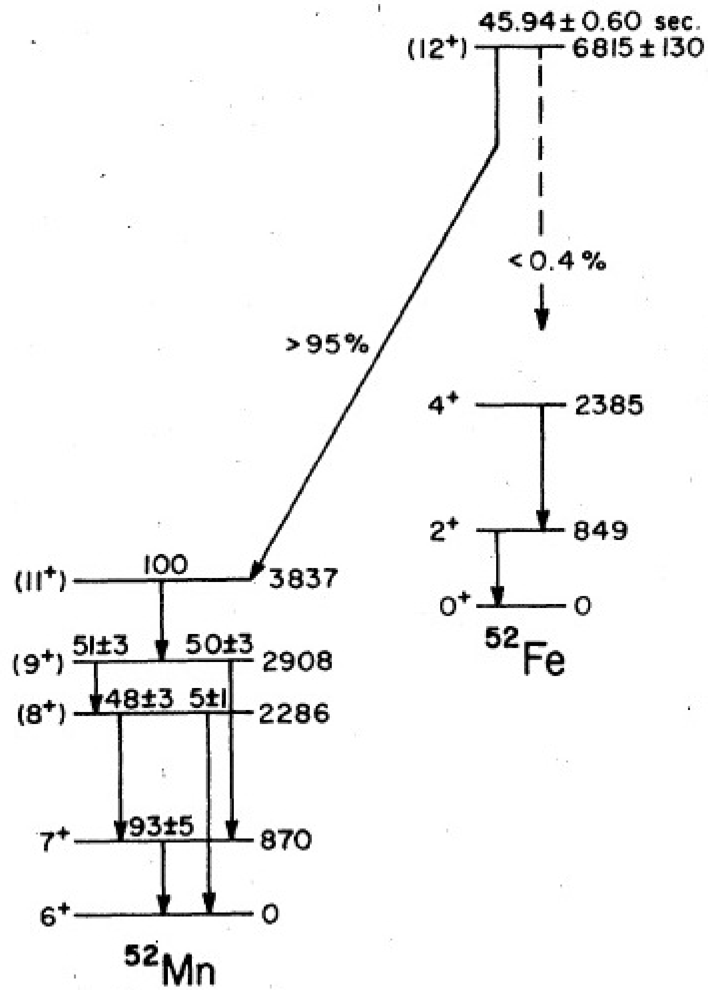


FIG. 9. Comparison of experimental and $(1f_{7/2})^{\pm 4}$ model level schemes of ^{44}Ti and ^{52}Fe. Two different empirical effective interactions taken from ^{42}Sc and ^{54}Co spectra were used for ^{44}Ti and ^{52}Fe, respectively.



45.94 ± 0.60 sec.
(12⁺)
6815 ± 130
>95%
<0.4%
4⁺
2385
2⁺
849
0⁺
0
52Fe
(11⁺)
100
3837
(9⁺)
51±3
50±3
2908
(8⁺)
48±3
5±1
2286
7⁺
93±5
870
6⁺
0
52Mn

2005 search for E4 gamma in ^{52}Fe – found (GASP)

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PHYSICS LETTERS B

Physics Letters B 619 (2005) 88–94

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Hindered E4 decay of the 12^+ yrast trap in ^{52}Fe

A. Gadea [a], S.M. Lenzi [b], D.R. Napoli [a], M. Axiotis [a], C.A. Ur [b,c], G. Martínez-Pinedo [d], M. Górska [e], E. Roeckl [e], E. Caurier [f], F. Nowacki [f], G. de Angelis [a], L. Batist [g], R. Borcea [e], F. Brandolini [b], D. Cano-Ott [h], J. Döring [e], C. Fahlander [i], E. Farnea [b], H. Grawe [e], M. Hellström [i], Z. Janas [e,j], R. Kirchner [e], M. La Commara [e], C. Mazzocchi [e,k], E. Nácher [h], C. Plettner [l], A. Płochocki [j], B. Rubio [h], K. Schmidt [e], R. Schwengner [l], J.L. Tain [h], J. Żylicz [j]

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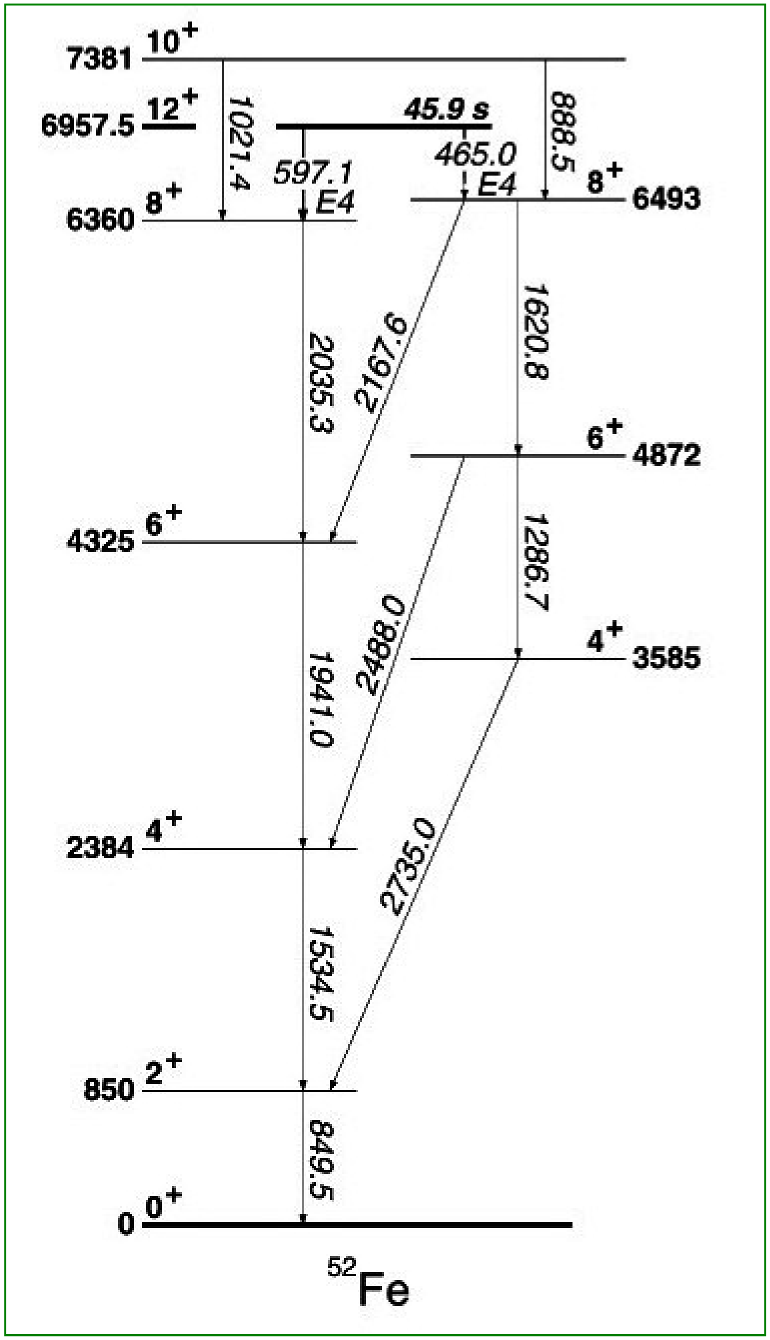
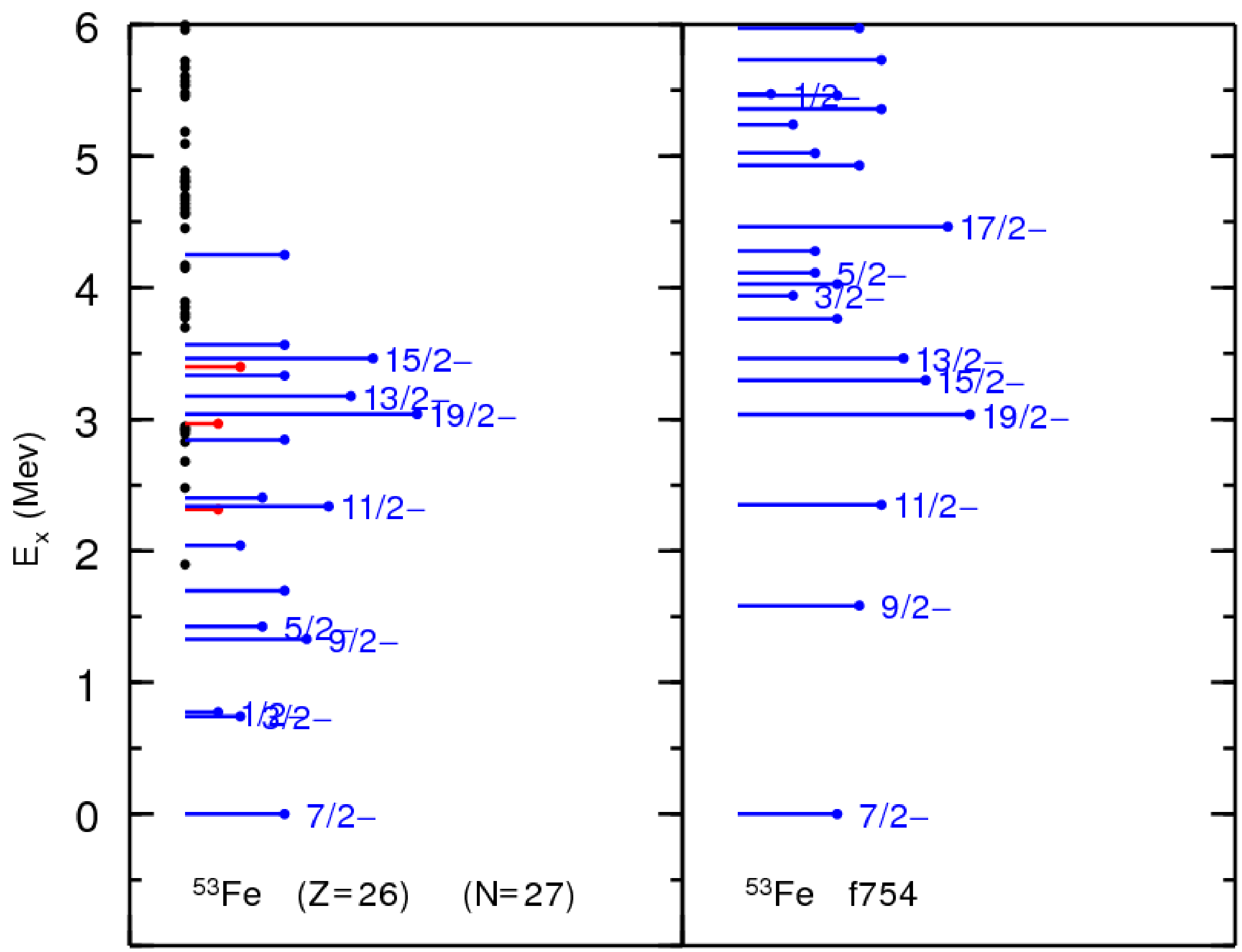
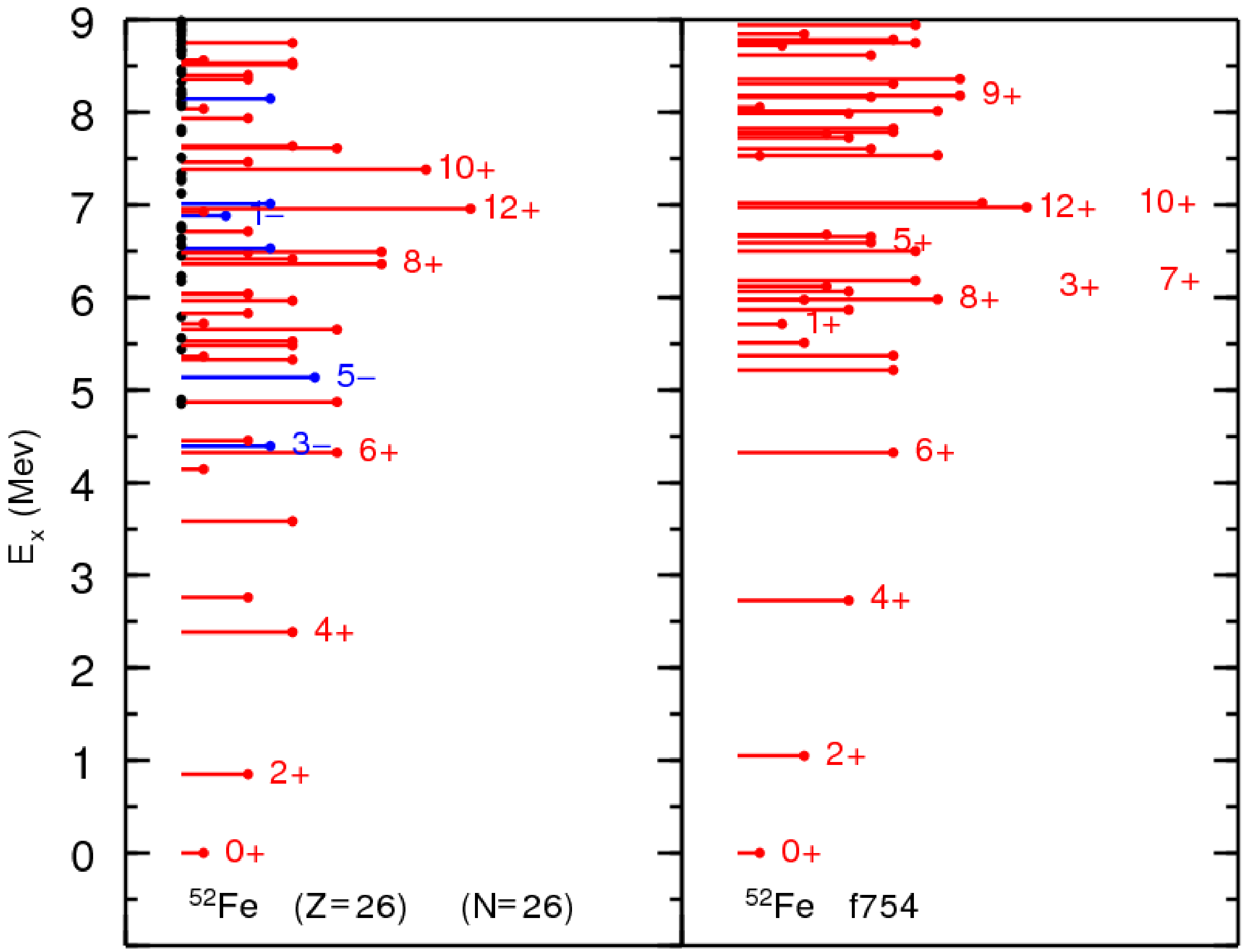


