GALILEAN ELECTRODYNAMICS

Experience, Reason, and Simplicity Above Authority
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EDITORIAL POLICY

Galilean Electrodynamics aims to publish high-quality scientific papers that discuss challenges to accepted orthodoxy in physics, especially in the realm of relativity theory, both special and general. In particular, the journal seeks papers arguing that Einstein's theories are unnecessarily complicated, have been confirmed only in a narrow sector of physics, lead to logical contradictions, and are unable to derive results that must be postulated, though they are derivable by classical methods.

The journal also publishes papers in areas of potential application for better relativistic underpinnings, from quantum mechanics to cosmology. We are interested, for example, in challenges to the accepted Copenhagen interpretation for the predictions of quantum mechanics, and to the accepted Big-Bang theory for the origin of the Universe.

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From the Editor's File of Important Letters:

On the Fine Structure Constant α

Sommerfeld introduced the fine structure constant α in 1916 to describe the spacing of splitting of spectral lines in multi-electron atoms. It is a dimensionless quantity, expressed in terms of electric charge e, speed of light c, and Planck's constant h:

$$\alpha = 2\pi e^2 / ch \quad . \tag{1}$$

The fine structure constant provides a relativistic correction to the Bohr theory of the energy level of an electron:

$$E_{n,k} = -Z^2/n^2 [1 + \alpha^2 (n/k - 3/4)] \quad . \tag{2}$$

where Z is the number of protons in the atomic nucleus, and n is the orbital quantum number. For example, Hydrogen has $Z = 1$, and $n = 1, 2, 3...$

Later, Dirac expressed the state energies with expression

$$E_{n,j} = -\left[\mu e^4 / (4\pi\varepsilon_0) 2\hbar^2 n^2\right]\left[1 \ + \ (\alpha^2/n)(j+\tfrac{1}{2})^{-1} - 3/4n\right] \ , \tag{3}$$

where μ is the reduced electron mass, $\mu = mM/(m+M)$, and n and j are integer quantum numbers.

Besides being a measure of the fine structure of spectral lines, the fine structure constant α also measures the coupling strength of the interaction of two electrons. It is considered a fundamental physical constant characterizing the strength of the electromagnetic interaction.

The fine structure constant can be expressed in MKS SI units as

$$\alpha = k_{\mathrm{e}}(e^2/\hbar c) = 0.0072973552 \approx 1/137 \quad , \tag{4}$$

where: k_{e} is Coulomb constant, $k_{\mathrm{e}} = 1/4\pi\varepsilon_0$; ε_0 is the permittivity of free space; $\hbar = h/2\pi$ is the reduced Planck constant.

The fine-structure constant has several interpretations, including ratio scaling in tangential velocity v to velocity of light c, electromagnetic force to maximum force $F_{\max}$ at the Compton radius R_{C}, ratio of of free space impedance Z_0 to electron impedance Z_{e}, ratio of unstable elementary particle lifetimes τ_i/τ_π, Bohr radius R_0 to Compton radius R_{C}, classical electron radius R_{e} to Compton radius R_{C}; Compton radius R_{C} to electromagnetic radius R_{em}, electric charge e/Planck charge q_{P}, resonance frequency $\omega_{\mathrm{P}}/\omega$; Phi ratio Φ, *etc.*

For example:

$$\begin{aligned}\alpha &= v_0/c = Z_0/Z_{\mathrm{e}} = R_0/R_{\mathrm{C}} = R_{\mathrm{C}}/R_{\mathrm{em}} \\ &= (e/q_{\mathrm{P}})^2 = \omega_{\mathrm{P}}/\omega \cong 1/20\Phi^4\end{aligned} \tag{5}$$

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Spectral Line Splitting in a Magnetic Field and the Physical EM Vacuum

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This article addresses the Zeeman splitting of spectral lines in an external magnetic field from a classical viewpoint, based on a model for light radiation from an electron, including the polarization and the frequency spectrum of light. The radiation model is in turn based on a model for a physical electromagnetic vacuum. All Zeeman effects are explained from action on an electron orbiting in an external magnetic field, using only Lorentz forces and a vortex electric field. The mechanism for spectral line splitting is demonstrated in examples involving of the spectral line D_1 and D_2 of Na atoms.

1. Introduction

The Zeeman effect is the splitting of spectral lines radiated by an electron in an external magnetic field. Traditional Quantum Mechanics (QM) explains the Zeeman effects in terms of the energy received by the atom in the magnetic field. At the same time, radiating the electron of an atom receives energy in the interaction of the orbital and spin magnetic moments with the external magnetic field.

But from the classical viewpoint, one electron moving in an orbit *cannot* create an orbital magnetic moment, because the configuration of the magnetic field created by *one* electron moving in an orbit does not match the configuration of the magnetic field created by *many* electrons moving on that orbit. Only the large number of the electrons, moving on an orbit, can create the magnetic field inside an orbit, which is almost completely neutralized outside of the orbit.

One electron moving on an orbit could create orbital magnet moment if only its charge were evenly distributed on an orbit. But all experiments show that the electron is the charged particle having certain sizes. Therefore, the magnetic field, located inside an orbit, having the intensity vector, directed along an orbit axis, can be created only with, at least, a pair of electrons, oppositely located in an orbit and rotating in the identical direction.

Therefore, the orbit of one electron, for example, an electron of the atom of Hydrogen, in an external magnetic field will *not* precess due to the interaction of the external magnetic field with the orbital magnetic moment of the electron, because of the action on the electron, moving on an orbit, of Lorentz forces. Therefore, the explanation of the Zeeman effect, as in QM, by the amount of the additional energy received by the radiating electron at interaction of its orbital magnet moment with external the magnetic, is *not* correct.

2. New Formulations

Fig. 2.1 shows two electrons, rotating in the same direction, disposed in diametrically opposite points of the orbit. Magnetic field lines, produced by one of the electrons inside the orbit, have the same direction with the magnetic field lines, produced by the second electron. Therefore, the total magnetic field, formed within the orbit, similar to the magnetic field of the magnetic sheet, and the magnetic field outside the orbit neutralized.

If one electron moves on an orbit, like a classical particle with the charge not distributed over the orbit, then inside the orbit does not produce a magnetic field, similar to the magnetic field of the magnetic sheet, which is clearly seen in Fig. 2.1. (The mechanism of formation of circular magnetic field lines CMFLs around the moving electron is shown in [1] "The magnetic charge of a moving electron").

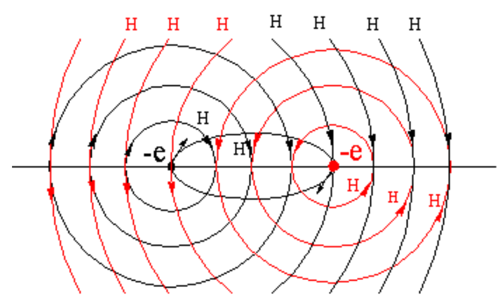

Figure 2.1. Axial magnetic field lines generated by two orbiting electrons.

In Lorentz's theory, cyclic circulation of an electron with frequency ω_0 in an orbit, which plane is inclined at any angle φ to the direction of the external magnetic field, can be decomposed into **1)** harmonic oscillation at frequency ω_0 along the direction of the magnetic field, and **2)** circular motion in a plane perpendicular to the magnetic field. So the movement of the electron in the plane, perpendicular to the direction of the external magnetic field, can be decomposed into two circular rotations of the electron, with identical angular frequency ω_0, occurring in opposite directions.

In a constant external magnetic field, the frequency ω_0 ω_0 of oscillations of the electron along the direction of the magnetic field does not change, and the frequencies of both circular motions ω_0, because of action of Lorentz forces, change by an amount $\pm\Delta\omega$, determined by the size of the kinetic energy of additional orbital rotation, received by the radiating electron from a vortex electric field at switching on of the external magnetic field.

In Lorentz's theory, components of cyclic oscillation of an electron with frequency $\omega_0 \omega_0$ along the direction of the magnetic field lead to light radiation at frequency ω_0, which can be observed in the direction, perpendicular to the direction of the magnetic field. This is the π component of the light radiated at frequency ω_0.

A change of the cyclic frequency of circular motions of electric vectors, occurring in opposite directions in the plane, perpendicular to the magnetic field, leads to the formation of two $\pm\sigma$ components of light, that are observed along the direction of the magnetic field. These are the $\pm\sigma$ components of light, radiated by the electron at frequencies $\omega_0 \pm \Delta\omega$, with circular polarization.

Thus, according to Lorentz's theory, the splitting of the spectral line, radiated by the electron in a circular orbit, into the Lorentz triplet, requires a component of cyclic oscillations of the electron, directed along the direction of the external magnetic field. That is, the orbital angular momentum of the electron has to be inclined at angle φ from the direction of the external magnetic field.

It is known that the frequency ν_0 of light, radiated by the electron, is not equal to the cyclic frequency ω_0 of rotation of the electron in its orbit, as was supposed in the theory of Lorentz. Refs. [1-3] said that the radiation from an electron occurs, not due to its kinetic energy of rotation, but rather due to electron oscillations, arising from the action on the electron of fluctuation electromagnetic impulse of the physical electromagnetic vacuum PhEMV.

The frequencies of oscillations of an electron that lead to light radiation are proportional to the kinetic energy of its movement on an elliptic orbit with root-mean-squared tangential and radial velocities. Refs. [1-3] said that the physical electromagnetic vacuum forming space of our Universe - world ether of classical physics, is the electromagnetic microwave field with a very high energy density, formed by uncountable quantity of micro electromagnetic waves with very small amplitude and wavelength.

The model of the physical vacuum formed by electromagnetic fields of micro electromagnetic waves (microEMWs) is based on the idea saying, that in electric field there are tension forces, which are equal to density of energy of a field. Density of energy of unit of volume of electric field E^2 equal to tension force in electric field, it is possible to interpret as the modulus of elasticity of electric field at stretching and compression. Therefore, if in electric field there are tension forces, then on electric field of electric power lines (EFLs) of the physical electromagnetic vacuum the running waves, being electromagnetic waves, can propagate.

The bend and shift of infinitesimal volumes of electric field by the running waves, propagating on this electric field, leads to formation in the oscillating infinitesimal volumes of this electric field of the own electromagnetic fields of the running waves. Kinetic energy of oscillations of volume unit of electric field of the PhEMV, arising at propagation on electric field of the PhEMV of electromagnetic waves, is equal to the current density of energy of self electric field of EMWs and potential energy of volume unit of the oscillating electric field is equal to the current density of energy of own magnetic field of EMWs.

The self electric fields of the running wave are simply the components of electric field of the PhEMV (directed perpendicular to the direction of propagation of a wave), arising at its bend.

The layers of electric field located in longitudinal sections of the bent infinitesimal volumes of electric field are exposed to stretching and compression, and shift that lead to formation in these layers of the circular electric field which corresponds to Maxwell's equation: $\nabla \times \mathbf{E} = -(1/c)\, \partial \mathbf{H} / \partial t$

The energy of this circular electric field equal to potential energy of infinitesimal volumes of electric field, bent by the propagating wave, it is equal to energy of the arisen magnetic field. Therefore, the magnetic field of the running wave is directed perpendicular to the direction of propagation of a wave and its electric field. Therefore the running waves propagating on electric field are electromagnetic waves.

Therefore, uncountable quantity of microEMWs, the electromagnetic fields of which form the microwave field of the PhEMV, having a very high energy density, propagate on electric fields of EFLs, formed by electric components of the electromagnetic fields of the same microEMWs.

It is assumed that the energy density of an electromagnetic field of the PhEMV is comparable, in equal volumes, with the energy density of a nucleon. In this theory, based on the PhEMV model, any electric field; for example, the external electric field of an electron, it is formed by the electric components of electromagnetic fields of microEMWs of the physical vacuum, connected to the electric field of the electron charge.

Thus, self electric fields, which are formed in oscillating, that are moving EFLs, are moving. The velocity of the movement of electric fields is defined by their kinetic energy, the size of which is characterized by intensity of electric field. Therefore EMWs, including transverse light EMWs, propagate on moving electric fields of the PhEMV. Therefore, as shown on [1, 3], on the surface of the Earth light EMWs will propagate on electric fields, which velocity is determined by Earth velocity in the direction of propagating of light, which explains the experiments of Michelson - Morley.

The PhEMV has some properties of a solid body, owing to which on the electromagnetic field PhEMV cross and longitudinal EMWs, including cross light EMWs, can propagate.

But the energy, transfer by elementary particles, forming bodies, to the electromagnetic field of the PhEMV, happens only at their movement with acceleration. Therefore the physical bodies, which do not have acceleration, move in the PhEMV without resistance.

