American Journal of Modern Physics
2014; 3(6): 218-223
Published online October 30, 2014 (http://www.sciencepublishinggroup.com/j/ajmp)
doi: 10.11648/j.ajmp.20140306.12
ISSN: 2326-8867 (Print); ISSN: 2326-8891 (Online)

Features of the Zeeman splitting and g-factors of 2p5f configuration levels of carbon atom

Galina Pavlovna Anisimova[1], Igor Cheslavovich Mashek[1], Olga Aleksandrovna Dolmatova[1], Anna Petrovna Gorbenko[1, *], Robert Ivanovich Semenov[1], Martin Tchoffo[2], Galina Aleksandrovna Tsygankova[1]

[1]Saint-Petersburg State University, Saint-Petersburg, Russian Federation
[2]Mesoscopic and Multilayer Structure Laboratory, Department of Physics, Faculty of Science, University of Dschang, Po Box 67 Dschang, Cameroon

Email address:
spbgor@mail.ru (A. P. Gorbenko), mtchoffo2000@yahoo.fr (M. Tchoffo), olgadolmatova@gmail.com (O. A. Dolmatova)

To cite this article:
Galina Pavlovna Anisimova, Igor Cheslavovich Mashek, Olga Aleksandrovna Dolmatova, Anna Petrovna Gorbenko, Robert Ivanovich Semenov, Martin Tchoffo, Galina Aleksandrovna Tsygankova. Features of the Zeeman Splitting and G-Factors of 2p5f Configuration Levels of Carbon Atom. *American Journal of Modern Physics*. Vol. 3, No. 6, 2014, pp. 218-223. doi: 10.11648/j.ajmp.20140306.12

Abstract: The gyromagnetic ratios of levels (the g-factors) – are one of the most important characteristics of atoms. There are no corresponding experimental data in the literature for *npn`l* configurations of carbon atom. That is why the theoretical study of the fine and the Zeeman structures for the determination of the g-factors is ongoing. All the calculations are effected in one configuration approximation, with the energy operator matrix, in which the maximum possible number of interactions is taken into account, including the magnetic, spin-orbit (own and other) and spin-spin interactions. The fine structures were studied in three approximations (*LS*, *LK*, *jK*) for the establishment of the character of the coupling in 2*p5f* C I configuration. During the study of Zeeman splitting (except the g-factors) features of it were determined: the fields of crossings and anticrossings of magnetic components. In all steps of calculations the numerical digitalization of corresponding energy operator matrices were effected, e.g. the results presented in the paper were obtain in the intermediate coupling approximation.

Keywords: Fine Structure, Zeeman Splitting, Crossings and Anticrossings of Magnetic Components, G-Factors, Energy Operator Matrix

1. Introduction

For all 2*pnl* C I configurations, including $l = 3$, there are no experimental data except the fine structure energy levels. For this reason, it is possible to precise semiempirical calculations of the fine structure parameters, with numerical diagonalization of the energy operator matrix in the absence of a magnetic field, and taking into account the interaction of the atom with the magnetic field. It seems of interest to determine the Lande factors from the calculated Zeeman pattern. This is possible if, in the absence of magnetic field, upon diagonalization of the matrix of the energy operator separated with respect to quantum number J (J is the total electron angular momentum of the atom), the obtained energy levels are almost coincide with corresponding experimental quantities (zero energy residuals). For the considered 2*p5f* configuration of C I this was reached, which will be confirmed below by corresponding figures and tables.

2. Fine Structure

The fine structure of higher excited 2*p*4*f* and 2*p5f* C I configurations were studied in detail in our work [1]. The experimental energies are taken from [2], where they are measured with accuracy of 0.001 cm^{-1}. The classification of levels in [2] is given in the *jK*-coupling. There are also experimental energies in [3]. Their accuracy is 0.01 cm^{-1}, and the classification of levels is given in the *LK*-coupling. The authors [2] and [3] differ in assessing the closeness of the systems considered to *jK* or *LK* types of coupling. Our calculation of fine structure parameters in [1] were executed with energies taken from [2] in the *jK*-coupling approximation. Further the numerical values of fine structure parameters (see [1]) were introduced in the energy operator matrices, written in the *LK* and *LS* types of coupling approximation with further

numerical diagonalization. In all the three bases (*jK*, *LK*, *LS*) the calculated energies and the coefficients of intermediate coupling were obtained. With their help the g-factors in the absence of magnetic field were calculated (see the Table 1 below). (The calculated energies agreed with the experimental data from [2] to the last significant figure).

