

One and the Same “Double the Q ” Becomes 5.69×10^{18} , 32, and 8

— The Single Word “Half-Life” Points at Three Mechanisms Whose Sensitivities Differ by 10^{17} — The Geiger--
Nuttall Law Fits Four Nuclides across 24 Orders at $R^2 = 0.99983$ — [Paper 283]

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— *From thinking to syncing.* —

Abstract

“Half-life” is not one mechanism. Alpha decay, beta decay, and gamma transition are called by one word yet depend on the released energy in different forms. This paper asks how large that difference is—the answer is a factor of 10^{17} . No new mathematical theorem and no new law is claimed. First, we actually fit the Geiger--Nuttall law to four nuclides. $\log_{10} t_{1/2} = 1.470203(Z_d/\sqrt{Q}) - 46.749203$, with $R^2 = 0.99983298$ (Section 2). Second, those four points span 24 orders of magnitude. From 2.99×10^{-7} s for ^{212}Po to 1.41×10^{17} s for ^{238}U , with a largest residual of 0.164 decades (Section 2). Third, a mere factor of 2.097 in Q gives a factor of 4.7161×10^{23} in lifetime (Section 3). Fourth, this is the core of the paper. The same “double the Q ” gives 5.69×10^{18} for alpha, 32 for beta, and 8 for gamma (Section 4). Fifth, the span the one word covers is $10^{52.84}$. From 10^{-21} s for resonances to 6.94×10^{31} s for ^{128}Te (Section 5). Sixth, the separator is what has to pass a barrier. Only alpha sends a charged particle under a Coulomb barrier (Section 6).

Scope of this paper (scope note): No new mathematical theorem and no new law is claimed—the Geiger–Nuttall law, Sargent’s rule ($\propto Q^5$), the $\propto E^3$ of E1 transitions, and the measured values of the four nuclides are all standard. We do not build a nuclear model—all we use is one straight-line fit and three exponents. We do not derive Gamow’s theory—we merely quote the form $1/\sqrt{Q}$ and do not enter the WKB approximation. We do not discuss nuclear structure—shell model, deformation, and preformation factors are not treated at all. We claim no generality for the fit—the four nuclides of Section 2 are a sample restricted to ground-state transitions of even-even nuclei, and odd nuclei or hindered transitions depart greatly. The $R^2 = 0.99983$ is a value for these four points. We do not say $Z_d/\sqrt{Q}$ is the only variable—preformation probability, angular-momentum barrier, and nuclear deformation all act. This paper pushes them into the intercept b . We claim no precision for the exponents—both Sargent’s Q^5 and E1’s E^3 are asymptotic forms, and in actual transitions matrix elements move by orders. 32 and 8 are numbers showing whether the form is exponential or a power, not predicted values. We do not assert the two ends of $10^{52.84}$ —the 10^{-21} s is an estimate converted from resonance widths, and the ^{128}Te value also has measurement spread. They are numbers for showing the structure of the orders. Relation to earlier papers: Paper 272 showed that one and the same “twice as strong” opens by a factor of 6.70 on the stimulus side—this paper is the case where the same doubling opens into 5.69×10^{18} , 32, and 8, the same figure at a different order. Paper 240 counted seven things called “mass”—this paper turns “half-life” pointing at three mechanisms into a number, as a difference of sensitivity. Paper 190 measured “rare” on a logarithmic scale—both the 24 decades and the 52.84 decades here must be read logarithmically. Paper 262 showed there are three ways to break and that strength does not decide which—this paper likewise sees three mechanisms under one word. What is added is actually fitting the Geiger–Nuttall law to four nuclides and obtaining $R^2 = 0.99983298$, computing that a factor of 2.097 in Q corresponds to 4.7161×10^{23} in lifetime, lining up the three mechanisms’ responses to the same “doubling” as $5.69 \times 10^{18} / 32 / 8$, and measuring the span the one word covers as $10^{52.84}$.

1. Notation and Standing

The half-life $t_{1/2}$ is defined through the decay constant λ by $t_{1/2} = \ln 2 / \lambda$. This definition applies in the same way to every decay.

Question: Even if the usage is the same, is what sets λ the same?

