ALPHA & LAMBDA MODEL

DEFINE SOME UNITS:

$AMU := 1.66 \cdot 10^{-27} \cdot kg$ $eV := 1.6 \cdot 10^{-19} \cdot J$ $MeV := 10^{6} \cdot eV$

CHOOSE TAMPER MATERIAL; "DU" OR "WC"

Avogadro's Number $N_A := 6.02214076 \cdot 10^{23} \cdot \frac{1}{mol}$ $mol = 1\,mol$

Tamper := "WC" **TAMPER RADIUS:** $R_T := 21.21 \cdot cm$

$Ton_{TNT} := 4.2 \cdot 10^{9} \cdot J$ $KT := 1000 \cdot Ton_{TNT}$

CORE DEFINITION

HEU - 235U FRACTION: $HEU\% := 80$ $HEUMASS := 65.8 \cdot kg$ $M_{core} := HEUMASS \cdot \frac{HEU\%}{100} = 52.64\,kg$

GRAM MOLECULAR WEIGHT OF U235 IS
$U235_{gmw} := 235 \cdot gm$

$MolesU235_{kg} := \frac{kg}{U235_{gmw}} \cdot mol = 4.255\,mol$

$NumberAtomsU235_{kg} := MolesU235_{kg} \cdot N_A = 2.563 \times 10^{24}$

DATA := ..\MANHATTAN DATA.xlsx

DATA =

	0	1	2	3	4
0	"ELEMENT"	"r (gm/cm3)"	"lf (cm)"	"lt (cm)"	"n "
1	"U235"	18.71	16.89	3.596	2.637
2	"Pu239"	15.6	14.14	4.108	3.172
3	"DU"	18.95	0	4.342	0
4	"WC"	14.8	0	3.159	0
5	0	0	0	0	0

$\rho := DATA_{1,1} \cdot \frac{gm}{cm^3} = 18.71 \cdot \frac{gm}{cm^3}$ $\lambda_f := DATA_{1,2} \cdot cm = 16.89 \cdot cm$ $\lambda_t := DATA_{1,3} \cdot cm = 3.596 \cdot cm$ $v := DATA_{1,4} = 2.637$

$\rho_{pu} := DATA_{2,1} \cdot \frac{gm}{cm^3} = 15.6 \cdot \frac{gm}{cm^3}$ $\lambda_{f.pu} := DATA_{2,2} \cdot cm = 14.14 \cdot cm$ $\lambda_{t.pu} := DATA_{2,3} \cdot cm = 4.108 \cdot cm$ $v_{pu} := DATA_{2,4} = 3.172$

$\rho_{DU} := DATA_{3,1} \cdot \frac{gm}{cm^3} = 18.95 \cdot \frac{gm}{cm^3}$ $\lambda_{Tamp.DU} := DATA_{3,3} \cdot cm = 4.342 \cdot cm$

$\rho_{wc} := DATA_{4,1} \cdot \frac{gm}{cm^3} = 14.8 \cdot \frac{gm}{cm^3}$ $\lambda_{Tamp.WC} := DATA_{4,3} \cdot cm = 3.159 \cdot cm$

WE NEED TO DEVELOP λs IN TERMS OF ATOMIC CROSS SECTION AND NUCLEI NUMBER DENSITY;

$\rho = 18.71 \cdot \frac{gm}{cm^3}$ $A := 235.04 \cdot \frac{gm}{mol}$ $N_A = 6.022 \times 10^{23} \frac{1}{mol}$ $n := \frac{\rho \cdot N_A}{A} = 1.1267425 \times 10^{22} \frac{kg}{A \cdot mol} \cdot cm^{-3}$

$\sigma_f := 1.235 \cdot barn$ $\lambda_f := \frac{1}{\sigma_f \cdot n} = 0.719 \frac{A \cdot mol}{kg}$ $\sigma_{el} := 4.566 \cdot barn$ $\sigma_t := \sigma_f + \sigma_{el}$ $\lambda_t := \frac{1}{\sigma_t \cdot n} = 15.299 \frac{A \cdot mol}{kg}$ $\sigma_{el.WC} := 6.857 \cdot barn$

$GramMoledWt_{WC} := 195.85 \cdot \frac{gm}{mol}$ $n_{WC} := \frac{\rho_{wc} \cdot N_A}{GramMoledWt_{WC}} = 4.551 \times 10^{22} \cdot cm^{-3}$ $\lambda_{Tamp.WC} := \frac{1}{\sigma_{el.WC} \cdot n_{WC}} = 0.032\,m$

FOR DEPLETED URANIUM:

$\sigma_{el.DU} := 9.360 \cdot barn$ $ADU := 238.05 \cdot \frac{gm}{mol}$ $n_{DU} := \frac{\rho_{DU} \cdot N_A}{ADU} = 4.794 \times 10^{22} \cdot cm^{-3}$ $\lambda_{Tamp.DU} := \frac{1}{\sigma_{el.DU} \cdot n_{DU}} = 0.0223\,m$

$\lambda_T := if(Tamper = "DU", \lambda_{Tamp.DU}, \lambda_{Tamp.WC})$ $\rho_T := if(Tamper = "DU", \rho_{DU}, \rho_{wc})$

REEDS TRANSCENDENTAL EQUATION

Now we let Rc increase to Rexp to allow for expansion of the core during chain reaction. This will decrease ρ and thusdecrease n which increases λs.