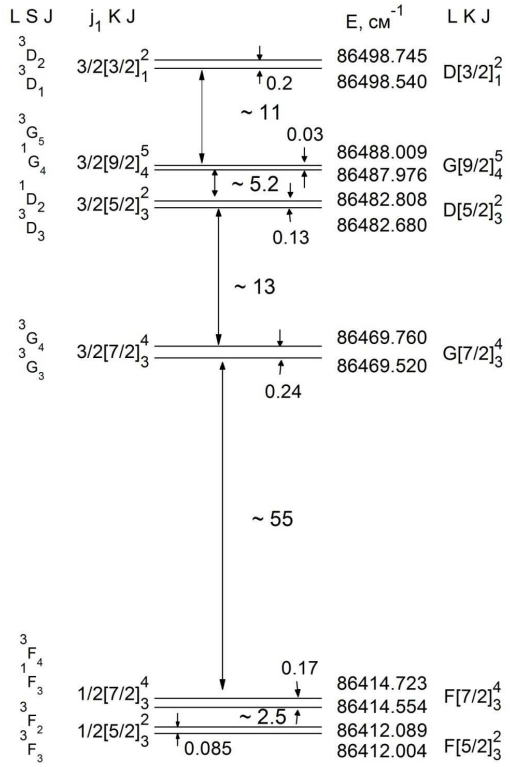

Figure 1. *Energy spectrum of the 2p5f configuration of the carbon atom (on the left - the classification of the levels in LS- and jK-coupling. On the right - in LK-coupling).*

The work in three bases permitted at the same time to collate the *jK*-coupling designation of levels with the counterparts in *LK* and *LS* approximations. The corresponding level classification is presented in Fig.1. From the figure, it's seen that the considered system 2*p5f* is completely isolated from other configurations with the same parity (2*pnp*). The 2*p*5*g* configuration is "embedded" in it (see [2]), but it has another parity. That is why the question of superposition of configurations and their influence on each other is not considered.

From the figure it is also seen, that the energy spectrum of the 2*p5f* configuration is a combination of 6 pairs of levels. Every doublet has the same value of the intermediate momentum *K*. In the lower part of the spectrum, there are *F* levels with $j_1 = 1/2$ ($j_1 = l_1 + s_1$). They are considerably far from the rest of 8 configuration levels with $j_1 = 3/2$, in which the pairs *G* and *D* levels are alternated. All the singlets are inside the corresponding triplet systems.

The doublet structure of the energy spectrum is characteristic for configurations in which *jK* or *LK*-couplings take place. However in the case of *LK*-coupling, two doublets with the same value of orbital angular momentum *L* lie close to each other and resemble the quartet [4]. Such a situation is observed in 3*p5f* configuration of Silicon atom (see *F* levels with $j_1 = 1/2$ on Fig.1 in [5]). In the 2*p5f* C I studied system, the tendency to form a quartet of lower *F* levels with $j_1 = 1/2$ (see, Fig.1) is observed.

To assess the degree of proximity of the 2*p5f* configuration in one type of coupling to another type of vector coupling let's compare the g-factors, calculated with intermediate coupling coefficients in three bases [1], with each other and with their vector counterparts (Table 1).

In this table, for brevity, the levels indicated in the *LS*-coupling approximation, and the corresponding calculated energies are shown on the Fig.1 (they are completely consistent with the experimental energies of [2]). Table 1 shows the 10 levels of the configuration: $J = 3$ – the 4th -rank matrix; $J = 4$ and $J = 2$ – (matrices of the 3rd rank). $^3G_5$, $^3D_1$ levels have the single value of the full angular momentum of the atom *J*, and they are independent of the type of coupling, and their g-factors are the same in all types of coupling $g^{LS} = g^{LK} = g^{jK} = 1.200$ ($^3G_5$) and $g^{LS} = g^{LK} = g^{jK} = 0.499$ ($^3D_1$). Below, we will see from the Zeeman splitting, how this is true.

