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Elastic Scattering of Electrons and Positrons by Point Nuclei

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The Mott cross section has been systematically tabulated, by means of an electronic computer, for intermediate relativistic energies. Results are presented at 15° angular intervals, for electrons and positrons, for $Z=6$, 13, 29, 50, 82, and 92 and for energies 10, 4, 2, 1, 0.7, 0.4, 0.2, 0.1, and 0.05 Mev. Intercomparisons with earlier results are presented, as well as a subsidiary tabulation of a function important in the limit $\theta \rightarrow 0$.

I. INTRODUCTION

THE cross section for elastic scattering of electrons by a point nucleus has been obtained by Mott in terms of Legendre expansions.[1] Various authors have summed these expansions numerically for special situations. In particular, (a) Feshbach has made calculations for many values of the atomic number Z at extreme relativistic energies ($E>4$ Mev)[2]; (b) Bartlett and Watson have determined cross sections for $Z=80$ and energies from 0.024 to 1.7 Mev[3]; (c) Massey has extended the work of Bartlett-Watson to positrons ($Z=-80$)[4]; and (d) Yadav has applied the methods of Bartlett-Watson to $Z=92$, with energies from 0.074 Mev up.[5] In addition, approximate expressions have been derived which converge adequately for small to moderate values of the parameter $q=(Z/137\beta)$.[6,7] As far as we know, systematic tabulations have not been published for most Z at energies below the extreme relativistic range.[8]

As a preliminary to systematic calculations of electron penetration, which require these cross sections as input data, we have produced extensive tabulations for both positrons and electrons. The following paragraphs sketch our calculation procedures, which utilized the SEAC,[9] and discuss the comparison with results obtained in earlier calculations.

II. CALCULATION PROCEDURES

Since our work parallels Feshbach's rather closely, we use his notation in the following brief outline.

The Mott cross section may be written in terms of two functions $F_1(\alpha,q,\theta)$ and $G_1(\alpha,q,\theta)$ which are defined by Legendre expansions. (The dependence on Z and E is expressed parametrically through q and $\alpha=q\beta$.) The coefficients of these two expansions involve complex numbers D_k which depend on ratios of gamma functions with complex arguments. We first wrote a SEAC code to calculate the complex gamma functions by means of

TABLE I. Comparison of typical σ/σ_R values as obtained by different authors.

Z	E	θ	SEAC results	Bartlett and Watson	Feshbach	Curr (α^5)	Curr (α^8, $\beta\approx 1$)	Massey
+80	1.71	30°	1.341	1.34	1.29		1.342	
		150°	0.506	0.51	0.49		0.506	
	0.023	150°	2.057	2.04				
−80	1.71	30°	0.791		0.743		0.788	0.77
		150°	0.1091		0.107		0.12	0.13
	0.023	150°	0.943					0.95
+29	4.0	30°	1.0934		1.08	1.0932	1.0931	
		150°	0.1157		0.113	0.1158	0.1159	
−29	4.0	30°	0.8366		0.828	0.8389	0.8388	
		150°	0.0652		0.07	0.0651	0.0651	
+ 6	0.05	150°	0.8460			0.8460		
− 6	0.05	150°	0.8414			0.8416		

TABLE II. Sample convergence tests for σ/σ_R.

Z	E	θ	18 terms	20 terms	25 terms	30 terms
+80	1.71	30°	1.3385	1.3396	1.3411	1.3407
		150°	0.5077	0.5046	0.5073	0.5068
+80	0.023	30°	1.0248	1.0215	1.0161	1.0160
		150°	2.0609	2.0526	2.0590	2.0573
+29	2.0	30°	1.0923	1.0926	1.0930	1.0932
		150°	0.1444	0.1446	0.14443	0.14447

TABLE III. Values of a coefficient important in the limit $\theta \rightarrow 0$.

q	$\cos\chi$	q	$\cos\chi$
0	1.000	0.50	0.5290
0.05	0.9905	0.60	0.4471
0.10	0.9631	0.80	0.3323
0.15	0.9208	1.00	0.2610
0.20	0.8680	1.20	0.2145
0.30	0.7478	1.50	0.1696
0.40	0.6303	2.00	0.1261

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[1] N. F. Mott, Proc. Roy. Soc. (London) **A124**, 426 (1929); N. F. Mott, Proc. Roy. Soc. (London) **A135**, 429 (1932). See especially N. F. Mott and H. S. W. Massey, *The Theory of Atomic Collisions* (Oxford University Press, New York, 1949), second edition, Chap. IV.

