particle and σ the spin of the nuclear particle. The interaction (3) can successfully explain the properties of the proton and neutron. However, for a free heavy electron with wave number k (3) can be considered as the first term in an expansion of a more general interaction with respect to k/λ, e.g., for *small* energies of the heavy electron. There is no reason whatsoever to expect that the same form of the interaction (3) also holds for higher energies $k>\lambda$. In fact, if we apply (3) for higher energies the theory leads to divergences which are even more serious than the well-known divergences occurring in quantum electrodynamics. In all probability, the right interaction between a heavy particle and a heavy electron will be of a *nonlinear type* and this fact marks the limits of applicability of the present quantum mechanics. The same considerations apply to the β-interaction between electrons and nuclear particles.

Thus, the problem of the interaction between heavy electrons (and electrons or light quanta) and nuclear particles for high energies seems to be a very fundamental one, leading beyond the limits of the present quantum theory. Fortunately, it seems that this problem is well accessible to experiments. The behavior of heavy electrons in traversing matter, in particular the nuclear disintegrations caused by them, provide a direct experimental test for the interaction in question.

This was not so in quantum electrodynamics. There the departure from the linear laws has only found an expression in quite general facts such as the finite rest mass of the electron and the merely theoretical difficulties occurring in higher order calculations. All the radiation effects of an electron could very well be treated by a first-order approximation theory and there are no experiments giving any indication for higher order effects.

It seems that experiments on the behavior of the hard cosmic-ray component could, for the first time in physics, open an insight in the laws of physics which are beyond the validity of the quantum theory.

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The Zeeman Effect in the Spectrum of Argon

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New measurements on the Zeeman effect of about 140 lines of the spectrum of argon have been completed, yielding g values for several complete configurations, in particular the $3p^56s$, $3p^57s$, $3p^54d$, and $3p^55d$, and several levels of the $3p^56d$. These have been compared with the g values calculated by means of the quantum mechanics. In some cases the agreement is good, but g sums show discrepancies. These are discussed in detail. The measurements differ in several cases from those of other observers. Concrete evidence of the jj parentage of some of the levels is presented.

The classification of the argon spectrum was practically completed by Meissner.[1, 2] His classifications were slightly modified in a few instances by Rasmussen,[3] who also extended the classifications to include some weak lines not given by Meissner.

Work on the Zeeman effect was begun by Bakker[4] who reported the g values for the $3p^54s$ configurations, and carried on by Pogany,[5] who investigated the $3p^54p$ configurations, and Terrien and Dykstra,[6] who investigated the $3p^54p$ and $3p^55p$ configurations. Since then, Jacquinot[7] has reported some measurements on the $3p^5ms$

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[1] Meissner, Ann. d. Physik **51**, 115 (1916).

[2] Meissner, Zeits. f. Physik **39**, 172 (1926); **40**, 839 (1927).

[3] Rasmussen, Zeits. f. Physik **75**, 695 (1932).

[4] Bakker, Nature **126**, 955 (1930).

[5] Pogany, Zeits. f. Physik **93**, 364 (1935).

[6] Terrien and Dykstra, J. de Phys. **5**, 439 (1934).

[7] Jacquinot, Comptes rendus **206**, 1635 (1938).

TABLE I. *Summary of the measurements of the $3p^54p$ configuration.*

λ	COMB.	J_1J_2	PATTERN	g_1	g_2
*9224.50	$1s_2-2p_6$	1, 2	(0), (0.202), –, –, *1.508*	1.104	1.306
*9122.98	$1s_5-2p_{10}$	2, 1	(0), (0.475), *1.029*, 1.505, 1.994	1.507	1.987
8667.94	$1s_3-2p_7$	0, 1	(0), 0.836	0/0	0.836
8521.442	$1s_2-2p_4$	1, 1	(0.283), 0.820, 1.109	1.107	0.821
8424.648	$1s_4-2p_8$	1, 2	(0), (0.285), *0.821*, 1.119, 1.404	1.401	1.115
8408.213	$1s_2-2p_3$	1, 2	(0), (0.170), –, 1.271, *1.429*	1.101	1.265
8265.524	$1s_2-2p_2$	1, 1	(0.288), 1.102, 1.385	1.101	1.387
†8115.309	$1s_5-2p_9$	2, 3	(0), (0.169), (0.368), *0.979*, 1.187, 1.368	1.518	1.338
8103.692	$1s_4-2p_9$	1, 1	(0.569), 0.839, 1.402	1.403	0.838
8014.785	$1s_5-2p_8$	2, 2	(0.383), [0.752], *1.110*, *1.489*, 1.878	1.489	1.110
7948.176	$1s_3-2p_9$	0, 1	(0), 0.823	0/0	0.823
7724.210	$1s_3-2p_2$	0, 1	(0), 1.390	0/0	1.390
7723.759	$1s_5-2p_7$	2, 1	(0), (–), –, 1.507, *2.131*	1.507	0.833
7635.107	$1s_5-2p_6$	2, 2	(–), (–), 1.091, *1.308*, *1.506*, 1.726	1.513	1.302
7514.650	$1s_4-2p_5$	1, 0	(0), 1.399	1.399	0/0
7503.868	$1s_2-2p_1$	1, 0	(0), 1.099	1.099	0/0
7471.18	$1s_4-2p_4$	1, 1	(0.590), 0.822, 1.411	1.410	0.822
7383.978	$1s_5-2p_1$	2, 1	(0), (–), –, 1.508, *2.200*	1.508	0.816
7147.042	$1s_4-2p_3$	1, 2	(0), (0.152), *1.109*, 1.259, –	1.410	1.260
7067.218	$1s_5-2p_3$	2, 2	(0.213), (*0.507*), 0.983, *1.250*, *1.508*, 1.779	1.504	1.264
6965.431	$1s_5-2p_2$	2, 1	(0), 1.622	*1.501*	1.378
6677.282	$1s_4-2p_1$	1, 0	(0), 1.402	1.402	0/0