In the theory based on the PhEMV model, charged particles create the external electric and magnetic fields, using electric and magnetic components of microEMWs the PhEMV. On average the electromagnetic field of the PhEMV, formed by electromagnetic fields of microEMWs, is neutralized. But at an interference of microEMWs the PhEMV in micro volumes of the PhEMV single resultants oscillation - fluctuation of the PhEMV, which energy is not equal to zero, can be formed.

The fluctuation electromagnetic impulses (FEMis), arise in the PhEMV as a result of an interference of microEMWs the

PhEMV, having various amplitudes, frequencies and phases. Therefore the FEM1s having average energy, equal to: $\frac{1}{2}h/\sec$, where h is Planck's constant, can be non-harmonic.

In the theory based on the PhEMV model, the electron and other elementary particles except for a neutrino are formed by transverse electromagnetic impulses (TEMIs), propagating on circular electric power lines (CEFL). In this theory, the neutrino is the longitudinal electromagnetic impulse arising with β decay of the nucleus. An atomic nucleus, having received recoil energy, moving with acceleration, radiates a longitudinal electromagnetic impulse, which is fixed as a neutrino. The mass of the electromagnetic field of the CEFL forms the rest mass of an electron m_{e} and electric field of TEMIs forms an electron charge. The electric field of an inside electric layer of the two-layer electric field of complex particles, created by electric fields of TEMIs, forms nuclear forces.

The kinetic energy of the electron $m_e V^2_{\mathrm{current}}/2$, it is accelerated moving with the current speed V_{current}, it is equal to the current energy of the kinetic electromagnetic field of the electron, which arose in volume of an electromagnetic field of the CEFL of this electron. The electron, moving with acceleration, transfers kinetic energy to the electromagnetic field of the PhEMV, which is connected in all volume to a kinetic electromagnetic field of an electron. Therefore, the electromagnetic field of the PhEMV, which is connected in all electron volume to a kinetic electromagnetic field of an electron, is the radiation field of an electron.

As the volume and density of energy of a radiation electromagnetic field of an electron is equal to the volume and density of energy of a kinetic electromagnetic field of an electron, the mass of a radiation electromagnetic field of an electron is equal to the mass of a kinetic electromagnetic field of an electron equal to $m_{\mathrm{e}} V^2_{\mathrm{current}}/2c^2$. Therefore the mass of the electron moving with acceleration and with the current speed V_{cur} is equal to:

$$m_{\mathrm{e}} + m_{\mathrm{e}} V^2_{\mathrm{current}} / C^2 = m_{\mathrm{e}}\left(1 + V^2_{\mathrm{current}}/C^2\right) \quad .$$

As electron CEFL, the kinetic and radiation electromagnetic fields of an electron are part of an electromagnetic field of the PhEMV, then FEMIs arise and in the electromagnetic fields, forming all mass of an electron. Therefore the elementary particles, forming all substance of the Universe, under the action of fluctuation EMIs, are oscillates, radiating transverse and longitudinal microEMWs with the frequencies, which are defined by electromagnetic energy, forming the particle rest mass, its kinetic and radiation mass. These microEMWs propagate in the PhEMV, as classical waves in the various directions on the electric fields formed by electric components of the electromagnetic fields of the same microEMWs of the PhEMV.

It was assumed above that the average size of energy of FEM1s, which arose in an electromagnetic field of the PhEMV, is equal to: $\frac{1}{2}h\sec^{-1} = \frac{1}{2}6.62\times10^{-27}\,\mathrm{erg}$. In this case in an electromagnetic field of the PhEMV, having the certain size of density of energy, for 1sec there has to be a unit electromagnetic impulse with the energy equal to: $\frac{1}{2}h\sec^{-1}$. In this case in the electromagnetic field of the PhEMV, having the certain size of the density of energy for 1sec there will be an unit fluctuation oscillation with the average energy equal to: $h/\sec$.

Each particle, forming substance of the Universe, under the action of these fluctuation EMIs oscillations, have an average frequency $\nu_{\mathrm{V}} = m_{\mathrm{e}} V^2 / h$ proportional to the sum of energy of a kinetic and radiation electromagnetic field of a particle, radiating longitudinal and transverse microEMWs.

The amplitude of transverse EMWs and energy of the longitudinal electromagnetic impulses propagating on electric fields of PhEMV as longitudinal EMWs, decreases step-by-step in the process of movement in the PhEMV. Therefore the speed of propagation of transverse light EMWs on moving electric fields of the longitudinal EMWs radiated, for example, by a moving Star, in process of the movement in the PhEMV step-by-step decreases from speed and acceleration of the Star at the moment of light radiation to the speed C.

Loss of speed and the acceleration of propagation of light radiated by Stars, together explain many space phenomena, including the one that was the reason for the hypothesis of 'dark matter'. Longitudinal microEMWs, radiated by the elementary particles forming all substance of the Universe, are a basis of forces of gravitation.

In this theory based on the PhEMV model, the wavelength of an electron is understood as the distance passed by it during one oscillation, which arose upon interaction with fluctuation electromagnetic impulses of the PhEMV. Therefore the wavelength of the electron $\lambda_{\mathrm{e}} = V/\left(m_{\mathrm{e}} V^2 h^{-1}\right)$ oscillating with the frequency: $\nu_V = m_{\mathrm{e}} V^2 / h$, it is equal to the de Broglie wavelength:

$$\lambda_{\text{de Broglie}} = h / m_{\mathrm{e}} V \quad , \tag{2.1}$$

Therefore, in the theory based on the PhEMV model, as shown in [1 & 3], the wave properties of the moving electron, which are shown in the phenomena of diffraction, photo effect, Compton's phenomenon, can be discussed with the help of de Broglie wavelength, arising at interaction of a moving electron with fluctuations of the PhEMV.

Ref. [1] showed that, the size of the kinetic energy of the electron, moving under the action of external force with acceleration, consequently, and the frequency of its oscillations, arising under the action of fluctuation EMIs, changes for each period Δt in proportion to the size of external force. Thus, change of the kinetic energy of an electron on size ΔW, corresponding to change of the frequency of its oscillations on the size equal to unit, depends on the size of acceleration of an electron.

Applying the principle of independence of action on a body of external forces and the movements of the body with various sizes of accelerations, it is possible to assume, that the electron moving on an elliptic orbit, has to oscillate with the various frequencies which are defined by the kinetic energy of an electron arising under action on an electron of each of external forces.

The energy of oscillation of an electron under the action of fluctuation EMIs is on average equal to $h/\sec$, therefore the oscillation amplitudes of the electron, moving on an elliptic orbit with length-waves which are defined by average tangential and radial velocities are various.

Upon quantization of a Keplerian ellipse, it was established that the correct energy levels of the electron moving on the elliptic orbit, corresponding to frequencies of light radiated by it, fulfill quantum conditions:

$$\oint P_r\, dr = n'h \quad \text{and} \quad \oint P_\varphi\, d\varphi = kh \quad , \qquad (2.2)$$

where h is Planck's constant, and the sum of quantum numbers $n' + k = n$, where n is the principal quantum number.

Upon fulfillment of the condition (2.2), the electron moving in a circular orbit will radiate light if its orbital angular momentum is equal to:

$$l = m_e VR = nh / 2\pi \quad . \qquad (2.3)$$

As the electron wavelength $\lambda_e = h / m_e V$ from (2.1), using expression (2.3), we find: in light radiation by an electron in a circular orbit, the length of the circular orbit is:

$$L_{\text{circle}} = 2\pi R = nh / m_e V = n\lambda_e \qquad (2.4)$$

Refs. [1-3] showed that, according to expression (2.2), light is radiated by an atom electron in such elliptic orbits which length of orbits L_{ellipse}, during the light radiation, is equal to the product of an integer and average lengths of waves of an electron $\lambda_{\text{avg. tangential}}$ or $\lambda_{\text{avg. radial}}$, moving with average tangential and radial velocities, $V_{\text{avg. tangential}}$ and $V_{\text{avg. radial}}$. That is, it is fulfillment of the conditions requires:

$$L_{\text{ellipse}} = k\lambda_{\text{avg tan}} \quad , \qquad (2.5)$$

or

$$L_{\text{ellipse}} = n'\lambda_{\text{avg rad}} \quad . \qquad (2.6)$$

In this case the forced oscillations of an electron happening under the action of fluctuation EMIs and quasi-elastic Coulomb force, as shown in § 4, leading to light radiation are steady.

And, for the radiation of light fulfillment of the conditions has to be still (2.7): the frequency of forced oscillations of an electron has to be close to the self-resonant frequency of oscillations of an electron in atom. So, for example, in radiation the spectrum of Hydrogen, the brightest spectral line in the Balmer series is determined by R_0 / n^2, where $R_0 = 2\pi^2 m_e e^4 / h^2$ is the Rydberg constant and n is the principal quantum number. The intensities of other Hydrogen spectral lines depend on the difference between their frequency and the electron self-resonant frequency, shown in [1,2] to equal $2R_0 / n^3$. QM alone cannot predict the intensity of spectral lines.

Refs. [1-3] showed that, upon fulfillment of the conditions, Eq. (2.2) becomes:

$$I_{\tan} = \oint P_\varphi d\varphi = kh / 2\pi \quad \text{and} \quad I_{\text{rad}} = \oint P_r dr = n'h / 2\pi \quad , \qquad (2.7)$$

the electron moving on an elliptic orbit with root-mean-square tangential velocity $V_{\text{tan rms}}$ or with root-mean-square radial velocity $V_{\text{rad rms}}$ will oscillate and radiate light with frequencies:

$$\nu_{\text{tan rms}} = m_e V^2_{\text{tan rms}} / h \quad \text{or} \quad \nu_{\text{rad rms}} = m_e V^2_{\text{rad rms}} / h$$

Refs. [1,2] showed that the electron of atom of Hydrogen radiates light with frequencies: $\nu_1 = R_0 / (n')^2$ and $\nu_2 = R_0 / k^2$, are defined by the root-mean-square radial velocity and by the root-mean-square tangential velocity, where $R_0 = 2\pi^2 m_e e^4 / h^2$ is the Rydberg constant.

High-frequency fluctuations of an electron ν_1 can be modulated by lower frequency ν_2. Therefore, in the spectrum of radiation of an electron there are frequencies equal to the sum and difference of the frequencies ν_1 and ν_2, equal to

$$\nu_3 = R_0 / k^2 - R_0 / (n')^2 \quad \text{and} \quad \nu_4 = R_0 / k^2 + R_0 / (n')^2 \quad .$$

The electron oscillation frequency $\nu_4 = R_0 / k^2 + R_0 / (n')^2$ differs from the self-resonant frequency of oscillations of an electron in atom of Hydrogen more, than the frequencies ν_1, ν_2 & ν_3, and therefore it is extinguished by the atom of Hydrogen.

The kinetic energy of the electron moving on an orbit after switching on of an external magnetic field changes due to energy of vortex electric field. Therefore, in the theory of radiation based on the PhEMV model, after the switching on of an external magnetic field, the oscillation frequency of an electron, and therefore the frequency of the radiated light, is changed. Therefore the electron, moving on a circular orbit and radiating light with frequency ν_0 before the switching on of an external magnetic field, after switching on of an external magnetic field stops light radiation with frequency ν_0. Therefore in the theory, based on the PhEMV model, the frequency of light, radiated by an electron, is *not* equal to the rotation frequency of the electron.

In §8.2 it will be show that, according to the theory based on the PhEMV model, the splitting of the spectral line in an external magnetic field, corresponding to the normal Zeeman effect, happens upon radiation of light by an electron in an elliptic orbit of very small eccentricity in a plane perpendicular to an external magnetic field. In this case the additional kinetic energy, received by the electron from the vortex electric field at switch-on of an external magnetic field, is spent not for increase in velocity of the orbital movement of the electron, but rather for precession rotation of the orbit with a cyclic frequency Ω.

Therefore, in the spectrum of oscillations of the electron, radiating light before switching on of an external magnetic field light with the frequency ν_0, after switching on of an external magnetic field there are oscillations of an electron with the frequency ν_0, forming the π light component. Nevertheless, Lorentz's theory allows us to calculate the additional cyclic frequency of rotation of the electron in a circular orbit that arises upon switch-on of an external magnetic field, and to show the mechanism for occurrence of the $\pm\pi$ and the $\pm\sigma$ components of light, which is radiated by an electron of an atom in an external magnetic field.

3. Line Splitting in a Magnetic Field: from Singlet to Triplet

With the help of Lorentz forces it is possible to calculate the size of additional cyclic frequency $\Delta\omega$ of the orbital movement of the electron, rotating with a cyclic frequency ω_0 in a circular orbit, the plane of which is perpendicular to an external magnetic field with intensity H.

