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# Study of g-factors in ionized Neon for Zeeman splittings of electronic states

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## Abstract

*In the Zeeman splittings of ionized Neon, g-factors arise from 3s, 3p and 4s states have been studied. The intensity of the spectral lines associated with the 4s state is weak and therefore, it is limited to study the g-factors upto 3s and 3p states. The theoretical values of g-factor are compared with observed values of 3s and 3p states. It is shown that some spectral terms $^2S_1$ and $^2P_1$ of 3p state have anomalous values of g-factors. In the inert gases, the deviation in the anomalous values of g-factors from normal values increases with increase of atomic number.*

**Keywords:** Splittings, Spin-orbit interactions, Non-degenerate, Sputtering, Excitation- potential, Spectral terms.

## Introduction

Experimental study of Zeeman splittings in the spectrum of ionized Argon indicate that different spectral terms related to different energy levels have different g-factors. The values of g-factors measure the relative separations of the Zeeman levels for different spectral terms of ionized Argon. The value of g-factors changes due to spin-orbit interactions. The Zeeman splittings are determined by $g^* \mu_B B$ where $g^*$,$\mu_B$ and B are the effective g-factor, Bohr magneton and magnetic field respectively. After the study by the Researchers on the Spin-orbit interactions and Coulomb interactions in the Zeeman levels of ionized Argon, it was most significant to study about the similar type of spectra of ionized atom of the other inactive gases. The deviations in the Zeeman splittings from one ionized atom of the inactive gas to another depend on the atomic number. This paper is associated with the study of the g-factors for Zeeman splittings in ionized Neon in presence of magnetic field. In the spectrum of ionized Neon, most of the lines exhibit the anomalous Zeeman Effect. Due to Zeeman Effect, some degenerate levels split into several non-degenerate energy levels with different energy. These transitions are observed as new spectral lines. Splittings of the spectral lines are extremely small ($\Delta\omega/\omega \sim 10^{-5}$) corresponding to a difference in wavelength of about $\Delta\lambda \sim 0.01$nm[1-4].

## Methodology

**Experimental:** To study the Zeeman splittings in ionized Neon and hence to measure the g-factors, the same approach and technique has been implemented as in the case of Zeeman splittings of ionized Argon. The Neon gas was placed into a copper vacuum box enclosing the poles of the large magnet. To get the brilliant discharges, the pressure of the Neon in vacuum must be adjusted. Aluminium electrodes were used in the magnetic field for small sputtering coefficient of aluminium. The duration of exposure was continued to seven hours. Due to such discharges of long duration, impurity developed, which weighed down the pure Neon gas spectrum. For that, it was necessary to refill the Neon for two hours. Strong transformer was used to supply uncondensed high potential alternating current. This discharging method in the magnetic field gives the spectrum of ionized Neon, which is weaker than the spectrum of ionized Argon. This is due to the higher ionization potential of natural Neon and the higher excitation potentials of ionized Neon. The maximum strength of magnetic field, achieved during the study was 41200±130 Gauss. The measurement of the magnetic separations in the 2nd and 3rd order of a large six inch Rowland grating mounted in the stigmatic grating[5-8].

## Results and Discussion

In the Zeeman splittings of ionized Argon, g-factors of different spectral terms formed from 4s, 4p and 5s states were studied. In this case the aim is to study and measure the g-factors for different spectral terms in ionized Neon for Zeeman splittings of electronic states. In the Zeeman splittings of ionized Neon, g-factors arise from 3s, 3p and 4s states are studied. The intensity of the spectral lines associated with 4s term is weak and therefore, there is limitation to study the g-factor up to 3s and 3p terms in ionized Neon. The interaction of 3s electron with the inner electrons of ionized Neon gives 3s $^4P_{3,2,1}$ and 3s $^2P_{2,1}$ spectral terms. The interaction of a 3p electron with inner electrons gives 3p $^4D_{4,3,2,1}$ , 3p $^4P_{3,2,1}$, 3p $^4S_2$ and 3p $^2D_{3,2}$, 3p $^2P_{2,1}$, 3p $^2S_1$ spectral terms. The triplet and quartet spectral term are obtained by substantial study where as the doublet spectral terms are obtained by study of Zeeman splittings.

