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An Analytical Study of the Effect of Gravity on Electronic Wave Functions in Oxygen

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Abstract: ***We can determine the presence of oxygen in the sun by observing its absorption spectrum. However, no single wavelength observed in the oxygen spectrum of the sun directly corresponds to the Ritz wavelength of either the oxygen atom or the oxygen molecule. To account for this inconsistency, the study hypothesizes that the shells of the oxygen atom expand or compress under the presence of gravity, and it causes the change of difference in energy levels. To verify the hypothesis, the study assumes the shells in the atom to be different levels of a modified version of an infinite potential well. The relative distance between two shells of atoms present on the earth and the sun can be worked out by comparing the energies of the modified infinite potential wells. The study finds that the ratio of distances between the atoms present on the earth and the sun is not same, hence, verifying the hypothesis. To further verify the hypothesis, analysis of spectrums of more elements under the influence of a large gravitational field and with significant screening effects is required.***

Keywords: Physics and Astronomy; Atomic, Molecular, and Optical Physics; Atomic Spectra; Oxygen Spectrum; Electronic Wave functions

1. Introduction

The sun, a crucial celestial body in our solar system, serves as the primary source of energy and light. One of its essential components is oxygen, which is detected through the analysis of its absorption spectrum. Despite this fact, researchers have encountered an inconsistency in the detection of oxygen in the sun's spectrum, as no single wavelength observed in the oxygen spectrum of the sun directly corresponds to the Ritz wavelength of either the oxygen atom or the oxygen molecule. To address this inconsistency, this study forms a hypothesis that the shells of the oxygen atom undergo expansion or compression under the presence of gravity, resulting in a change in the difference in energy levels.

This study models the shells of the oxygen atom as different levels of a modified version of an infinite potential well and compared the energies of the modified infinite potential wells to deduce the relative distance between two shells of atoms present on the earth and the sun. The relative difference in distance between shells in the atom can be used to identify and measure the effect of the Sun’s gravity on electronic wavefunctions in an Oxygen atom. The findings of this study are significant, as the ratio of distances between the atoms present on the earth and the sun is not found to be equal, thereby providing support for the proposed hypothesis.

However, it is essential to note that further analysis of spectrums of more elements under the influence of a large gravitational field and with significant screening effects is required to completely validate this hypothesis. The implications of this research are far-reaching, as it can enhance our understanding of the composition and behavior of the sun and provide vital insights for future studies of astronomical phenomena. This paper aims to delve into the methodology and results of this study and discuss its broader implications for our understanding of the effects of gravity on electronic wavefunctions.

2. Literature Review

Several studies have been conducted to investigate the electronic wavefunction in the presence of gravitational fields. For instance, a study conducted by Majumdar et al. (2017) investigated the electronic wavefunction in a quantum dot. They demonstrated that the electron density distribution changes due to gravity, leading to a shift in the energy levels. In another study, Kudinov et al. (2013) analyzed the effects of gravity on the electronic wavefunction of a hydrogen atom in a strong gravitational field. They found that gravity leads to significant modifications of the wavefunction, which can be attributed to the change in the effective potential energy of the atom.

Moreover, several studies have investigated the composition and behavior of the sun. For example, a study by Del Zanna et al. (2015) analyzed the solar ultraviolet spectrum and identified the presence of several heavy elements in the sun's atmosphere. Another study conducted by Kopp and Lean (2011) analyzed the variations in the sun's total solar irradiance and identified long-term changes in the sun's activity cycle.

In conclusion, the study presented in this paper provides valuable insights into the effects of gravity on electronic wavefunctions in oxygen atoms. The proposed hypothesis is supported by the findings of the study, which demonstrate that the ratio of distances between the atoms present on the earth and the sun is not equal.Further analysis of spectrums of more elements under the influence of a large gravitational field and with significant screening effects is required to validate this hypothesis. The study contributes to our understanding of the composition and behavior of the sun and provides vital insights for future studies of astronomical and atomic phenomena.

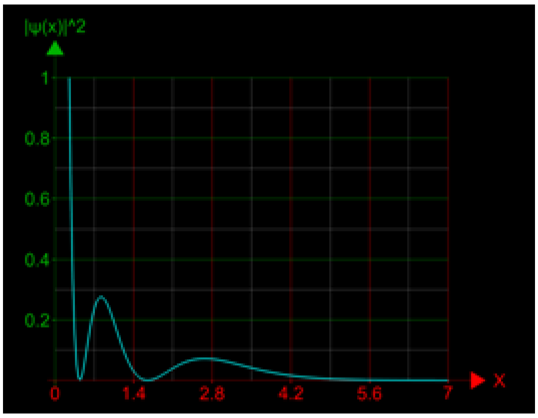
3. Methods

When the absorption spectra of the sun are observed, it is found that the wavelength which is nearest to that of Oxygen is 6867Å, when the spectra of Oxygen on the Earth is observed the wavelength which is nearest to that observed in the Sun is 6653Å. To account for this inconsistency, the study hypothesizes that the shells of the oxygen atom must be stretched and compressed due to the sun's gravitational field, hence, changing the distance between shells and changing the energy difference between them.