* Not previously reported. † Not reliable.

configurations, with which the present work is in disagreement, and Lörinczi[8] has made some calculations of the g factors to be expected in the $3p^54d$ and $3p^55d$ configurations, together with measurements of a few argon lines.

The present investigation covers the region λλ5000–9700 of the spectrum of argon, and was carried out with the same apparatus and under the same conditions as reported in a previous paper,[9] on the spectrum of neon, with this slight difference which we think is worthy of note. In the case of the discharge in neon, a pressure of about 7 mm was found to operate best, while in the case of argon, in order to produce a strong discharge, a pressure of 0.7 mm was found satisfactory. This is just the opposite set of conditions that usually exists in these two gases outside a magnetic field. Even under these circumstances, the spectrum of argon II is very strongly excited and changing the pressure, up or down, did very little to alter the relative intensity of arc and spark spectra. While the part of the discharge tube between the poles was intensely blue, the rest of the tube glowed red, and this gave a very simple means of separating arc from spark spectrum.

Exposures were usually about 48 hr.; Eastman special spectroscopic plates were used and developed in Edwal 12 developer.

Table I is a summary of the measurements of the $3p^54s-3p^54p$ multiplet, and is given for the sake of completeness. Pogany[5] measured a few of these lines in the parallel polarization, assuming Bakker's[4] results for the g factors of the $3p^54s$ configurations, while Terrien and Dykstra[6] were not able to resolve some of them. These measurements yield the results given in Table II. Wave-lengths and classifications are by Meissner. The agreement is within the limit of error. The results for the $3p^54p$ configuration will be summarized in a later table.

Table III contains a summary of the measurements of lines not previously reported. Except in the few cases where Zeeman effect measurements indicate a preference for Rasmussen's[3] classifications (indicated by an asterisk), the

TABLE II. *Summary of results for $3p^54s$ configuration.*

	AUTHORS	BAKKER	CALCULATED
$1s_2$ $1s_4$	1.102 1.404	1.100 1.400	1.101 1.399
Σg	2.506	2.500	2.500
$1s_5$	1.506	1.50	1.500

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[8] Lörinczi, Zeits. f. Physik **109**, 175 (1938).

[9] Green and Peoples, Phys. Rev. **54**, 602 (1938).

TABLE III. *Summary of the measurements of lines of argon not previously reported.*