Such a calculation appears, for example, in the third volume of the physics course Optics, by G.S. Landsberg edition, 1940, Leningrad. Centripetal force in the absence of a magnetic field is set by a quasi-elastic attraction f_{rad}, so the cyclic frequency of rotation $\omega = 2\pi / T$ is determinates from a condition: $f_{\mathrm{rad}} = m_{\mathrm{e}}\omega^2 r$. And, consequently, $\omega = \sqrt{f} / m_{\mathrm{e}} = \omega_0$ - it is a cyclic frequency in absence of an external magnetic field.

Under the action of a magnetic field there is a Lorentz force, acting along rotation radius on an electron, changing the centripetal force when the frequency of orbital rotation changes:

For the left circle, $$f_{\mathrm{left}} - eV_{\mathrm{left}}H = m_e\omega_{\mathrm{left}}^2 r \quad , \tag{3.1}$$

For the right circle, $$f_{\mathrm{right}} + eV_{\mathrm{right}}H = m_e\omega_{\mathrm{right}}^2 r \quad . \tag{3.2}$$

As $$V_{\mathrm{left}} = \omega_{\mathrm{left}} r \quad \text{and} \quad V_{\mathrm{right}} = \omega_{\mathrm{right}} r \quad ,$$

we have $$m_{\mathrm{e}}\omega_{\mathrm{left}}^2 + e\omega_{\mathrm{left}}H - f = 0$$

and $$m_{\mathrm{e}}\omega_{\mathrm{right}}^2 - e\omega_{\mathrm{right}}H - f = 0 ,$$

We find:

$$\begin{aligned}\omega_{\mathrm{left}} &= -\tfrac{1}{2}(e / m_{\mathrm{e}})H \pm \sqrt{f} / m_{\mathrm{e}} + \tfrac{1}{4}(e^2H^2 / m_{\mathrm{e}}^2)\\ &= -\tfrac{1}{2}(e / m_{\mathrm{e}})H \pm \omega_{\mathrm{e}}\sqrt{1 + \tfrac{1}{4}e^2H^2 / m_{\mathrm{e}}^2\omega_{\mathrm{e}}^2}\end{aligned}$$

$$\begin{aligned}\omega_{\mathrm{right}} &= +\tfrac{1}{2}(e / m_{\mathrm{e}})H \pm \sqrt{f} / m_{\mathrm{e}} + \tfrac{1}{4}(e^2H^2 / m_{\mathrm{e}}^2)\\ &= +\tfrac{1}{2}(e / m_{\mathrm{e}})H \pm \omega_{\mathrm{e}}\sqrt{1 + \tfrac{1}{4}e^2H^2 / m_e^2\omega_{\mathrm{e}}^2}\end{aligned}$$

Neglecting size: $\frac{1}{4}e^2H^2 / m_e^2\omega_{\mathrm{e}}^2$, we find:

$$\omega_{\mathrm{left}} = \omega_0 - \tfrac{1}{2}(e / m_e)H \quad \text{and} \quad \omega_{\mathrm{right}} = \omega_0 + \tfrac{1}{2}(e / m_e)H$$

Thus, at the switching on of an external magnetic field, there are additional cyclic frequencies $\pm\Delta\omega$ orbital rotation of an electron on a circular orbit, which plane is perpendicular to an external magnetic field.

$$\Delta\omega = 2\pi\Delta\nu = \pm\tfrac{1}{2}(k / n)H \quad . \tag{3.3}$$

The radiating electron in a circular orbit, the plane of which is perpendicular to an external magnetic field, having received additional kinetic energy from vortex electric field, changes the frequency of the radiated light to size:

$$\Delta\nu = \pm\frac{1}{4\pi}(e / m_{\mathrm{e}})H = \nu_{\mathrm{L}} \quad , \tag{3.4}$$

where ν_{L} is the Larmor frequency - the size of the frequency change of the light radiated by an electron in a circular orbit in the normal Zeeman effect.

The direction of additional orbital rotation of the electron with a cyclic frequency $\pm\Delta\omega$, arising at an electron during a transient period after switching on of an external magnetic field, depends on orientation of the orbital angular momentum about of external magnetic field.

4. Action of a Magnetic Field on an Electron

A magnetic field affects the radiating electron as it moves in an elliptic orbit about an atomic nucleus. In § 2, and in [2], it was stated that, according to the theory based on the PhEMV model, the frequency of light radiated by an electron moving on an elliptic orbit in a Hydrogen atom, defined by quantum numbers k and n', is a function of the average tangential and radial velocities of this electron.

§ 3 showed that additional kinetic energy is received from the vortex electric field by an electron in a circular orbit in a plane perpendicular to an external magnetic field H. This energy corresponds to an additional frequency of oscillations $\Delta\nu$ $\Delta\upsilon$ of this electron. From Eq. (3.4),

$$\Delta\nu = \pm\frac{1}{4\pi}(e / m_{\mathrm{e}})H = \nu_{\mathrm{L}}$$

Depending on the direction of orbital rotation of the electron about the external magnetic field, the additional kinetic energy received by the electron in a circular orbit from vortex electric field, decreases or increases the cyclic frequency of orbital rotation of the electron, decreases or increases the frequency of the σ components of light, radiated by an electron, by size ν_{L}.

§1 said that in an elliptic orbit the levels of kinetic energy of an electron, corresponding to frequencies of light, radiated by it, are defined by its root-mean-square tangential and radial velocities, are defined by quantum numbers k and n', and $k + n' = n$, where n is the main quantum number.

The energy of an electron in an elliptic orbit is equal to the energy of an electron in a circular orbit, which radius is equal to a semi major axis of the elliptic orbit. Therefore, it can be assumed that the energy of the vortex electric field which is spent for the change of the kinetic energy of the electron, rotating on a circular orbit with R radius, is equal to the kinetic energy, received by the electron from the vortex electric field in the elliptic orbit, in which the length of the semi major axis is equal to the radius of R the circular orbit.

The energy, received from vortex electric field by an electron in an elliptic orbit, is spent for change of kinetic energy of the movement of an electron both with tangential, and with a radial velocity. Therefore it is possible to assume that energy distribution, received by an electron from vortex electric field, is realized according to levels of energy of an electron, determined by its tangential and radial velocities. Therefore, we can assume that at switching on of an external magnetic field the electron, which moves on an elliptic orbit, which plane is perpendicular to an external magnetic field, with an average tangential velocity, receive from the vortex electric field the kinetic energy, proportional to frequency:

$$\nu_L(k/n) = (4\pi)^{-1}(e/m_e)(k/n)H \quad , \tag{4.1}$$

where ν_L is the frequency change of the light radiated by an electron in the normal Zeeman effect in a circular orbit, the radius which is equal to a major semi axis of an elliptic orbit of an electron.

The electron moving on an elliptic orbit in a plane perpendicular to an external magnetic field with an average radial velocity receives from the vortex electric field a kinetic energy defined by the electron's root-mean-square radial velocity. This energy is proportional to frequency:

$$\nu_L(n'/n) = (4\pi)^{-1}(e/m_e)(n'/n)H \tag{4.2}$$

The sum of quantum numbers $k + n' = n$, where n is the principal quantum number, which in this case determines the size of the energy of vortex electric field, which is spent for total change of kinetic energy of the electron, moving in an elliptical orbit.

Sommerfeld proved that, because of the change of centripetal force owing to relativistic change of mass of the electron, corresponding to the orbital velocity of an electron, the electron's elliptic orbit precesses with a constant cyclic frequency Ω. The precession rotation of an orbit with a cyclic frequency Ω provides equality of centripetal and centrifugal force. The sum of the centrifugal and centripetal force, acting on the electron, moving on an elliptic orbit, the plane of which is perpendicular to an external magnetic field, at switching on of an external magnetic field because of action of Lorentz forces and vortex electric field, is changes. Therefore, at switching on of an external magnetic field the elliptic orbit of the electron, which plane is perpendicular to an external magnetic field, should start precession rotations.

The orbital precession of the electron moving on an elliptic orbit perpendicular to an external magnetic field, because which there is a splitting of the spectral line in Zeeman effects, comes due to of receiving by an electron of additional kinetic energy from vortex electric field, proportional to frequency $\nu_L(k/n)$: from Eq. (4.1). Owing to this received energy the electron moves with the additional constant tangential velocity, which is the velocity of this precession orbital rotation of this electron. Therefore the angular velocity of the arisen precession is changing. The direction of precession rotation of an orbit is defined by the direction of the orbital angular momentum of an electron about of an external magnetic field. Therefore, the size of cyclic frequency of the orbital precession, occurring in the orbit plane, has to be defined by the kinetic energy received from vortex electric field by the electron, moving on an elliptic orbit with a tangential velocity. Therefore, the angular frequency of the orbital precession, occurring in the orbit plane is:

$$\Omega = 2\pi\Delta\nu = \pm\frac{1}{2}(e/m_e)(k/n)H \quad , \tag{4.3}$$

$$\Delta\nu = \pm(4\pi)^{-1}(e/m_e)(k/n)H = \nu_{\text{Lar}}(k/n) \quad . \tag{4.4}$$

The kinetic energy received by an electron in a weak magnetic field is small.

Wavelengths of light arising when splitting the spectral line in a weaker magnetic field differ by small amounts from the wavelength of the un-split spectral line. The wavelength λ_{light} corresponding to a frequency of oscillations of an electron equal to: $\nu_e = h^{-1}m_eV^2$ is equal to $C/m_e(V^2/h)$. From § 1, the electron wavelength λ_e, corresponding to a frequency of oscillations of the electron equal to: $\nu_e = h^{-1}m_eV^2$, is equal to:: $\lambda_e = V/(\hbar^{-1}m_eV^2)$. Therefore, $\lambda_{\text{light}}/\lambda_e = C/V$.

The Change of wavelengths of light radiated by an electron in a weaker external magnetic field is insignificant. Therefore, even more minor change of wavelength of the radiating electron in a weaker external magnetic field can be neglected. Therefore, after the switching on of a weak external magnetic field, the conditions for electron radiation from Eq. (2.5) and Eq. (2.6),

$$L_{\text{ellipse}} = k\lambda_{\text{e avg tan}} \quad \text{or} \quad L_{\text{ellipse}} = n'\lambda_{\text{e avg rad}} \quad .$$

in the not-closed, precessing orbit do not change.

In § 1 it was noted that the frequency of oscillation of the electron due to the action of fluctuation EMIs, proportional to its kinetic energy. Therefore, the electron radiating light in an elliptic orbit, having received additional kinetic energy after switching on of an external magnetic field, changes the frequency of oscillations.

Thus, the electron radiating light before switching on of an external magnetic field with a frequency $\nu_{0\text{ avg tan}}$, corresponding to its average tangential velocity in an elliptic orbit, after switching on of an external magnetic field and receiving additional energy, proportional to: frequency increment $\Delta\nu_{\text{avg tan}} = (4\pi)^{-1}(e/m_e)(k/n)H$ will radiate light, depending on the direction of orbital rotation, with frequencies:

$$\begin{aligned} \nu_{1,2\text{ avg tan}} &= \nu_{\text{avg tan}} \pm \Delta\nu_{\text{avg tan}} \quad , \\ \nu_{0\text{ avg tan}} \pm (4\pi)^{-1}(e/m_e)(k/n)H &= \nu_{0\text{ avg tan}} \pm \nu_L(k/n) \quad . \end{aligned} \tag{4.5}$$

The electron radiating before the switch-on of an external magnetic field with the frequency $\nu_{0\text{ avg rad}}$ corresponding to its average radial velocity in an elliptic orbit after switching on of an external magnetic field and receiving additional energy, proportional to $\Delta\nu_{\text{avg rad}} = (4\pi)^{-1}(e/m_{\text{e}})(n'/n)H$ will radiate light, depending on the direction of orbital rotation, with frequencies:

$$\begin{aligned}\nu_{1,2\text{ avg rad}} &= \nu_{0\text{ avg rad}} \pm \Delta\nu_{\text{avg rad}} \\ &= \nu_{0\text{ avg rad}} \pm (4\pi)^{-1}(e/m_{\text{e}})(n'/n)H \\ &= \nu_{0\text{ avg rad}} \pm \nu_{\text{L}}(n'/n)\end{aligned} \tag{4.6}$$

If the electron moves on an elliptic orbit whose plane is perpendicular to the external magnetic field, and the eccentricity of the orbit so small that we can neglect the radial velocity of the electron, after switching on of an external magnetic field all the energy of the vortex electric field is spent for produce of the kinetic energy of the orbital precession. Therefore, in a spectrum of oscillations of the electron, radiating light, before switching on of an external magnetic field, with a frequency ν_0 in such orbit and after switching on of an external magnetic field there will be oscillations with a frequency ν_0, due to which there are the π light component. Therefore, as will be shown in § 8.2, light radiated by an electron in such orbits is split into Lorentz's triplet.

