Physics 499

Extra Homework Assignment
Meson-Nucleus elastic scattering

Due Before March 18th

Problem : $K^+ - {}^{12}C$ elastic scattering
Reference: Phys. Rev. C30, 1256-1266 (1984).

For this assignment you will determine (numerically) the elastic scattering cross section for K^+ scattering off of nuclei, and if you have time determine the best values of the two parameters to match the data. You will use the Born approximation, which involves solving the following integral numerically:

$$\int_0^\infty V(r) r sin(qr) dr \tag{1}$$

where $q = 2pc/(\hbar c) sin(\theta/2)$. In this expression, θ is the scattering angle, p is the K^+ momentum. We will take the potential to be that of the spherical square well:

$$\begin{aligned} V(r) &= V_0 \; for \; r < R \\ &= 0 \;\; otherwise \end{aligned}$$

The scattring amplitude, $f(\theta)$ from the Born approximation is:

$$f(\theta) = -\frac{1}{\hbar c}\frac{mc^2}{pc}\frac{1}{sin(\theta/2)}\int_0^\infty V(r) r sin(qr) dr \tag{2}$$

and the differential cross section is

$$\frac{d\sigma}{d\Omega} = |f(\theta)|^2 \tag{3}$$

I have attached the data for $K^+ - {}^{12}C$ elastic scattering for a kaon momentum of 800 MeV/c. The rest mass of the K^+ is 493 MeV/c^2.

Your goal is to determine the parameters R and V_0 for a "best fit" of the data, and to graph your calculation with the data. You can build up to this in two parts:

First
Write a computer program that calculates just the differential cross section, $|f(\theta)|^2$

for $K^+ - {}^{12}C$ elastic scattering at K^+ momentum 800 MeV/c. Your program should ask the user to input the potential strength V_0 and nuclear size R. Your program should then output to the screen the cross section for angles $10^\circ \rightarrow 38^\circ$ at two degree increments.

Second
Add to the first part a publication quality graph of your calculation with the $K^+ - {}^{12}C$ elastic scattering data plus error bars from the data of Marlow et. al., that is on the next page.

$^{12}C(K^+,K^-)^{12}C$

Angle		Elastic c.m. cross section		2^+ (4.4 MeV) Cross section	
lab	c.m.	(mb/sr)	Error	(mb/sr)	Error
3.5	3.79	971.00	280.62		
4.5	4.87	522.00	99.70		
5.5	5.95	343.32	44.29		
6.5	7.03	299.51	30.25		
7.5	8.11	257.63	20.38		
8.5	9.19	214.80	16.95	1.069	1.069
9.5	10.28	175.09	13.81	2.937	2.153
10.5	11.35	134.36	9.83	3.061	2.103
11.5	12.43	104.19	7.65	3.587	1.338
12.5	13.51	83.600	5.869	3.390	0.993
13.5	14.69	61.899	4.407	3.613	0.954
14.5	15.67	50.012	3.456	5.036	0.836
15.5	16.75	33.891	2.616	4.978	0.657
16.5	17.83	23.335	1.862	6.027	0.711
17.5	18.91	16.449	1.336	5.475	0.613
18.5	19.99	11.177	0.942	5.483	0.581
19.5	21.06	7.380	0.652	4.944	0.514
20.5	22.14	4.951	0.525	4.870	0.492
21.5	23.21	2.826	0.387	4.494	0.445
22.5	24.29	1.744	0.286	3.639	0.368
23.5	25.37	1.056	0.216	3.529	0.350
24.5	26.44	0.547	0.146	3.057	0.303
25.5	27.51	0.302	0.106	2.587	0.264
26.5	28.59	0.287	0.096	2.064	0.213
27.5	29.66	0.305	0.090	1.613	0.173
28.5	30.73	0.215	0.069	1.310	0.143
29.5	31.80	0.294	0.076	0.964	0.119
30.5	32.87	0.305	0.069	0.552	0.084
31.5	33.94	0.291	0.066	0.421	0.073
32.5	35.01	0.247	0.058	0.267	0.057
33.5	36.08	0.161	0.046	0.237	0.059
34.5	37.14	0.222	0.509	0.181	0.056
35.5	38.21	0.111	0.041	0.138	0.053
36.5	39.27	0.110	0.049		
37.5	40.34	0.147	0.072		
38.5	41.40	0.023	0.026		