λ	COMB.	j_1j_2	PATTERN	g_1	g_2
8053.33	$2p_6-4d_5$	2, 1	(*0*), (0.173), *1.132*, –, –	1.305	1.478
8046.08	$2p_7-4d_6$	1, 0	(0), 0.838	0.838	0/0
7891.10	$2p_6-4d_3$	2, 2	(–), (*0.250*), –, –, –, –	*1.305*	1.430
7484.24	$2p_7-4d_1''$	1, 2	(0), 0.943	*0.838*	0.908
7435.33	$2p_6-3s_5$	2, 2	(–), (*0.385*), –, –, –, –	*1.305*	1.498
7425.24	$2p_3-4s_1'''$	2, 3	(0), 0.938	*1.260*	1.099
7412.31	$2p_4-4s_1''$	1, 2	(0), 1.152	*0.818*	0.985
7392.97	$2p_6-3s_4$	2, 1	(0), 1.431	*1.305*	1.179
7372.12	$2p_9-4d_4'$	3, 4	(0), 1.021	*1.333*	1.255
7353.32	$2p_8-4d_4$	2, 3	(0), 1.040	*1.112*	1.076
7350.78	$2p_2-3s_3$	1, 0	(0), 1.377	1.377	0/0
7316.00	$2p_2-3s_2$	1, 1	(0.121), 1.330	1.390	1.270
7311.71	$2p_7-3s_4$	1, 1	(0.344), 0.834, 1.179	0.834	1.179
7206.99	$2p_3-3s_2$	2, 1	(0), 1.255	*1.260*	1.270
7162.57	$2p_5-4s_1'$	0, 1	(0), 0.876	0/0	0.876
7158.83	$2p_4-3s_3$	1, 0	(0), 0.817	0.817	0/0
7125.80	$2p_4-3s_2$	1, 1	(0.443), 0.817, 1.274	0.821	1.271
7107.50	$2p_8-3s_5$	2, 2	(0.402), [0.757], –, *1.105*, *1.488*, 1.860	1.105	1.488
7086.70	$2p_5-3s_2$	0, 1	(0), 1.274	0/0	1.274
7030.25	$2p_9-3s_5$	3, 2	(*0*), (0.167), (0.338), *1.015*, 1.194, –, –, –	1.347	1.512
6951.46	$2p_6-4s_1''$	2, 2	(–), (0.653), –, 0.994, –, 1.644	1.319	0.993
6937.67	$2p_{10}-4d_6$	1, 0	(0), 1.984	1.984	0/0
6888.17	$2p_7-4s_1''''$	1, 2	(*0*), (0.213), –, –, *1.271*	0.844	1.057
6879.59	$2p_7-4s_1''$	1, 2	(0), 1.080	*0.838*	0.999
6871.29	$2p_{10}-4d_5$	1, 1	(0.517), 1.461, 1.979	1.979	1.461
6766.56	$2p_6-4s_1'$	2, 1	(*0*), (0.424), –, 1.307, *1.726*	1.305	0.883
6752.83	$2p_{10}-4d_3$	1, 2	(*0*), (0.540), *0.894*, 1.438, 1.985	1.980	1.437
6719.20	$2p_5-5d_5$	0, 1	(0), 1.395	0/0	1.395
6698.85	$2p_6-3s_2$	2, 1	(0), 1.328	*1.305*	1.259
6664.02	$2p_8-4s_1''$	2, 2	(–), (*0.244*), 1.046	1.107	0.984
6660.64	$2p_7-3s_3$	1, 0	(0), 0.847	0.847	0/0
6632.04	$2p_7-3s_2$	1, 1	(0.429), 0.849, 1.270	0.847	1.272
6604.85	$2p_8-4s_1'''$	2, 3	(0), 1.165	*1.112*	1.139
6596.10	$2p_9-4s_1''$	3, 2	(*0*), (0.359), (0.711), –, –, 1.334, 1.704, *2.061*	1.343	0.984
6594.66	$2p_1-4s_2$	0, 1	(0), 1.286	0/0	1.286
6538.12	$2p_9-4s_1'''$	3, 3	(0.187), (0.395), (0.611), –, 0.934, *1.129*, *1.332*, 1.537, 1.758	1.338	1.133
6513.84	$2p_4-4s_4$	1, 1	(0.332), 0.811, 1.171	0.817	1.164
6493.97	$2p_8-4s_1'$	2, 1	(*0*), (0.241), –, 1.120, *1.359*	1.119	0.879
6481.15	$2p_5-4s_4$	0, 1	(0), 1.158	0/0	1.158
6466.56	$2p_5-5d_2$	0, 1	(0), 0.820	0/0	0.820
6431.57	$2p_8-3s_2$	2, 1	(*0*), (–), *0.964*, –, –	*1.112*	1.260
6416.31	$2p_{10}-3s_5$	1, 2	(*0*), (0.482), *1.019*, 1.505, 1.988	1.985	1.502
6384.72	$2p_{10}-3s_4$	1, 1	(0.801), 1.187, 1.991	1.990	1.188
6369.58	$2p_6-5d_5$	2, 1	(0), 1.251	*1.305*	1.413
6364.89	$2p_7-5d_6$	1, 0	(0), 0.833	0.833	0/0
6349.20	$2p_{10}-4d_2$	1, 1	0.768, (1.210), 1.994	1.986	0.768
6309.14	$2p_7-5d_5$	1, 1	(0.555), 0.844, 1.399	0.844	1.399
6307.66	$2p_6-5d_3$	2, 2	(*0.161*), 1.343	1.303	1.383
6296.88	$2p_2-5s_1''$	1, 2	(*0*), (–), *1.157*, –, –	*1.380*	1.269
6248.40	$2p_7-5d_3$	1, 2	(*0*), (0.540), –, 1.382, *1.914*	0.844	1.380
6243.39	$2p_2-6d_6$	1, 0	(0), 1.364	1.364	0/0
6215.95	$2p_3-5s_1''$	2, 2	(0), 1.269	*1.260*	1.278
6212.51	$2p_6-5d_1'$	2, 3	(0), 1.113	*1.305*	1.209
6173.10	$2p_7-5d_1''$	1, 2	(0), 1.054	*0.838*	0.946
6170.18	$2p_6-4s_5$	2, 2	(–), (*0.403*), 1.090, *1.306*, *1.527*, 1.744	1.305	1.512
6165.11	$2p_3-5s_1''''$	2, 2	(0.411), [0.872], 1.260, 1.698	1.260	0.822
6155.23	$2p_6-4s_4$	2, 1	(0), 1.441	*1.305*	1.169
6145.43	$2p_3-5s_1'''$	2, 3	(0), 0.890	*1.260*	1.075
6128.71	$2p_2-6d_3$	1, 2	(0), 1.078	*1.380*	1.179
6127.38	$2p_8-5d_5$	2, 1	(*0*), (0.305), *0.830*, 1.120, –	1.122	1.418
6119.67	$2p_4-6d_5$	1, 1	(0.413), 0.810, 1.230	0.812	1.228
6113.47	$2p_7-4s_5$	1, 2	(*0*), (0.676), –, 1.517, *2.187*	0.842	1.514
6105.64	$2p_4-5s_1''''$	1, 2	(0), 0.799	*0.818*	0.806
6104.60	$2p_4-6d_6$	1, 0	(0), 0.811	0.811	0/0
6101.16	$2p_2-4s_2$	1, 1	(0), 1.337	*1.380*	1.294
6098.81	$2p_7-4s_4$	1, 1	(0.323), 0.826, 1.170	0.831	1.165
6090.76	$\left\{\begin{array}{l}2p_5-6d_5\\2p_1-8d_5\end{array}\right.$	0, 1 0, 1	(0), 1.232	0/0	1.232
6085.86	$2p_7-5d_2$	1, 1	(0), 0.819	*0.838*	0.800