[2] H. Feshbach, Phys. Rev. **88**, 295 (1952).

[3] J. H. Bartlett and R. E. Watson, Proc. Am. Acad. Arts Sci. **74**, 53 (1940).

[4] H. S. W. Massey, Proc. Roy. Soc. (London) **A181**, 14 (1942).

[5] H. N. Yadav, Proc. Phys. Soc. (London) **A68**, 348 (1955).

[6] W. A. McKinley and H. Feshbach, Phys. Rev. **74**, 1759 (1948).

[7] The expansion used in reference 6 has recently been extended by R. M. Curr, Proc. Phys. Soc. (London) **A68**, 156 (1955).

[8] More recently we have learned that N. Sherman [Bull. Am. Phys. Soc. Ser. II, **1**, 2 (1956) has been evaluating the Mott expression in this energy range on UNIVAC using Feshbach's methods. Sherman has also determined the polarization for many situations. See N. Sherman, Phys. Rev. **103**, 1601 (1956), following paper.

[9] This is the electronic digital computer at the National Bureau of Standards in Washington, D. C.

TABLE IV. The ratio σ/σ_R of the Mott to the Rutherford cross section: electron scattering.

E(Mev) θ	10	4	2	1	0.7	0.4	0.2	0.1	0.05
				$Z=6$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	0.999	0.999	1.000	1.000	1.001	1.002	1.003	1.004	1.004
30	0.961	0.962	0.963	0.967	0.970	0.977	0.987	0.996	1.001
45	0.888	0.890	0.894	0.903	0.911	0.929	0.954	0.976	0.990
60	0.788	0.790	0.797	0.814	0.828	0.860	0.906	0.946	0.974
75	0.666	0.669	0.680	0.705	0.728	0.776	0.846	0.909	0.953
90	0.532	0.537	0.551	0.586	0.617	0.683	0.781	0.868	0.930
105	0.397	0.403	0.421	0.466	0.505	0.590	0.714	0.826	0.905
120	0.269	0.277	0.298	0.352	0.400	0.501	0.651	0.786	0.882
135	0.1591	0.1680	0.1923	0.254	0.308	0.425	0.596	0.751	0.862
150	0.0742	0.0839	0.1106	0.1787	0.238	0.366	0.554	0.725	0.846
165	0.0206	0.0310	0.0591	0.1310	0.1938	0.328	0.527	0.708	0.836
180	0.0024	0.0129	0.0416	0.1148	0.1786	0.316	0.518	0.702	0.833
				$Z=13$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	1.020	1.020	1.020	1.020	1.019	1.019	1.018	1.015	1.013
30	0.997	0.998	0.999	1.001	1.003	1.008	1.013	1.017	1.017
45	0.935	0.936	0.939	0.947	0.954	0.968	0.988	1.004	1.013
60	0.838	0.840	0.846	0.861	0.874	0.903	0.943	0.977	0.999
75	0.714	0.718	0.727	0.752	0.773	0.818	0.883	0.941	0.979
90	0.575	0.580	0.594	0.628	0.658	0.722	0.815	0.898	0.955
105	0.431	0.438	0.455	0.499	0.538	0.621	0.743	0.852	0.928
120	0.294	0.302	0.323	0.377	0.424	0.525	0.674	0.808	0.902
135	0.1742	0.1831	0.207	0.270	0.324	0.441	0.613	0.769	0.879
150	0.0813	0.0912	0.1179	0.1868	0.247	0.376	0.566	0.738	0.861
165	0.0226	0.0329	0.0614	0.1342	0.1980	0.334	0.536	0.719	0.850
180	0.0024	0.0131	0.0419	0.1163	0.1811	0.320	0.526	0.712	0.846
				$Z=29$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	1.069	1.068	1.068	1.066	1.064	1.059	1.050	1.038	1.026
30	1.094	1.093	1.093	1.092	1.091	1.089	1.082	1.070	1.054
45	1.066	1.066	1.068	1.072	1.074	1.080	1.085	1.082	1.072
60	0.987	0.988	0.993	1.004	1.013	1.032	1.057	1.073	1.076
75	0.865	0.868	0.876	0.896	0.914	0.952	1.004	1.045	1.067
90	0.712	0.716	0.729	0.761	0.788	0.847	0.931	1.003	1.047
105	0.543	0.549	0.566	0.610	0.648	0.729	0.848	0.952	1.022
120	0.375	0.383	0.405	0.460	0.508	0.611	0.763	0.900	0.995
135	0.224	0.234	0.259	0.325	0.382	0.505	0.687	0.852	0.970
150	0.1052	0.1157	0.1446	0.218	0.282	0.420	0.626	0.813	0.950
165	0.0289	0.0402	0.0710	0.1497	0.218	0.366	0.587	0.789	0.937
180	0.0026	0.0141	0.0456	0.1261	0.1964	0.348	0.573	0.780	0.932
				$Z=50$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	1.124	1.123	1.121	1.115	1.109	1.096	1.072	1.043	1.018
30	1.235	1.234	1.231	1.223	1.216	1.197	1.161	1.113	1.060
45	1.292	1.292	1.290	1.284	1.279	1.264	1.232	1.183	1.120
60	1.274	1.274	1.275	1.277	1.277	1.276	1.262	1.228	1.173
75	1.177	1.179	1.184	1.197	1.208	1.227	1.246	1.242	1.207
90	1.013	1.017	1.028	1.055	1.078	1.126	1.188	1.226	1.225
105	0.801	0.807	0.825	0.869	0.907	0.988	1.101	1.190	1.230
120	0.569	0.578	0.602	0.664	0.718	0.832	0.999	1.142	1.229
135	0.348	0.359	0.390	0.467	0.535	0.682	0.899	1.093	1.225
150	0.1651	0.1781	0.214	0.305	0.385	0.557	0.815	1.053	1.221
165	0.0452	0.0594	0.0983	0.1980	0.285	0.475	0.760	1.026	1.219
180	0.0033	0.0180	0.0581	0.1608	0.251	0.446	0.741	1.017	1.219
				$Z=82$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	1.127	1.125	1.120	1.108	1.098	1.074	1.042	1.024	1.024
30	1.358	1.354	1.344	1.315	1.290	1.230	1.133	1.040	0.998
45	1.658	1.653	1.638	1.599	1.564	1.479	1.328	1.157	1.023
60	1.918	1.912	1.897	1.857	1.819	1.728	1.555	1.336	1.122
75	2.044	2.040	2.029	2.000	1.971	1.896	1.741	1.518	1.267
90	1.981	1.980	1.979	1.974	1.966	1.936	1.844	1.672	1.435
105	1.726	1.731	1.745	1.777	1.801	1.842	1.859	1.786	1.614
120	1.324	1.335	1.366	1.444	1.510	1.640	1.799	1.866	1.799
135	0.855	0.874	0.924	1.050	1.159	1.385	1.698	1.920	1.978
150	0.422	0.446	0.513	0.683	0.830	1.143	1.592	1.955	2.130
165	0.1158	0.1444	0.222	0.422	0.595	0.969	1.514	1.974	2.233
180	0.0068	0.0368	0.1187	0.328	0.511	0.908	1.486	1.978	2.267

