Predictions of Spontaneous Fission Half-Lives for Heavy Nuclei*

DAVID W. DORN
Lawrence Radiation Laboratory, University of California, Livermore, California
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Swiatecki's work on correlation of spontaneous fission half-lives has been modified and extended to include elements beyond $Z=100$. The values of spontaneous fission half-lives predicted on these bases are unexpectedly high. For example, the partial half-life for $Z=106$, $A=271$ is predicted to be about 13 years.

In the past, various authors have attempted to correlate spontaneous fission half-lives.[1–7] Swiatecki,[4] who was able to show the regular dependence of the half-life on ground-state masses, has been the most successful at establishing a physical interpretation.

The present work is an extension and minor revision of Swiatecki's. The constant term of his formulation has been changed and an additional term in $Z^{\frac{1}{2}}/A$ has been added. The revised expression used in these calculations is

$$\log_{10}\begin{Bmatrix} T_{\frac{1}{2}}\ e\text{-}e \\ T_{\frac{1}{2}}\ \text{odd-}A \\ T_{\frac{1}{2}}\ o\text{-}o \end{Bmatrix} = \begin{Bmatrix} -30.06 \\ -23.46 \\ -18.56 \end{Bmatrix} -7.8\theta+0.35\theta^2+0.073\theta^3 +1389(Z^{\frac{1}{2}}/A)-(4\text{-}\theta)\delta m. \quad (1)$$

$\theta=Z^2/A-37.5$; δm is the difference in Mev between the semiempirical ground-state mass of a nucleus as given by Cameron[8] and the smooth mass surface as quoted by Swiatecki[4]:

$$M=1000A-8.3557A+19.120A^{\frac{2}{3}}+0.76278(Z^2/A^{\frac{1}{3}}) +25.444(N\text{-}Z)^2/A+0.420(N\text{-}Z). \quad (2)$$

The half-life given by (1) is in seconds.

Table I shows the logarithm of the predicted spontaneous fission half-lives for selected nuclei up through element 106. Where possible, the experimental value as given in reference 7, is also listed.

Perhaps the most important conclusion to be drawn is that, contrary to some estimates,[6] the spontaneous fission half-life of these heavy elements may indeed be long enough to make their production feasible.[9]

TABLE I. Logarithm (base 10) of the spontaneous fission half-life in seconds.

Element	Experimental[a]	Theoretical	Element	Experimental[a]	Theoretical
U^{233}	...	25.75	E^{255}	...	9.86
U^{234}	23.69	23.03	E^{256}	...	11.55
U^{235}	24.75	26.58			
U^{236}	23.79	23.53	Fm^{254}	7.32	6.28
U^{237}	...	26.90	Fm^{255}	>9.27	10.75
U^{238}	23.26	22.93	Fm^{256}	4.04	4.63
U^{239}	...	25.31	Fm^{257}	...	8.75
U^{240}	...	21.30	Fm^{258}	...	2.56
Np^{236}	...	25.74	Mv^{258}	...	12.02
Np^{237}	...	24.01	Mv^{259}	...	7.29
Np^{238}	...	26.07	Mv^{260}	...	9.78
Np^{239}	...	23.54	Mv^{261}	...	5.09
Pu^{237}	...	22.37	No^{259}	...	8.65
Pu^{238}	18.18	18.77	No^{260}	...	2.15
Pu^{239}	23.23	23.06	No^{261}	...	7.03
Pu^{240}	18.57	18.78	No^{262}	...	0.58
			No^{263}	...	5.01
Am^{241}	...	20.48			
Am^{242}	...	22.77	103^{265}	...	4.71
Am^{243}	...	19.88	103^{266}	...	7.49
Am^{244}	...	22.00	103^{267}	...	2.39
			103^{268}	...	4.70
Cm^{242}	14.35	14.48			
Cm^{243}	...	19.03	104^{266}	...	0.24
Cm^{244}	14.64	14.34	104^{267}	...	5.37
Cm^{245}	...	18.75	104^{268}	...	−1.54
Cm^{246}	14.79	14.69	104^{269}	...	3.17
			104^{270}	...	−3.73
Bk^{247}	...	16.49			
Bk^{248}	...	20.00	105^{270}	...	9.82
Bk^{249}	16.27	17.01	105^{271}	...	4.25
Bk^{250}	...	18.33	105^{272}	...	7.31
			105^{273}	...	1.76
Cf^{248}	11.34	10.88			
Cf^{249}	16.67	16.11	106^{271}	...	8.18
Cf^{250}	11.67	11.30	106^{272}	...	0.70
Cf^{251}	...	15.05	106^{273}	...	6.09
Cf^{252}	9.31	9.21	106^{274}	...	−1.35
			106^{275}	...	3.71
E^{253}	12.97	12.26	106^{276}	...	−3.67
E^{254}	12.67	14.30			

[a] See reference 7.

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9 *Note added in proof.* A similar conclusion has also been reached by F. Hoyle and W. A. Fowler, Astrophys. J. **132**, 565 (1960), on the basis of unified model calculations by S. A. E. Johansson, Nuclear Phys. **12**, 449 (1959).