TABLE III—*Continued.*

λ	COMB.	j_1j_2	PATTERN	g_1	g_2
6081.23	$2p_2-6d_2$	1, 1	(0.212), 1.281	1.387	1.175
6059.38	$2p_{10}-4s_1''''$	1, 2	(0), [0.985], 1.988	1.988	—
6052.73	$2p_{10}-4s_1''$	1, 2	(0), [0.995], 1.989	1.989	—
6043.22	$2p_8-5d_4$	2, 3	(0), 1.038	*1.112*	1.075
6032.13	$2p_9-5d_4'$	3, 4	(0), 1.011	*1.333*	1.253
6025.14	$2p_3-4s_2$	2, 1	(0), 1.231	*1.260*	1.289
6013.68	$2p_9-5d_3$	3, 2	(0), 1.299	*1.333*	1.367
6005.74	$2p_3-6d_2$	2, 1	(0), 1.293	*1.260*	1.194
5999.00	$2p_8-5d_1''$	2, 2	(*0.317*), 1.020	1.099	0.941
5987.29	$2p_9-5d_4$	3, 3	(–), (0.521), [0.805], *1.082*, *1.338*, 1.604, 1.892	1.344	1.076
5981.90	$2p_8-5d_1'$	2, 3	(0), 1.355	*1.112*	1.193
5971.59	$2p_4-4s_3$	1, 0	(0), 0.823	0.823	0/0
5968.31	$2p_4-4s_2$	1, 1	(0.474), 0.821, 1.298	0.822	1.297
†5964.46	$2p_5-5s_1'$	0, 1	(0), 0.850	0/0	0.850
5949.26	$2p_4-6d_2$	1, 1	(0.375), 0.816, 1.192	0.816	1.192
5942.67	$2p_8-4s_5$	2, 2	(0.413), (*0.754*), –, *1.115*, *1.498*, 1.876	1.120	1.498
5940.86	$2p_5-4s_2$	0, 1	(0), 1.295	0/0	1.295
5928.82	$2p_8-4s_4$	2, 1	(0), 1.090	*1.112*	1.156
5927.13	$2p_9-5d_1'$	3, 3	(*0.303*), 1.248	*1.305*	1,191
5916.58	$2p_8-5d_2$	2, 1	(*0*), (–), –, 1.091, *1.387*	1.091	0.795
5912.09	$2p_{10}-4s_1'$	1, 1	0.873, (1.116), 1.984	1.985	0.871
5882.63	$2p_1-3s_3$	1, 0	(0), 1.999	1.999	0/0
5860.31	$2p_{10}-3s_2$	1, 1	(0.714), 1.266, 1.981	1.981	1.266
5834.27	$2p_6-5s_1''$	2, 2	(0), 1.284	*1.305*	1.263
5802.08	$2p_6-6d_5$	2, 1	(0), 1.350	*1.305*	1.215
5772.12	$2p_6-5s_1'''$	2, 3	(0), 0.785	*1.305*	1.132
5739.52	$2p_7-5s_1''''$	1, 2	(0), 0.788	*0.838*	0.805
5738.40	$2p_7-6d_6$	1, 0	(0), 0.824	0.824	0/0
5712.48	$2p_5-7d_5$	0, 1	(0), 1.321	0/0	1.321
5689.91	$2p_2-6s_1''$	1, 2	(0), 1.215	*1.380*	1.273
*5689.64	$2p_6-6d_3$	2, 2	(*0.191*), 1.244	1.292	1.196
5681.90	$2p_6-6d_1'$	2, 3	(0), 1.184	*1.305*	1.244
5659.13	$2p_6-5s_5$	2, 2	(0.379)	*1.305*	1.495
5650.71	$2p_{10}-5d_6$	1, 0	(0), 1.984	1.984	0/0
5648.66	$2p_6-6d_2$	2, 1	(0), 1.369	*1.305*	1.177
*5641.34	$2p_7-6d_3$	1, 2	(*0*), (0.378), –, 1.216, *1.594*	0.838	1.216
‡5639.11	$2p_7-5s_1'$	1, 1	(0), 0.838	*0.838*	0.838
5635.54	$2p_7-6d_1''$	1, 2	(0), 1.241	*0.838*	1.107
5623.76	$2p_3-6s_1''$	2, 2	(0), 1.260	*1.260*	1.260
5620.89	$2p_7-4s_3$	1, 0	(0), 0.824	0.824	0/0
5617.97	$2p_7-4s_2$	1, 1	(0.480), 0.841, 1.307	0.844	1.304
5606.74	$2p_{10}-5d_5$	1, 1	(0.578), 1.391, 1.985	1.981	1.395
5597.46	$2p_3-6s_1'''$	2, 3	(0), 0.915	*1.260*	1.087
5588.69	$2p_8-5s_1''''$	2, 2	(0.639)	*1.112*	0.793
5581.83	$2p_9-5s_1''$	3, 2	(0), 1.407	*1.333*	1.259
5572.55	$2p_8-5s_1'''$	2, 3	(0), 1.128	*1.112*	1.120
5558.71	$2p_{10}-5d_3$	1, 2	(*0*), (0.592), *0.808*, 1.391, 1.985	1.988	1.398
5523.93	$2p_9-5s_1'''$	3, 3	(0.628)	*1.333*	1.124
5506.11	$2p_8-6d_4$	2, 3	(0), 0.989	*1.112*	1.051
5495.88	$2p_9-6d_4'$	3, 4	(0), 1.027	*1.333*	1.256
5457.37	$2p_8-6d_2$	2, 1	(0), 1.044	*1.112*	1.248
5451.66	$2p_{10}-4s_5$	1, 2	(*0*), (0.481), *1.023*, 1.501, –	1.981	1.501
5443.21	$2p_6-7d_3$	2, 2	(0), 1.274	*1.305*	1.243
5442.22	$2p_9-6d_1'$	3, 3	(0), 1.291	*1.333*	1.248
5439.97	$2p_{10}-4s_4$	1, 1	(0.814), 1.168, 1.982	1.982	1.168
5373.49	$2p_7-7d_1''$	1, 2	(0), 1.035	*0.838*	0.970
5254.48	$2p_7-6s_1''''$	1, 2	(0), 0.746	*0.838*	0.777
5252.80	$2p_8-7d_4$	2, 3	(0), 1.045	*1.112*	1.078
5187.75	$2p_{10}-5s_1''$	1, 2	(*0*), [0.616], –, 1.265, *1.975*	1.975	1.265
5162.29	$2p_{10}-6d_5$	1, 1	(0.742), 1.239, 1.985	1.984	1.239
5151.40	$2p_{10}-6d_6$	1, 0	(0), 1.981	1.981	0/0
5118.20	$2p_8-6s_1'''$	2, 3	(0), 1.105	*1.112*	1.109
5087.09	$2p_8-8d_4$	2, 3	(0), 0.954	*1.112*	1.032
5054.18	$2p_{10}-4s_2$	1, 1	(0.687), 1.298, 1.977	1.978	1.296
5048.81	$2p_{10}-5s_5$	1, 2	(*0*), (0.491), *1.016*, 1.493, –	1.982	1.499
4887.95	$2p_{10}-7d_5$	1, 1	(0.624), 1.357, –	1.981	1.357