Alex Brown, May 19, 2010

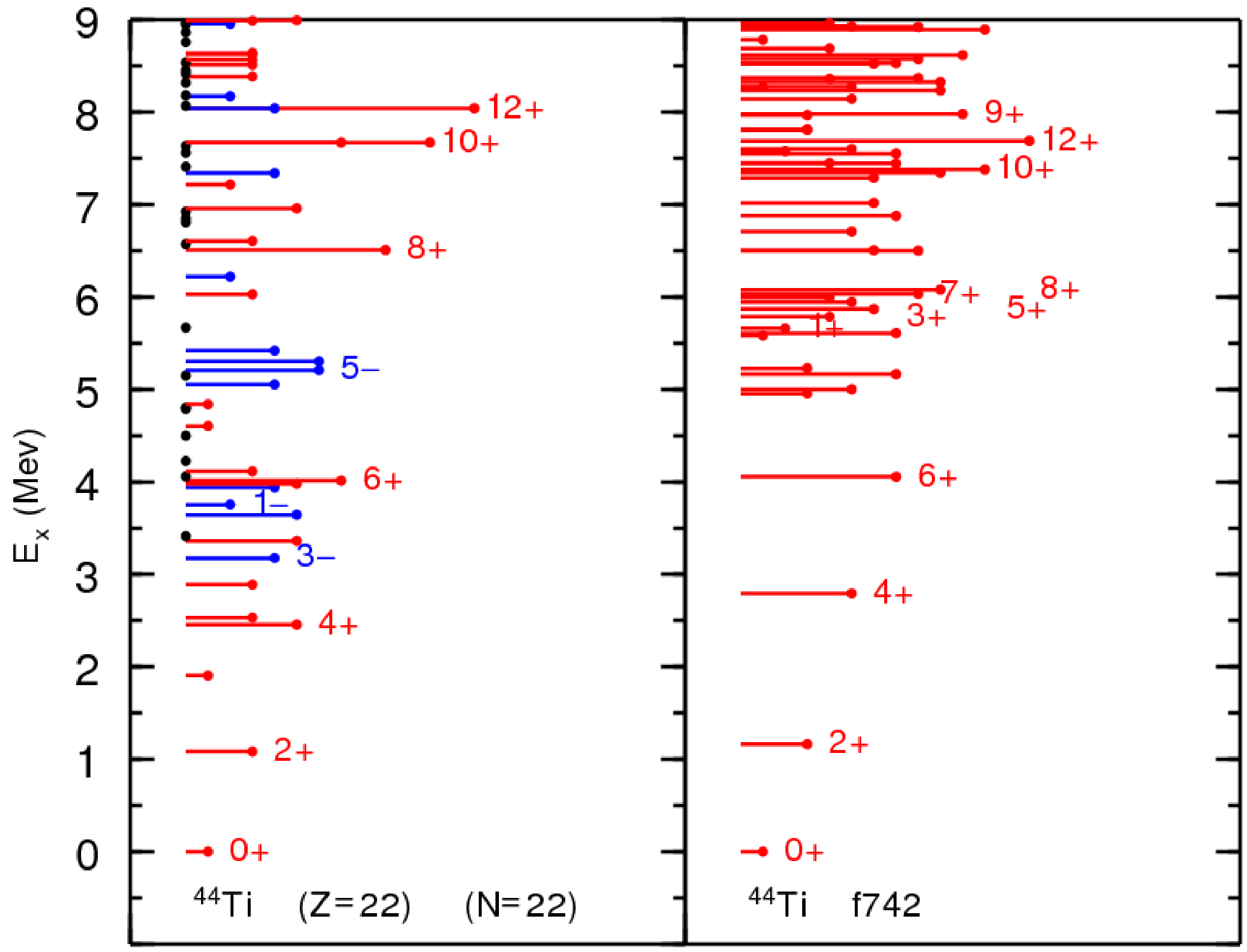


6
5
4
3
2
1
0
E_x (Mev)
7/2−
1/3/2−
5/2
9/2−
11/2−
19/2−
13/2−
15/2−
53Fe (Z=26) (N=27)
7/2−
9/2−
11/2−
19/2−
15/2−
13/2−
3/2−
5/2−
17/2−
1/2−
53Fe f754

