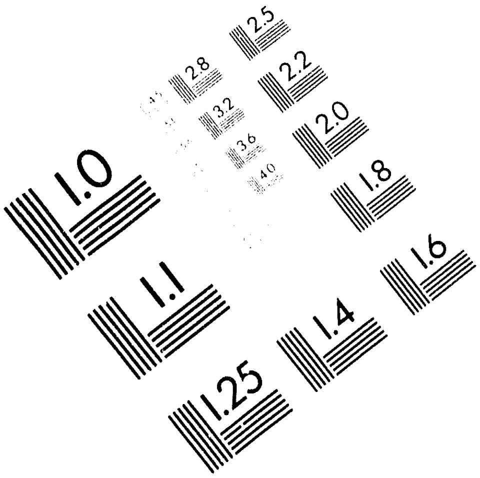
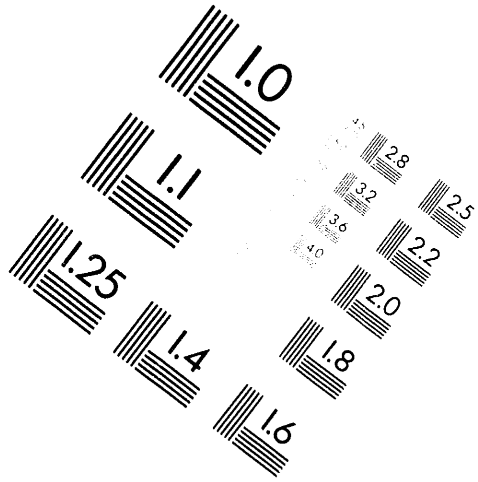

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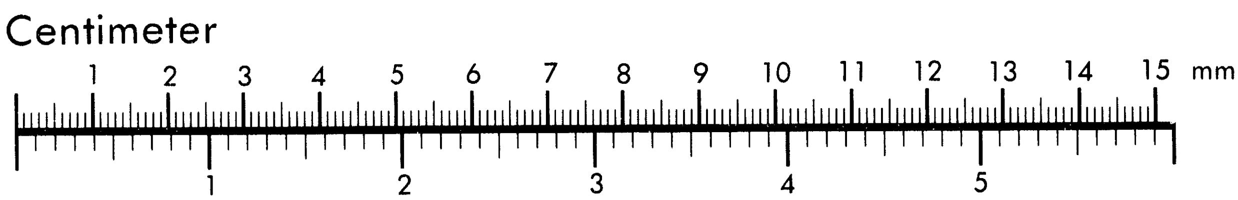

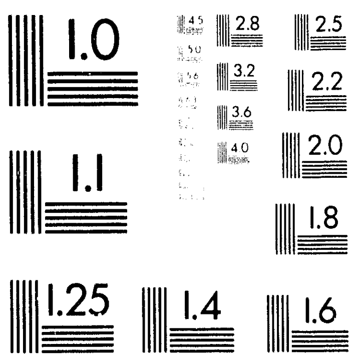

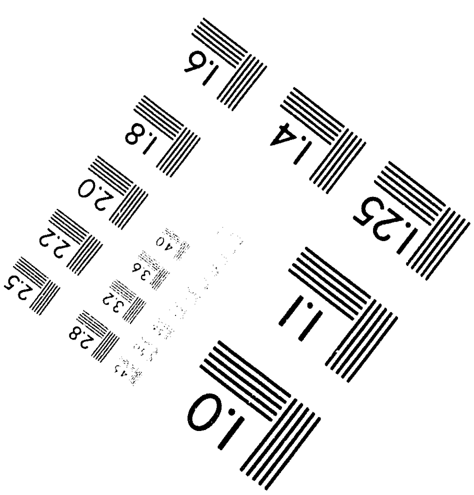
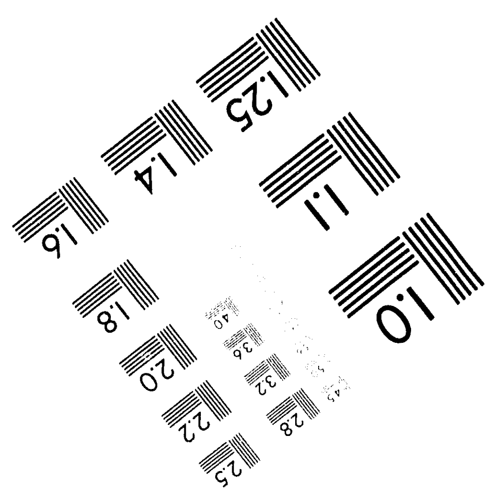

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Title: Proposal for Experiments with Actinide Elements

Author(s): R. G. Sanchez

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Proposal for Experiments with Actinide Elements

It is well known that actinides with even number of neutrons, for example $_{93}Np^{237}$, $_{94}Pu^{238}$, $_{94}Pu^{240}$, $_{95}Am^{241}$, $_{95}Am^{243}$, and $_{96}Cm^{244}$, can most probably be made critical with fast neutrons. Computer calculations and replacement measurement techniques have predicted that critical masses for these elements may be in kilogram quantities. Nonetheless, no direct measurements have been performed to estimate the critical masses for these elements.