Note:—Squared bracket [ ] means overlapped parallel and perpendicular components.
* Given by Meissner as $2p-5s_1'$.
† Not classified by Meissner.
‡ Improperly classified by Meissner as $2p_5-6s_4$.

TABLE IV. *Summary of results for the $3p^56s$ and $3p^57s$ configuration.*

$3p^56s$					$3p^57s$				
	TERM VALUE	g CALC.*	g OBS. (AUTHORS)	g OBS. (JACQUINOT)		TERM VALUE	g CALC.*	g OBS. (AUTHORS)	g OBS. (JACQUINOT)
$3s_2$	5950.13	1.311	1.271	1.36	$4s_2$	3229.21	1.326	1.296	1.30
$3s_4$	7351.29	1.189	1.184	1.18	$4s_4$	4632.09	1.174	1.164	1.15
Σg		2.500	2.455	2.54	Σg		2.500	2.460	2.45
$3s_5$	7428.39	1.500	1.500	1.50	$4s_5$	4671.41	1.500	1.506	1.50

Note: Jacquinot observed for the $5s_5$ term of the $3p^58s$ g value 1.499.

* Houston, Phys. Rev. **33**, 297 (1929).

TABLE V. *Summary of results for the $3p^54p$ configuration.*

LEVEL	J	g (CALC.)*	g (POGANY)	g (T. & D.)	g (AUTHORS)[a]	g (AUTHORS)[b]
$2p_2$	1	1.363	1.379	1.37	1.380	1.388
$2p_4$		0.887	0.819	0.815	0.818	0.820
$2p_7$		0.774	0.840	0.825	0.838	0.837
$2p_{10}$		1.976	—	—	1.984	1.987
	Σg	5.000	—	—	5.020	5.032
$2p_3$	2	1.280	1.248	1.26	1.260	1.260
$2p_6$		1.271	1.302	1.30	1.305	1.304
$2p_8$		1.116	1.121	1.11	1.112	1.113
	Σg	3.667	3.671	3.67	3.677	3.677
$2p_9$	3	1.333	—	—	1.338	1.339

[a] Averages from $2p-md$ lines.