In orbits for which the orbit plane is inclined at an angle φ to the external magnetic field, the angle β between the direction of the external magnetic field and the velocity vector of the electron in the orbit constantly changes. Therefore, as will be shown in § 6, at increase in the angle φ the Lorentz forces, acting in a magnetic field on the radiating electron, moving on an elliptic orbit, can stop light radiation.

5. Mechanism for Formation of Components

In § 2 above, and in [2], it was said that light radiation by an electron of atom happens at its oscillations arising under the action of fluctuation electromagnetic impulses, the frequency of which is proportional to the kinetic energy of the electron. The electron of an atom radiates light at fulfillment of the conditions of (2.5) and (2.6). Besides, light radiation by an electron of atom occurs also on condition of (2.7): frequency of the forced oscillations of an electron has to be close to the self-resonant frequency of oscillations of an electron in atom.

In § 2 above and § 8.2 further on, it is told that splitting of the spectral line of light in a magnetic field into Lorentz's triplet happens at the radiation an electron in nearly circular orbits, which planes are perpendicular to an external magnetic field. Therefore, it is convenient to explain the mechanism of occurrence of the π and the σ light components in a spectrum of splitting on the example of splitting of the spectral line of light on Lorentz's triplet.

The direction of vectors of the maximum intensity of fluctuation electromagnetic impulses, reacting with the electron, moving in an orbit, is arbitrary. Therefore, the oscillations of an electron, made under the action of fluctuation electromagnetic impulses, can be decomposed into oscillations, perpendicular to the orbit plane, and the oscillations, located in the orbit plane.

The movement of an electron in atom of Hydrogen is carried out under the action of the sum of Coulomb force $\mathbf{F}_{\text{Coul}}$ and centrifugal force $\mathbf{F}_{\text{cent}}$ forces. The resultant force returning an electron to position of balance at oscillations under action of the fluctuation electromagnetic impulses, occurring in the orbit plane, it is possible to calculate, according to Fig. 5.1.

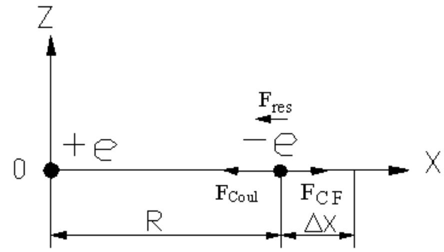

Figure 5.1. Forces acting on an electron in its orbit plane due to EMI fluctuations..

On Fig. 5.1 the orbit of an electron is located in the YOX plane. The electron is located at radius R from the atomic nucleus, which is in a point (0) of the origin of coordinates; ΔX is the size of movement of the electron under the action of electromagnetic impulses of the PhEMV in the orbit plane.

In §2 it was said that, in the theory based on the PhEMV models, the electron, moving with velocity V, oscillates at frequency $\nu = m_{\text{e}}V^2/h$ under the action of single microwave fluctuation oscillations of the PhEMV, energy of each of which is on average equal to h/sec, where h is Planck's constant. Therefore, energy E of oscillation of the first harmonic of expansion in Fourier series of non-harmonic oscillations of an electron with frequency $\omega = 2\pi\nu = 2\pi m_{\text{e}}V^2/h$ is $E = \frac{1}{2}m_e\omega^2 A^2 = \ h/\text{sec}$, where A is the amplitude of oscillation. Therefore:

$$A = \sqrt{2}\ h/m_{\text{e}}\omega^2 = \omega^{-1}\sqrt{2}\ h/m_{\text{e}} \quad . \tag{5.1}$$

The magnitude of amplitude A determines the real magnitude of uncertainty for a moving electron arising because of interaction with fluctuations of the PhEMV unlike formal methods of QM.

The quasi-elastic force, returning an electron in position of balance (on Fig. 5.1), acting on the electron, rotating on a circular orbit and oscillating in the orbit plane with a frequency of the radiated light, is the resultant force F_{result}, equal to the combination of Coulomb force $F_{\text{Coul.}}$ and centrifugal forces $F_{\text{centrif.}}$:

$$F_{\text{result}} = F_{\text{Coul.}} - F_{\text{centrif.}}$$

where

$$\begin{aligned}F_{\text{Coul.}} &= e^2\big/(R+x)^2 = (e^2\big/R^2)\big/(1 + 2x/R + x^2/R^2) \\ &\approx (e^2\big/R^2)\times(1 - 2x/R - x^2/R^2 + 4x^2/R^2 ...) \\ &= (e^2\big/R^2)\times(1 - 2x/R + 3x^2/R^2 ...)\end{aligned}$$

and

$$\begin{aligned}F_{\text{centri.}} &= m_{\text{e}}V^2\big/(R+x) \\ &= (m_{\text{e}}V^2/R)\times(1 - x/R + x^2/R^2 ...)\end{aligned}$$

Since $x << R$, it is possible to neglect all further expansion terms. Then, since $m_e V^2 / R = e^2 / R$:

$$F_{\text{centrif,}} = e^2 / R^2 - xe^2 / R^3 \quad , \quad F_{\text{Coul.}} = e^2 / R^2 \qquad , \qquad (5.2)$$
$$F_{\text{result}} = F_{\text{Coul.}} - F_{\text{centrif.}} = +xe^2 / R^3$$

Thus, the oscillations of an electron in the plane of a orbit happen under the action of the components fluctuation electromagnetic impulses, located in the orbit plane, and the linear quasi-elastic returning force, equal to: $F = xe^2 / R^3$.

The resultant force, returning the electron in the plane of the circular orbit at oscillations, perpendicular to the orbit planes, can be calculated, according to Fig. 5.2

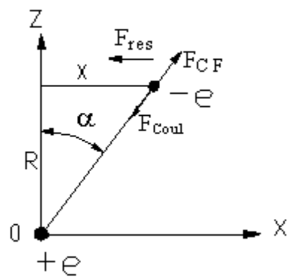

Figure 5.2. Forces due to of EMI fluctuations acting perpendicular to the orbit plane of an electron.

On Fig. 5.2 the orbit of the electron is located in the ZOY plane. The electron is located at radius R from the atomic nucleus, which is at the origin of coordinates. X is the size of movement of an electron under the action of impulses electromagnetic fluctuation of the PhEMV in the direction perpendicular to the orbit plane.

$$F_{\text{result}} = -F_{\text{Coul.}} \sin\alpha + F_{\text{centrif.}} \sin\alpha$$

Since $X << R$, angle $\alpha \to 0$, $\sin\alpha \to \tan\alpha \to x / R$. The Coulomb contribution to F_{result} then becomes

$$-F_{\text{Coul.}} \sin\alpha = -\left[e^2 / (R^2 + x^2)\right] x / R$$
$$= -e^2 (x / R^3) \times \left[1 - x^2 / R^2 + x^4 / R^4 - .....\right]$$

Because $x << R$, it is possible to neglect the last displayed term and all further terms. So then

$$-F_{\text{Coul.}} \sin\alpha \approx -e^2 (x / R^3) \times \left[1 - x^2 / R^2\right].$$

Similarly, the centrifugal force becomes

$$F_{\text{centrif.}} \sin\alpha = \left[m_e V^2 \Big/ \sqrt{R^2 + x^2}\right] x / R$$
$$= m_e V^2 (x / R^3) \times \left[1 - x^2 / R^2\right]$$

Then with $m_e V^2 / R \approx e^2 / R^2$,

$$F_{\text{result}} \approx -e^2 (x / R^3) + e^2 (x / R^3) \approx 0 \quad .$$

Thus, the oscillations of an electron, perpendicular to the orbit plane made under the action of the components of fluctuation electromagnetic impulses, perpendicular to the orbit planes, happen only under the action of these components of fluctuation electromagnetic impulses, without quasi-elastic returning force.

The direction of the resulting vectors of electric field intensity of fluctuation electromagnetic impulses of the PhEMV acting on an electron about of the plane of its orbit is any. Therefore it is possible to assume that vectors of average values of electric field intensity of fluctuation electromagnetic impulses and, therefore, average values of oscillation amplitudes of an electron, are located at an angle 45° to the electron orbit plane. It is possible to decompose the oscillations of an electron, corresponding to frequency ν_0 not split spectral line, to the oscillations that are happening along the direction of a magnetic field and perpendicular to it, happening in this case in the orbit plane.

It was noted above that the components of forced oscillations of an electron, located in the orbit plane, happen under the action of electric field of fluctuation electromagnetic impulses and the quasi-elastic returning force, and in the plane, perpendicular to the plane of an orbit - without the quasi-elastic returning force. Therefore, the light amplitude of the oscillations of an electron, occurring in the orbit plane, is not equal to the amplitude of oscillations of an electron, perpendicular to the plane of an orbit, and depends on the size of the central electric field of atom and self-resonant frequency of oscillations of an electron in atom.

The oscillations of an electron, perpendicular to the plane of an orbit, lead to light radiation, being the π component split spectral line, as was shown in § 4 and will be recalled in § 8.1. Therefore, the $\pm\pi$ components of the split spectral line of light it is observed in the direction, perpendicular to an external magnetic field.

The components of oscillations of the electron with a frequency ν_0, which happen in the plane of the orbits, perpendicular to an external magnetic field, lead to light radiation, being of the $\pm\sigma$ components of the split spectral line. The frequencies of the $\pm\sigma$ components of the split spectral line change with the frequency of precession according to Eq. (3.4):

$$\Delta\nu = \pm(4\pi)^{-1} (e / m_e) H = \nu_L \quad ,$$

yielding:

$$\nu_{\pm\sigma} = \nu_0 \pm (4\pi)^{-1} (e / m_e) H = \nu_0 \pm \nu_L \qquad (5.3)$$

Oscillations of an electron with a frequency ν_0, directed along the direction of a magnetic field, occurring at its movement in an approximately circular orbit, which plane is perpendicular to an external magnetic field, lead to the radiation of light, which is observed across the direction of a magnetic field. These oscillations of an electron lead to occurrence of the π component of light.

The components of oscillations of the radiating electron with a frequency ν_0, located in the plane of approximately circular orbit, perpendicular to an external magnetic field, change with the precession frequency, becoming:

$$\nu_{1,2} = \nu_0 \pm (4\pi)^{-1}(e / m_e)H = \nu_0 \pm \nu_L \quad .$$

Light frequencies $\nu_0 \pm \nu_L$ observed along the direction of a magnetic field form two the $\pm\sigma$ components of the radiated light with circular polarization.

In the direction of observation, perpendicular to the direction of an external magnetic field, besides of the π component of the split light, pass the $\pm\sigma$ components of light, arising from the components of oscillations of an electron, location in the plane of an orbit, but perpendicular to the direction of observation.

If at light radiation by an electron amplitude of oscillations of an electron in the plane of an orbit is equal to amplitude of oscillations of an electron, perpendicular to the orbit plane, intensity of the $\pm\sigma$ light components is equal to a half of intensity of the π light component, observed in the direction, perpendicular to an external magnetic field.

If the direction of precession rotation of an orbit coincides with the direction of orbital rotation of an electron, the total circular velocity of the electron, oscillating with frequency υ_0, increases and, consequently, the frequency of the σ component the radiated light increases by the size of frequency of precession rotation of an orbit, becomes equal to:

$$\nu_{+\sigma} = \nu_0 + (4\pi)^{-1}(e / m_e)H = \nu_0 + \nu_L \quad .$$

If the direction of the precession rotations of an orbit, which happened under the action of vortex electric field, to opposite to orbital rotation of an electron, a frequency of the σ component of the radiated light decreases by the size of frequency of precession rotation of an orbit, becomes equal to:

$$\nu_{+\sigma} = \nu_0 - (4\pi)^{-1}(e / m_e)H = \nu_0 - \nu_L$$

If light passes in the direction of the vector **H,** then polarization of light with a frequency: $\nu_{+\sigma} = \nu_0 + \nu_L$ will be left, and polarization of light with a frequency $\nu_{-\sigma} = \nu_0 - \nu_L$ will be right. Thus, when using model of splitting of the spectral line of light in an external magnetic field, based on the PhEMV model, both frequencies, and polarization of the split light easily speak.

Cyclic frequency of the precession of the little elongated elliptic orbit in a magnetic field changes in small limits therefore in normal Zeeman effect there are only two of the ±σ components of the splitting light.

Cyclic frequency Ω of the precession of the strongly elongated elliptic orbit changes over a wide range. Therefore, as will be shown in § 8.1, the quantity and energy of the harmonic, component, multiple of the fundamental frequency Ω of precession, increases depending on the degree of elongation of this elliptic orbit, and therefore, the quantity of the ±σ components in a spectrum of splitting of the spectral line increases.

6. Effects of Orbit Inclination

Consider the action of a magnetic field on the radiating electron, moving on the elliptic orbit, which is inclined at an angle φ to an external magnetic field.