TABLE IV.—(*Continued*).

θ \ E(Mev)	10	4	2	1	0.7	0.4	0.2	0.1	0.05
				$Z=92$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	1.103	1.102	1.097	1.086	1.076	1.058	1.038	1.034	1.029
30	1.321	1.316	1.304	1.270	1.240	1.174	1.075	1.005	1.007
45	1.702	1.694	1.674	1.619	1.569	1.456	1.267	1.080	0.978
60	2.119	2.110	2.085	2.019	1.958	1.815	1.561	1.272	1.038
75	2.418	2.410	2.388	2.326	2.268	2.127	1.859	1.521	1.193
90	2.482	2.477	2.465	2.429	2.393	2.295	2.083	1.770	1.413
105	2.264	2.266	2.272	2.284	2.290	2.280	2.198	1.991	1.679
120	1.797	1.809	1.840	1.918	1.981	2.096	2.206	2.177	1.979
135	1.191	1.213	1.273	1.423	1.551	1.809	2.141	2.226	2.287
150	0.598	0.629	0.715	0.932	1.120	1.510	2.048	2.436	2.561
165	0.1652	0.203	0.307	0.572	0.801	1.287	1.970	2.505	2.753
180	0.0091	0.0496	0.1600	0.441	0.685	1.206	1.940	2.523	2.826

TABLE V. The ratio σ/σ_R of the Mott to the Rutherford cross section: positron scattering.