[b] Averages from $1s-mp$ lines.

* Green, Phys. Rev. **52**, 736 (1937).

TABLE VI. *$3p^54d$ configuration of argon. Parameters for the least square calculation are: $F_0=-1064.6$; $F_2=86.39$; $G_1=69.80$; $G_3=5.60$; $\zeta_p=893.05$; $\zeta_d=3.85$.*

LEVEL	ENERGY LEVEL (ABSOLUTE)	ENERGY LEVELS (CALC.)[a]	ENERGY LEVELS (CALC.)[b]	ENERGY LEVELS (OBS.)	g (CALC.)[b]	g (CALC.)[a]	g (OBS.)[a]
d_6	8599.40	7.56		0.0	0/0	0/0	0/0
d_5	8460.07	124.7	115	131.3	1.29	1.461	1.467
d_2	7263.70	1328.7	1321	1335.7	0.86	0.766	0.768*
s_1'	6099.53	2524.0	2430	2499.9	0.84	0.773	0.877
				$J=1$	Σg 2.99	3.000	3.112
d_3	8204.85	387.9	381	394.6	1.30	1.433	1.437*
d_1''	7666.55	942.4	919	932.9	0.87	0.864	0.908†
s_1''	6492.46	2055.7	2060	2106.9	1.12	0.875	0.987
s_1''''	6510.60	2193.6	2108	2088.9	1.05	1.161	1.057*
				$J=2$	Σg 4.34	4.333	4.389
d_4	7898.59	639.5	644	700.8	1.083	1.075	1.077†
d_1'	[7546]‡	1114.6	935	[1053]‡	1.210	1.190	—
s_1'''	6357.99	2204.7	2276	2241.4	1.110	1.152	1.133
				$J=3$	Σg 3.403	3.417	—
d_4'	8087.81	449.1		511.6		1.250	1.255†

[a] Authors.

[b] Lörinczi.

* Based on one resolved line.

† Based on one unresolved line.

‡ Meissner lists no $4d_1'$.

wave-lengths and classifications are as given by Meissner.[2]

Using only resolved patterns to determine the g factors, we find for the $3p^56s$ and $3p^57s$ configurations the results given in Table IV.

There can be no question but that Jacquinot's[7] measurement of $3s_2$ is in error. The value indicated by him is based on measurements of only one line, which appears as a weak line just on the verge of resolution. The g values we have indicated are averages based on well-resolved lines, five for $3s_2$ and $4s_2$, three for $3s_4$ and four for $4s_4$, and when used to determine "blend"[10] patterns for unresolved lines yield results in agreement with observed patterns, as may be seen by consulting Table III.

The accuracy of the g values indicated in Table IV is at least one-half percent and we are therefore compelled to consider the discrepancy in the g sums as being significant. Both the $3p^56s$ and the $3p^57s$ configurations show g sums for the $j=1$ levels which fall far short of the predicted theoretical values. This discrepancy can only be accounted for as a result of interaction between the $3p^5ms$ and $3p^5md$ configurations. We shall discuss this in greater detail later on.

Table V is a summary of the results for the $3p^54p$ configuration. This has been reported before, but is given here to show the agreement among the several observers, and does include the g value of $2p_{10}$ which has not hitherto been recorded.

The agreement between the authors' two sets of values is in all cases within the one-half percent we usually allow ourselves, and in most cases better than that, but the results in column *a* are more reliable than *b*; the latter based, except for $2p_3$, on only two or three lines; and in the case of $2p_{10}$ the value 1.987 comes from only one line. But between observers, in the case of $2p_3$, Pogany's[5] value 1.248 appears too small, and the value 0.825 given by Terrien and Dykstra[6] appears too small. In both cases we found it was necessary to use values for $2p_3$ and $2p_7$ indicated by our own measurements in order to get agreement between observation and calculation of "blend" patterns.

Mr. J. F. Eichelberger of this laboratory has calculated parameters for the $3p^54d$ configuration of argon by the method of least squares, and has kindly allowed us to publish the following data for that configuration. Table VI lists the g values calculated from his data.

Table VII is a summary of observed and calculated data for $3p^55d$. No parameters have been calculated for $3p^56d$, and although a large number of lines involving this configuration appeared on our plates, most of them were not resolved patterns. We have, however, listed the g values obtained from these patterns in Table VIII.