Three mechanisms:

Mechanism	What leaves	Dependence on released energy
Alpha decay	${}^4\text{He}$ nucleus (charge +2)	$\log_{10} t \propto Z_d/\sqrt{Q}$ (exponential)
Beta decay	Electron and antineutrino	$\lambda \propto Q^5$ (power)
Gamma transition (E1)	Photon	$\lambda \propto E^3$ (power)

Observation 1.1

Only the first row has a different form. Q sits inside the exponent, and moreover as an inverse square root —this is where the difference in orders is born.

2. Fitting the Geiger--Nuttall Law to Four Nuclides

Setting: For alpha decay we take $x = Z_d/\sqrt{Q}$ (Z_d the daughter's atomic number, Q in MeV) as abscissa and $\log_{10} t_{1/2}$ as ordinate.

Check 2.1: We line up the values for four nuclides.

Nuclide	$t_{1/2}$ [s]	Q [MeV]	Z_d	$x = Z_d/\sqrt{Q}$
${}^{238}\text{U}$	1.4101×10^{17}	4.270	90	43.5541
${}^{226}\text{Ra}$	5.0496×10^{10}	4.871	86	38.9663
${}^{222}\text{Rn}$	3.3035×10^5	5.590	84	35.5282
${}^{212}\text{Po}$	2.9900×10^{-7}	8.954	82	27.4035

Check 2.2: We fit by least squares.

Quantity	Value
Slope a	1.470203
Intercept b	−46.749203
Coefficient of determination R^2	0.99983298

Check 2.3: We look at the residuals.

Nuclide	Measured $\log_{10} t$	Predicted	Difference
^{238}U	+17.1492	+17.2841	−0.1348
^{226}Ra	+10.7033	+10.5392	+0.1641
^{222}Rn	+5.5190	+5.4845	+0.0345
^{212}Po	−6.5243	−6.4606	−0.0638

Observation 2.4

The four points span **23.67** decades, yet the largest residual is 0.164 decades. In relative terms, linearity is better than **0.7%**—a single straight line runs through twenty-four orders of magnitude.

Observation 2.5

A point to write honestly—this is a sample chosen to be ground-state transitions of even-even nuclei only. Odd nuclei and transitions that change angular momentum depart by several orders— $R^2 = 0.99983$ is a value for these four points, not for alpha decay in general.

3. A Factor of 2.097 in Q , a Factor of 4.72×10^{23} in Lifetime

Check 3.1: We compare the two ends of the table.

	^{238}U	^{212}Po	Ratio
Q [MeV]	4.270	8.954	2.0970
$t_{1/2}$ [s]	1.4101×10^{17}	2.9900×10^{-7}	4.7161×10^{23}
Spread in $\log_{10}$			23.6736 decades

Observation 3.2

A mere factor of 2.1 in Q gives 4.7×10^{23} in lifetime. ^{238}U lives about the age of the Earth; ^{212}Po is gone in a third of a microsecond—and both are “alpha decay”.

Observation 3.3

This extreme sensitivity follows from Q sitting inside an exponential. Z_d moves slightly too ($90 \rightarrow 82$), but what dominates is the $\sqrt{Q}$ side.

4. The Core: The Same “Doubling” Gives 5.69×10^{18} , 32, and 8

Setting: We apply exactly the same operation to all three mechanisms. We double the released energy exactly.

Check 4.1:

Mechanism	Form of dependence	Factor on the decay rate
Alpha ($Z_d = 90$, $Q : 4.270 \rightarrow 8.540$)	$\log_{10} t \propto 1/\sqrt{Q}$	5.6874×10^{18}
Beta (Sargent’s rule)	$\lambda \propto Q^5$	$2^5 = 32$
Gamma (E1 transition)	$\lambda \propto E^3$	$2^3 = 8$

Observation 4.2

This is the core of the paper. The input is “exactly double” in every case, yet the outputs are 5.69×10^{18} , 32, and 8—top and bottom differ by 7.1×10^{17} , that is a sensitivity gap of about 10^{17} .

Observation 4.3

32 and 8 are close (a factor of 4). Beta and gamma are both powers, differing only in exponent 5 versus 3—the one standing apart is alpha.

Check 4.4: We look at beta’s Q^5 numerically.

Q [MeV]	Relative decay rate Q^5
0.5	0.0312
1.0	1.0000
2.0	32.0000
4.0	1024.0000

Observation 4.5

An eightfold Q gives only 32768 for beta. For alpha a twofold Q gives 5.69×10^{18} —the gap between power and exponential widens the further the comparison is extended (Paper 190).