Table 1. *Comparison of g-factors, calculated with intermediate coupling coefficients in LS, LK, jK bases (see, formula (5) in [6]), with their vector counterparts in the zero field.*

Level	Intermediate coupling			Vector coupling		
	g_{LS}	g_{LK}	g_{jK}	g^{LS}	g^{LK}	g^{jK}
$^3F_3$	1.119	1.117	1.201	1.083	1.048	1.207
$^1F_3$	0.888	0.891	0.832	1.0	1.036	0.821
$^3G_3$	0.897	0.896	0.955	0.749	0.749	0.964
$^3D_3$	1.263	1.263	1.178	1.334	1.334	1.175
$^3F_4$	1.132	1.132	1.089	1.251	1.251	1.083
$^3G_4$	1.147	1.147	1.189	1.050	1.028	1.195
$^1G_4$	1.022	1.022	1.022	1.0	1.022	1.022
$^3F_2$	0.770	0.769	0.885	0.666	0.666	0.889
$^1D_2$	0.969	0.964	0.849	1.0	1.067	0.844
$^3D_2$	1.094	1.100	1.100	1.167	1.100	1.100

From the Table 1 it's also seen that in the intermediate coupling for the majority of levels, the g-factors are practically the same in *LS* and *LK* bases. They are considerably different from g-factors, calculated in *jK*-coupling approximation (g_{jK} in the Table 1). For the level $^3D_2$ the g-factors completely coincide with *LK* and *jK* bases ($g_{LK} = g_{jK}$). They slightly differ from the *LS* basis (g_{LS}). Only for one level $^1G_4$: $g_{LS} = g_{LK} = g_{jK}$, they also are equal with the vector values $g^{LK} = g^{jK}$. The corresponding coupling coefficients on the leading diagonal for the $^1G_4$ level have the value 0.999993, the same in *LK* and *jK* approximations. The $^3D_2$ level has almost complete agreement with the g-factors in the three bases corresponding to the coupling coefficient on the leading diagonal and is slightly smaller compared to the above ($^1G_4$), but still close to unity and is equal to 0.9992 in the *LK* and *jK* bases (see intermediate coupling coefficients in [1]).

Apparently reliable g-factors of levels in the intermediate coupling in the Table 1 can be regarded as those which coincide with each other (completely or with a small error of the order of a few thousandths of accuracy) in at least two bases. With respect to three bases, the coincidence of the g-factors of the $^1G_4$

level is total, it is quasi-total for $^3D_2$. One can consider that these levels are nearest to *jK*-coupling, as the calculation of fine structure parameters is effected in the *jK*-coupling approximation. If all the configuration levels were nearest to *jK*-coupling, then there must be coincidence of g_{LS}, g_{LK}, g_{jK} as for the $^1G_4$ level in the Table 1. From the Table 1 it is seen that this is not the case. That is why the g-factors of the rest of the levels, coinciding in two bases, are compared with their vector counterparts. One obtains the following: the $^3F_3$ and $^1D_2$ levels are nearest to *LS*-coupling; $^1F_3$, $^3G_3$, $^3F_4$, $^3G_4$ levels are near to *jK*-coupling; $^3D_3$ level is near to *LK*-coupling; $^3F_2$ level is approximately in the middle of the *LK* and *jK*-couplings.

Thus the majority of the levels of 2*p5f* configuration lie close to the *jK*-coupling. The classification in [2] is confirmed by the doublet structure of the energy spectrum in the Fig.1.

3. Zeeman Splitting and it`s Particularities

The magnetic field totally erases the degeneracy of levels due to the quantum number M [7]. The energy operator matrix is labeled with M for the following values: M = ± 5 (first rank); M = ± 4 (fourth rank); M = ± 3 (eighth rank); M = ± 2 (eleventh rank); M = ± 1 and M = 0 (twelfth rank). In the numerical experiment, all the cited matrices were diagonalized when the magnetic field varied from zero to 62 kOe.

The energy operator matrix for the *npn`f* configurations in the absence of the field was published in the works [8-12]. The coefficients of radial integrals (fine structure parameters) are calculated in two representations: *LSJM* (*LS*-coupling approximation) and in the independent moments approximation in order to exclude possible errors. In the matrix the following interactions were taken into account: electrostatic, spin-orbit (own and other), spin-spin, orbit-orbit, which are represented by 18 radial integrals. The numerical values of fine structure parameters can be seen in [1].