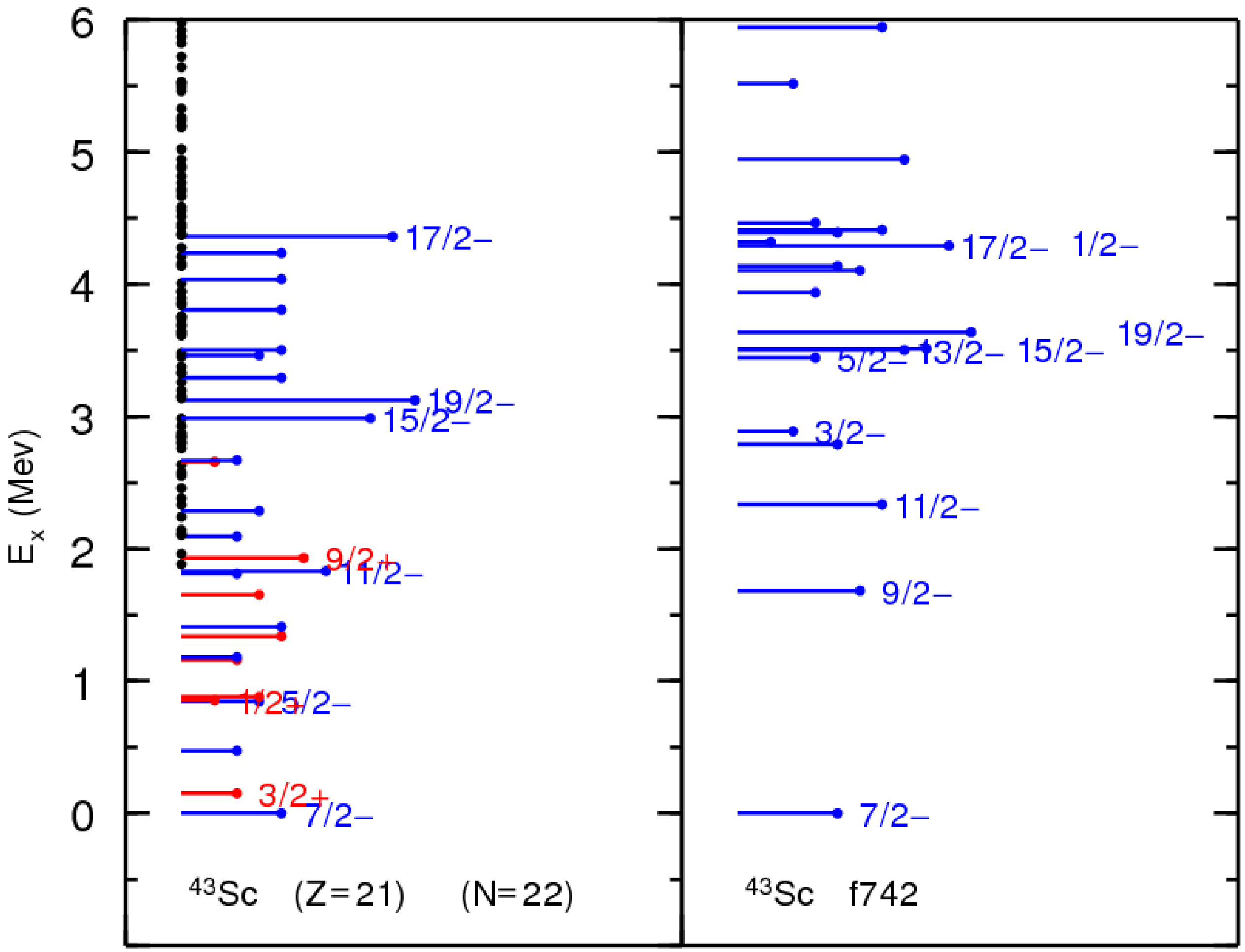


9
8
7
6
5
4
3
2
1
0
E_x (Mev)
10+
12+
1−
8+
5−
3−
6+
4+
2+
0+
^{52}Fe (Z=26) (N=26)
9+
12+
10+
5+
3+
7+
8+
1+
6+
4+
2+
0+
^{52}Fe f754

NSCL



E_x (Mev)
9
8
7
6
5
4
3
2
1
0
12+
10+
8+
5−
6+
1−
3−
4+
2+
0+
44Ti (Z=22) (N=22)
9+
12+
10+
7+
8+
5+
3+
1+
6+
4+
2+
0+
44Ti f742



6
5
4
3
2
1
0
Ex (Mev)
17/2–
19/2–
15/2–
9/2+
11/2–
1/2+
5/2–
3/2+
7/2–
43Sc (Z=21) (N=22)
17/2–
1/2–
19/2–
5/2–
13/2–
15/2–
3/2–
11/2–
9/2–
7/2–
43Sc f742

Why is there an isomer for holes and not for particles? The energy difference can be expressed in terms of $f_{7/2}$ two-body matrix elements

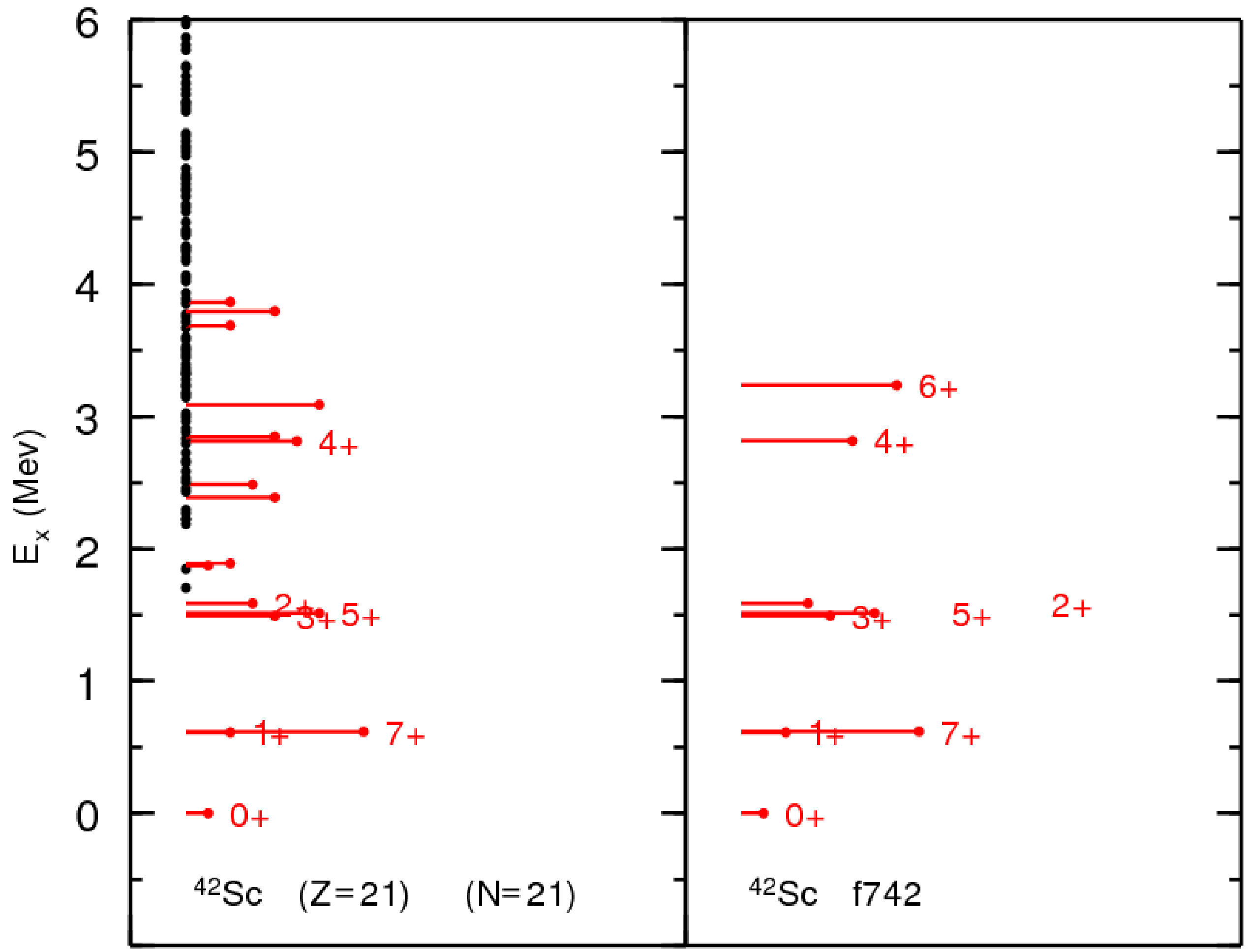
$$V_{JT} = < f_{7/2}, f_{7/2}, J, T \mid V \mid f_{7/2}, f_{7/2}, J, T >$$