The tables 1 and 2 contain the values of g-factor obtained theoretically by formula ($g_f$) and the observed g-factors ($g_o$) obtained due to the interaction between 3s and 3p states. The last columns in the tables associated with $g_{total}$ . It is clear from the table 1 and 2 that the sum of g-factors due to observation is equal to the sum of g-factors due to formula for the same inner quantum number j. The spectral terms related to 3s state in ionized Neon have normal values of g-factor. This agrees with analogous spectral terms forming from 4s states in ionized Argon have normal values of g-factor. This indicates that $g_{total}$ is satisfied. The spectral terms $^2S_1$ and $^2P_1$ of 3p state in ionized Neon have anomalous values of g-factor which show deviations from normal values of g-factor. In the spectrum of ionized Argon, the analogous spectral terms of 3p state are 4p $^2S_1$ and 4p $^2P_1$which show the largest deviation in the values of g-factor from normal values of g- factor[9-11].

**Table-1**
**Spectral Terms of 3s state and g-factors[12-14]**

| J | g | $^4p_3$ | $^4p_2$ | $^4p_1$ | $^2p_2$ | $^2p_1$ | $g_{total}$ |
|---|---|---|---|---|---|---|---|
| j=1 | $g_f$ | | | 2.65 | | 0.65 | $\sum g_f$=3.30 |
| | $g_o$ | | | 2.65 | | 0.65 | $\sum g_o$=3.30 |
| j=2 | $g_f$ | | 1.71 | | 1.32 | | $\sum g_f$=3.03 |
| | $g_o$ | | 1.71 | | 1.32 | | $\sum g_o$=3.03 |
| j=3 | $g_f$ | 1.59 | | | | | $\sum g_f$=1.59 |
| | $g_o$ | 1.59 | | | | | $\sum g_o$=1.59 |

**Table-2**
**Spectral Terms of 3p state and g-factors**

| J | g | $^4P_3$ | $^4P_2$ | $^4P_1$ | $^4D_4$ | $^4D_3$ | $^4D_2$ | $^4D_1$ | $^2D_3$ | $^2D_2$ | $^4S_2$ | $^2S_1$ | $^2P_2$ | $^2P_1$ | $g_{total}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| j=1 | g | | | 2.65 | | | | 0.00 | | | | 1.98 | | 0.65 | $\sum g_f$=5.28 |
| | $g_o$ | | | 2.65 | | | | 0.00 | | | | 1.95 | | 0.68 | $\sum g_o$=5.28 |
| j=2 | g | | 1.71 | | | | 1.18 | | | 0.78 | 2.00 | | 1.32 | | $\sum g_f$=6.99 |
| | $g_o$ | | 1.71 | | | | 1.18 | | | 0.78 | 2.00 | | 1.32 | | $\sum g_o$=6.99 |
| j=3 | $g_f$ | 1.59 | | | | 1.36 | | | 1.20 | | | | | | $\sum g_f$=4.15 |
| | $g_o$ | 1.59 | | | | 1.36 | | | 1.20 | | | | | | $\sum g_o$=4.15 |
| j=4 | $g_f$ | | | | 1.42 | | | | | | | | | | $\sum g_f$=1.42 |
| | $g_o$ | | | | 1.42 | | | | | | | | | | $\sum g_o$=1.42 |

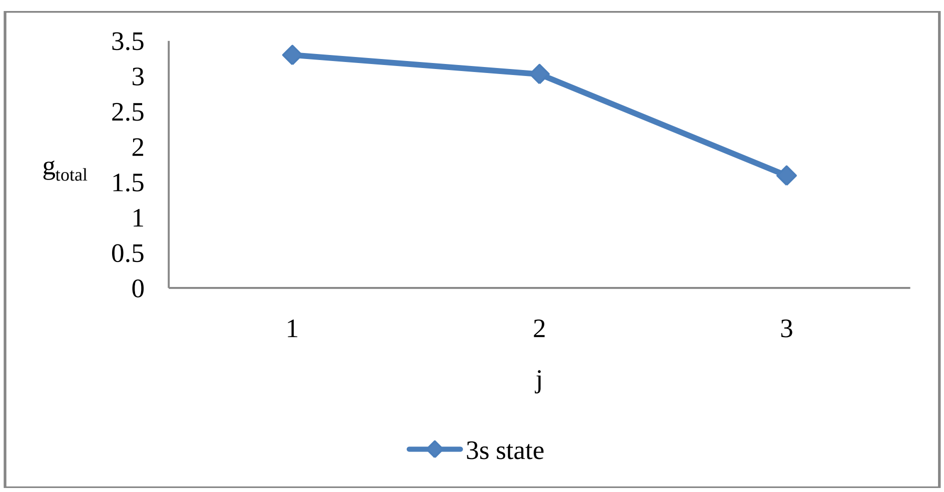


**Figure-1**
**g-factor ($g_{total}$) vs inner quantum number (j) for 3s state. In this state g-factor in ionized Neon decreases gradually with increasing j**