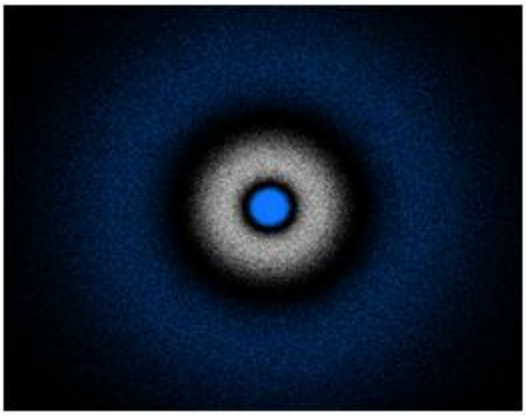
The radial distribution function for an electron present in 3s is:

$$|\psi_{3s}(x)|^2 = \left|\frac{1}{9\sqrt{3}} * \left(6 - 17.2x + \frac{73.96}{9}x^2\right) * 4.3^{\frac{3}{2}} * e^{\frac{-4.3}{3}x}\right|^2$$

The graph (1.1) and the orbital diagram of the function till 3s is as follows:



The Graph (1.1)
[1 unit on X axis = a_0(52.9pm)]

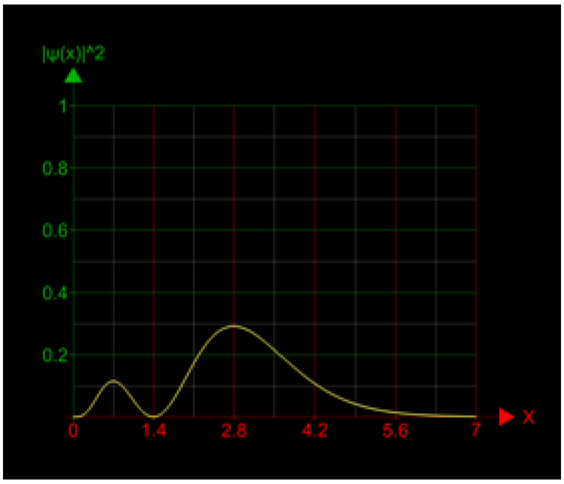


The "Dot-Density" Diagram
[The diagram depicts 1s, 2s and 3s orbitals]

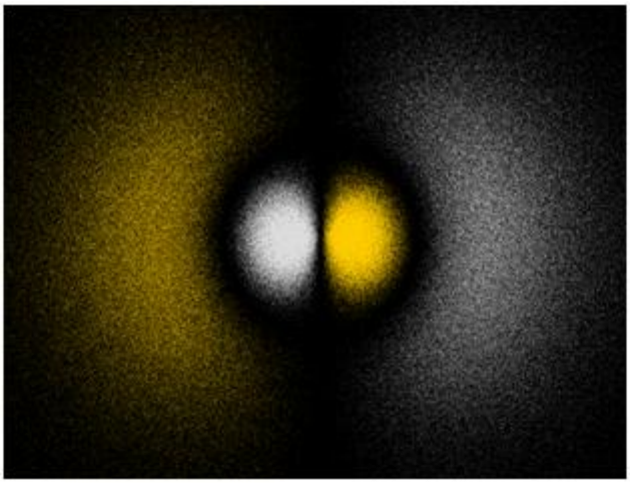
The radial distribution function for an electron present in 3p is:

$$\left|\psi_{3p}(x)\right|^2 = \left|\frac{1}{9\sqrt{6}} * \left(\left(\frac{8.6}{3}x\right) * \left(4 - \frac{8.6}{3}x\right)\right) * 4.3^{\frac{3}{2}} * e^{\frac{-4.3}{3}x}\right|^2$$

The graph (1.2) and the orbital diagram of the function till 3p is as follows:



The Graph (1.2)
[1 unit on X axis = a_0(52.9pm)]