θ \ E(Mev)	10	4	2	1	0.7	0.4	0.2	0.1	0.05
				$Z=-6$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	0.941	0.942	0.943	0.946	0.948	0.954	0.963	0.972	0.980
30	0.896	0.897	0.899	0.905	0.911	0.923	0.942	0.960	0.974
45	0.818	0.819	0.824	0.836	0.847	0.870	0.904	0.937	0.961
60	0.715	0.717	0.725	0.745	0.762	0.799	0.855	0.906	0.944
75	0.596	0.601	0.611	0.640	0.665	0.718	0.798	0.871	0.924
90	0.472	0.478	0.493	0.530	0.563	0.634	0.739	0.835	0.905
105	0.350	0.357	0.375	0.422	0.463	0.511	0.682	0.800	0.885
120	0.237	0.245	0.266	0.322	0.370	0.474	0.628	0.768	0.868
135	0.1388	0.1478	0.1724	0.235	0.290	0.408	0.582	0.740	0.853
150	0.0645	0.0743	0.1011	0.1696	0.229	0.357	0.547	0.719	0.841
165	0.0188	0.0291	0.0573	0.1292	0.1920	0.327	0.526	0.706	0.834
180	0.0024	0.0129	0.0415	0.1147	0.1786	0.315	0.518	0.701	0.832
				$Z=-13$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	0.940	0.941	0.942	0.943	0.948	0.953	0.963	0.973	0.982
30	0.877	0.878	0.881	0.886	0.895	0.909	0.930	0.952	0.968
45	0.790	0.792	0.797	0.807	0.822	0.848	0.887	0.924	0.953
60	0.685	0.688	0.696	0.714	0.736	0.776	0.836	0.893	0.935
75	0.568	0.573	0.584	0.612	0.640	0.697	0.781	0.860	0.918
90	0.448	0.454	0.469	0.506	0.542	0.616	0.725	0.826	0.900
105	0.331	0.338	0.356	0.402	0.446	0.537	0.671	0.794	0.883
120	0.223	0.231	0.253	0.308	0.359	0.465	0.622	0.765	0.868
135	0.1309	0.1398	0.1649	0.227	0.284	0.404	0.582	0.741	0.856
150	0.0609	0.0707	0.0979	0.1654	0.228	0.357	0.549	0.723	0.846
165	0.0174	0.0280	0.0561	0.1270	0.1924	0.328	0.530	0.711	0.840
180	0.0024	0.0130	0.0417	0.1139	0.1803	0.319	0.523	0.707	0.838
				$Z=-29$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	0.919	0.920	0.921	0.926	0.931	0.938	0.952	0.967	0.979
30	0.835	0.837	0.840	0.850	0.858	0.878	0.908	0.938	0.963
45	0.738	0.740	0.746	0.763	0.777	0.810	0.859	0.908	0.946
60	0.631	0.635	0.644	0.669	0.690	0.737	0.809	0.877	0.929
75	0.519	0.524	0.537	0.570	0.599	0.663	0.758	0.848	0.914
90	0.406	0.412	0.429	0.471	0.508	0.589	0.709	0.820	0.900
105	0.298	0.305	0.325	0.376	0.422	0.518	0.663	0.794	0.887
120	0.200	0.208	0.231	0.291	0.344	0.456	0.622	0.772	0.877
135	0.1172	0.1268	0.1531	0.220	0.278	0.404	0.588	0.753	0.868
150	0.0547	0.0652	0.0936	0.1660	0.229	0.364	0.563	0.740	0.862
165	0.0156	0.0265	0.0562	0.1321	0.1981	0.339	0.547	0.732	0.859
180	0.0025	0.0136	0.0438	0.1208	0.1880	0.331	0.542	0.729	0.857
				$Z=-50$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	0.899	0.900	0.902	0.908	0.914	0.926	0.945	0.964	0.978
30	0.800	0.802	0.807	0.820	0.831	0.856	0.895	0.934	0.962
45	0.696	0.698	0.706	0.727	0.745	0.784	0.845	0.904	0.947
60	0.588	0.592	0.603	0.632	0.658	0.713	0.797	0.875	0.931
75	0.479	0.485	0.500	0.537	0.571	0.643	0.750	0.849	0.918

TABLE V.—(*Continued*).

