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If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
DETERMINATION OF $g_J$ FACTORS IN THE np $^2P_{3/2}$ SERIES
OF THE Cs-I SPECTRUM

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Landé $g_J$ factors are determined for the three lowest $^2P_{3/2}$ levels in the Cs atom from measured level crossing positions together with $a$ factors determined by zero field double resonance. The hyperfine anomalies between $^{133}\text{Cs}$, $^{135}\text{Cs}$ and $^{137}\text{Cs}$ are discussed.

In an earlier work [1], we calculated the $g_J$ factors of the Cs-I $7p ^2P_{3/2}$ and $8p ^2P_{3/2}$ levels from the position of the first level crossing of $^{133}\text{Cs}$ and the coupling constants $a$ and $b$ for the dipole and quadrupole interactions as obtained in double resonance experiments [2-4]. The $g_J$ factor of the $6p ^2P_{3/2}$ level has been determined by Ullrich and Zu Putlitz [5]. In a recent letter, Violino [6] calculates this $g_J$ value by comparison between his level crossing measurements on $^{133}\text{Cs}$ [7] and the results of Buck et al. in a modified double resonance experiment [8]. He obtains a value in disagreement with ref. [5]. The level crossing positions in the $6p ^2P_{3/2}$ level which we have measured [1] do not agree with those of Violino, who attributes this discrepancy to "instrumental shifts" (modulation broadening and time constant effects [9]) present in our measurement. However, we want to emphasize that with the modulation coils calibrated by optical pumping and with the quoted small modulation amplitude the broadening was very accurately taken into account in the fit of our experimental results to a theoretical modulation broadened structure. Our quoted sweeping rate and detection system time constant correspond to well above 1000 time constants over the halfwidth of a crossing. We find that the error in our level crossing field values due to time constant effects and uncertainty in the modulation is less than 3% of our quoted errors. On the other hand the magnetic field calibration in refs. [6] and [7] seems to be less reliable. The cesium vapour pressure used by Violino is even somewhat high according to our experience. We have used the three $^{133}\text{Cs}$ level crossing fields of ref. [1] together with the results of Buck et al. [8] to calculate a $g_J$ factor in good agreement with the value of ref. [5]. In the $7p ^2P_{3/2}$ level we calculate the $g_J$ factor in the same way from our three level crossings and the double resonance $a$ factor of ref. [2]. In the $8p ^2P_{3/2}$ level we have made additional level crossing measurements with the same experimental arrangement as before. The three level crossing positions are found to be 13.206(5) gauss, 17.777(11) gauss, and 18.335(11) gauss, yielding a $b/a$ ratio of $-0.0118(32)$. Comparing with the double resonance results of ref. [3] we obtain the $g_J$ factor of the $8p ^2P_{3/2}$ level. In all our present $g_J$ factor determinations we use the double resonance $a$ factors, whereas the more accurate level crossing $g_J$ independent $b/a$ ratios were employed. The nuclear $g_I$ factor, which is necessary for the calculation, is obtained from Stroke et al. [10]. The results are given in table 1.

<table>
<thead>
<tr>
<th>level</th>
<th>$g_J$ factor</th>
<th>ref.</th>
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<tbody>
<tr>
<td>$6p ^2P_{3/2}$</td>
<td>-1.3419(33) *</td>
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</tr>
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<td></td>
<td>-1.3444(34) *</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>-1.3365(38) *</td>
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<tr>
<td></td>
<td>-1.3438(30) **</td>
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<td></td>
<td>-1.345 **</td>
<td>5</td>
</tr>
<tr>
<td>$7p ^2P_{3/2}$</td>
<td>-1.3348(5)</td>
<td>This work</td>
</tr>
<tr>
<td>$8p ^2P_{3/2}$</td>
<td>-1.3363(10)</td>
<td>This work</td>
</tr>
</tbody>
</table>

* With $a = 50.60(12)$ MHz recalculated from ref. [8] by Violino [7]. We also find this value in a least square fit of the data of ref. [8]. The error in the $g_J$ factor due to the double resonance $a$ factor is (32).

** With $a = 50.67(11)$ MHz (Original value of ref. [8]).
which includes the value of the above mentioned authors and a 6p $^2P_{3/2}$ $g_J$ value, calculated from an unpublished level crossing work by Hese and Weise [11]. The method used for the $g_J$ factor determinations assumes that no rf shifts have affected the double resonance results [4, 12]. We also have performed level crossing measurements in the $9p ~^2P_{3/2}$ and the $10p ~^2P_{3/2}$ levels of $^{133}$Cs [13]. Since no corresponding double resonance measurements exist $g_J$ factors for these levels could not be calculated. In the alkali metal $^2P_{3/2}$ levels a negligible hyperfine structure anomaly between different isotopes is often assumed. Thus if we calculate the $a$ factor for $^{135}$Cs and $^{137}$Cs from the $^{133}$Cs $a$ factor and the $g_J$ ratios of ref. [10] it could be possible to get additional information on the $g_J$ factors from the level crossing positions for $^{135}$Cs and $^{137}$Cs obtained in our previous work [1]. However, small shifts in the $g_J$ factors are then found, indicating the presence of a hyperfine anomaly

$$x'\Delta_y = (a' \Delta_g a^2 / a^2 \Delta_g') - 1.$$  

In table 2 we give the results of the hyperfine structure anomaly calculation based on the $a$ factors of ref. [1]. Since the $a$ factor ratios are unaffected by possible systematic influences on the level crossing positions, accounted for in the quoted $a$ factor errors the uncertainty in the $a$ factor ratios could be reduced by about 20% in the present calculation. An anomaly in the $6p ~^2P_{3/2}$ and the $7p ~^2P_{3/2}$ levels would be explained by the core polarisation s-wave contribution ($\approx 10\%$ in the both states) to the dipole coupling [1, 13]. Thus the anomaly in the $^2P_{3/2}$ levels should be considerably smaller than in the pure s-electron $^2S_{1/2}$ ground state [10]. However, this is not borne out in the experimental anomalies (table 2). The discrepancy indicates that further consideration of the ground state anomalies might be needed.

We gratefully acknowledge valuable discussions with Professor I. Lindgren. This work was supported by Statens Naturvetenskaplige Forskningsråd.

References

Table 2

<table>
<thead>
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<th>level</th>
<th>$^{135}$A$^{133}$</th>
<th>$^{137}$A$^{133}$</th>
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<tbody>
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<td>-0.0003(7)</td>
</tr>
<tr>
<td>$7p ~^2P_{3/2}$</td>
<td>-0.0004(4)</td>
<td>-0.0003(4)</td>
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<tr>
<td>$6s ~^2S_{1/2}$[10]</td>
<td>-0.00037(9)</td>
<td>-0.00090(10)</td>
</tr>
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</table>

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460