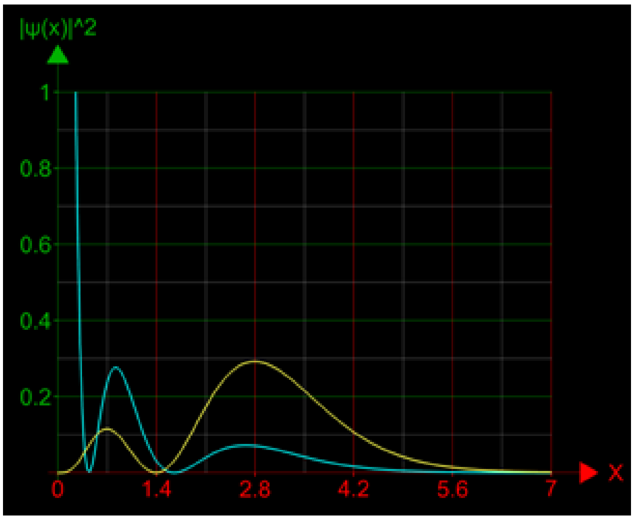


The "Dot-Density" Diagram
[The diagram depicts 3p orbital]

It is observed that the maximum probability of the wavefunction for the 3s orbital $(2.757 * 10^{-1})$ is at the distance $\left(8.049 * 10^{(-1)}\right)a_0$ and the maximum probability of the electron present in 3p orbital $(2.917 * 10^{-1})$ is observed to be at the distance $2.8a_0$. The value of $|\psi_{3s}(x)|^2$ exponentially decreases before $(4.9 * 10^{-1})a_0$ and after $(1.365)a_0$ and the value of $\left|\psi_{3p}(x)\right|^2$ exponentially decreases before $(1.505)a_0$ and after $(4.97)a_0$, hence, they can be said to said to be boundaries outside of which the electron will generally not exist. When the graphs are overlapped, it is found that some parts of the graphs overlap so it is assumed that the electron is only present in the part of the curve with the maxima of each of the function.

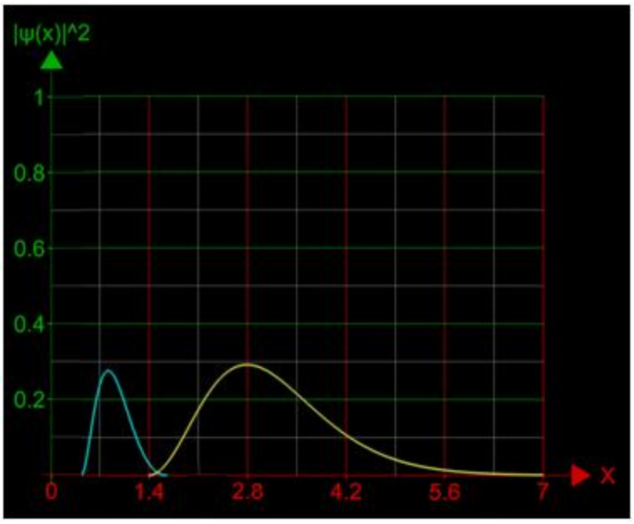
The following graph (1.3) represents $|\psi_{3s}(x)|^2 (cyan)$ and $\left|\psi_{3p}(x)\right|^2 (yellow)$ graphed in a single plane.
In the graph of $|\psi_{3s}(x)|^2$, only the values that lie between $x = (4.9 * 10^{-1})$ and $x = (1.365)$.
In the graph of $\left|\psi_{3p}(x)\right|^2$, only the values that lie between $x = (1.505)$ and $x = (4.97)$.

A new graph (1.4) can be drawn in which only the considered values are included, it can be used to represent an electron which either jumps from 3s to 3p orbital or from 3p to 3s orbital.



The Graph (1.3)

The graph (1.4) is observed to be similar to that of an infinite potential well with the equation $|\Psi(x)|^2 = \left|A_n Sin\left(\frac{2\pi x}{L_E}\right)\right|^2$ where L_e is the length of the well ($4.48a_0$ in this case). The graph (1.4) can be said to have the equation $|\psi(x)|_E^2 = \left|A_n Sin\left(\frac{2\pi x}{L_E}\right)\right|^2 * f(x)$ where $f(x)$ is a function which is multiplied by the standard equation of the infinite potential well ($\Psi(x)$) to make its shape similar to that of the graph (1.4). Hence, it becomes a modified infinite potential well. The energy of the modified potential well will be given by the equation $E_E = \left(\left(\frac{\hbar^2}{2m_e}\right) * \left(\frac{2\pi}{L_E}\right)^2\right) * g(x)$ where $g(x)$ is a function which, when multiplied, makes the energy of the modified infinite potential well equal to the energy difference between the two shells (3s and 3p in this case).