To calculate the Zeeman splitting in the fundamental energy operator matrix from [8-12], elements of energy operator matrix of interaction of the atom with the magnetic field are added. The results are published in [5] for all the cited upper values of M. The Zeeman structure was calculated with the energy operator matrix in the LS-coupling approximation. In this approximation it is more compact as compared to the many matrices in the non-coupling moments representation.

Table 2. *The fields of the crossing of Zeeman components with ΔM = ±1, ±2 in the range H = 0 – 62 kOe.*

№	The crossing sublevels		H, Oe	№	The crossing sublevels		H, Oe
	Upper	Lower			Upper	Lower	
1	$^3G_5$ (M = -2)	$^1G_4$ (M = -4)	266.44	37	$^3D_2$ (M = -1)	$^3D_1$ (M = 1)	3777.942
2	$^3G_5$ (M = -1)	$^1G_4$ (M = -3)	282.55	38	$^3G_4$ (M = -3)	$^3G_3$ (M = -2)	3945.23
3	$^3G_5$ (M = 0)	$^1G_4$ (M = -2)	316.627	39	$^3F_4$ (M = -2)	$^1F_3$ (M = -1)	4155.77
4	$^3G_5$ (M = 1)	$^1G_4$ (M = -1)	345.642	40	$^1D_2$ (M = -1)	$^3D_3$ (M = 0)	5379.17
5	$^3G_5$ (M = 3)	$^1G_4$ (M = 1)	398.44	41	$^3G_4$ (M = -2)	$^3G_3$ (M = -1)	6269.47
6	$^3G_5$ (M = 4)	$^1G_4$ (M = 2)	448.72	42	$^3F_4$ (M = -1)	$^1F_3$ (M = 0)	7393.77
7	$^3F_2$ (M = 1)	$^3F_3$ (M = 3)	736.97	43	$^3G_4$ (M = -1)	$^3G_3$ (M = 0)	13387.2
8	$^3F_2$ (M = 0)	$^3F_3$ (M = 2)	919.215	44	$^3F_4$ (M = 0)	$^1F_3$ (M = 1)	16146.62
9	$^1D_2$ (M = 1)	$^3D_3$ (M = 3)	998.58	45	$^3F_4$ (M = -4)	$^3F_2$ (M = -2)	17944.28
10	$^3F_2$ (M = 2)	$^3F_3$ (M = 3)	1089.45	46	$^1F_3$ (M = -3)	$^3F_2$ (M = -1)	18392.091
11	$^1D_2$ (M = 0)	$^3D_3$ (M = 2)	1153.298	47	$^1F_3$ (M = -2)	$^3F_2$ (M = 0)	18820.231
12	$^3F_2$ (M = -1)	$^3F_3$ (M = 1)	1157.779	48	$^1F_3$ (M = -1)	$^3F_2$ (M = 1)	19242.028
13	$^1D_2$ (M = -1)	$^3D_3$ (M = 1)	1334.829	49	$^1F_3$ (M = 0)	$^3F_2$ (M = 2)	19653.551
14	$^1D_2$ (M = 2)	$^3D_3$ (M = 3)	1403.93	50	$^1F_3$ (M = 1)	$^3F_3$ (M = 3)	20059.62