$$E(12^+) - E(10^+) =$$

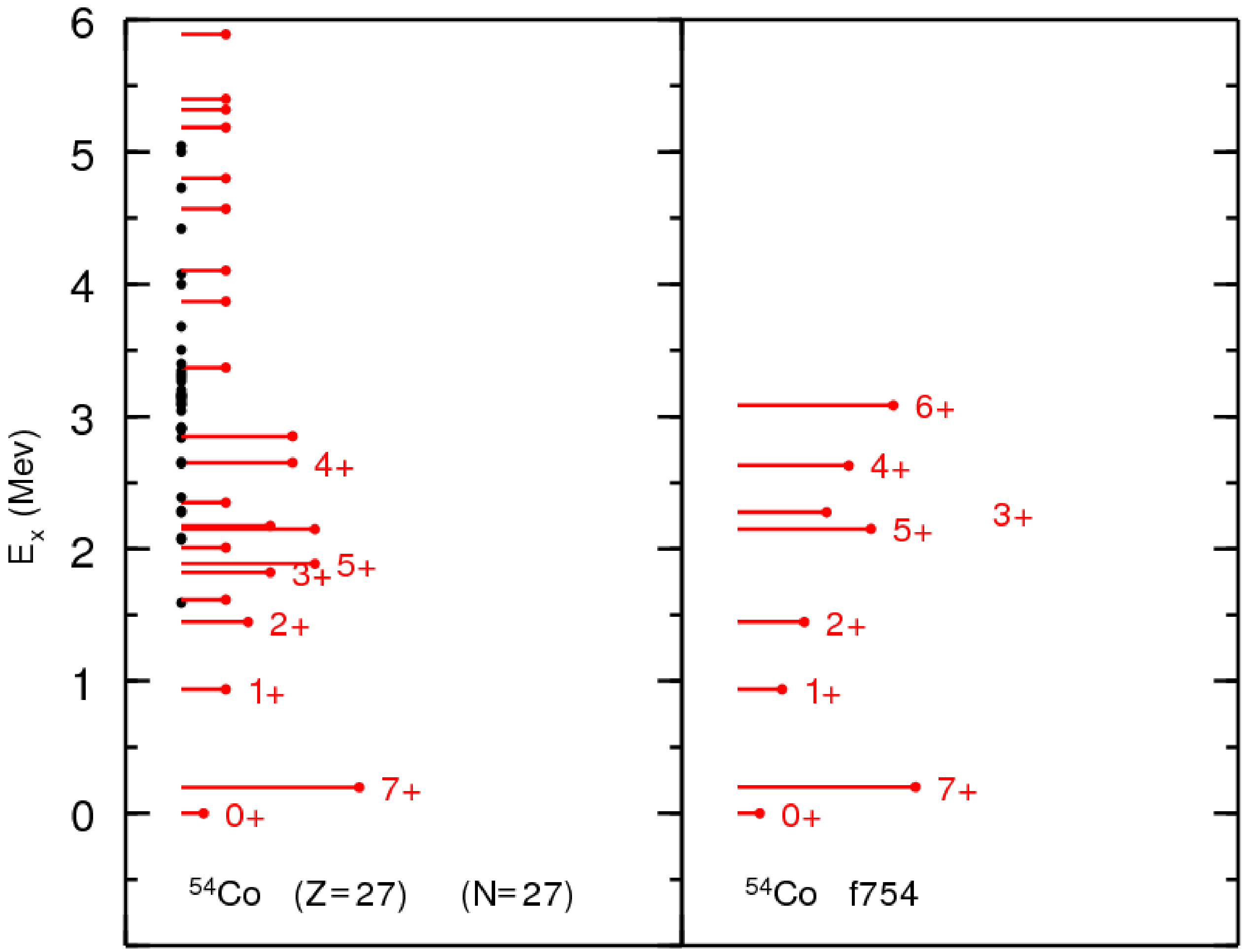
$$+0.35\, V_{70} - 0.11\, V_{50} - 0.24, V_{30}$$

$$+1.47\, V_{61} - 1.47\, V_{41}$$

NSCL



6
5
4
3
2
1
0
E_x (Mev)
4+
2+
3+
5+
1+
7+
0+
^{42}Sc (Z=21) (N=21)
6+
4+
3+
5+
2+
1+
7+
0+
^{42}Sc f742



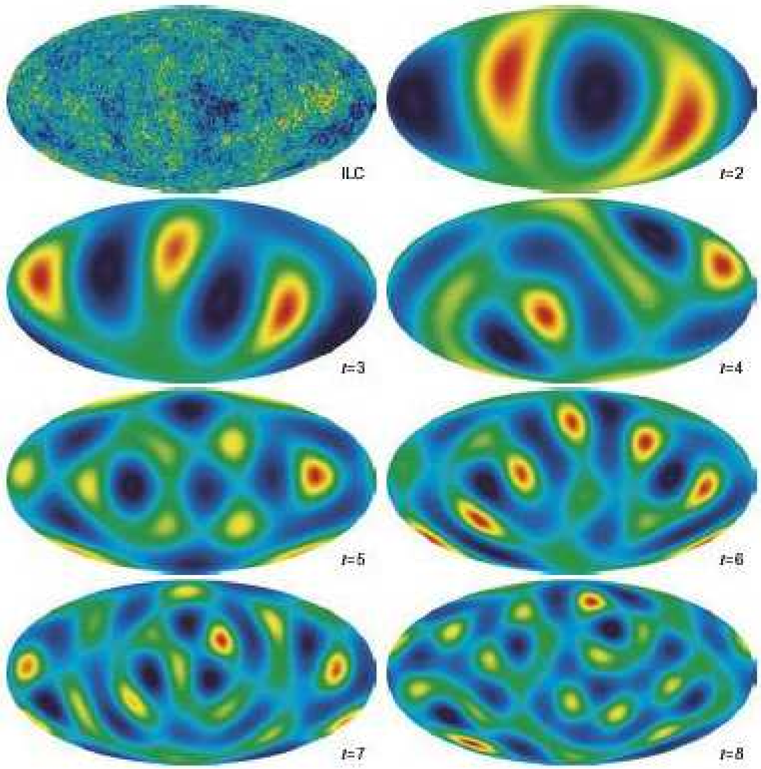
6
5
4
3
2
1
0
E_x (Mev)
6+
4+
4+
3+
5+
5+
3+
2+
2+
1+
1+
7+
7+
0+
0+
^{54}Co (Z=27) (N=27)
^{54}Co f754

E6 decay - from the 19/2$^-$ ^{53}Fe isomer

E2 $2^2 = 4$ tetrapole

E4 $2^4 = 16$ hexadecapole

E6 $2^6 = 64$ hexacontatetrapole



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^{53}Fe E6 decay 19/2$^-$ to 7/2$^-$

$$B(E6)_{exp} = 0.26(4) \cdot 10^6 \mathrm{e}^2\mathrm{fm}^{12}$$

$f_{7/2}$ model space with $\hbar\omega = 45A^{-1/3} - 25A^{-2/3}$, $e_p = 1.5$ and $e_n = 0.5$

$$B(E6) = 6.03 \cdot 10^6 \mathrm{e}^2\mathrm{fm}^{12}$$

$f_{7/2}$ model space with $\hbar\omega = 45A^{-1/3} - 25A^{-2/3}$, $e_p = 1$ and $e_n = 0$

$$B(E6) = 2.62 \cdot 10^6 \mathrm{e}^2\mathrm{fm}^{12}$$

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$$B(E6) = \frac{M^2}{2J_i + 1}$$

$$M_{exp} = 2.3 \cdot 10^3 \mathrm{efm}^6$$

$f_{7/2}$ model space with $\hbar\omega = 45A^{-1/3} - 25A^{-2/3}$, $e_p = 1$ and $e_n = 0$

$$M = 7.2 \cdot 10^3 \mathrm{efm}^6$$

The $E6$ operator is

$$O(E6) = Y^{(6)}(\hat{r}_q)\, r_q^6\, e_q$$

summed over all protons ($q = p$) and neutrons ($q = n$).

Where does this factor of three come from?

Isomer is "pure" compared to ground state in terms of mixing beyond $f_{7/2}$?

The radial integeral $< f_{7/2}|r^6 \mid f_{7/2} >$ is uncertain?

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$$M = A_p e_p + A_n e_n$$

with A_p and A_n in units of 10^3 e fm^6 $f_{7/2}$ model space
with $\hbar\omega = 45A^{-1/3} - 25A^{-2/3}$,

$$A_p = 7.25$$

$$A_n = 0.21$$

$$M_{exp} = 2.3$$

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BAB notes from around 1980

$\sqrt{B(E4)}$

$\langle 11/2 \| E4 \| 19/2 \rangle \times \sqrt{20}$

$\delta e \times \Delta E$

$$
\begin{array}{ll}
-0.846 & \sqrt{12}\Big[\,0.794 \overset{-0.08006}{\begin{Bmatrix} 2 & 11/2 & 7/2 \\ 19/2 & 6 & 4 \end{Bmatrix}} \overset{11.605}{\langle 2 \| E4 \| 6 \rangle} \quad -0.738 \\
0.655 & \\
0.323 & \quad + 0.561 \overset{-0.01986}{\begin{Bmatrix} 4 & 11/2 & 7/2 \\ 19/2 & 6 & 4 \end{Bmatrix}} \overset{24.242}{\langle 4 \| E4 \| 6 \rangle} \quad -0.270 \\
0.402 & \\
0.090 & \quad + 0.234 \overset{-0.00190}{\begin{Bmatrix} 6 & 11/2 & 7/2 \\ 19/2 & 6 & 4 \end{Bmatrix}} \overset{-12.904}{\langle 6 \| E4 \| 6 \rangle} \quad +0.006 \\
2.627 & \\
 & \quad + 0.234 \overset{-0.02002}{\begin{Bmatrix} 7/2 & 11/2 & 6 \\ 19/2 & 7/2 & 4 \end{Bmatrix}} \overset{20.254}{\langle 7/2 \| E4_{\nu} \| 7/2 \rangle}\Big]
\end{array}
$$

$\times\, 14.393 \longrightarrow (1.01 A^{1/3})^2$

$= -49.86\,[-1.002\, e_p + 0.0949\, e_n]$

1975 considered one-nucleon excited to $f_{5/2}$

PHYSICAL REVIEW C VOLUME 11, NUMBER 5 MAY 1975

$E6$ transition in ^{53}Fe†

D. H. Gloeckner* and R. D. Lawson
Argonne National Laboratory, Argonne, Illinois 60439
(Received 24 February 1975)

The $\frac{19}{2}^- \to \frac{7}{2}^-$ $E6$ transition in ^{53}Fe is calculated in a model including all basis states of the configurations $(f_{7/2})^{13}{}_{IT}$ and $[(f_{7/2})^{12}{}_{I'T'} \times f_{5/2}]_{IT}$. Several interactions, which yield the observed amount of $f_{5/2}$ configuration mixing, have been considered. In all cases an effective charge $\delta \cong -0.4$ is needed to fit experiment (where $e_p = 1 + \delta$, $e_n = \delta$).