Similarly, other actinides such as $_{94}Pu^{241}$, $_{95}Am^{242m}$, $_{96}Cm^{243}$, and $_{96}Cm^{245}$ among others with odd number of neutrons more likely can be made critical because they exhibit high fission cross sections at low neutron energies. Analytical studies indicate that when these elements are mixed and reflected with water, their critical masses may be in gram quantities. However, no experiments have been performed to confirm these results.

Thus, we have completed an analytical study where critical masses for some of these elements were calculated with the Monte Carlo Neutron Photon (MCNP) Transport computer code. For each case, a total of three-hundred-thousand source histories was run and continuous energy cross section data used.

For those actinide elements with even number of neutrons, the computer model consisted of a sphere which was assumed to contain any of the even-neutron nuclides in a metal form. This sphere was surrounded in some cases by a reflector which was assumed to be beryllium, steel, or water. On the other hand, for those actinides with odd number of neutrons, the computer model consisted of a sphere in which any of those odd-neutron nuclides was assumed to be idealized metal-water mixtures. The sphere was surrounded by a 20 cm thick water or beryllium reflector. The computer models are shown in Fig. 1 and 2.

Table 1 shows the critical masses obtained in this analytical study for some of the actinide elements. In addition, critical masses that have been deduced from indirect data from reactivity coefficient measurements are presented in this table.

It is important to point out that for those actinide elements with even number of neutrons, there are significant uncertainties in the critical masses predicted by computational calculations compared to those estimated by the data from the reactivity coefficient measurements as seen in table 1 and reported in Ref. 1. No experiments have been performed involving actinide elements with odd number of neutrons. Therefore, we strongly believe that an experimental program for actinides should be established so that we can address the inadequacies seen in table 1 and be able to benchmark our computational calculations against well-characterized experiments.

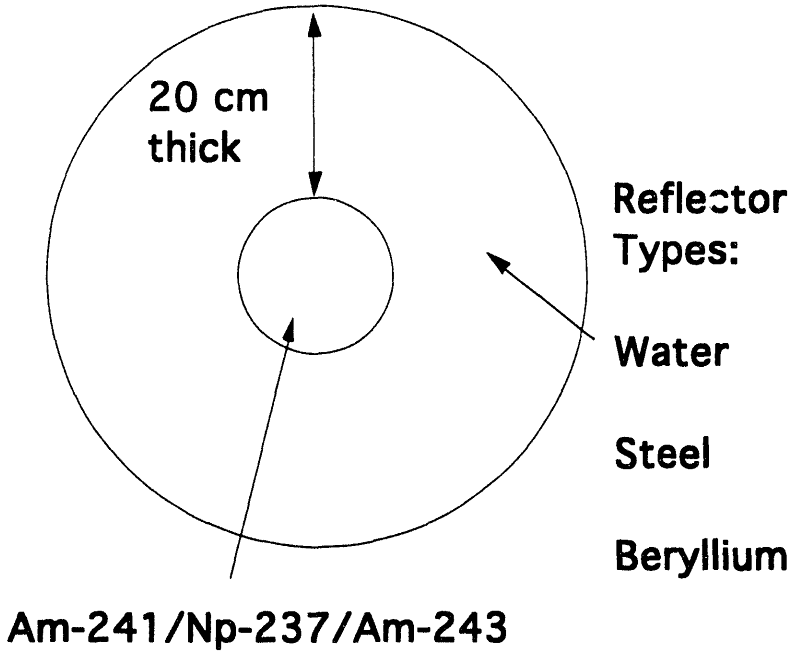

Figure 1 Computer model used for actinide elements with even number of neutrons.