THE CORE MASS REMAINS CONSTANT, BUT THE DENSITY DECREASES WITH INCREASING R_c TO R_{exp}. THE MEAN-FREE-PATHS CORRESPONDLING INCREAST

$M_{core} = 52.64\,kg$ $R_c := \sqrt[3]{\frac{3 \cdot M_{core}}{4 \cdot \pi \cdot \rho}} = 8.758 \cdot cm$ $M_{Tamper} := \frac{4}{3} \cdot \pi \cdot \left(\rho_T \cdot R_T^3 - \rho_T \cdot R_c^3\right) = 549.885\,kg$

NOW WE DEFINE A RANGE OF 25 R_{exp} VALUES TO GET THE RESULTING α VALUES $maxk := 50$

$k := 0..maxk$ $\Delta r := 0.01 \cdot cm$ $R_{exp_k} := R_c + k \cdot \Delta r$ $max(R_{exp}) = 9.258 \cdot cm$ $R_{Texp_k} := R_T + k \cdot \Delta r$ $max(R_{Texp}) = 21.71 \cdot cm$

$\rho_{exp} := \frac{3}{4 \cdot \pi} \cdot M_{core} \cdot (R_{exp})^{-3}$ $n_{exp} := \frac{\rho_{exp} \cdot N_A}{A}$ $\rho_{Texp_k} := \frac{3 \cdot M_{Tamper}}{4 \cdot \pi \cdot \left[(R_{Texp_k})^3 - (R_{exp_k})^3\right]}$ $n_{Texp} := if\left(Tamper = "DU", \frac{\rho_{Texp} \cdot N_A}{A}, \frac{\rho_{Texp} \cdot N_A}{GramMoledWt_{WC}}\right)$

$\lambda_t := \frac{1}{\sigma_t \cdot n_{exp}}$ $\lambda_f := \frac{1}{\sigma_f \cdot n_{exp}}$ $\lambda_T := \text{if}\left(\text{Tamper} = \text{"DU"}, \frac{1}{\sigma_{el.DU} \cdot n_{Texp}}, \frac{1}{\sigma_{el.WC} \cdot n_{Texp}}\right)$ $\max(\lambda_T) = 0.034\,m$ $\min(\lambda_T) = 0.032\,m$

$\Lambda := \frac{\lambda_T}{\lambda_t}$

$\alpha := \overrightarrow{\text{Ans}(R_{exp}, R_{Texp}, \lambda_T, \lambda_f, \lambda_t, v, \Lambda)}$ $r := R_{exp}$ $\frac{\max(\lambda_T)}{\min(\lambda_T)} = 1.064$

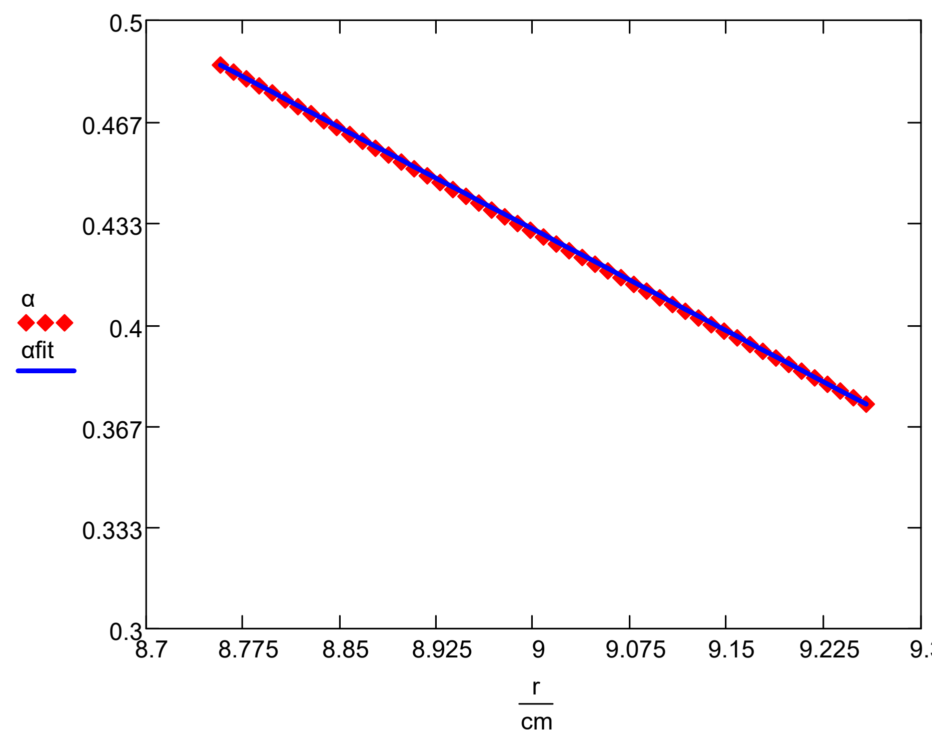
$\text{zero}\alpha := \text{maxk}$ $\text{slope} := \frac{\alpha_{\text{zero}\alpha} - \alpha_0}{\frac{r_{\text{zero}\alpha}}{cm} - \frac{r_0}{cm}} = -0.223$ $\alpha\text{fit} := \text{slope} \cdot \left(\frac{r - r_0}{cm}\right) + \alpha_0$ $\text{alphafit} := \begin{pmatrix} \alpha_0 \\ \text{slope} \end{pmatrix}$ $\text{alphafit} = \begin{pmatrix} 0.485 \\ -0.223 \end{pmatrix}$