15	$^3F_2$ (M = -2)	$^3F_3$ (M = 0)	1453.241	51	$^3F_4$ (M = -3)	$^3F_2$ (M = -1)	25533.8
16	$^1D_2$ (M = -2)	$^3D_3$ (M = 0)	1542.691	52	$^1F_3$ (M = -3)	$^3F_2$ (M = -2)	26601.64
17	$^3F_4$ (M = -3)	$^1F_3$ (M = -1)	1544.09	53	$^3F_4$ (M = -2)	$^3F_2$ (M = 0)	27069.411
18	$^3G_5$ (M = 3)	$^3G_4$ (M = 2)	1559.65	54	$^1F_3$ (M = -2)	$^3F_2$ (M = -1)	27713.96
19	$^3G_5$ (M = 2)	$^1G_4$ (M = 1)	1560.21	55	$^3F_4$ (M = -4)	$^3F_3$ (M = -2)	28029.52
20	$^3G_5$ (M = 4)	$^1G_4$ (M = 3)	1650.93	56	$^3F_4$ (M = -1)	$^3F_2$ (M = 1)	28621.461
21	$^3F_4$ (M = -2)	$^1F_3$ (M = 0)	1765.643	57	$^1F_3$ (M = -1)	$^3F_2$ (M = 0)	28772.43
22	$^3G_4$ (M = -4)	$^3G_3$ (M = -2)	1896.89	58	$^1F_3$ (M = -3)	$^3F_3$ (M = -1)	29224.634
23	$^3F_4$ (M = -1)	$^1F_3$ (M = 1)	2026.208	59	$^1F_3$ (M = 0)	$^3F_2$ (M = 1)	29738.99
24	$^3F_4$ (M = -4)	$^1F_3$ (M = -3)	2045.19	60	$^1F_3$ (M = -2)	$^3F_3$ (M = 0)	30165.902
25	$^3G_4$ (M = -3)	$^3G_3$ (M = -1)	2166.68	61	$^3F_4$ (M = 0)	$^3F_2$ (M = 2)	30169.305
26	$^1D_2$ (M = 1)	$^3D_3$ (M = 2)	2203.53	62	$^1F_3$ (M = 1)	$^3F_2$ (M = 2)	30600.9
27	$^3F_4$ (M = 0)	$^1F_3$ (M = 2)	2328.976	63	$^1F_3$ (M = -1)	$^3F_3$ (M = 1)	30842.604
28	$^3G_4$ (M = -2)	$^3G_3$ (M = 0)	2486.016	64	$^1F_3$ (M = 0)	$^3F_3$ (M = 2)	31176.379
29	$^3F_4$ (M = 1)	$^1F_3$ (M = 3)	2676.22	65	$^1F_3$ (M = 2)	$^3F_3$ (M = 3)	31360.94
30	$^3F_4$ (M = -3)	$^1F_3$ (M = -2)	2765.09	66	$^3F_4$ (M = 1)	$^3F_3$ (M = 3)	31705.65
31	$^3G_4$ (M = -4)	$^3G_3$ (M = -3)	2855.91	67	$^3F_4$ (M = -3)	$^3F_2$ (M = -2)	46529.71
32	$^3G_4$ (M = -1)	$^3G_3$ (M = 1)	2860.29	68	$^3F_4$ (M = -4)	$^3F_3$ (M = -3)	51690.18
33	$^3D_2$ (M = -2)	$^3D_1$ (M = -1)	3013.9	69	$^3F_4$ (M = -2)	$^3F_2$ (M = -1)	53669.27
34	$^3G_4$ (M = 0)	$^3G_3$ (M = 2)	3290.421	70	$^3F_4$ (M = -3)	$^3F_3$ (M = -1)	55535.76
35	$^1D_2$ (M = 0)	$^3D_3$ (M = 1)	3378.59	71	$^3F_4$ (M = -1)	$^3F_2$ (M = 0)	61835.15
36	$^3G_4$ (M = 1)	$^3G_3$ (M = 3)	3774.32				