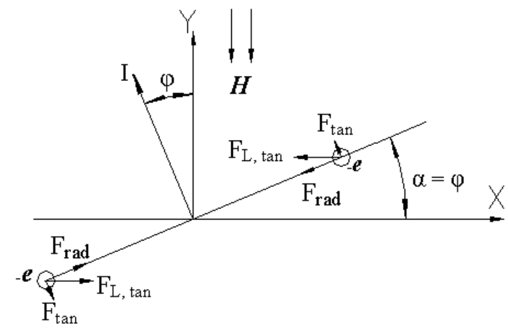

Figure 6.1. Components of Lorentz forces acting on an electron in an elliptic orbit inclined at angle φ to external magnetic field H.

Fig. 6.1 shows the intersection with the XY plane of an elliptic orbit of an electron, on which the orbital angular momentum of the electron I is inclined at an angle φ to the direction of an external magnetic field. The electron orbit plane on Fig. 6.1 is perpendicular to the XY plane and is inclined at an angle $\alpha = \varphi$ to the X axis, perpendicular to the direction of an external magnetic field. The major axis of the elliptic orbit coincides with the Z axis.

The direction of the Lorentz forces, acting in a magnetic field on the electron, moving on an elliptic orbit, are determined by tangential and radial components of orbital velocity of an electron.

The Lorentz force $F_{L\ tan}$, depicted on Fig. 6.1, is determined from the periodically changing tangential velocity of an electron. It can be decomposed into radial force F_{rad}, directed along the radius of rotation of an electron, and tangential force F_{tan}, directed perpendicular to radius.

The Lorentz force F_{orb}, which is not represented on Fig. 6.1, is determined from the periodically changing radial velocity of an electron. The force F_{orb}, acting on an electron at its movement with a radial velocity, periodically changes the tangential velocity of an electron. The F_{rad} changes the size of the centripetal force acting on the electron, and the F_{tan} forms the moment of forces, tilting the vector of the orbital angular momentum of an electron.

The Lorentz forces, acting in a magnetic field on the electron, moving on an elliptic orbit, in which the vector of the orbital angular momentum of an electron is inclined at an angle φ to the direction of an external magnetic field, depends not only on the orbital velocity of an electron and parameters of an orbit, but also on periodically changed angle β between a vector of velocity of an electron and the direction of an external magnetic field, depending on an angle φ. Therefore upon a big increase of the angle φ, the Lorentz forces acting in a magnetic field on the radiating electron moving on an elliptic orbit can stop light radiation.

In § 3 it was shown that the elliptic orbit of an electron in atom under the action of the Lorentz forces, arising at switching on of an external magnetic field, has to precess with a cyclic frequency Ω in the orbit plane. The Lorentz force F_{orb}, which is defined by periodically changing radial velocity of the electron, addition periodically changes the tangential velocity of the electron.

In § 3 it was told that the value of additional current tangential velocity of an electron in the elliptic orbit arising at switching on of an external magnetic field is the current velocity of the arisen precession orbital rotation of an electron. Therefore additional periodic change of tangential velocity of an electron under the action of force F_{orb} leads to that the angular velocity of an orbital precession becomes the value changing. Therefore the cyclic frequency Ω of an orbital precession of elongated elliptic orbit can be expanding into a series of frequencies $N\Omega$, integer multiples of cyclic frequency Ω.

If the tilt angle φ of a vector of the orbital angular momentum of an electron to the direction of an external magnetic field is sufficiently great, under the action of the Lorentz force $F_{\tan}$, forming the moment of forces, tilting a vector of the orbital angular momentum of an electron, there has to be an electron orbit precession round the direction of an external magnetic field with cyclic frequency $\Omega_{\text{prec.}}$.

In § 3 it was assumed that the electron radiating light with a frequency ν_0 in an elliptic orbit, perpendicular to an external magnetic field, at little change of the wavelength, happening at switch-on of a weak external magnetic field, continues light radiation with frequencies $\nu_0 \pm \Delta\nu$. Therefore it is possible to assume, as at the small inclination of a vector of the orbital angular momentum to the direction of an external magnetic field, leading to little change of the energy, received by the radiating electron at switching on of an external magnetic field, the electron will continue light radiation with the changed frequencies equal to: $\nu_0 \pm \Delta\nu_1$, where $\Delta\nu_1 \to \Delta\nu$. Therefore broadening of spectral lines of light can be explained with light radiation by the electrons moving on elliptic orbits with a little changed kinetic energy and, therefore, with a little changed lengths of waves of an electron, which is equal to: $h / m_e V$.

7. Multiple Splitting of Spectral Lines

In the theory based on the PhEMV model, it is possible to explain multiple splitting of spectral lines by radiation of the electrons rotating on elliptic orbits with identical length of the major semi axis, but with various size of focal semi-parameter q, defined by quantum number k, changing depending on elongation of an elliptic orbit.

In § 2 it was shown that for radiance by an electron of light the length of its elliptic orbit, during the light radiation, should be equal to the product of an integer with the average electron wavelength, corresponding to its root-mean-square tangential or radial velocity. That is, the condition that should be satisfied is, from Eqs. (2.4) and (2.5):

$$L_{\text{ellipse}} = k\,\lambda_{\text{e avg tan}} \quad \text{or} \quad L_{\text{ellipse}} = n'\,\lambda_{\text{e avg rad}} \quad .$$

The elliptic orbits that have identical lengths of the major semi axis, but various values of focal semi-parameter q, have various lengths. Therefore average lengths of waves: $\lambda_{\text{e avg tan}}$ or $\lambda_{\text{e avg rad}}$ the electrons, moving on elliptic orbits with a different length, for fulfillment of conditions (2.5) and (2.6) have to be various. Therefore sizes of average velocities: $V_{\text{e avg tan}}$ or $V_{\text{e avg rad}}$ and, therefore, sizes of kinetic energy of electrons in such orbits the various. Therefore the electrons, moving on such orbits, radiate light with slightly changed frequencies. Therefore, as shown in § 8 and § 9, each of the elliptic orbits of electrons, radiating light with a frequency of spectral lines, for example, of the doublet of Na atoms, has to be determined by to the product of the quantum numbers k or n' with the average electron wavelength, corresponding to its average tangential or radial velocity.

In § 9.2 it will be shown that really elliptic orbit of an electron of Na atom, radiating light with a frequency of the spectral line D_2 of a doublet of Na atom, is more elongated, than an orbit of an electron of Na atom, radiating light with a frequency of the spectral line D_1.

8. Normal & Abnormal Zeeman Effects

This Section shows that in the theory based on the properties of the PhEMV, Zeeman splitting occurs for spectral lines radiated by the oscillating electron in an elliptic orbit the plane of which is perpendicular to the external magnetic field. The energy received by the radiating electron from the vortex electric field, and which is spent for change of frequencies of the split light, is distributed between energy of the light components change in proportions k / n and n' / n, where, k, n', and n are quantum numbers.

8.1 The Anomalous Zeeman Effect

In §2 it was said that radiation by an electron of atom of light occurs at the oscillations, which arose under the action of fluctuation EMI's, which frequency is proportional to its kinetic energy, at fulfillment of conditions (2.5), (2.6) and, besides, at fulfillment of the condition (2.7): oscillation frequency of an electron has to be close to the self-resonant frequency of oscillations of an electron in atom.

In § 4 it was shown that in a weaker external magnetic field change of the kinetic energy of an electron and, therefore, the frequency change of oscillations of an electron happens on small size. Therefore, at the switching on of a weak external magnetic field, the changed oscillation frequency of an electron remains nearly to the self-resonant frequency of oscillations of an electron in atom.

<u>Formation of the π and the σ components of the spectral line of light, radiated by the electron moving on an elliptic orbit having the average value of elongation, split in a weaker magnetic field.</u>

In § 4 it was said that it is possible to assume that kinetic energy of the electron, moving with a tangential velocity on an elliptic orbit, at switching on of a weak external magnetic field, perpendicular to the orbit planes, changes on the small size, proportional to frequency as given by Eq. (4.1):

$$\Delta\nu = (4\pi)^{-1}(e/m_e)(k/n)H = \nu_L(k/n) \quad ,$$

where ν_L is the frequency change of the radiated light by an electron in normal Zeeman effect in the circular orbit, of which the radius is equal to the major semi axis of the elliptic orbit of the electron.

Therefore at switching on of a weak external magnetic field the changed oscillation frequency of an electron remains nearly to the self-resonant frequency of oscillations of an electron in atom.

Therefore, the electron, radiating before switching on of a weak external magnetic field with the frequency: $\nu_{0\text{ avg tan}}$, after switching on of an external magnetic field and change under the action of vortex electric field of the kinetic energy, depending on the direction of orbital rotation about the direction of an external magnetic field, will radiate light with the frequencies given by Eq. (4.5):

$$\nu_{1,2\text{ avg tan}} = \nu_{0\text{ avg tan}} \pm \nu_L(k/n) \quad .$$

Kinetic energy of the electron, moving with a radial velocity on such orbit, at switching on of a weak external magnetic field changes on the size, proportional to frequency from Eq. (4.2):

$$\Lambda\nu = \nu_L(n'/n) = \pm(4\pi)^{-1}(e/m_e)(n'/n)H \quad .$$

Therefore, the electron, radiating before switching on of an external magnetic field with the frequency: $\nu_{0\text{ avg t an}}$, or $\nu_{0\text{ avg rad}}$ after switching on of a weak external magnetic field, depending on the direction of orbital rotation about the direction of an external magnetic field, will radiate light with the frequencies from Eqs. (4.5) & (4.6):

$$\nu_{1,\,2\text{ avg tan}} = \nu_{0\text{ avg tan}} \pm \nu_L(k/n) \quad ,$$

$$\nu_{1,\,2\text{ avg rad}} = \nu_{0\text{ avg rad}} \pm \nu_L(n'/n) \quad .$$

Oscillations of an electron with frequencies (4.5) or (4.6), happening in the plane, perpendicular to the plane of an elliptic orbit, form the $\pm\pi$ components of the split spectral line.

In § 4 it was said the size of cyclic frequency of the orbital precession, happening in the orbit plane, has to be defined by the kinetic energy received from vortex electric field by the electron, moving on an elliptic orbit with a tangential velocity.

§ 6 said that the Lorentz force F_{orb}, which is defined by periodically changing radial velocity of the electron in an elliptic orbit, in addition periodically changes the tangential velocity of an electron. Therefore additional periodic change of tangential velocity of an electron under the action of force F_{orb} leads to that the angular velocity of an orbital precession becomes the value changing. Therefore the cyclic frequency from Eq. (4.3)

$$\Omega = 2\pi\Delta\nu = \pm\frac{1}{2}(e/m_e)(k/n)H \tag{8.1.1}$$

for precession of the elliptic orbit can be expanded into series of frequencies to: $N_1\Omega$, multiples of Ω, where from Eq. (4.4)

$$\Delta\nu = \pm(4\pi)^{-1}(e/m_e)(k/n)H = \nu_L(k/n) \quad .$$

Oscillations of an electron with frequencies from Eqs. (4.5), (4.6):

$$\nu_{1,2\text{ avg tan}} = \nu_{0\text{ avg tan}} \pm \nu_L(k/n)$$

or

$$\nu_{1,2\text{ avg rad}} = \nu_{0\text{ avg rad}} \pm \nu_L(n'/n) \quad .$$

located in the plane of an elliptic orbit, after modulation by precession frequency:

$$N_1\Delta\nu = N_1(4\pi)^{-1}(e/m_e)(k/n)H = N_1\nu_L(k/n) \quad . \tag{8.1.2}$$

form the $\pm\sigma_i$ components of the split spectral line with frequencies:

$$\left[\nu_{0\text{ avg tan}} \pm \nu_L(k/n)\right] \pm N_1\nu_L(k/n) \tag{8.1.3}$$

or

$$\left[\nu_{0\text{ avg rad}} \pm \nu_L(n'/n)\right] \pm N_1\nu_L(k/n) \quad , \tag{8.1.4}$$

where N_1, defining the quantity of the $\pm\sigma_i$ $\pm\sigma_i$ components in a splitting spectrum depends on distribution of energy between harmonious components of expansion into a series of the changing cyclic frequency Ω (8.1.1).

So, for example, as will be shown in § 9.1 and § 9.2, light with frequencies of spectral lines D_1 and D_2 is also radiated by electrons of atoms of Na in elliptic orbits with average elongation.

It would be possible to expect that in spectrums of splitting of spectral lines D_1 and D_2, besides of the $\pm\pi$ components, have to be on two pairs of the σ component, which are $\pm\sigma_1$ and $\pm\sigma_2$ components.

But, as shown in § 9.1 and § 9.2, the elliptic orbit of an electron of Na atom, radiating light with a frequency of the D_2 spectral line, is more elongated, therefore only in the splitting spectrum of the D_2 spectral line there is the second pair of the σ components.