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Thanks to Bill Rae with NuShellX and many years work on the effective Hamiltonian, the full pf shell can now be done.

$$0f_{7/2}\ D(M = 7/2) = 16$$

$$0f_{7/2}\ D(J = 7/2) = 4$$

$$0f_{7/2}\ D(J = 19/2) = 1$$

$$pf\ \ D(M = 7/2) = 177,805,002$$

$$pf\ \ D(J = 7/2) = 21,131,892$$

$$pf\ \ D(J = 19/2) = 14,333,584$$

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model space	J	$n(f_{7/2})$	percent $(f_{7/2})^{13}$
$f_{7/2}$	7/2	13	100
pf	7/2	12.0	54
$f_{7/2}$	19/2	13	100
pf	19/2	12.3	62

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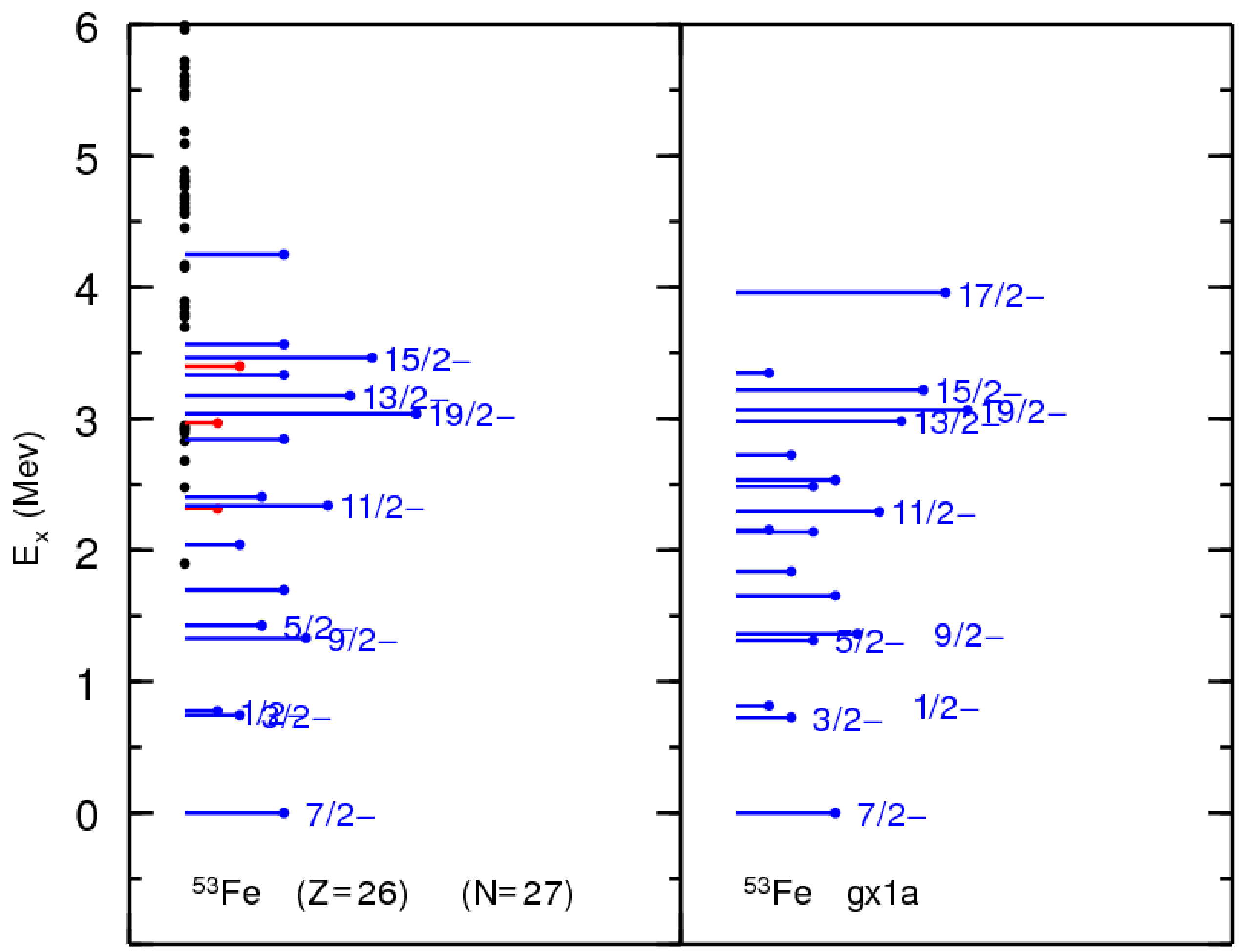
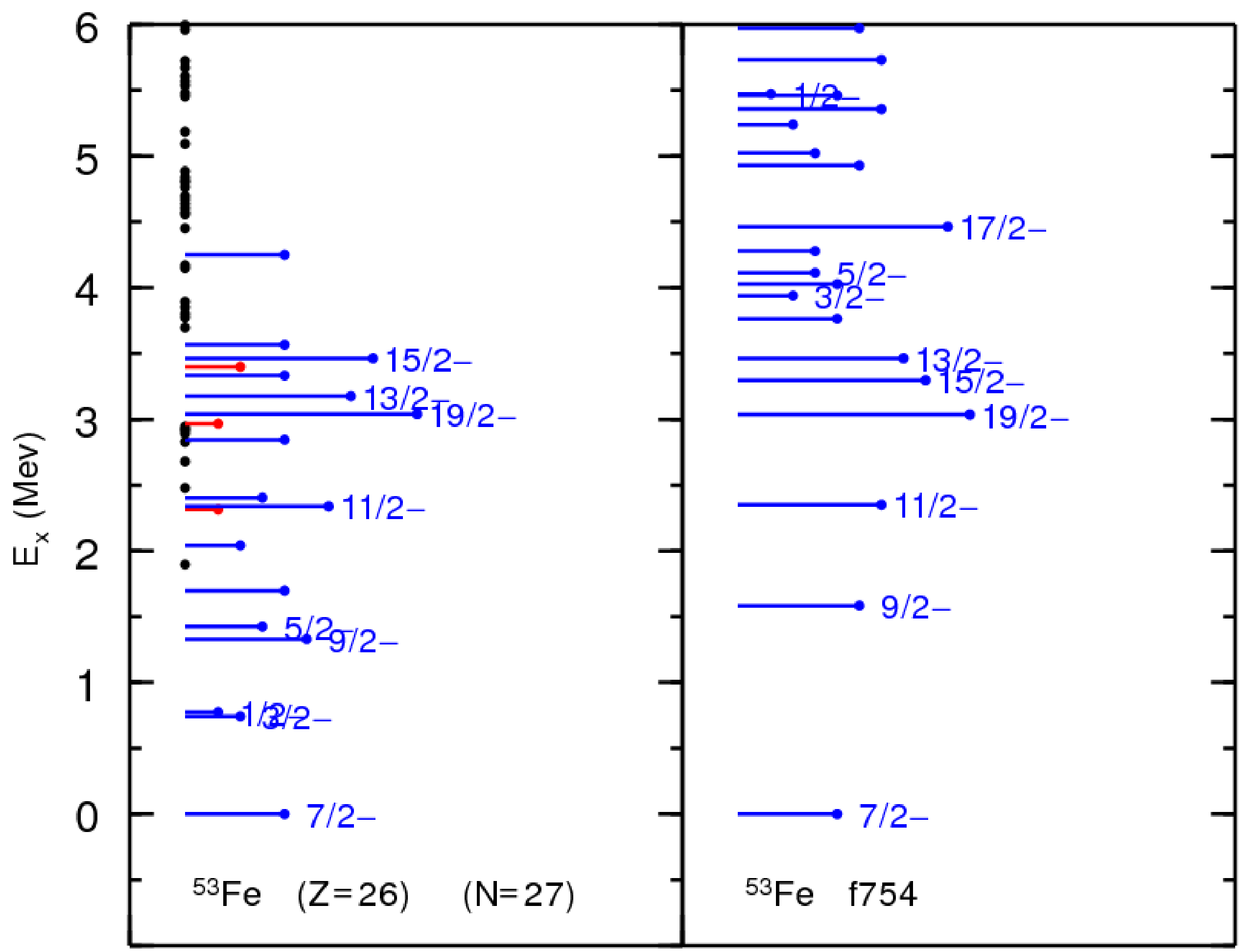


E_x (Mev)
6
5
4
3
2
1
0
15/2–
13/2–
19/2–
11/2–
5/2–
9/2–
1/2–
3/2–
7/2–
53Fe (Z=26) (N=27)
17/2–
15/2–
13/2–
19/2–
11/2–
5/2–
9/2–
3/2–
1/2–
7/2–
53Fe gx1a


E_x (Mev)
6
5
4
3
2
1
0
15/2−
13/2−
19/2−
11/2−
5/2
9/2−
1/3/2−
7/2−
53Fe (Z=26) (N=27)
1/2−
17/2−
5/2−
3/2−
13/2−
15/2−
19/2−
11/2−
9/2−
7/2−
53Fe f754

Results for the $E6$ matrix elements obtained with various pf shell Hamiltonians with $\hbar\omega = 45A^{-1/3} - 25A^{-2/3}$.