To begin with, the following corrections and additions to Meissner's classifications are suggested by these measurements. The level called $5s_1'^{(j=1)}$ by Meissner[2] has clearly a j value of 2 and together with the other levels already assigned to $3p^56d$ by Meissner, supplies the missing $6d_3$ level of this configuration. This assignment is substantiated by the very satisfactory g sum. To supply the $5s_1'$ level, Rasmussen[3] has suggested the level 3296, not classified by Meissner. This suggestion is verified by the measurements which indicate that it has a j value equal to 1 and the g value agrees very well with the calculated g value. We were unable to obtain any lines involving either Meissner's $6s_1'$ or Rasmussen's $6s_1'$ and were therefore unable to make any decision with respect to these levels. Meissner has omitted the level $4d_1'$ from his list of classifications. The calculated position of this level is 7485. This would yield a line in combination with p_6 in the region of λ7475. At 7500.70 is a line questioningly classified as $2p_3-4s_1''$, by Meissner. The discrepancy between observed and calculated positions is 0.88 cm^{-1}, which is much too large. We have therefore assumed this line to be the missing $2p_6-4d_1'$ and have listed the corresponding value of 7546 for $4d_1'$ in Table VI to compare with the calculated position of this level. Other lines in Meissner's list might have been chosen, but this is the only one which gives the correct relative position of $4d_1'$ with respect to $4d_1''$.

The situation with respect to the levels ms_1'' and ms_1'''' is of very particular interest. Both of these levels have j values of 2 and are separated from each other in jj coupling only as a result of the ζ_d separation; that is, by the

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[10] Shenstone and Blair, Phil. Mag. **8**, 765 (1929).

TABLE VII. *Observed and calculated data for the $3p^5 5d$ configuration.*

LEVEL	ENERGY LEVEL (ABSOLUTE)	ENERGY LEVELS (CALC.)[10]	ENERGY LEVELS (CALC.)[b]	ENERGY LEVELS (OBS.)		g (CALC.)[b]	g (CALC.)[a]	g (OBS.)[a]
d_6	5317.39	38		0.0		0/0	0/0	0/0
d_5	5178.63	117	124	139		1.457	1.412	1.400
d_2	4597.22	765	830	720		0.734	0.758	0.813
s_1'	3296.04‡	1976	1950	2021		0.815	0.830	0.846
				$J=1$	Σg	3.006	3.000	3.059
d_3	5024.56	265	264	293		1.363	1.365	1.387§
d_1''	4829.28	460	502	488		0.939	0.938	0.941*
s_1''	3738.54	1692	1638	1579		0.895	1.239	1.265*‖
s_1''''	3605.97	1638	1669	1711		1.138	0.791	0.802†
				$J=2$	Σg	4.335	4.333	4.395
d_4	4951.29	339	345	366		1.067	1.086	1.076*
d_1'	4781.81	557	585	536		1.215	1.205	1.199
s_1'''	3554.04	1762	1730	1763		1.125	1.127	1.127†
				$J=3$	Σg	3.407	3.418	3.402
d_4'	5075.38	244	—	242		—	1.250	1.253†

[a] Authors. [b] Lörinczi. * Based on one resolved line. † Based on unresolved patterns.
‡ Not classified as $5s_1'$ by Meissner. § Lörinczi gives 1.40. ‖ Lörinczi gives 0.929.

influence of the *md*-electron. Yet, in spite of this, the g values of the two levels, which approach each other as m increases, approach the g values for jj coupling, namely 1.267 and 0.767 for the $\frac{1}{2}$, $\frac{5}{2}$ and the $\frac{1}{2}$, $\frac{3}{2}$ levels respectively. Theoretically the $\frac{1}{2}$, $\frac{5}{2}$ level should lie above the $\frac{1}{2}$, $\frac{3}{2}$ level and associated with it should be the larger g value. We find in the case of argon $3p^5 5d$ and $3p^5 6d$ that the larger g value is associated with the lower level, in both cases called s_1'', and therefore consistent with the neon spectrum. In the case of $3p^5 4d$, however, the larger g value is also associated with the lower level but this is called $4s_1''''$ by Meissner. To be consistent with the rest of the assignments in the argon spectrum we should call this level $4s_1''$, and vice versa, even though this inverts the whole system, and shows that some serious perturbation is at work, since ζ_d should be essentially positive, instead of negative, as the positions of these levels would indicate. This is the case in several of the ^2D and ^2F terms of alkali-like spectra. We believe that this is the first time that definitive information regarding the jj coupling genealogy has ever been obtained. Incidentally, the calculations of the g values indicate that Sampson's[11] correlations of $5s_1''$ and $5s_1''''$ are incorrect, and we have corrected them in Table VII.

We are unable to account for the fact that the observed and calculated values given by Lörinczi[8] differ so markedly from our own, especially when his calculated term-values are about as good as ours, and in some cases even closer to the observed values. He has given a set of general formulas for the calculation of g values for p^5d configurations, and we have not taken the trouble to check it, because such a formula, we have found, serves very little purpose. It is much easier to find the g values from the original matrix, making each case a special one.

The spectrum of argon, like that of all the rare gases, has each configuration divided into two groups, an upper, converging toward $^2P_{\frac{1}{2}}$ and a lower, converging toward $^2P_{3/2}$. In addition to this, the *md* and $(m+2)s$ configurations occupy practically the same positions. Furthermore, in particular, the upper group of the $3p^5 5d$ and the lower group of the $3p^5 6d$ and the upper group of $3p^5 7s$ and the lower group of $3p^5 8s$ all lie between 3175 cm^{-1} and 3738 cm^{-1}. We should therefore expect the g sums to be very seriously perturbed since these configurations have the same parity. We have already remarked a negative discrepancy of 0.045 in

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[11] Sampson, Phys. Rev. **52**, 1157 (1937).

