Some words about fundamental problems of physics

Part 2: Electron spin

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A very gross error was made by theorists to explain the experimental results obtained by Einstein and de Haas in their measurements of magnetomechanical (gyromagnetic) ratio [1]. From the resulting data it follows that the ratio of the magnetic moment $\mu_{e,\exp}$ of an electron, moving along the Bohr orbit (they relied on the Bohr model of an atom), to its mechanical moment $\hbar = m_e \upsilon_0 r_0$ is equal to

$$\frac{\mu_{e,\exp}}{\hbar} = -\frac{e}{m_e c} \,. \tag{1}$$

This result exceeded twice the expected value, which followed from the calculations made by theorists:

$$\frac{\mu_{e,theor}}{\hbar} = -\frac{e}{2m_e c} \tag{2}$$

(minus sign indicates that the direction of the moments are opposite).

Clearly in this situation it would be prudent to carefully check the validity of the relevant basic formulas used in the derivation of the theoretical ratio (2). By definition, that modern physics holds still, the calculation of the orbital magnetic moment of an electron in an atom is realized by a simple formula, which determines the magnetic moment of a closed circular loop of electric current,

$$\mu_{orb} = \frac{I}{c} S \,, \tag{3}$$

where I is an average value of circular current, *S* is the area of the circuit (orbit), *c* is the speed of light.

In accordance with the definition of electric current used in electrical engineering, considered as a flow of electric charge ("electron fluid") in a conductor, the calculation of the average value of electric current generated by the orbiting electron was carried out (as proven to be here, poorly thought-out and wrong) by the following formula

$$I = \frac{e}{T_{orb}} \,, \tag{4}$$

where T_{orb} is the period of electron revolution along the orbit, *e* is the electron charge. Hence,

$$\mu_{orb,theor} = \frac{I}{c}S = \frac{e}{cT_{orb}}S = \frac{e\upsilon_0}{c2\pi r_0}\pi r_0^2 = \frac{\upsilon_0}{2c}er_0\,, \qquad (5)$$

that led to the ratio (2) of the moments twice less than the experimentally obtained value (1). It is obvious, one needed to find the error. However, for some reason no one did not put the question, is formula (4) valid or not? This circumstance first had to draw the attention of theorists. The matter is that we are not dealing with a current of "electron fluid" (or "electron gas"), but with a current generated by a single electron charge, moreover, while moving along a closed circuit.

We filled the gap in this matter by revealing shortcomings and finding an answer to the question posed above. Here are our arguments.

1. Let us consider what the average value of current in fact is created by a single (discrete) charge moving along a closed path.

In a general case, the charge transfer of the electron, *e*, through any cross-section *S* along any path during the time *T* is accompanied with disappearance of the charge from one side (-*e*, point A) and appearance on the other side (+ *e*, point B) of an arbitrary cross-section, as shown in Fig. 1.

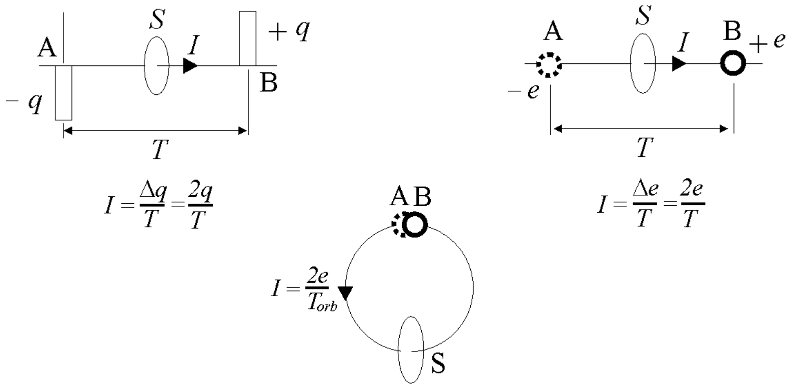

Fig. 1. The charge transfer of the electron, *e*, through any cross-section *S* of a conductor.