Hamiltonian	A_p 10^3 (e fm^6)	A_n 10^3 (e fm^6)
$f_{7/2}$	7.25	0.21
FPD6	3.76	0.27
KB3G	4.66	0.36
GPFX1A	4.40	0.22
experiment	$M = 2.3$	

For FPD6 we would conclude for the effective charge $e_p = 0.60$ or with $e_p = 1 + \delta e_p$, $\delta e_p = -0.4$.

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2005 search for E4 gamma in ^{52}Fe – found

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Physics Letters B 619 (2005) 88–94

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Hindered E4 decay of the 12^+ yrast trap in ^{52}Fe

A. Gadea[a], S.M. Lenzi[b], D.R. Napoli[a], M. Axiotis[a], C.A. Ur[b,c], G. Martínez-Pinedo[d], M. Górska[e], E. Roeckl[e], E. Caurier[f], F. Nowacki[f], G. de Angelis[a], L. Batist[g], R. Borcea[e], F. Brandolini[b], D. Cano-Ott[h], J. Döring[e], C. Fahlander[i], E. Farnea[b], H. Grawe[e], M. Hellström[i], Z. Janas[e,j], R. Kirchner[e], M. La Commara[e], C. Mazzocchi[e,k], E. Nácher[h], C. Plettner[l], A. Płochocki[j], B. Rubio[h], K. Schmidt[e], R. Schwengner[l], J.L. Tain[h], J. Żylicz[j]

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$e_p = 1.5$ and $e_n = 0.5$

	$J_i \rightarrow J_f$	B(E4) (W.u.)			
		Exp	FPD6	KB3G	GXPF1
^{52}Fe	$12^+ \rightarrow 8_1^+$	$4.6(17) \times 10^{-4}$	2.4×10^{-3}	3.3×10^{-1}	6.5×10^{-2}
^{52}Fe	$12^+ \rightarrow 8_2^+$	$3.5(13) \times 10^{-3}$	4.7×10^{-3}	2.6×10^{-2}	2.3×10^{-2}
^{44}Sc	$6^+ \rightarrow 2^+$	1.42	1.96	1.79	1.65
^{46}Ti	$4^+ \rightarrow 0^+$	1.6	10.7	7.9	7.39
^{52}Mn	$2^+ \rightarrow 6^+$	0.138	0.272	0.422	0.728
^{53}Fe	$\frac{19}{2}^- \rightarrow \frac{11}{2}^-$	0.256	0.151	1.23	0.84
^{54}Fe	$10^+ \rightarrow 6^+$	0.79	1.80	0.98	1.25

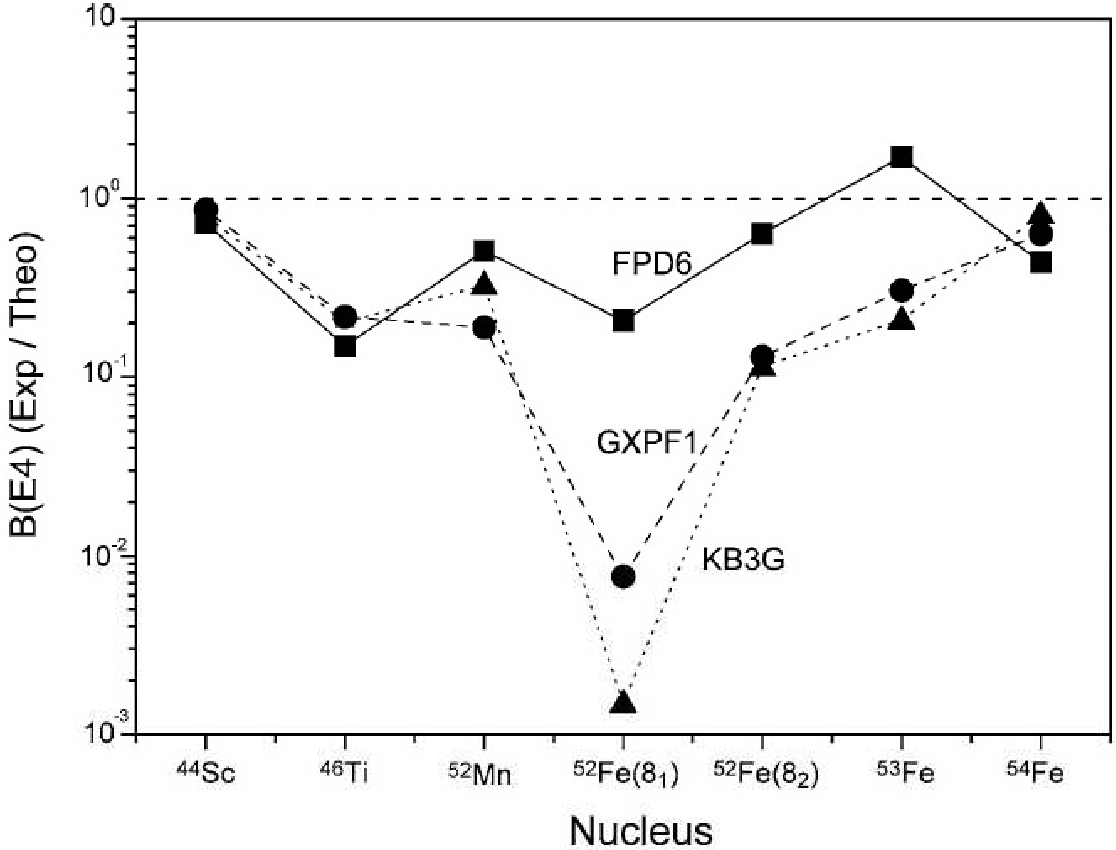

Fig. 4. Ratio between experimental and theoretical B(E4) values for nuclei in the $f_{7/2}$ shell. Results obtained by using the FPD6, GXPF1 and KB3G interactions are shown by squares (full line), full circles (dashed-line) and triangles (dotted-line), respectively. See Table 2 for details.

Results for the $E6$ matrix elements obtained with various radial wavefunctions for GPFX1A.

Radial	A_p 10^3 (e fm^6)	A_n 10^3 (e fm^6)
$\hbar\omega = 45A^{-1/3} - 25A^{-2/3}$	4.66	0.27
Skx	3.23	0.15
SLy4	3.73	0.18
experiment	$M = 2.3$	

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Ni 48 ~2 ms ?
Ni 49 13 ms
Ni 50 12 ms
Ni 51 >200 ns
Ni 52 38 ms
Ni 54 104 ms
Ni 55 209 ms
Ni 56 6.075 d
Ni 57 36.0 h
Ni 58 68.0769
Ni 59 7.5 · 10⁴ a
Co 49 <35 ns
Co 50 44 ms
Co 51 <200 ns
Co 52
Co 53
Co 54
Co 55 17.54 h
Co 56 77.26 d
Co 57 271.79 d
Co 58
Fe 46 10.3 ms
Fe 47 21.6 ms
Fe 48 51 ms
Fe 49 75 ms
Fe 50 150 ms
Fe 52
Fe 53
Fe 54 5.845
Fe 55 2.73 a
Fe 56 91.754
Fe 57 2.119
Mn 45 <70 ns
Mn 46 34.4 ms
Mn 47 ~100 ms
Mn 48 158 ms
Mn 49 382 ms
Mn 50
Mn 51 46.2 m
Mn 52
Mn 53 3.7 · 10⁶ a
Mn 54 312.2 d
Mn 55 100
Mn 56 2.58 h
Cr 44 53 ms
Cr 45 50 ms
Cr 46 0.26 s
Cr 47 472 ms
Cr 48 21.6 h
Cr 50 4.345
Cr 51 27.70 d
Cr 52 83.789
Cr 53 9.501
Cr 54 2.365
Cr 55 3.50 m
V 43 >800 ms
V 44
V 45 547 ms
V 46 422.6 ms
V 47 32.6 m
V 49 330 d
V 50 0.250
V 51 99.750
V 52 3.75 m
V 53 1.6 m
V 54 49.8 s
Ti 42 0.20 s
Ti 43 509 ms
Ti 44 60.4 a
Ti 45 3.08 h
Ti 46 8.25
Ti 48 73.72
Ti 49 5.41
Ti 50 5.18
Ti 51 5.8 m
Ti 52 1.7 m
Ti 53 32.7 s
Sc 41 596 ms
Sc 42
Sc 43 3.89 h
Sc 44
Sc 45 100
Sc 47 3.35 d
Sc 48 43.67 h
Sc 49 57.2 m
Sc 50 1.7 m
Sc 51 12.4 s
Sc 52 8.2 s
Ca 42 0.647
Ca 43 0.135
Ca 44 2.086
Ca 45 163 d
Ca 46 0.004
Ca 47 4.54 d
Ca 48 0.187
K 41
K 42
K 43
K 44
K 45
K 46
K 47

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	E6 transition	A_p 10^3 (e fm^6)	A_n 10^3 (e fm^6)
^{53}Fe	$19/2^- \rightarrow 7/2^-$	4.40	0.22
^{52}Cr	$0^+ \rightarrow 6^+$	5.01	1.51
^{50}Ti	$0^+ \rightarrow 6^+$	5.63	1.62
^{58}Ni	$0^+ \rightarrow 6^+(2)$	6.42	7.25
^{58}Ni	$0^+ \rightarrow 6^+(3)$	2.98	−3.50

