Energy loss of α particles

For the measurements outlined in this experiment the dE/dx of alphas can be written as follows[6]:

$$\frac{dE}{dx} = \frac{2\pi Z_1^2 e^4 N Z}{M_0^2} \ln\left(\frac{2M_0^2 Q_{max} - 2\beta^2}{I^2(1-\beta^2)}\right) \qquad (1)$$

where

- Z_1 The atomic number of the alpha
- e The electronic charge (esu)
- M_0 = rest mass of the electron (g)
- v = velocity of the alpha cm/s
- β = v/c
- NZ = number of electrons/cm^3
- Q_{max} = maximum kinematic transfer from an electron to an alpha particle (ergs)
- I = mean ionization potential (ergs)
- E = energy of the incident particle

The logarithmic term in eq. (1) varies slowly with energy and hence it is approximately correct to write:

$$dE/dx = \frac{\text{constant}}{E} \qquad (2)$$

For a thin foil:

$$E = \left(\frac{dE}{dx}\right) \Delta X \qquad (3)$$

However, from fig. 4.2 it is obvious that for a fairly thick foil there is need to integrate the dE/dx expression over the thickness of the foil since the dE/dx upon entry will be different than its value for the last row of atoms in the foil, the true energy loss can be found as follows:

$$\Delta E = \int \left(\frac{dE}{dx}\right) dx \qquad (4)$$

In eq. (4), the analytic expression for dE/dx is used. It is seen from the experiment that the range curves are perhaps the easiest and best way to get the theoretical value for energy loss. Rearranging eq. (4) and integrating from the incident alpha energy E_0 to zero gives:

$$\text{Range} = \int_{E_0}^{0} \frac{dE}{\left(\frac{dE}{dx}\right)} \qquad (5)$$

In this experiment, both the (dE/dx) and range method of calculating the energy loss of alphas in a variety of materials will be used.

Table 4.1 shows the integrated ranges for the foils that will be studied in this report. These semiempherical values were taken from ref. 7.

Table 4.1 Range of Alpha Particles Versus Energy For Al, Ni, Cu, Ag, Ag and Mylar (Taken from Reference 7)

Range in Units of mg/cm^2

Energy (MeV)	Al	Ag	Au	Cu	N	O	Ne	Mylar	He
.050	.142	.371	.746	.479	.123	.132	.149	.097	.081
.080	.190	.487	.976	.525	.170	.181	.204	.133	.113
.128	.252	.634	1.269	.605	.232	.247	.277	.180	.158
.201	.327	.812	1.620	.726	.312	.330	.367	.238	.219
.400	.497	1.199	2.362	.968	.490	.513	.560	.366	.364
.500	.574	1.369	2.675	1.085	.563	.588	.639	.421	.425
.640	.680	1.597	3.086	1.300	.654	.684	.739	.493	.500
.800	.802	1.854	3.539	1.440	.750	.783	.844	.570	.579
1.000	.959	2.178	4.099	1.688	.863	.900	.969	.665	.671
1.60	1.475	3.209	5.825	2.503	1.193	1.246	1.346	.959	.937
2.00	1.86	3.955	7.039	3.107	1.428	1.493	1.620	1.174	1.121
2.401	2.283	4.758	8.323	3.758	1.687	1.765	1.925	1.412	1.320
2.80	2.745	5.622	9.687	4.455	1.979	2.073	2.269	1.678	1.538
3.20	3.244	6.544	11.126	5.196	2.308	2.418	2.655	1.973	1.778
4.000	4.349	8.549	14.205	6.808	3.079	3.227	3.564	2.658	2.331
5.00	5.920	11.339	18.411	9.057	4.236	4.444	4.931	3.682	3.156
6.40	8.460	15.759	24.929	12.610	6.189	6.487	7.222	5.422	4.556
8.00	11.835	21.512	33.237	17.280	8.851	9.277	10.321	7.829	6.504