E 16 High-Order Corrections to Electron Radial Wave Functions

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In recent years, radial wave functions for free[1] and bound[2,3] electron states have been recalculated several times. One of the problems in such calculations is the choice of average potentials. Recently[2] capture ratios were calculated for different types of potentials and compared with experimental values. In this calculation the screening was represented by a linear combination of exponential functions, the parameters of which were determined by fitting the Hartree-Fock[4] (HF), Thomas-Fermi-Dirac[5] (TFD), or Herman-Shillman[6] (HS) potentials for a given atom.

1. Since the HS potentials are most extensively tabulated[6], we used them for the screening function and solved the Dirac one-electron radial equations. Extrapolation to the nuclear radius and the interpolation between the tabulated values of the HS potentials were performed. Our $(g_{LI}/g_K)^2$ values for $Z > 30$ and the nuclear radius parameter $r_0 = 1.2$ agree within 1% with the values of Band and Zyryanova[7], as one can see from Table 1. This indicates that the

TABLE 1

$(g_{LI}/g_K)^2$

Z	*BZ*	*Our*	*BB*	*Exp.*
30	0.0987	0.0998	0.098	0.105
40	0.109	0.109	0.100	0.110
50	0.118	0.119	0.103	0.119
60	0.128	0.130	0.106	0.130
78	0.150	0.151	0.108	0.150

BZ ref. 7), $r_0 = 1.2$
Our our results, HS potential, $r_0 = 1.2$
BB from Fig. 1, ref. 2), HS potential, $r_0 = ?$
Exp from Fig. 2, ref. 2)

choice of the potential is not essential in this case. On the other hand, the HS potentials have been tabulated for all atoms, which is not the case with the HF and TFD potentials. It may happen that greater error is introduced by using a parameter fit to the relativistic HF and TFD potentials than by using an exact nonrelativistic HF, as in the HS tables.

2. We recalculated the *ft* values for $0^+ - 0^+$ transitions using free electron wave functions. A lot of work was done and some effects such as the compressibility[8] of the nucleus, were taken into account to obtain the uniformity of the *ft* values. (Table 2, column III).

Keeping the phase convention for β^+ decay correct, we obtain slightly different values (Table 2, column IV). Good agreement between the *ft* values is lost whether we take the correction to the nuclear matrix elements[8] (column V) into account, or not. Our calculations support the results of Bhalla[9] listed in column VI and show a greater difference between the *ft* values for ^{16}O and ^{34}Cl and those for other elements. These results will not affect the value of the vector coupling constant which is based on the decay of ^{16}O.

TABLE 2
ft values for $0^+ - 0^+$ transitions

ft	Freeman		Yamada	Our results		Bhalla
ref.	10[a]	10[b]	8[b,c]	a)	a,c)	b)
	I	II	III	IV	V	VI
^{14}O	3139	3127	3133	3138	3143	3127
^{26}Al	3098	3086	{3102 {3131	3090	{3102 {3131	3085
^{34}Cl	3150	3138	3141	3140	3140	3131
^{42}Sc	3134	3122	3132	3111	3111	3109
^{46}V	3143	3131	3133	3119	3113	3116
^{50}Mn	3137	3125	3130	3104	3096	—
^{54}Co	3144	3132	3131	3104	3094	3102

a) Källen radiation corrections;
b) Kinoshita-Sirkin radiation corrections;
c) Nuclear matrix element corrections.

In all calculations, finite size and screening corrections are taken into account.

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