E(Mev) / θ	10	4	2	1	0.7	0.4	0.2	0.1	0.05
				$Z=-50$ *Continued*					
90	0.372	0.379	0.398	0.445	0.486	0.575	0.707	0.825	0.906
105	0.272	0.280	0.302	0.359	0.408	0.514	0.668	0.805	0.896
120	0.1817	0.191	0.217	0.282	0.339	0.459	0.635	0.787	0.888
135	0.1066	0.1171	0.1456	0.218	0.281	0.415	0.608	0.774	0.882
150	0.0500	0.0613	0.0921	0.1704	0.238	0.382	0.588	0.764	0.877
165	0.0146	0.0264	0.0586	0.1406	0.212	0.362	0.576	0.758	0.874
180	0.0027	0.0147	0.0475	0.1306	0.203	0.355	0.572	0.756	0.873
				$Z=-82$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	0.888	0.889	0.892	0.900	0.907	0.922	0.945	0.964	0.977
30	0.779	0.781	0.788	0.804	0.818	0.848	0.894	0.934	0.963
45	0.669	0.673	0.683	0.707	0.729	0.776	0.846	0.907	0.948
60	0.561	0.565	0.579	0.613	0.643	0.706	0.780	0.880	0.933
75	0.453	0.460	0.477	0.521	0.559	0.640	0.756	0.856	0.922
90	0.350	0.358	0.380	0.434	0.480	0.579	0.719	0.836	0.911
105	0.255	0.264	0.290	0.354	0.410	0.526	0.687	0.818	0.901
120	0.1702	0.1811	0.211	0.285	0.348	0.480	0.660	0.804	0.894
135	0.0997	0.1118	0.1446	0.227	0.297	0.442	0.638	0.793	0.888
150	0.0469	0.0599	0.0955	0.1844	0.260	0.415	0.623	0.785	0.885
165	0.0144	0.0282	0.0654	0.1586	0.237	0.399	0.614	0.780	0.882
180	0.0032	0.0171	0.0549	0.1496	0.229	0.394	0.612	0.778	0.882
				$Z=-92$					
0°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	0.888	0.889	0.892	0.900	0.907	0.923	0.945	0.963	0.976
30	0.778	0.780	0.786	0.803	0.818	0.849	0.894	0.935	0.963
45	0.667	0.671	0.681	0.707	0.729	0.777	0.848	0.908	0.948
60	0.558	0.563	0.577	0.612	0.643	0.708	0.802	0.881	0.934
75	0.450	0.457	0.475	0.520	0.559	0.642	0.759	0.858	0.922
90	0.348	0.356	0.378	0.434	0.482	0.583	0.723	0.838	0.911
105	0.253	0.263	0.289	0.356	0.413	0.531	0.691	0.820	0.902
120	0.1690	0.1803	0.211	0.288	0.353	0.487	0.666	0.806	0.895
135	0.0989	0.1116	0.1458	0.232	0.304	0.451	0.646	0.796	0.889
150	0.0465	0.0602	0.0973	0.1897	0.268	0.425	0.631	0.789	0.885
165	0.0146	0.0290	0.0680	0.1649	0.246	0.410	0.623	0.783	0.883
180	0.0033	0.0180	0.0576	0.1560	0.239	0.405	0.620	0.781	0.883

the asymptotic series of Stirling.[10] Using this code, the D_k's were evaluated by SEAC and appropriate combinations were made to obtain the Legendre coefficients in the expansions for F_1 and for $(1-\cos\theta)G_1$. [Note that $(1-\cos\theta)G_1$ has a more rapidly converging expansion than G_1.] In performing the sums over the index k, Legendre polynomials $P_k(\cos\theta)$ were generated by SEAC as needed, using the recursion formula and the initial terms $P_0=1$, $P_1=\cos\theta$.

Having calculated F_1 and G_1, the SEAC then calculated F_0 and G_0 from their analytic expressions. Finally, the appropriate combinations were performed to generate the ratio (σ/σ_R) of the Mott to the Rutherford cross section, where

$$\sigma_R d\Omega = d\Omega(Z^2e^4/m_0{}^2c^4)(1-\beta^2)\beta^{-4}(1-\cos\theta)^{-2}. \quad (1)$$

Initially, the SEAC printed out much intermediate information such as the D_k's, the Legendre coefficients, and the F_0, F_1, G_0, G_1. However, with the completion of the code checking, the SEAC was required to print out only the ratios σ/σ_R. All results recorded in Tables I, IV, and V were determined in this way, using terms up to $k=30$ in the Legendre sums. To estimate errors due to lack of convergence, trial calculations were made using fewer terms. Table II contains representative samples from this investigation. The residual fluctuation is seen to be not more than a few tenths of a percent in all cases.

In preparing the input data, the fine structure constant was given the value (1/137) and the electron rest energy the value 0.511 Mev.