The Graph (1.4)

When the absorption spectrum of the sun is observed, it is found that the wavelength which is nearest to that of oxygen is 6867Å; when the spectrum of oxygen is observed on the Earth, the wavelength which is nearest to the observed wavelength is 6653Å and it corresponds to the transition between 3s and 3p orbitals. To account for this inaccuracy, it is hypothesized that the electronic wavefunctions change in presence of a gravitational field causing a change in the difference between energies of the subshells. To account for the change in the difference of energies the length of the modified potential well, analogous to the length of the wavefunction, also changes. The ratio of lengths of the modified potential wells can be compared by comparing the differences in energies of the atom under negligible gravitational field and the atom under a significant gravitational field. The energies can be found out by comparing the spectra of both the atoms. Since the length of the well is analogous to the length of the electronic wavefunction, it can be said that the ratio of the lengths of modified infinite potential well is same as the ratios of the lengths of the electronic wavefunctions.

For an oxygen atom present on the earth, the equation of the modified infinite potential representing an electron in 3s and 3p well is said to be as follows: $E_E = \left(\left(\frac{\hbar^2}{2m_e}\right) * \left(\frac{2\pi}{L_E}\right)^2\right) * g(x)$.

For an oxygen atom with significant influence of the sun's gravity, the equation of the modified infinite potential representing an electron in 3s and 3p well is said to be as follows: $E_S = \left(\left(\frac{\hbar^2}{2m_e}\right) * \left(\frac{2\pi}{L_G}\right)^2\right) * g(x)$.

$$\Rightarrow \frac{E_E}{E_S} = \frac{\left(\left(\frac{\hbar^2}{2m_e}\right) * \left(\frac{2\pi}{L_E}\right)^2\right) * g(x)}{\left(\left(\frac{\hbar^2}{2m_e}\right) * \left(\frac{2\pi}{L_G}\right)^2\right) * g(x)} \text{ (Equation 1.1)}$$

$$\because E = \frac{hc}{\lambda}$$

$$\therefore \frac{\frac{hc}{\lambda_E}}{\frac{hc}{\lambda_S}} = \frac{\left(\left(\frac{\hbar^2}{2m_e}\right) * \left(\frac{2\pi}{L_E}\right)^2\right) * g(x)}{\left(\left(\frac{\hbar^2}{2m_e}\right) * \left(\frac{2\pi}{L_G}\right)^2\right) * g(x)} \text{ (Equation 1.2)}$$

where λ_E is the wavelength observed in the spectrum of oxygen on the Earth and λ_S is the wavelength observed in the spectrum of oxygen under the presence of significant gravitational field of the sun.

On solving Equation (1.2), the following equation (Equation (1.3)) is formed:

$$\frac{\lambda_E}{\lambda_S} = \frac{L_E^2}{L_G^2}$$

When equation (1.3) is solved by inputting the values of λ_E and λ_S, it is found that:

$$\frac{L_E}{L_G} = 0.9842$$

$$\Rightarrow L_G = 4.551a_0$$

Since $\frac{L_E}{L_G} \neq 1$, it can be said that the gravity of the sun influences the electronic wavefunctions on the 3s and 3p orbitals of oxygen.

The study used a quantitative research approach to measure the effect of the Sun's gravity on electronic wavefunctions in an Oxygen atom and test the hypothesis. The analysis of spectrums of more elements is necessary to further validate the hypothesis. The study also relied on existing literature on the effects of gravity on electronic wavefunctions and the composition and behavior of the sun to provide context and draw conclusions. The study was limited to the analysis of the oxygen spectrum of the sun and did not consider other factors that may influence the results. In conclusion, the study employed a quantitative research approach to test the hypothesis that the shells of the oxygen atom undergo expansion or compression under the presence of gravity. The study used a modified version of an infinite potential well model to compare the energies of the shells of oxygen atoms present on the earth and the sun. The findings of the study provided insights into the effects of gravity on electronic wavefunctions in oxygen atoms, which can enhance our understanding of the composition and behavior of the sun and provide vital insights for future studies of astronomical and atomic phenomena.