Therefore it is possible to assume what, exactly for this reason, in a spectrum of splitting of the spectral line D_1 is not present the second pair of the σ components.

<u>We can study the formation of the π and σ components of the spectral line of light, radiated by the electron moving on a little elongated elliptic orbit, split in a weaker magnetic field.</u>

Due to work of the Lorentz force acting on the electron moving at average radial velocity on the precessing elliptic orbit, perpendicular to the external magnetic field, the tangential velocity and kinetic energy of this electron periodically change.

It is possible to assume, that the kinetic energy, which periodically receives the electron, moving with a tangential velocity on such orbit, due to work of Lorentz force, which is defined by the average radial velocity of this electron, also is proportional to.frequency:

$$\Delta\nu = \nu_L(n'/n) = \pm(4\pi)^{-1}(e/m_e)(n'/n)H$$

from Eq. (4.2).

Therefore, the electron, which is periodically receiving the additional kinetic energy in an external magnetic field, corresponding to the root-mean-square radial velocity of this electron, under the acting of fluctuation EMIs has additional oscillations with the average frequency:

$$\Delta\nu_{\text{avg rad orb}} = (4\pi)^{-1}(e/m_e)(n'/n)H = \nu_L(n'/n) \quad . \tag{8.1.5}$$

In § 1 it was said that, the fluctuation electromagnetic impulses FEMIs arise in the PhEMV as a result of an interference of microwaves of the PhEMV, having various amplitudes, frequencies and phases. Therefore the FEMIs can be non-harmonic.

The periodic no harmonic oscillations of an electron with an average frequency $\Delta\nu_{\text{avg rad orb}}$, arising under the action of no harmonic impulses PhEMV, can be expanding into series of frequencies to:

$$N\Delta\nu_{\text{abg rad orb}} = N(4\pi)^{-1}(e/m_e)(n'/n)H = N\nu_L(n'/n) \quad . \tag{8.1.6}$$

where N, defining quantity of harmonicas with sufficiently large value of energy, depends on parameters of no harmonic fluctuation EMIs.

Therefore, as a result of amplitude modulation of high-frequency oscillations of an electron, according to Eq. (4.6):

$$\nu_{1,2 \text{ avg rad}} = \nu_{0 \text{ avg rad}} \pm \nu_L(n'/n)$$

by low-frequency oscillations with frequencies according to Eq. (8.1.6):

$$N\Delta\nu_{\text{avg rad orb}} = N\nu_L(n'/n) \quad ,$$

in a spectrum of oscillations of an electron there have to be frequencies:

$$\nu = \left[\nu_{0 \text{ avg rad}} \pm \nu_L(n'/n)\right] \pm N\nu_L(n'/n) \quad . \tag{8.1.7}$$

That in a spectrum of splitting there were frequencies, determined by expression (8.1.7), which produced as a result of amplitude modulation, these frequencies have to be closely spaced to frequencies according to Eq. (4.6):

$$\nu_{1,2 \text{ avg rad}} = \nu_{0 \text{ avg rad}} \pm \nu_L(n'/n) \quad .$$

In the low elongated elliptic orbit, the radial speed of the radiating electron is several times is less than its tangential velocity.

If an electron radiates light in the low elongated elliptic orbit at a frequency defined by its root-mean-square radial velocity $\nu_{\text{avg rad}}$, the additional energy received by it in the weaker external magnetic field is small. Therefore, the oscillation frequencies of the electron (which is moving on such a little elongated elliptic orbit), which produced as a result of amplitude modulation of frequencies $\nu_{1,2 \text{ avg rad}}$ by frequencies $\Delta\nu_{\text{avg rad orb}}$ are closely spaced to frequencies of $\nu_{1,2 \text{ avg rad}}$.

In this case, as was shown in §4, electron radiation conditions, according to Eq. (2.5), on not-closed, precessing elliptic orbit are satisfied. Therefore, the π components of the split light with frequencies:

$$\begin{aligned} \nu &= \nu_{0 \text{ avg rad}} \pm \nu_L(n'/n) \pm N\nu_L(n'/n) \\ &= \nu_{1,2 \text{ avg rad}} \pm N\nu_L(n'/n) \end{aligned} \tag{8.1.8}$$

can be observed in the splitting spectrum, for example, as one of spectral lines of a septet of Cr atom, which is split into 21 components.

It was said above that the Lorentz force that acts on the electron, which is moving with a radial velocity on an elliptic orbit in an external magnetic field, periodically changes the tangential velocity of this electron.

As the tangential velocity of an electron determines the angular velocity of an orbital precession Ω, the cyclic frequency of precession of the elliptic orbit Ω, arising in an external magnetic field, is changing. Therefore, according to Eq. (4.4) the periodically changing cyclic frequency of a precession an elliptic orbit

$$\Omega = \frac{1}{2}(e/m_e)(k/n)H$$

can be expanded into series of frequencies according to Eq. (8.1.1): $N_1\Omega$, where N_1 is an integer.

After switching on of an external magnetic field the number of frequencies, on which the spectral line of light, radiated by the electron, radiating in elliptic orbits with various elongation, is split is various.

The oscillations of an electron corresponding, for example, to frequencies from Eq. (8.17):

$$\begin{aligned} \nu &= \nu_{0 \text{ avg rad}} \pm \nu_L(n'/n) \pm N\nu_L(n'/n) \\ &= \nu_{1,2 \text{ avg rad}} \pm N\nu_L(n'/n) \end{aligned} \quad , \tag{8.1.8}$$

arising at switching on of an external magnetic field, can be decomposition to oscillations along a magnetic field and perpendicular to it, occurring inp this case in the orbit plane.

The oscillations of an electron with frequencies, determined by expression (8.1.7), occurring along of a magnetic field, lead to light radiation, being of the $\pm\pi_i$ components of light, which is observed across of an external magnetic field. Here $i = 1...I$ is the serial number of the $\pm\pi_i$ light components.

The vector of electric field of the $\pm\pi_i$ components of light is directed along an external magnetic field. Each of the electron oscillation frequencies, determined by expression (8.1.7), occurring in the plane of an orbit, perpendicular to an external magnetic field, changes on sizes of the cyclic frequencies of the precession $N_1\Omega$ (8.1.1), forming $\pm\sigma_i$ light components with the vector of electric field, directed across of an external magnetic field. Here $i = 1...I$ is the serial number of the $\pm\sigma_i$ light components.

If the direction of precession rotation of an elliptic orbit coincides with the direction of orbital rotation of an electron, frequency of the $+\sigma_i$ components of the split spectral of light, radiated by the electron moving with a radial velocity, increase by sizes of frequencies of the precession rotation of an orbit $N_1\Omega$, becoming:

$$\nu_{+\sigma_i} = [\nu_{1\text{aver.rad}} + N\nu_L(n'/n)] + N_1\nu_L(k/n) \quad . \quad (8.1.9)$$

If the direction of precession rotation of an orbit an opposite to direction of orbital rotation of an electron, frequencies of the $-\sigma_i$ components of the radiated light become:

$$\nu_{-\sigma_i} = [\nu_{1\text{aver.rad}} - N\nu_L(n'/n)] - N_1\nu_L(k/n) \quad . \quad (8.1.10)$$

Thus, each of the $\pm\pi_i$ components that arose when splitting, for example, of the spectral line of light with a frequency $\nu_{0aver.rad}$, forms a number of the $\pm\sigma_i$ light components.

It was told above that in a weaker external magnetic field the additional kinetic energy, received by the electron, moving on a little elongated elliptic orbit with a radial velocity is small.

Therefore also additional frequencies of oscillations of an electron of: $N\Delta\nu_{\text{avg rad orb}}$ are small.

Therefore, frequencies of the $\pm\pi_i$ components of the split spectral line of light, radiated by the electron, moving with a radial velocity on a little elongated orbit, are close to the self-resonant frequency of oscillations of the electron in atom.

Therefore, the splitting spectrum, for example, of spectral lines of a septet of Cr atom, consists of a large number of the $\pm\pi$ and the $\pm\sigma$ components.

8.2 The Normal Zeeman Effect

In §2 it was said that in the theory based on the PhEMV model, the electron radiates light at the oscillations that arose under the action of fluctuation EMIs which frequency is defined by kinetic energy of this electron. Therefore, according to the theory which is based on models PhEMV, the electron moving on a circular orbit and radiating light, forming the singlet spectral line with a frequency ν_0, having received at switching on of an external magnetic field from vortex electric field additional kinetic energy, has to stop light radiation with the frequency ν_0.

In § 2 and § 8.1 it was said that radiation an electron of atom of light occurs at its oscillations which arose under the action of fluctuation EMIs at fulfillment of conditions (2.4), (2.5) and (2.6). The additional kinetic energy, received by the electron radiating light in an elliptic orbit, changes kinetic energy of the motion of this electron both with tangential, and with a radial velocity,

In § 4 and § 8.1 it was said that the energy of the external magnetic field, changing kinetic energy of the movement of the electron on an elliptic orbit with a tangential velocity, is equal to energy of the cyclic frequency Ω of an orbital precession. Therefore, that there was a splitting of the singlet spectral line into the Lorentz's triplet, the elliptic orbit of the electron, radiating with a frequency υ_0, has to have such small eccentricity at which it would be possible to neglect by the size of radial velocity of this electron in such elliptic orbit. Therefore in such orbit all energy of the vortex electric field, arising at switching on of an external magnetic field, is spent for produce of additional current tangential velocity of an electron that, as was said in § 4, is the current velocity of the arisen precession orbital rotation of an electron. Therefore if the electron moves on almost circular orbit, which plane is perpendicular to an external magnetic field, all energy of vortex electric field is spent for creation of an orbital precession with a cyclic frequency $\Omega = 0.5(e/m_e)H$ from Eq. (3.3), without changing electron oscillation frequency υ_0. Thus, splitting in an external magnetic field of the singlet spectral line with a frequency υ_0 on Lorentz's triplet happens in case the electron radiates light in almost circular orbit which plane is perpendicular to an external magnetic field.

The oscillations of an electron, perpendicular to planes of an orbit, lead to light radiation, being the π component of the split spectral line, as it was shown in § 4 and § 8.1. Therefore the π component of the split spectral line of light it is observed in the direction, perpendicular to an external magnetic field.

The components of oscillations of the electron with a frequency υ_0, which are located in the plane of the orbits, perpendicular to an external magnetic field, lead to light radiation, being the $\pm\sigma$ components of the split spectral line.

Frequencies of the $\pm\sigma$ component of the split spectral line because of the arisen precession of an orbit change on sizes by Eq. (3.4):

$$\Delta\nu = \pm(4\pi)^{-1}(e/m_e)H = \nu_L \quad ,$$

approaching:

$$\nu_{\pm\sigma} = \nu_0 \pm (4\pi)^{-1}(e/m_e)H = \nu_0 \pm \nu_L \quad , \quad (8.2.1)$$

where ν_L is the Larmor frequency – the frequency change of radiated light by an electron in the normal Zeeman effect.

The normal Zeeman effect differs from anomalous Zeeman effect also in that it happens in a stronger external magnetic field. Therefore, all additional oscillation frequencies of an electron $\Delta\nu$ (including the frequency ν_{orb} discussed in § 8.1), arise at switching on of a strong external magnetic field, and are larger.

Therefore the de Broglie wavelengths of the electron,

$$\lambda_{\text{de Broglie}} = h / m_e V \quad , \qquad (2.1)$$

corresponding to frequencies of all its additional oscillations, orbiting in almost circular orbit in a stronger magnetic field change on considerable value.

Therefore electron radiation conditions in an orbit: (2.5), (2.6) and (2.7) for additional oscillations of the electron orbiting in almost circular orbit in a stronger magnetic field are not executed. Therefore light with frequencies of the additional oscillations of an electron $\nu_0 \pm \Delta\nu$, orbiting in almost circular orbit in a stronger magnetic field, are not observed in the spectrum of splitting of the singlet spectral line. Therefore the singlet spectral line in a stronger external magnetic field is split only as a Lorentz triplet.

9. Splitting Spectra in Weaker Magnetic Field

In this Section, the mechanism of splitting of spectral lines D_1 and D_2 of the Na atom on the basis of PhEMV properties, and information in §2, §6 and §8, is described. It is shown that the energy received by the radiating electron from vortex electric field and spent for change of frequencies of the split light, is determined by the energy of the movement of the radiating electron in tangential or radial speed.

9.1 Spectrum splitting of the D1 Line of the Na Atom in Weak Magnetic Field

In § 6 it was shown, that in the theory, which is based on properties of the PhEMV, multiple splitting of spectral lines can be explained with the radiation of the electrons, rotating on elliptic orbits with an identical length of a semi major axis, but with various lengths of an elliptic orbit, which are defined by expressions (2.5) or (2.6).