Table 3. *Minimal energy intervals and corresponding values of the magnetic fields in the anticrossing "necks" magnetic components with ΔM = 0*

The anticrossing sublevels		H, Oe	ΔE, cm^{-1}
Upper	**Lower**		
$^1F_3$ (M = 0)	$^3F_2$ (M = 0)	66605 ± 5	0.11821
$^1F_3$ (M = 1)	$^3F_2$ (M = 1)	70050 ± 50	0.19252
$^1F_3$ (M = -1)	$^3F_2$ (M = -1)	61035 ± 15	0.06489
$^1F_3$ (M = 2)	$^3F_2$ (M = 2)	70905 ± 5	0.29085
$^1F_3$ (M = -2)	$^3F_2$ (M = -2)	54550 ± 10	0.0286

In the studied range of the magnetic field (0 - 62 kOe) 71 crossings of Zeeman components with ΔM = ±1, ±2 and 5 anti-crossing with ΔM = 0 were detected. The crossing of sublevels and their corresponding values of the magnetic field are presented in the Table 2.

From the Table 2 it is seen that, the crossings of magnetic components of levels of 2*p*5*f* configuration start with comparatively smaller magnetic fields (a hundred Oest). As the crossings are many, the general view of Zeeman splitting is not shown. Let`s pay attention to the anticrossings. They are represented on the Fig. 2. The most narrow anticrossings with M = -1 and M = -2 in increasing order are shown on the Fig. 3.

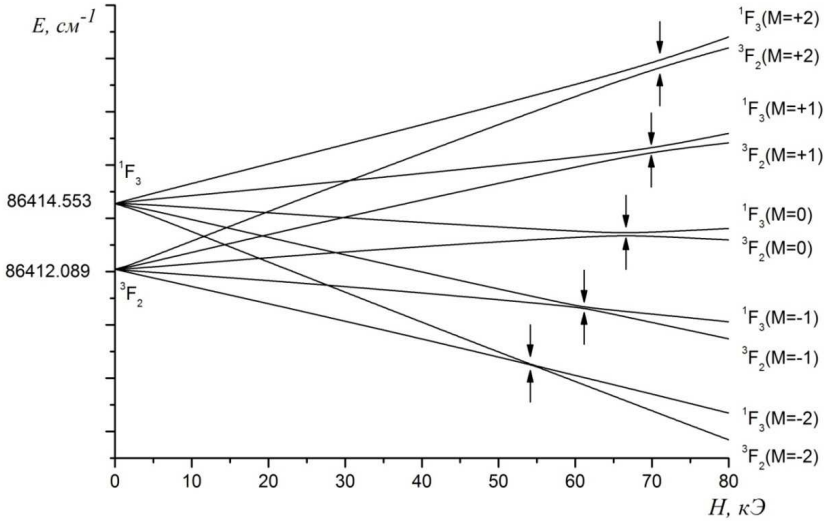

Figure 2. *Anticrossins of magnetic components with ΔM=0 of the $^1F_3$ and $^3F_2$ levels of the 2p5f configuration of C I.*

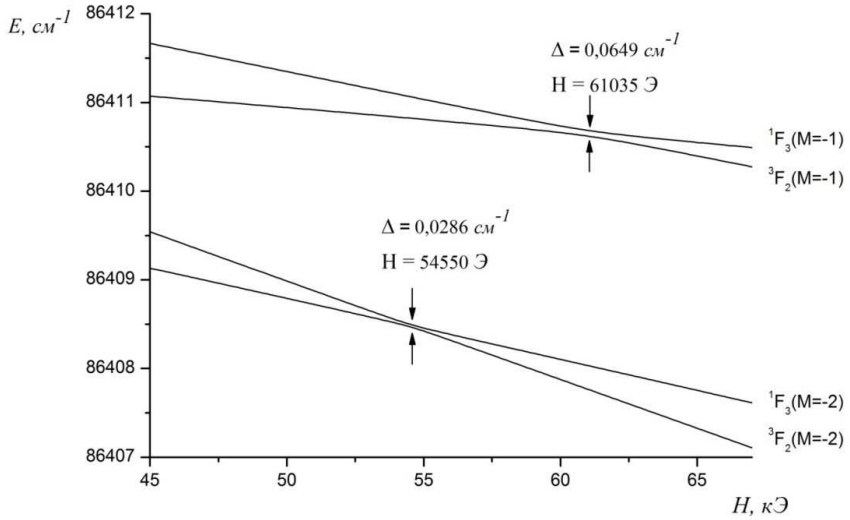

Figure 3. *Fragment of the Zeeman pattern in the range of anticrossing of magnetic components with M = 0.*

Table 3 shows the minimum energy intervals in the anticrossing "necks" and the corresponding values of the magnetic fields. This error defines the area of the magnetic field, where the curves E(H) are parallel.

As is known, anticrossings are experienced by sublevels from different terms. Figure 2, 3, and Table 3 show that in the *LS*-coupling approximation, $^1F_3$ and $^3F_2$ – the terms are different. In the *jK*-coupling,

$$\frac{1}{2}\left[\frac{7}{2}\right]_3 \text{and } \frac{1}{2}\left[\frac{5}{2}\right]_2$$

the terms are different also, as they have different intermediate moments *K*. The anticrossing from different terms is observed also in series of Helium atom configurations (see for example, [6]).