The over-all accuracy of different portions of the tabulations can be expected to differ; however, we estimate that except for the largest angles at high energies it should be 0.5% or better. We have accordingly rounded off the values to three or four significant figures.

III. SMALL ANGLES

The summations described in the preceding section cannot be used at zero angle; however, it is known that as $\theta\rightarrow 0$, σ/σ_R becomes unity, and this limiting case has been included in the tabulations for completeness.

In some applications it is important to know rather accurately the quantity (σ/σ_R-1) for small angles. To

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[10] Actually, what was calculated was the logarithm of the gamma function. Further, when the real part of the argument was less than 10, a real integer was added to the argument to increase the rapidity of convergence of the expansion. The gamma-function recursion formula was then used to work back to the desired argument.

obtain this, one may supplement the tables with an asymptotic formula given by Bartlett and Watson, namely

$$(\sigma/\sigma_R-1)\sim\pi\alpha\beta(\cos\chi)(\theta/2)+O(\theta^2), \qquad (2)$$

where

$$\cos\chi=\mathrm{Re}\left\{\frac{\Gamma(\frac{1}{2}-iq)\Gamma(1+iq)}{\Gamma(\frac{1}{2}+iq)\Gamma(1-iq)}\right\}$$

is tabulated in Table III. In the course of investigating the adequacy of the 15° interval size, it proved convenient to plot the quantity $(\sigma/\sigma_R-1)/\sin(\theta/2)$.

IV. DISCUSSION OF RESULTS

Table I summarizes intercomparisons with earlier results. By and large the agreement is seen to be excellent. The Feshbach results are extended in this table to energies where they are expected to be borderline in their accuracy. Curr's formulas give remarkable agreement except for the large-angle scattering of positrons in Hg, where even the α^8 term is an appreciable fraction of the total. The values for positron scattering which were obtained from Massey's paper were read from his curves. Not given in this table are sample intercomparisons with Yadav's results for $Z=92$, which also showed satisfactory agreement in most cases. We have performed additional calculations for the Z,β values used by Sherman in his recent work[8] and have obtained agreement to about 1% in all portions of his cross-section tables.

At very low energies and large angles in Hg and U, there were significant discrepancies between the SEAC results and values given by Bartlett and Watson and by Yadav. An investigation revealed that this should be attributed to an inadequate number of terms used by these authors in their calculation of the F_1.

Regarding interpolation between results quoted in Tables IV and V, the mesh is such that for a given Z for which the tabulations exist, it is possible to interpolate graphically to a percent or so except at the largest angles at high energies. Trial interpolations bear this out. The same statements hold regarding interpolation in Z using tabulated values at fixed energy and angle. An interpolation in all three variables would not be so accurate but could be valuable for orientation purposes. When high accuracy is required, it would be better to go back to the SEAC and do another original calculation, which is quite feasible now that the code exists. Requests of this nature should be addressed to the Computation Laboratory of the National Bureau of Standards, Washington, D. C.

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Coulomb Scattering of Relativistic Electrons by Point Nuclei*

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The Mott series for the Coulomb scattering of electrons by point nuclei have been evaluated numerically with the aid of the UNIVAC computer. Calculations of the series for $F(\theta)$ and $G(\theta)$, the scattering cross section, and the polarization asymmetry factor, $S(\theta)=\delta^{\frac{1}{2}}$, were performed for scattering by nuclei of charge Z equal to 80, 48, and 13 at ratios of electron velocity to light velocity, $\beta=v/c$, equal to 0.2, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9. The results are tabulated.

INTRODUCTION

THE Dirac theory of the electron was applied by Mott[1] to the scattering of electrons by nuclei in order to investigate possible polarization effects in double scattering experiments. The theoretical results for the expected polarization and for the single scattering cross sections involve slowly and conditionally convergent series which are not amenable to easy calculation. Mott calculated results for gold ($Z=79$) at 90 degrees. Bartlett and Watson[2] have summed the series numerically for mercury nuclei ($Z=80$) over a range of angles and energies. More recently, other investigators[3–6] have performed numerical calculations. This collection of data is augmented by the results of this paper, in which the Mott series, the polarization, and the differential scattering cross section are evaluated for the scattering of electrons by nuclei of charge $Z=80$, 48, and 13, at energies given by the ratio of electron velocity to light velocity, $\beta=v/c=0.2$, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9, through scattering angles, θ, in 15-degree intervals from 15 degrees to 165 degrees. These calculations were performed with the aid of the UNIVAC computer.

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