Radiation by an electron of atom of light happens at fulfillment of conditions from Eqs. (2.4) & (2.5):

$$L_{\text{ellipse}} = k\ \lambda_{\text{e avg tan}} \text{ or } L_{\text{ellipse}} = n'\ \lambda_{\text{e avg rad}}$$

where L_{ellipse} is the length of an elliptic orbit, and $\lambda_{\text{e avg tan}}$ and $\lambda_{\text{e avg rad}}$ are wavelengths of the electron, according to (2.1), radiating light, frequency of which is defined by the value of the kinetic energy, corresponding to its movement with root-mean-square tangential or radial velocities; k and n' are quantum numbers.

Besides, radiation by an electron of atom of light happens at fulfillment of the condition (2.7): the electron oscillation frequency, which proportional to its kinetic energy, has to be close to the self-resonant frequency of oscillations of an electron in atom.

Therefore according to the theory, which is based on properties of the PhEMV, light frequencies corresponding to the spectral lines of D_1 and D_2 of Na atoms, are radiated by electrons in elliptic orbits with an identical length of a semi major axis, but with different lengths of elliptic orbits, corresponding to expressions (2.5) or (2.6).

Light frequency, corresponding to the D_1 spectral line, as shown below, is defined by the kinetic energy of the radiating electron of a Na atom, corresponding to the root-mean-square tangential velocity of this electron in an elliptic orbit, which length is defined by expression (2.5): $L_{\text{ellipse}} = k\ \lambda_{\text{e avg tan}}$.

And light frequency, corresponding to the spectral D_2 line, is defined by the kinetic energy of the radiating electron of the Na atom, corresponding to the root-mean-square radial velocity of this electron in an elliptic orbit, which length is defined by expression (2.6): $L_{\text{ellipse}} = n'\ \lambda_{\text{e avg rad}}$.

In § 4 it was shown that in a weaker external magnetic field a change of kinetic energy of an electron and, therefore, a change of frequency of oscillations of an electron happens on small size.

Therefore, at switching on of a weak external magnetic field the changed oscillation frequency of an electron remains close to the self-resonant frequency of oscillations of an electron in atom.

In § 4 it was said, that minor change of wavelength of the radiating electron, moving on not closed precessing elliptic orbit in a weaker external magnetic field, can be neglected. Therefore the conditions of radiation of an electron in an elliptic orbit (2.5); (2.6) and (2.7) in a weaker external magnetic field are executed.

An electron of Na atom, moving on an elliptic orbit with the average value of elongation, which length is equal to (2.5) or (2.6):

$$L_{\text{ellipse}} = k\ \lambda_{\text{e avg tan}} \quad \text{or} \quad L_{\text{ellipse}} = n'\ \lambda_{\text{e avg rad}}$$

can radiate light with frequencies of the spectral line: $\nu_{0\text{ avg tan}}$ or $\nu_{0\text{ avg rad}}$, corresponding to its root-mean-square tangential or radial velocity of the movement.

In § 4 it was shown that, at switching on of a weak external magnetic field, happens as change of kinetic energy of the movement of the radiating electron on an elliptic orbit, which plane is perpendicular to an external magnetic field, and occurrence of an orbital precession. As a result of this, it in the split spectral line arise the $\pm\pi$ light components and the $\pm\sigma$ light components.

Shift of frequencies of the $\pm\pi$ and the $\pm\sigma$ components of the split spectral line happens on sizes: $\nu_{\mathrm{L}}(k/n)$ (4.1) and $\nu_{\mathrm{L}}(n'/n)$ (4.2) which, as shown in § 4, are proportional to shares of the energy received by an electron in an external magnetic field, corresponding to the average tangential and radial rate of the radiating electron, are proportional to size from Eq. (3.4):

$$\Delta\nu = (4\pi)^{-1}(e/m_e)H = \nu_{\mathrm{L}} \quad ,$$

where ν_{L} is the size of frequency change of the radiated light by an electron in normal Zeeman effect in a circular orbit, which radius is equal to a major semi axis of an elliptic orbit of an electron.

If the electron of Na atom, radiating light before switching on of an external magnetic field with the frequency $\nu_{\text{avg tan}}$, which defines by the kinetic energy of its movement on an elliptic orbit with a root-mean-square tangential velocity, the frequencies of the $\pm\pi$ components of the split spectral line are equal to the frequencies from Eq. (4.5):

$$\nu_{1,2\ \mathrm{avg\ tan}} = \nu_{0\ \mathrm{avg\ tan}} \pm \nu_{\mathrm{L}}(k/n) \quad ,$$

and the frequencies of the $\pm\sigma$ components are from Eq. (8.1.3):

$$\nu_{0\ \mathrm{avg\ tan}} \pm \nu_{\mathrm{L}}(k/n) \pm N_1 \nu_{\mathrm{L}}(k/n) \quad .$$

Thus, if the electron of Na atom radiated light before switching on of an external magnetic field with the frequency $\nu_{0\ \mathrm{avg\ tan}}$, it is possible to draw **Conclusion 9.1.1:**

The shift of the frequencies of the $\pm\pi$ components of the split spectral line, radiated by an electron of Na atom about of the frequency $\nu_{\mathrm{avg\ tan}}$, has to happen at the size of $\nu_{\mathrm{L}}(k/n)$, and shift of the frequencies of the $\pm\sigma$ components about of the frequencies of the $\pm\pi$ components, has to happen too on the size of $\nu_{\mathrm{L}}(k/n)$.

If the electron of Na atom, radiating light before switching on of an external magnetic field with the frequency $\nu_{0\ \mathrm{avg\ rad}}$, which defines by the kinetic energy of its movement on an elliptic orbit with the root-mean-square radial velocity, the frequencies of the $\pm\pi$ components of the split spectral line are equal to the frequencies from Eq. (4.6):

$$\nu_{1,2\ \mathrm{avg\ rad}} = \nu_{0\ \mathrm{avg\ rad}} \pm \nu_{\mathrm{L}}(n'/n)$$

and the frequencies of the $\pm\sigma$ components are equal to the frequencies from (8.1.4):

$$\nu_{0\ \mathrm{avg\ rad}} \pm \nu_{\mathrm{L}}(n'/n) \pm N_1 \nu_{\mathrm{L}}(k/n) \quad .$$

Thus, if the electron of a Na atom radiated light before the switching on of an external magnetic field with the frequency $\nu_{0\ \mathrm{avg\ rad}}$, it is possible to draw **Conclusion 9.1.2:**

A shift of the frequencies of the $\pm\pi$ components of the split spectral line, radiated by an electron of Na atom about of the frequency $\nu_{0\ \mathrm{avg\ rad}}$, has to happen on the size of $\nu_{\mathrm{L}}(n'/n)$, and shift of the frequencies of the $\pm\sigma$ components about of the frequencies of the $\pm\pi$ $\pm\pi$ components, has to happen on the size of $\nu_{\mathrm{L}}(k/n)$.

The chart of splitting of the D_1 spectral line of Na atoms published in the book **Atomic Physics** by Max Born is represented on Fig. 9.1.1.

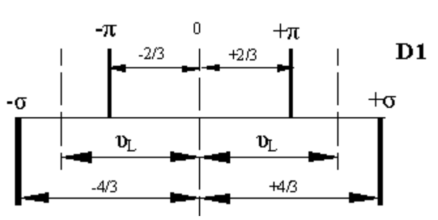

Figure 9.1.1. Splitting of the D_1 spectral line of the Na atom.

On Fig. 9.1.1 the $\pm\pi$ components and the $\pm\sigma$ components of the split spectral D_1 line of Na atom are represented. The frequency of the not-split spectral line D_1 corresponds to the central zero arrangement on this chart. The $\pm\pi$ components in both parties are shifted about the central zero arrangement by $\nu_{\mathrm{L}}/3$, at the size of $\pm 2/3$ in the scale of frequencies, in which distance between lines at normal Zeeman effect equally to unit, that is, on Fig. 9.1.1 the size of $\nu_{\mathrm{L}} = 1$, where ν_{L} is, as it was above, the size of frequency change of the light radiated by an electron in the normal Zeeman effect in a circular orbit, which radius is equal to the major semi axis of an elliptic orbit of an electron. The $\pm\sigma$ components are shifted about of the $\pm\pi$ components also at the size of $\pm 2/3$ in the same scale of frequencies.

The sizes of shift of the frequencies of the $\pm\sigma$ components of the split spectral line D_1 of the Na atom, represented on Fig. 9.1.1, about of the frequencies of the $\pm\pi$ components, are equal to the shift size of the $\pm\pi$ components about of central zero arrangement. Therefore, on the basis of the conclusion 9.1.1, it is possible to say, that the electron of Na atom, radiating light with the frequency of the spectral line D_y, radiates light, which frequency is defined by the kinetic energy, corresponding to its root-mean-square tangential velocity of the movement on an elliptic orbit, on which the ratio of $k/n = 2/3$ and the ratio of $n'/n = 1/3$.

Thus, the ratio of quantum numbers k/n and n'/n, defining shares of the energy, received by the radiating electron in an elliptic orbit from an external magnetic field, which are spent for change of the kinetic energy of the radiating electron and creation of an orbital precession, determine frequencies of the $\pm\pi$ and the $\pm\sigma$ components of the split spectral line D_1 in a weaker magnetic field.

In §8.1 it was said that the function determining the changing cyclic frequency of a precession of an elliptic orbit of the radiating electron can be spread out in a Fourier series.

Energy, frequencies and quantity of the harmonic components of this expansion are defined by the value of change of this cyclic frequency which is defined in this case by parameters of an elliptic orbit, degree of its elongation. §8.1 said that one could expect that in spectra of splitting of spectral lines D_1 and D_2, besides the $\pm\pi$ components, have to be on two pair of the $\pm\pi$ component, which are $\pm\sigma_1$ and $\pm\sigma_2$ components.

In §8.1 it was said that number N_1, from Eq. (8.1.3) and (8.1.4), defining the quantity of the $\pm\sigma_i$ components in a splitting spectrum depends on distribution of energy between harmonious components of expansion into a series of the changing cyclic frequency Ω (8.1.1). But as it is shown lower in §9.2, the orbit of an electron of Na atom radiating light with a frequency of the spectral line D_1 is less elongated, than an orbit of an electron of Na atom radiating light with a frequency of the spectral line D_2. Therefore energy of the second harmonious components of harmonic expansion of the changing frequency of a precession of this orbit has to be less than energy of the second harmonious components of harmonic expansion of the changing frequency of a precession of an orbit of an electron of Na atom radiating light with a frequency of the spectral line D_2.

Therefore energy of the second harmonious components of harmonic expansion of the changing frequency of a precession of this orbit has to be less than energy of the second harmonious components of harmonic expansion of the changing frequency of a precession of an orbit of an electron of Na atom radiating light with a frequency of the spectral line D_2. For exactly this reason, it is possible to assume that in a spectrum of splitting of the spectral line D_1 the second pair of σ components is not present.

9.2 Na D_2 Line Splitting in a Weaker Magnetic Field

In § 9.1 it was asserted that electrons of Na atoms radiating light with the frequencies of the D_1 and D_2 spectral lines move on elliptic orbits with identical major semi axes, but different total lengths. In the same place it was said that light frequency corresponding to the Na D_2 spectral line is defined by kinetic energy of the electron, corresponding to the root-mean-square radial velocity of this electron in an elliptic orbit, which length is defined by Eq. (2.5): $L_{\text{ellipse}} = n'\lambda_{\text{avg rad}}$.

The chart of splitting of the Na D_2 spectral line, published in the book **Atomic Physics** by Max Born, is shown on Fig. 9.2.1.

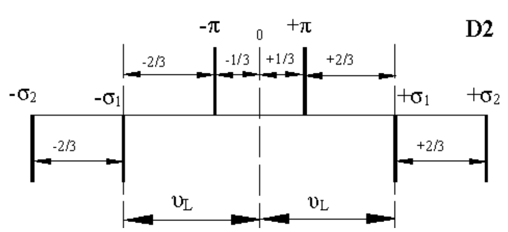

Figure 9.2.1. Splitting of the D_2 spectral line of the Na atom.

Fig. 9.2.1, represents the $\pm\pi$ components and the $\pm\sigma_{1,2}$ components of the split D_2 spectral line of a Na atom. The frequency of the un-split D_2 spectral line corresponds to the central zero arrangement. The $\pm\pi$ components are shifted in both parties about the central zero arrangement by $\nu_L / 3$, where ν_L is, as it was above, the size of frequency change of the light radiated by the electron in normal Zeeman effect in a circular orbit, which radius is equal to a major semi axis of an elliptic orbit of the electron. The first pair of the $\pm\sigma$ components (represented as $\pm\sigma_1$ components), is shifted about of the frequencies of the $\pm\pi$ components by $\pm(2/3)\nu_L$. The second pair of the $\pm\sigma$ components (represented as $\pm\sigma_2$), is shifted similarly.