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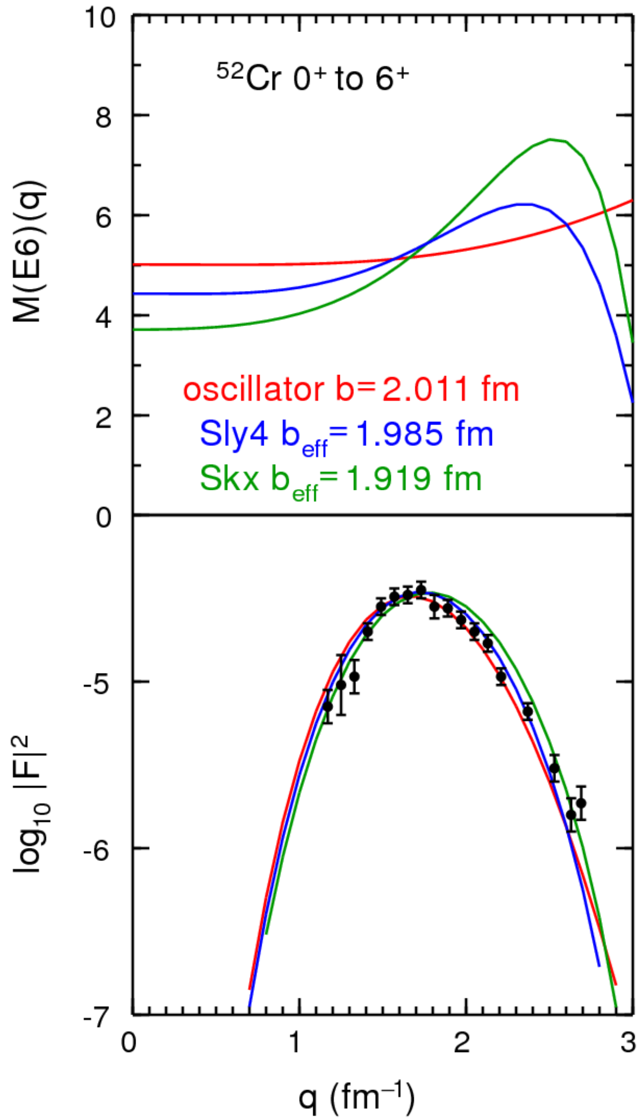
1983 ^{52}Cr(e,e')



$$e_p = 1 \text{ and } e_n = 0$$

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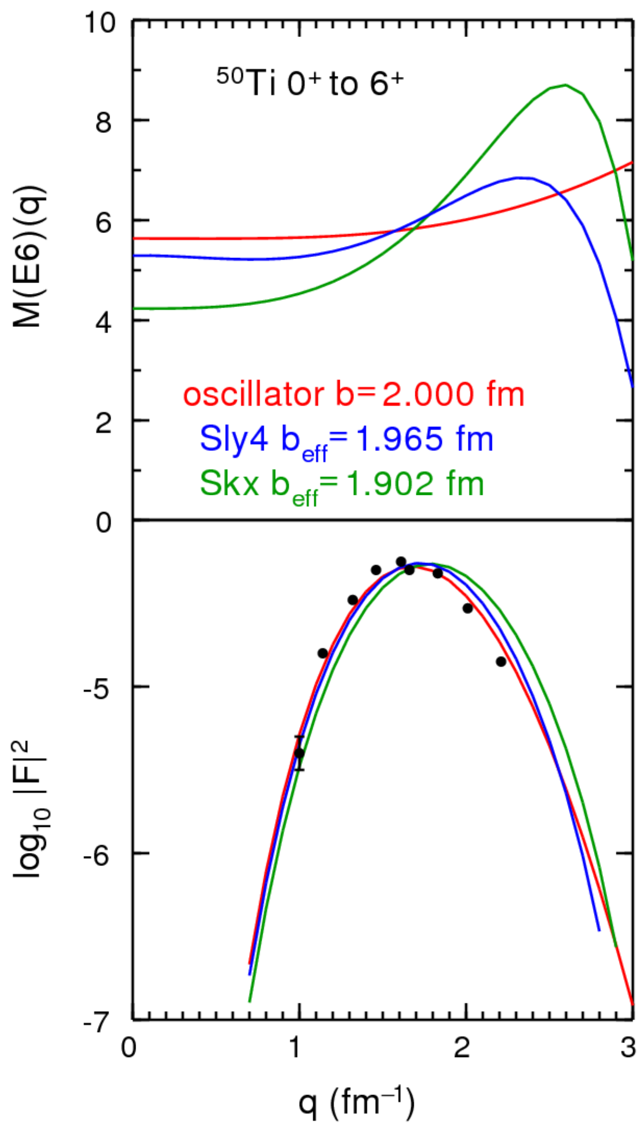
1988 ^{50}Ti(e,e')



$e_p = 1$ and $e_n = 0$

Longitudinal form factor for $E6(C6)$ in the oscillator model ($L = 6$, b is the oscillator length)

$$F(q) \approx (qb)^L \exp[-(bq)^2/2]$$

has a maximum at

$$q_{max} = \sqrt{2L/b^2}$$

and since

$$q_{max} b = \sqrt{2L}$$

the value at the maximum is independent of b

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VOLUME 41, NUMBER 25 PHYSICAL REVIEW LETTERS 18 DECEMBER 1978

Isoscalar Character of the $J^{\pi} = 6^{+}$, $E_x = 5.125$ MeV State in ^{58}Ni

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C. F. Williamson and S. Kowalski

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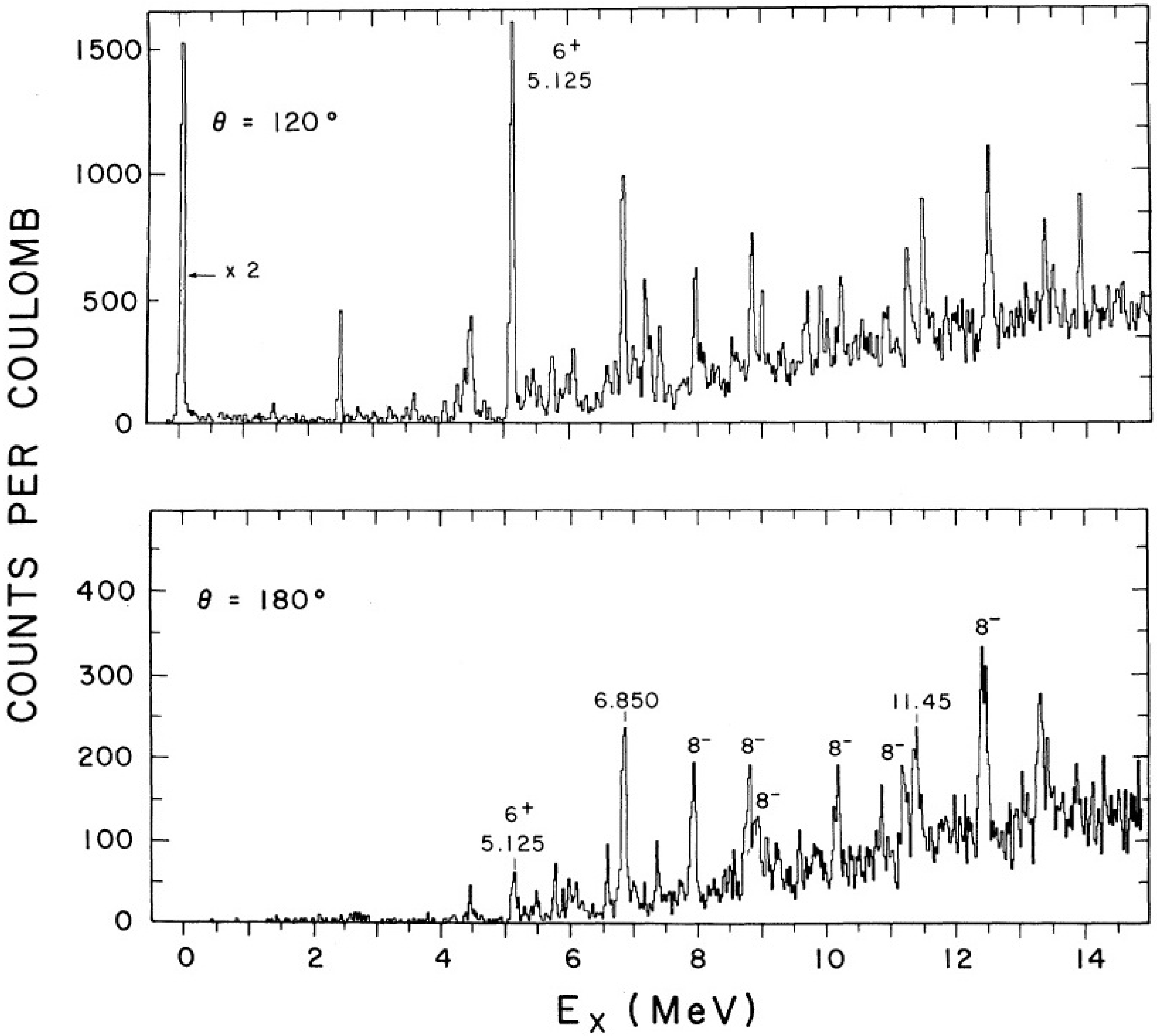
Alex Brown, May 19, 2010

1979 ^{58}Ni(e,e')