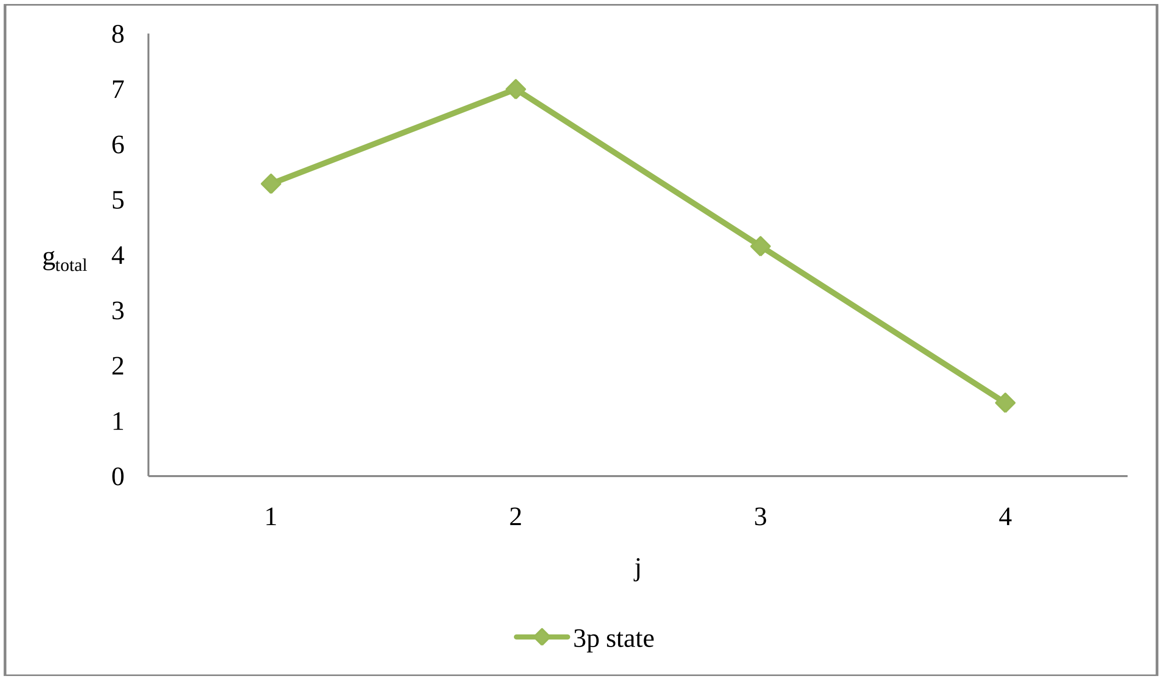


**Figure-2**
**g-factor ($g_{total}$) vs inner quantum number (j) for 3p state. In this state g-factor in ionized Neon first increases and then gradually decreases with increasing j**

**Table-3**
**Deviation of g-factors from normal g-factors in ionized Neon and ionized Argon**

| **Spectral terms n= 3 for ionized- Neon and n=4 for ionized- Argon** | **g-factors** | | |
|---|---|---|---|
| | Theoretical | Ionized Neon | Ionized Argon |
| np $^2P_1$ | 0.65 | 0.68 | 0.97 |
| np $^2S_1$ | 1.98 | 1.95 | 1.66 |

## Conclusion

Zeeman splittings in the spectrum of ionized Neon have been studied. The deviations in the Zeeman splittings from ionized Neon to ionized Argon, depending on the atomic number have been studied. The g-factors of the spectral terms arising from 3s and 3p of ionized Neon are compared with theoretical g-factors. Some anomalous g factors are obtained from the spectral terms of 3p state of ionized Neon and are compared with the g-factors of the analogous spectral terms of 4p state of the ionized Argon.

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