Therefore based on the conclusion 9.1.2, it is possible to say that the electron of Na atom radiating light with a frequency of the D_2 spectral line, radiates at a frequency defined by the kinetic energy, corresponding to the mean squared radial velocity of the movement on an elliptic orbit, on which the ratio $n'/n = 1/3$ and the ratio $k/n = 2/3$. For this reason, it agrees with (4.6), frequencies of the $\pm\pi$ components of the D_2 spectral line of the *Na* atom splitting in a weaker magnetic field, are shifted about a central zero arrangement of size $\pm\nu_L / 3$, and the frequencies of the $\pm\sigma_1$ components are shifted about the frequencies of the $\pm\pi$ components, by $\pm 2\nu_L / 3$.

As mentioned above, electrons of Na atoms radiating light with a frequencies of the spectral lines D_1 and D_2 have to move in elliptic orbits with identical semi major axes, but with different lengths of elliptic orbits. The electron radiating light with a frequency of the spectral line D_1, has to move on the orbit, corresponding to the condition from Eq. (2.4): $L_{\text{ellipse}} = k\lambda_{\text{avg tan}}$. The electron radiating light with the frequency of the spectral line D_2 has to move on the orbit, corresponding to the condition from Eq. (2.5): $L_{\text{ellipse}} = k\lambda_{\text{avg rad}}$.

The wavelength of the Na D_2 spectral line is 6 A° shorter, than the wavelength of the D_1 spectral line. But wavelengths of of an electron $\lambda_{\text{avg tan}}$ and $\lambda_{\text{avg rad}}$, as shown in § 4, differ by a much smaller amount. The electron of the Na atom radiating light at the D_1 spectral line frequency has to move on an elliptic orbit, on which the ratio of the quantum numbers $k/n = 2/3$, and from Eq. (2.4): $L_{\text{ellipse}} = k\lambda_{\text{avg tan}}$. The electron of the Na atom radiating light at the D_2 spectral line frequency has to move on an elliptic orbit, on which ratio of the quantum numbers $n'/n = 1/3$, and from Eq. (2.5), $L_{\text{ellipse}} = n\lambda_{\text{avg rad}}$. As the ratio of the quantum numbers $k/n' = 2$, the length of an elliptic orbit on which an electron of Na atom radiates light with the frequency of the spectral line D_1 is almost twice more than length of an elliptic orbit, in which the electron of the Na atom radiates light with the frequency of the D_2 spectral line.

Lengths of the major axes of elliptic orbits of the electrons radiating light with frequencies of the spectral lines of D_1 and D_2 are identical.

That is, the elliptic orbit, in which an electron of Na atom radiates light with the frequency of the spectral line D_1, is more elongated. This conclusion supports that suggested in §7, that multiple splitting of spectral lines can be explained with the radiation of the electrons rotating on elliptic orbits with an identical length of a semi major axis, but with various size of focal semi-parameter q, and so with various lengths of elliptic orbits.

Therefore energy of the second harmonic component of expansion in series the function determining the changing cyclic frequency of a precession of more elongated elliptic orbit of an electron of Na atom, radiating light with a frequency of the spectral line D_2, is more than energy of the second harmonic component of changing cyclic frequency of a precession of an electron of atom of Na radiating light with a frequency of the spectral line D_1.

For this reason in a splitting spectrum in a weaker magnetic field of the spectral line D_2 there is the second pair of the $\pm\sigma$ components with frequencies:

$$\begin{aligned}\pm\nu_{\sigma 2} &= \nu_{0\ \text{avg rad}} \pm (4\pi)^{-1}(e / m_e)(5/3) \\ &= \nu_{0\ \text{avg rad}} \pm \nu_L (5/3)\ .\end{aligned} \quad (9.2.1)$$

But, as these components result from modulation of electron oscillations in the orbit plane at at second harmonic frequencies, they are not very intense.

10. Conclusion

Refs. [1] and [2] explained, from the viewpoint of classical physics and based on properties of the three-dimensional physical electromagnetic vacuum, the occurrence of wave-corpuscle dualism of particles and radiation, which arises because of action of fluctuation electromagnetic impulses on elementary particles and atoms of substance.

In [1] and [2] such phenomena as diffraction of particles, photo effect, Compton's phenomenon, corpuscular properties of radiation, uncertainty of particles in space were explained from the point of view of classical physics.

In [1] and [2] the last quantum effects - Zeeman's effects were not explained from the point of view of classical physics.

In this manuscript Zeeman's effects are explained from the point of view of classical physics also, that is, all quantum effects, on which the philosophy of quantum mechanics is based, are explained from the point of view of classical physics.

The model of physical electromagnetic vacuum, allowing creating models of elementary particles, explains also mechanisms of their interactions.

The model of physical electromagnetic vacuum helps to explain from the classical point of view, without the theories of relativity of Einstein, the experiments of Michelson - Morley and the cause of the forces of gravity.

Thus, as shown in [1] and [2], if to accept a hypothesis that our space is physical electromagnetic vacuum, from the point of view of classical physics it is possible to explain all phenomena of physics without of the dark matter and dark energy.

Therefore, the model of physical electromagnetic vacuum allows upgrading traditional quantum mechanics, having excluded the possible errors in development of the theory caused only by mathematical models of the studied physical phenomena.

References

[1] V.M. Cheplashkin, "Physical electromagnetic vacuum and a pattern of the world without relativity theories", Engineer Magazine **6** (12) 2013.

[2] V.M. Cheplashkin, Manuscript "Physical Electromagnetic Vacuum: The mechanism of radiation of light by atom".

[3] V.M. Cheplashkin, Manuscript "The running wave, propagating along electric field..."

CORRESPONDENCE, ***On the Fine Structure Constant*** α**,** **Continued from page 82**

The inverse fine structure constant α^{-1} (=137.0359…) is associated with scaling in mass ratios, while the reduced fine structure constant $\alpha/2\pi$ (= 0.0011614…) is associated with scaling in angular velocity and energy ratios.

Eddington, Pauli, Born, Heisenberg, Feynman, *etc*., have famously written about the mysterious magic number 137 in quantum theory. In a letter to Heisenburg in 1934, Pauli wrote "Everything will become beautiful when [1/137] is fixed." [2] Feynman wrote: "It has been a mystery ever since it was discovered more than fifty years ago, and all good theoretical physicists put this number on their wall and worry about it. Immediately you would like to know where this number comes from…Nobody knows. It's one of the greatest mysteries of physics…" –[3] Penrose observed that "Many of today's physicists might be less optimistic than their predecessors about finding a direct mathematical 'formula' for α, or other 'constants of Nature'. Nowadays, physicists tend to regard these quantities as functions of the *energy* of the particles involved in an interaction, rather than as simple numbers." [4]

The electric charge-to-mass ratio of the electron, e/m_e, is conventionally expressed in dimensions of [Q/M] and in SI units has been experimentally measured: $e/m_e \cong$ 175,882,008,800… C/kg [CODATA 2010]. From measured deflection of electron beams in a magnetic field, the ratio may be calculated from the applied magnetic field magnitude B, electron speed v, electric potential V and path radius r:

$$e/m = v/Br = 2V/(B^2 r^2) \quad (6)$$

What is the origin of this quotient, and why does it have this value? Substituting the charge conversion dimensions ($Q = \theta M/T$) as derived by Klyushin [4] using Q = charge in Coulombs, θ is rotation angle in radians, M is mass, and T is time. The chage to mass ration e/m has dimensions of θT^{-1}.

$$\omega_{e/m} = e/m = 1.758820088 \times 10^{11}\ \text{rad/sec} \quad (7)$$

This angular velocity is quite small in comparison to the Compton angular frequency ω_C (= 7.76343E20 rad/sec), and is interpreted as a precession frequency. If we add the Schwinger ($\alpha/2\pi$) correction to the g-factor, where α = fine structure constant ($\cong 7.297352568 \times 10^3$):

$$\omega_{e/m}(1 + \alpha/2\pi) = 1.76086 \times 10^{11}\ \text{rad/sec} \quad (8)$$

The above calculated value corresponds to measured value of the gyromagnetic spin ratio γ_s ($\cong$ 1.706859708E11 C/kg = rad/(s·T)).

What is cause of this precession? Let us consider the electrostatic and magnetostatic energies of the electron. As shown by

$$E_{s0} = e^2 / 2C = 4.103212 \times 10^{-14}\,\mathrm{J} \tag{9}$$

where C is capacitance of a charged spinning ring, $C = C_0 / \gamma$, C_0 = 3.128125E-25 (F).

The magneto-static field energy E_{m0}, is given as

$$E_{m0} = \tfrac{1}{2} LI^2 = 4.08412 \times 10^{-14}\,\mathrm{J} \quad , \tag{10}$$

where L is self-inductance of a spinning ring, $L = \gamma L_0$, L_0 = 2.08991E-16 (H) and I is current, $I = e\omega / 2\pi = 19.979$ (A).

The total energy $E_t = \gamma E_{t0}$ where $E_{t0} = E_{s0} + E_{m0}$ = 8.18724E-14 J and γ is the Lorentz factor, $1\big/\sqrt{1 - v^2 / c^2}$.

If we compare the ratio of the magnetostatic energy to the electrostatic energy,

$$E_{m0} / E_{s0} = \frac{4.10312 \times 10^{14}\,\mathrm{J}}{4.08412 \times 10^{-14}\,\mathrm{J}} = 1.004652165 \tag{11}$$

and calculate the ½ average energy difference (kinetic plus potential):

$$\frac{1}{2}(E_{m0} - E_{a0}) \big/ (E_{m0} + E_{a0}) = 0.001160342 \tag{12}$$

we find this value is slightly less than the reduced fine structure constant ratio $\alpha / 2\pi$ (= 0.00116140973). The difference

$$\frac{\alpha}{2\pi} - \frac{1}{2}\left(E_{m0} - E_{a0}\right) \Big/ \left(E_{m0} + E_{a0}\right) \cong 0.0000010654 \tag{13}$$

Bergman [2], the electrostatic field energy E_{s0} of the electron may be expressed as

The factor of a half represents the kinetic energy portion of the energy differential - the potential energy having null effect. Based on the Virial theorem of R.E. Clausius, in a central force field of a bound system, the average kinetic energy $< T >$ ($= -mv^2 / 2$) is half the average potential energy (virial) $< V >$ ($= -2 < T >$).

The Thomas precession frequency ω_T ($\cong va / 2c^2$) for a relativistic velocity $v = c$ at the Compton radius R_C equals the orbital frequency. The Thomas precession is in a retrograde direction to the electron spin. The prograde geodetic (de Sitter) precession or gravito-magnetic effect is assumed to account for a portion of the slight difference between calculated $\alpha / 2\pi$ and the average energy imbalance ratio. Hence, the imbalance of magnetostatic and electrostatic energy appears responsible for nearly all of the observed precession.

References

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Schrödinger's Spin-1/2 Solution

It has been said for nearly a century that the Schrödinger equation cannot predict electron spin. Looking up at us from his Notebook N1, however, is a solution for electron spin energy. His biographer Walter Moore missed this point, but we are grateful that he photographed the page on which the solution exists. [1] As seen on the page, Schrödinger began with his angular momentum equation, which, written in present-day notation, is

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 \partial\psi / \partial r\right) + \left[Q - \ell(\ell+1) / r^2\right]\psi = 0 \tag{1}$$

where I have corrected what I believe to be a sign error in front of the square brackets.

He then made a substitution, $\psi = r^{-1/2}\vartheta$, whose use in (1) provides

$$\frac{\partial^2\vartheta}{\partial r^2} + \frac{1}{r}\frac{\partial\vartheta}{\partial r} + \left[Q - (\ell + 1/2)^2 / r^2\right]\vartheta = 0 \tag{2}$$

This is an energy equation. The $1/2$ inside the parentheses in the square brackets is the electron spin energy quantum number. The $\ell + 1/2$ therefore equals the total energy number, n. That is, $\ell + 1/2 = n$. For the $n = 1$ orbit, we must have $\ell = 1/2$. Therefore the electron in the orbit has total energy $\left(\frac{1}{2} + \frac{1}{2}\right) h\omega / 2\pi = h\omega / 2\pi$.

Why didn't Schrödinger publish this result? According to Moore, "Schrödinger expected all quantization conditions arise as whole number solutions, so when he obtained half-integers instead of integers, he thought the solution incorrect." [2]

References

[1] W. Moore, **Schrödinger: Life and Thought** (Cambridge University Press, New York, 1990, p. 193).

[2] Ibid, pp.196-197.

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