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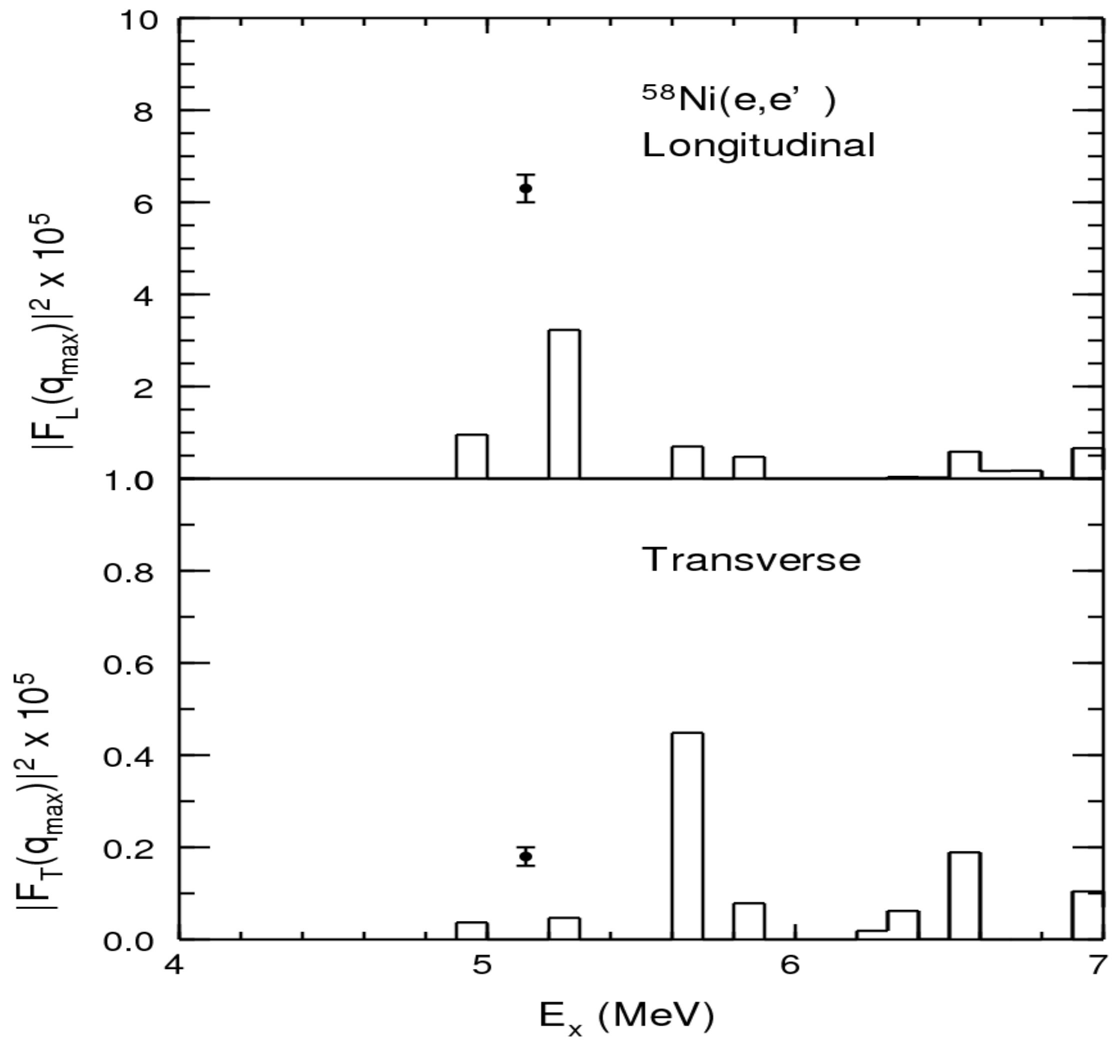
The main component for the E6 excitation in ^{58}Ni is
$(f_{7/2})^{16}(p_{3/2})^2(0^+) \rightarrow (f_{7/2})^{15}(p_{3/2})^2, f_{5/2}(6^+)$
e.g. an $f_{7/2}$ to $f_{5/2}$ transition



PHYSICAL REVIEW C VOLUME 19, NUMBER 2 FEBRUARY 1979

Core polarization charge for $E6$ transition

Hiroyuki Sagawa*

	δe_p			δe_η		
L	2	4	6	2	4	6
Gillet	0.095	0.114	0.103	0.457	0.428	0.212
G matrix	0.154	0.115	0.076	0.428	0.363	0.267
Serber	0.257	0.191	0.126	0.514	0.382	0.253
Wigner	0.483	0.067	−0.138	0.664	0.299	0.076
Rosenfeld	0.079	0.156	0.164	0.357	0.402	0.351
ATO	0.289	0.040	−0.083	0.462	0.344	0.227
Schematic	0.19	0.18	−0.06	0.81	0.82	0.52
Exp.	0.06 ± 0.07		−0.3 ± 0.1	0.57 ± 0.03		

Sagawa – theory summary

	δe_p	δe_n	$\delta e_p + \delta e_n$	$\delta e_p - \delta e_n$
E2	0.19	0.81	1.00	−0.62
E4	0.18	0.82	1.00	−0.64
E6	−0.06	0.52	0.46	−0.58

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experimental summary

	δe_p	δe_n	$\delta e_p + \delta e_n$	$\delta e_p - \delta e_n$
E2	0.2	0.8	1.0	−0.6
E4			1.0	
E6	−0.2	0.6	0.4	−0.8

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$\delta e_p + \delta e_n$ is determined by coupling of the valence nucleon with the L-pole isoscalar (ΔT=0) giant resonance. Attractive particle-hole interaction for ΔT=0 means that the energy of the resonance is lower than $L\hbar\omega$ and that $\delta e_p + \delta e_n > 0$.

$\delta e_p - \delta e_n$ is determined by coupling of the valence nucleon with the L-pole isovector (ΔT=1) giant resonance. Repulsive particle-hole interaction for ΔT=1 means that the energy of the resonance is higher than $L\hbar\omega$ and that $\delta e_p - \delta e_n < 0$.

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PRL 93, 222501 (2004) PHYSICAL REVIEW LETTERS week ending 26 NOVEMBER 2004

Effective Charges in the fp Shell

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Following the heavy-ion fusion-evaporation reaction $^{32}S + ^{24}Mg$ at 95 MeV beam energy the lifetimes of analogue states in the $T_z = \pm 1/2$ $A = 51$ mirror nuclei ^{51}Fe and ^{51}Mn have been measured using the Cologne plunger device coupled to the GASP γ-ray spectrometer. The deduced $B(E2; 27/2^- \rightarrow 23/2^-)$ values afford a unique opportunity to probe isoscalar and isovector polarization charges and to derive effective proton and neutron charges, ε_p and ε_n, in the fp shell. A comparison between the experimental results and several different large-scale shell-model calculations yields $\varepsilon_p \sim 1.15e$ and $\varepsilon_n \sim 0.80e$.

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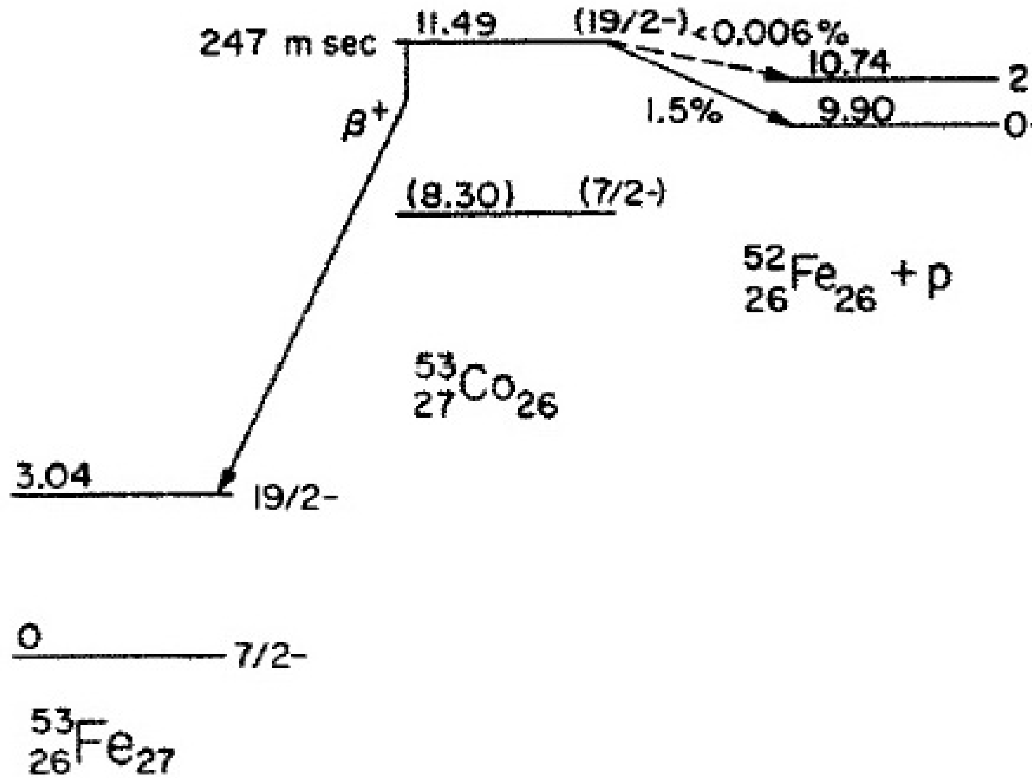
1970 first proton decay from an isomer - in ^{53}Co



Alex Brown, May 19, 2010

Isomeric proton decay ^{53}Co $19/2^-$ to ^{52}Fe 0^+

$Q_p = 1.59(3)$ MeV

$T_{1/2} = 17$ s

Must go by ℓ=9 due to mxing with the (n, ℓ, j^π) = (0,9,19/2$^-$) orbital

With Oxbash we can do a shell-model calculation in the model space

$(f_{7/2})^n + (f_{7/2})^{n-1}\ell_{19/2}$

with an Hamiltonian based on N3LO with V_{lowk}

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	S in units of 10^{-9}
exp with r_0 = 1.2 fm	57(20)
exp with r_0 = 1.4 fm	4(2)
theory	12

Typical two-body interaction matrix element

$$< f_{7/2} f_{7/2} 6^+ \mid V \mid f_{7/2} \ell_{19/2} 6^+ > = 50\,\mathrm{keV}$$

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