4. The Gyromagnetic Ratios

The gyromagnetic ratios can be calculated from Zeeman splitting only in a linear range, in which the spacing between the positive and negative values of M with respect to M = 0 is the same. Our calculation of g-factors are executed with the field H = 40 Oe. The demonstration of the linearity is presented in the Table 4. To this effect in the given point of the magnetic field the diagonalization of the energy operator matrix is done for the values M = 0, M = +1, M = -1. As a result the energies of Zeeman components are obtained when H = 40 Oe and coefficients of expansion of the wave functions with respect to LS-coupling basis (coefficients of intermediate coupling). It is seen that, the distances ΔE (M = +1) - (M = 0) cm^{-1} and ΔE (M = -1) - (M = 0) cm^{-1} are perfectly the same for all levels of the configuration.

The coefficients of intermediate coupling were used in the calculation of the g-factors when H = 40 Oe (see the method of calculation in [6]). The gyromagnetic ratios with accuracy 0.00001 are presented in the last column of Table 4. For comparison, in brackets, the g-factors with the same accuracy are indicated, calculated in the absence of the magnetic field (see Table 2 paragraph 2 in this work). In contrast to the Table 1, where the results of 10 levels of configuration are presented, in Table 4 we have all the 12 levels, including $^3G_5$ and $^3D_1$ with the unit value of the quantum number J.

Table 4. *The energies of Zeeman components with M =0, ±1 and the gyromagnetic ratios of levels of the 2p5f C I configuration when H = 40 Oe*

Levels	M = 0	M = +1	M = -1	g-factors
$^3F_3$	86412.004	86412.007	86412.002	1.11931 (1.11936)
$^3F_2$	86412.089	86412.090	86412.088	0.76972 (0.76967)
$^1F_3$	86414.553	86414.555	86414.552	0.88777 (0.88776)
$^3F_4$	86414.723	86414.725	86414.721	1.13187 (1.13187)
$^3G_3$	86469.520	86469.522	86469.518	0.89714 (0.89713)
$^3G_4$	86469.760	86469.762	86469.758	1.14671 (1.14672)
$^3D_3$	86482.680	86482.682	86482.678	1.26279 (1.26280)
$^1D_2$	86482.808	86482.810	86482.806	0.96902 (0.96900)
$^1G_4$	86487.976	86487.978	86487.974	1.02222 (1.02211)
$^3G_5$	86488.009	86488.011	86488.007	$1.20035\ (1.20046)^{LS}$
$^3D_1$	86498.540	86498.541	86498.539	$0.49886\ (0.49884)^{LS}$
$^3D_2$	86498.745	86498.747	86498.743	1.09426 (1.09427)

From Table 4 it is seen that, the g-factors, calculated when H = 40 Oe, with accuracy 0.001 totally coincide with g_{LS} from the Table 1 (the intermediate coupling with respect to the diagonalization of the energy operator matrix in the LS-coupling approximation). The distinctions are seen in the fourth or in the fifth decimal place. That is why in the brackets of the last column of Table 4, the g-factors are presented (in the absence of the field in the LS basis) with an accuracy of 0.00001. The same is extended also to $^3G_5$, $^3D_1$ levels. Their g-factors coincide with analogous *LS*-couplings (g^{LS}) only with a 0.001 accuracy. The insignificant deviation from the *LS*-coupling is remarkable when the accuracy is great.

Thus, for the 2*p5f* configuration of carbon atom the magnetic field in the linear range does not bring important changes in the calculation of values of g-factors in comparison with similar values in absence of the field with accuracy of 0.001. In other words for the carbon atom the energy of interaction with the magnetic field is small as compared to the rest of the interactions, in particular with the electrostatic interaction and the spin-own orbit interaction ($\xi_p = 42$ cm^{-1} [1]). With the increase of nuclear charge (for example, the 3*p5f* Si I configuration [5]) the role of the magnetic field increases a bit. Namely, the divergence of g-factors of $^3G_5$, $^3D_1$ levels, with respect to Zeeman splitting and the corresponding vector analogues to (g^{LS} in Table 1) are observed in the third decimal place. It is due to the fact that, for the atom of silicon $\xi_p \approx 190$ cm^{-1} [1], that means 4 times greater as compared to carbon. Further let's consider, what will happen to Germanium atom.