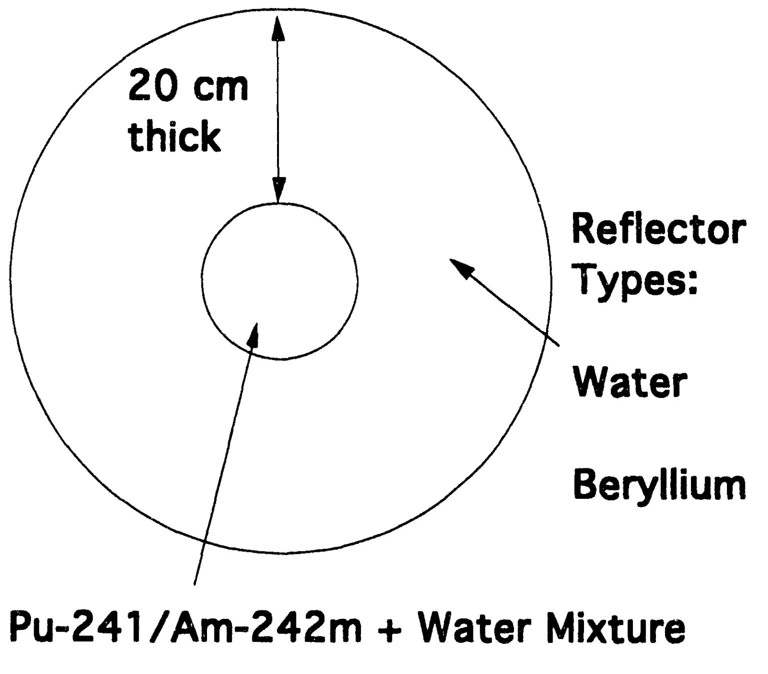

Figure 2 Computer model used for actinide elements with odd number of neutrons.

Table 1 Critical masses for actinide elements.

Even-neutron Nuclides

$_{93}Np^{237}$

Computational Results			Indirect Experimental Measurements	
Type of Reflector	Total Np-237 Mass (kg)	keff	Type of Reflector	Critical Mass (kg)
Bare	55.9	0.992 ± 0.0023	Bare	88
Steel	33.0	0.988 ± 0.0028	Steel	55
Water	51.1	0.992 ± 0.0029	Water	83
Beryllium	33.0	0.953 ± 0.0027	Beryllium	N/A
Nat. Uranium	33.0	0.993 ± 0.0024	Nat. Uranium	N/A

$_{94}Pu^{242}$

Computational Results			Indirect Experimental Measurements	
Type of Reflector	Total Pu-242 Mass (kg)	keff	Type of Reflector	Critical Mass (kg)
Bare	85.0	0.994 ± 0.0014	Bare	90
Water	80.0	0.997 ± 0.0014	Water	84
Steel	50.0	1.000 ± 0.0018	Steel	56
Beryllium	60.0	0.995 ± 0.0016	Beryllium	N/A

$_{95}Am^{241}$

Computational Results			Indirect Experimental Measurements	
Type of Reflector	Total Am-241 Mass (kg)	keff	Type of Reflector	Critical Mass (kg)
Bare	110.0	0.999 ± 0.0015	Bare	58
Steel	62.0	0.995 ± 0.0018	Steel	34
Water	95.0	0.993 ± 0.0017	Water	51
Beryllium	80.0	0.995 ± 0.0016	Beryllium	N/A

$_{95}Am^{243}$

Computational Results			Indirect Experimental Measurements	
Type of Reflector	Total Am-243 Mass (kg)	keff	Type of Reflector	Critical Mass (kg)
Bare	150.0	0.993 ± 0.0014	Bare	N/A
Steel	95.0	0.996 ± 0.0017	Steel	N/A
Water	140.0	0.997 ± 0.0019	Water	N/A
Beryllium	110.0	0.995 ± 0.0019	Beryllium	N/A

Table 1 Critical masses for actinide elements (cont.)

$_{94}Pu^{241}$					
Computational Results					
Metal (kg)			Solution (g)		
Type of Reflector	Total Pu-241 Mass (kg)	keff	Type of Reflector	Total Pu-241 Mass (g)	keff
Bare	13.0	1.005 ± 0.0014	Water	270.0	1.000 ± 0.0016
Water	5.7	0.994 ± 0.0016	Beryllium	105.0	0.995 ± 0.0017
Beryllium	3.0	0.999 ± 0.0019	-	-	-

$_{95}Am^{242m}$					
Computational Results					
Metal (kg)			Solution (g)		
Type of Reflector	Total Am-242m Mass (kg)	keff	Type of Reflector	Total Pu-241 Mass (g)	keff
Bare	9.0	0.991 ± 0.0012	Water	20.0	0.999 ± 0.0020
Water	3.25	1.007 ± 0.0020	Beryllium	6.6	0.995 ± 0.0018
Beryllium	1.55	0.997 ± 0.0021	-	-	-

References

1 C. C. Byers, G. E. Hansen, et al, "Reactivity Coefficients of Heavy Isotopes in LASL's Fast Critical Assemblies," Trans. Am. Nucl. Soc., 28, 295 (1978).

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