TABLE VIII. *Summary of results for the $3p^56d$ configuration.*

LEVEL	J	g (OBS.)	LEVEL	J	g (OBS.)
$6d_2$	1	1.186	$6d_1'$	3	1.245
$6d_5$	1	1.233*†	$6d_4$	3	1.052
$6s_1'$	1	—	$6s_1'''$	3	1.098
$6d_1''$	2	1.107‡		Σg	3.395
$6d_3$	2	1.206*‡			
$6s_1''$	2	1.264	$6d_4'$	4	1.256
$6s_1''''$	2	0.777			
	Σg	4.354			

* Based on resolved patterns. † Lörinczi finds 1.49 for $6d_5$.
‡ Meissner calls this level $5s_1'$.

the $J=1$ g sum of $3p^56s$ and of 0.040 in the $j=1$ g sum of $3p^57s$. In the $j=1$ g sum of the $3p^54d$ configuration, we find a positive discrepancy of 0.112 mainly attributable to $4s_1'$ if we compare observed and calculated values. In the $j=1$ g sum of $3p^55d$ we find a positive discrepancy of 0.059 mainly attributable to $5d_2$. If these discrepancies are real and not the result of experimental error, they certainly tend to compensate each other, as they should. A complete check, however, would necessitate a complete set of data on the g values of the whole spectrum, including the $3p^53d$ and $3p$ $5s$ configurations, and this is not available at present, and there seems to be little hope for it in the near future, at least with the present apparatus. We are inclined to believe that these are real discrepancies, although their accuracy may be as poor as ± fifty percent, if we consider that even for resolved patterns, an estimated ± one-half percent experimental error is reasonable. In the case of $j=2$ g sums, we find positive discrepancies of 0.056 for the $3p^54d$, mainly attributable to $4d_1''$ (the g sum of $4s_1''$ and $4s_1''''$ is about the same for calculated and observed, although neither g value by itself is a good fit, owing undoubtedly to the poor agreement of observed and calculated energy level positions), and 0.062 for the $3p^55d$. There is no discrepancy in the only $j=2$ levels of $3p^56s$ and $3p^57s$ that cannot be accounted for by experimental error. The situation here is somewhat different from the case of $j=1$, for here the g values in a number of cases were determined from unresolved patterns, yielding a maximum accuracy of ± one percent. There is a chance, therefore, that these discrepancies may be due to experimental error. The $j=3$ g sums are certainly within experimental error, and if the *ms* and *nd* configurations were the sole ones to influence each other, we should expect no perturbation in this g sum for there are no levels in the *ms* configurations with $j=3$.

In conclusion, we wish to state that it is indeed a great pleasure to dedicate this work to Professor Arnold Sommerfeld, the former teacher of one of us during his student days at the University of Wisconsin, and his ever-present inspiration.

Note by J. F. Eichelberger, of Ohio State University, added in proof at the request of the authors:—The following table gives the results of a least-squares solution of the energy levels of the $3p^56d$ configuration of argon, together with the g values calculated therefrom. The attempt to find a set of parameters which give a satisfactory set of solutions for these energy levels has not been very successful; in fact, the first approximation is almost as good as the second. This lack of success must be attributed to interaction between the $3p^56d$ configuration and $3p^55d$ and $3p^57s$ and $3p^58s$. The evidence for this suggestion is seen in the fact that the d_5 and d_6 levels are inverted with respect to their usual theoretical positions, and the calculated g value for d_6 shows poorest agreement. Further, the agreement of the g values for $j=3$ are much better than any of the others, and it is here that we should expect the smallest perturbation since there are no levels with $j=3$ in the $3p^5ms$ configurations.

Calculated and observed g values and energy levels for the $3p^56d$ configuration of argon.

LEVEL	ENERGY LEVELS (ABS.)	(CALC.)	(OBS.)	g (CALC.)	g (OBS.)
d_6	3602.55	−14.7	0.0	0/0	0/0
d_5	3643.51	+45.3	−41.0	1.412	1.233
d_2	3175.53	436.5	427.0	0.797	1.186
S_1'	1825.33	1743.8	1777.2	0.791	——
				Σg 3.000	——
d_3	3302.90	169.8	299.7	1.359	1.206
d_1''	3284.65	330.4	317.9	0.946	1.107
S_1''	2045.03	1612.3	1557.5	1.244	1.264
S_1''''	1998.09	1582.3	1604.5	0.784	0.777
				Σg 4.333	4.354
d_4	3337.54	223.0	265.0	1.079	1.052
d_1'	3279.03	385.1	323.5	1.218	1.245
S_1'''	1961.50	1660.3	1641.0	1.120	1.098
				Σg 3.417	3.395
d_4'	3458.28	142.7	144.3	1.250	1.256

$F_0=-657.78$; $F_2=+29.43$; $G_1=+23.32$; $G_3=+2.274$;
$\zeta_p=-920.66$; $\zeta_d=+4.11$.