The constant of spin-orbit splitting (spin-own orbit) ξ_p = 1178 cm^{-1} (4*p4f* Ge I) and ξ_p = 1176.9 cm^{-1} (4*p5f* Ge I) [1]. That means for germanium the magnetic interaction is sensibly 28 times greater as compared to carbon and 6 times greater as compared to silicon. The significant increase of the role of magnetic interactions for germanium was the cause of strong deviation from *LS*-coupling [1].

5. Conclusions

The Zeeman splitting and its features are determined for 12 levels 2*p5f* configuration of carbon atom. For this purpose the numerical diagonalization of energy operator matrices for all values of quantum number M in the range of the magnetic field from zero to 62 kOe was effected. In the established linear range when H = 40 Oe the energy of Zeeman sublevels and the coefficients of expansion of wave functions with respect to the LS-coupling basis were calculated, and later used for the calculation of the g-factors. A comparative analysis of the g-factors in the sense of splitting with similar values in the absence of the field (the fine structure) was done. The character of the coupling in the 2*p5f* configuration was established. It was shown that, the majority of levels of configuration are really near the *jK*-coupling in accordance with the experimental work [2].

References

[1] G.P. Anisimova, O.A. Dolmatova, V.A. Polischuk, and G.A. Tsygankova, Semiempirical Calculation of the Fine-Structure Parameters, the Intermediate Coupling Coefficients, and Gyromagnetic Ratios for npn`f Configurations C I, Si I, Ge I and P II, Vestnik SPbU 4 (1), 215 (2013) [in Russian].

[2] Edward S.Chang, and Murray Geller, Improved Experimental Energy Levels of Carbon I from Solar Infrared Spectra, Phys. Scr. 58, 330 (1998).

[3] L. Johansson, Spectrum and term system of the neutral carbon atom, Arkiv för Physik 31 (15), 201 (1966).

[4] A.P. Yutsis, and A.Yu. Savukinas, Mathematical Foundations of the Theory of Atom (Vil`nyus, 1973) [in Russian].

[5] G.P. Anisimova, O.A. Dolmatova, M. Choffo, Determination of Gyromagnetic Ratios from the Zeeman Splitting of Levels of the 3p5f Configuration of the Silicon Atom, Optics and Spectroscopy 114 (2), 177 (2013).

[6] G.P. Anisimova, I. Ch. Mashek, O. A. Dolmatova, A.P. Gorbenko, R. I. Semenov, M. Tchoffo, G.A. Tsygankova, The Fine-Structure Parameters and Zeeman Splitting of Levels of the Configurations 1sni (n = 7 − 10) of the Helium Atom, American Journal of Modern Physics 3 (4), 143 (2014).

[7] I.I. Sobelman, Introduction to the Theory of Atomic Spectras (Moscow, 1963) [in Russian].

[8] G.P. Anisimova, and E.L. Kapel`kina, Spin-Other-Orbit Interaction in Two-Electron Configurations with *p* and *f* Electrons: Direct Terms, Optics and Spectroscopy 84 (3), 313 (1998).

[9] G.P. Anisimova, and E.L. Kapel`kina, Spin-Other-Orbit Interaction in Two-Electron Configurations with *p* and *f* Electrons: Excharge Terms, Optics and Spectroscopy 84 (4), 476 (1998).

[10] G.P. Anisimova, and E.L. Kapel`kina, Two-Electron Matrices of the Total Energy Operator of the Spin-Orbit Magnetic Interaction for *pf*, p^5f, *fp*, and $f^{13}p$ Configurations, Optics and Spectroscopy 84 (6), 799 (1998).

[11] G.P. Anisimova, and E.L. Kapel`kina, Account for the Spin-Spin Interaction in the Energy Matrices of Two-Electron Configurations with p and f Electrons, Optics and Spectroscopy 87 (1), 9 (1999).

[12] G.P. Anisimova, and E.L. Kapel`kina, Orbit-Orbit Interaction in Two-Electron Matrices of the Energy Operator for *pf* Configurations, Optics and Spectroscopy 87 (6), 805 (1999).