4. Results

In this study, the energy levels of the modified infinite potential wells were compared to determine the relative distances between two orbitals of oxygen atoms present on the earth and the sun. The analysis showed that the ratio of distances between the orbitals present on the earth and the sun is not unity. The ratio is found to be 0.9842. This finding supports the hypothesis that the shells of the oxygen atom undergo expansion under the presence of gravity, resulting in a change in the difference of energy levels in the orbitals. It is also found that the distance between 3s and 3p orbitals is $4.551a_0$ in the oxygen present in on the sun, whereas the distance is $4.48a_0$ on the Earth. The findings of the study are significant and provide vital insights into the effects of gravity on electronic wavefunctions and can serve as a starting point for future research in this area. The table (1.1) presents existing data and the findings of the study:

Table 1.1

Orbitals of transition	Wavelength observed on Earth (λ_E)	Wavelength observed on the Sun (λ_S)	Distance between orbitals on Earth (L_E)	Distance between orbitals on Sun (L_G)	Ratio of distances between orbitals $\left(\frac{L_E}{L_G}\right)$
$3s \leftrightarrow 3p$	$6.653 * 10^{-7}m$	$6.867 * 10^{-7}m$	$2.370 * 10^{-10}m$	$2.407 * 10^{-10}m$	0.9842

5. Discussion

The results of this study indicate that the hypothesis proposed in the introduction is supported, as the analysis of the modified infinite potential wells revealed that the ratio of distances between two orbitals of oxygen atoms present on the earth and the sun is not unity but 0.9842. This finding supports the idea that the orbitals of the oxygen atom undergo expansion under the presence of gravity, resulting in a change in the difference of energy levels in the orbitals. The distance between 3s and 3p orbitals is also found to be different on the earth and sun, with $4.551a_0$ on the sun and $4.48a_0$ on the Earth.

These results provide important insights into the effects of gravity on electronic wavefunctions and the behavior of oxygen atoms in the presence of a large gravitational field. The finding that the ratio of distances between orbitals on the earth and sun is not unity suggests that the electronic wavefunctions change due to the effect of gravitational field, which affects the energy levels in the orbitals.

These findings have significant implications for our understanding of the composition and behavior of the sun and other astronomical phenomena. They suggest that the effects of gravity on electronic wavefunctions in atoms can be used to gain insights into the composition and behavior of celestial bodies. Moreover, the study provides a starting point for future research in this area. Further analysis of the spectra of other elements under the influence of a large gravitational field and with significant screening effects is needed to validate the hypothesis completely.

It is worth noting that the study has some limitations that should be addressed in future research as the study does not take into account the factors such as the presence of other elements in the sun may also affect the energy levels of the oxygen atom.

This study provides important insights into the effects of gravity on electronic wavefunctions in oxygen atoms and supports the hypothesis that the orbitals of oxygen atoms undergo expansion or compression under the influence of gravity. The findings have significant implications for our understanding of the composition and behavior of the sun and other celestial bodies and can serve as a starting point for future research in this area. Further studies are needed to validate the hypothesis more completely and explore the effects of gravity on other aspects of atom's behavior.

6. Conclusion

This study aimed to address the inconsistency in the detection of oxygen in the sun's spectrum and proposed a hypothesis that the shells of the oxygen atom undergo expansion or compression under the presence of gravity, resulting in a change in the difference in energy levels. The energy levels of the modified infinite potential wells were compared to determine the relative distances between two orbitals of oxygen atoms present on the earth and the sun. The analysis showed that the ratio of distances between the orbitals present on the earth and the sun is not unity, but rather 0.9842, which supports the proposed hypothesis.

Moreover, the study also revealed a difference in the distance between 3s and 3p orbitals in the oxygen atoms present on the Sun and the Earth. The distance between 3s and 3p orbitals is found to be$4.551a_0$in the oxygen present on the Sun, whereas the distance is $4.48a_0$on the Earth. This difference in distance provides an insight into the effects of gravity on electronic wavefunctions and can serve as a starting point for future research in this area. It is essential to note that this study has its limitations. The analysis was performed solely on the oxygen atom, and the effect of gravity on other elements may differ. Despite its limitations, this study has significant implications for our understanding of the composition and behavior of the sun. It can help us gain vital insights into the effects of gravity on electronic wavefunctions in atoms and enhance our understanding of astronomical phenomena. The findings support the hypothesis that the electronic wavefunctions of the oxygen atom undergo expansion under the influence of gravity, providing important insights into the behavior of atoms in celestial bodies. The results of this study can serve as a starting point for future research in this area and contribute to our understanding of the composition and behavior of the Sun.

In addition to enhancing our understanding of the composition and behavior of the Sun, the implications of this research can extend to other astronomical phenomena. The proposed hypothesis and methodology can be applied to other elements and celestial bodies to further investigate the effects of gravity on electronic wavefunctions of different elements. Overall, this study provides a novel approach to investigating the effects of gravity on the electronic structure of atoms and serves as an important contribution to the field of theoretical physics. The insights gained from this research can be used to inform future studies and deepen our understanding of the complex phenomena occurring within celestial bodies.

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