Observation 4.6

A point to write honestly—both 32 and 8 are numbers from asymptotic forms, and in actual transitions matrix elements move by orders. They are numbers showing whether the form is exponential or a power, not predictions for individual nuclides.

5. The Span the One Word Covers Is $10^{52.84}$

Check 5.1: We take the two ends of what is called a “half-life.”

	$t_{1/2}$
Resonance state (converted from width)	$\sim 10^{-21}$ s
^{128}Te double beta decay	2.2×10^{24} yr = 6.9427×10^{31} s
Ratio	$6.9427 \times 10^{52} = 10^{52.84}$

Observation 5.2

One word covers a factor of $10^{52.84}$. The age of the universe is about 4.35×10^{17} s, so the upper end is 1.6×10^{14} times the age of the universe—a region where “wait until half remains” cannot in principle be carried out.

Observation 5.3

The lower end cannot be carried out either. The 10^{-21} s was not measured directly but converted from a resonance width via $\Gamma\tau \sim \hbar$ —at both ends, nothing was measured as the definition literally says.

Observation 5.4

So “half-life” has one definition but three or more ways of being measured. Wait; fit a decay curve; convert from a resonance width—the same figure by which Paper 240 split “mass” into seven here lies on the side of the measurement method.

6. Separator: What Has to Pass a Barrier

Observation 6.1

Separator—what must be moved for the sensitivity to change from exponential to power? Whether what leaves carries charge.

Observation 6.2

An alpha particle carries charge $+2$ and must tunnel through the daughter’s Coulomb barrier. The transmission depends exponentially on the barrier’s height and width, and that width is set by Q —here the exponential is born.

Observation 6.3

An electron carries charge, but is created at the instant of decay and so does not tunnel. A photon carries no charge—for both there is no barrier problem, only the volume of phase space acts, and so the form is a power.

Observation 6.4

Hence what separates the three is neither the strength of the nuclear force nor the size of the nucleus. It is whether what leaves has a barrier to pass—a conclusion of the same shape as Paper 262's, that “breaking” cannot be separated by strength.

Check 6.5: Comparison with Paper 272.

	The same “doubling” as input	Spread of outputs
Paper 272 (sensation and stimulus)	Sensation doubles	6.70
This paper (three decay mechanisms)	Q doubles	7.1×10^{17}

Observation 6.6

The figure is the same and the order differs by 17. In Paper 272 only the power exponents differed, whereas here one of them is an exponential—even within “several mechanisms under one word,” there are classes of how widely they open.

7. Roll Call and Closing

1. $a = 1.470203$, $b = -46.749203$ (Check 2.2): Fit to four nuclides.
2. $R^2 = 0.99983298$ (Check 2.2): One line through 23.67 decades.
3. Largest residual 0.164 decades (Check 2.3): Under 0.7% relative.
4. Q by 2.0970 (Check 3.1): Lifetime by 4.7161×10^{23} .
5. Alpha: doubling gives 5.6874×10^{18} (Check 4.1): Because it is exponential.
6. Beta: doubling gives 32 (Check 4.1): Q^5 .

7. **Gamma: doubling gives 8** (Check 4.1): E^3 .
8. **Sensitivity gap 7.1×10^{17}** (Observation 4.2): **Identical input**.
9. **One word covers $10^{52.84}$** (Check 5.1): **Neither end measured directly**.
10. **The separator is charge** (Observation 6.4): **Only alpha passes a barrier**.

Closing: “Half-life” has one definition and three mechanisms. For alpha decay, the Geiger--Nuttall law runs through four nuclides and 23.67 decades at $R^2 = 0.99983298$, and a mere factor of 2.0970 in Q gives 4.7161×10^{23} in lifetime. We then apply the same operation——doubling the released energy exactly gives 5.6874×10^{18} for alpha, **32** for beta, and **8** for gamma. The input is identical, and the outputs open by 7.1×10^{17} . And the span the one word covers is $10^{52.84}$, with neither end measured as the definition “wait until half remains” literally says. One thing separates them——whether what leaves has a barrier to pass. If it has, the form is exponential; if not, a power. Not the strength of the nuclear force, not the size of the nucleus, but the presence or absence of charge makes a sensitivity gap of 10^{17} .

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