$\alpha =$

	0
35	0.407
36	0.404
37	0.402
38	0.4
39	0.398
40	0.396
41	0.393
42	0.391
43	0.389
44	0.387
45	0.385
46	0.382
47	0.38
48	0.378
49	0.376
50	...

$r =$ (·cm)

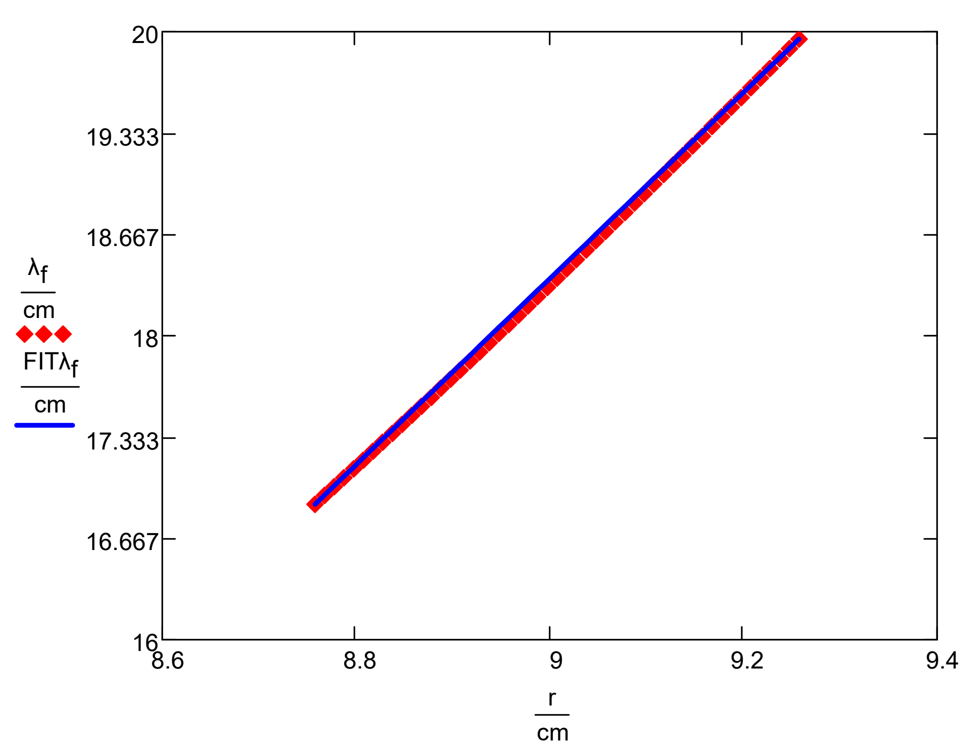
	0
0	8.758
1	8.768
2	8.778
3	8.788
4	8.798
5	8.808
6	8.818
7	8.828
8	8.838
9	8.848
10	8.858
11	8.868
12	8.878
13	8.888
14	8.898
15	...



$\lambda_f =$ (·cm)

	0
0	16.891
1	16.949
2	17.007
3	17.065
4	17.123
5	17.182
6	17.24
7	17.299
8	17.358
9	17.417
10	17.476
11	17.535
12	17.595
13	17.654
14	17.714
15	...

$\lambda\text{slope} := \frac{\lambda_{f_{maxk}} - \lambda_{f_0}}{r_{maxk} - r_0} = 6.123$ $\text{FIT}\lambda_f := \lambda\text{slope} \cdot (r - r_0) + \lambda_{f_0}$ $\lambda_{f_0} = 0.169\,m$ $\begin{pmatrix} \frac{\lambda_{f_0}}{m} \\ \lambda\text{slope} \end{pmatrix} = \begin{pmatrix} 0.169 \\ 6.123 \end{pmatrix}$



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