Let me explain once again. During a period of time *T*: disappearance of the charge from the left side means REDUCTION of the charge at this side from the value of +*e* down to 0, i.e. the reduction on the amount of charge –*e*. And appearance of the charge on the right side of the cross-section means GAIN of the charge at this side from the value of 0 up to +*e*, i.e. the gain on the amount of charge +*e*. Thus, during the time *T*, the complete charge change is $\Delta e = +e - (-e) = 2e$. Hence, an average rate of the charge change (current *I*) during the time *T* is

$$I = \frac{\Delta e}{T} = \frac{(+e-(-e))}{T} = \frac{2e}{T} \qquad (6)$$

And in the case of a circular orbit, when points A and B coincide, the electron, bearing the charge *e*, passes through the cross-section S with an average speed

$$I = \frac{2e}{T_{orb}}, \quad (7)$$

where T_{orb} is the period of electron's revolution on a circular orbit.

Additionally, let us come to the derivation (7) by the traditional way, without disturbing the existing logic in the accepted concept of determining the average current. To do this, for more clarity, we deform the orbit compressing it, as shown in Fig. 2. As a result, we obtain something like a closed two-wire line.

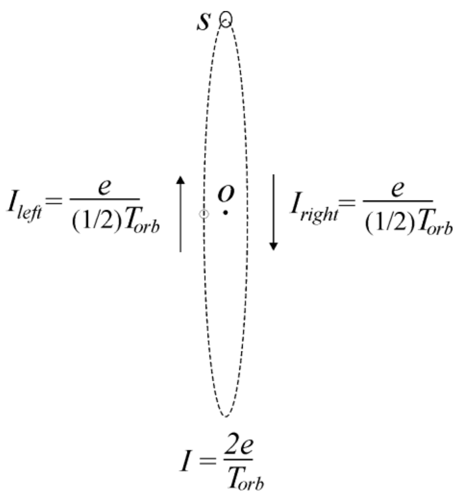

Fig. 2. An average current in a closed two-wire line.

How many times do you think, one orbital electron moving along the closed loop (i.e., during one complete revolution, T_{orb}) and passing in the vicinity of the point "O", first up (the average current in the left half of the trajectory is $I_{left} = e/(1/2)T_{orb}$) and then down (the average current on the right half of the trajectory is $I_{right} = e/(1/2)T_{orb}$), creates a transverse (vortical) magnetic field at that point?

As they say "no brainer" that two times: at first moving on the left side and then moving on the right side of the loop near the centre "O". It's like as 2 charges slipped... I wonder, is it? In this case the usual formula obtained from the definition of the average current adopted in physics ($I = q/T$) is not violated. The average value of current on both sides and, therefore, around a whole closed two-wire line is the same and equal to

$$I = I_{left} = I_{right} = 2e/T_{orb}$$

2. Since the electron just like any other elementary particle manifests duality, i.e. exhibit the behaviours of both waves and particles, it is reasonable and necessary without any doubts to derive the formula of the average current for the case of the wave motion of the electron.

a) Let's begin with the one-dimensional problem. From the well-known solution of the wave equation for the string of a length l, fixed at both ends, it follows that only one half-wave of the fundamental tone is placed at its full length, $l=\frac{\lambda_1}{2}$. If we join the ends of the string together, then we obtain a circle of the length $l=2\pi r_0$ with one node. As a result, we come to the equality

$$2\pi r_0=\frac{\lambda_1}{2}=\frac{\upsilon_0 T_0}{2}, \tag{8}$$

where υ_0 is the wave speed in the string, T_0 is the wave period.

б) In the simplest case of three-dimensional solutions of the wave equation for a spherical field [1], we arrive at the same equation (8): only one half-wave of the fundamental tone is placed on the Bohr orbit, and the electron is in a node of the wave.

Thus (according to (8)), the wave period of the fundamental tone at the wave surface of the radius r_0 is equal to

$$T_0=\frac{4\pi r_0}{\upsilon_0}. \tag{9}$$

An average value of electric current as the harmonic magnitude is determined by the known formulas:

$$I=\frac{2}{iT}\int_0^{T/2} I_m e^{i\omega t}dt=\frac{2}{\pi}I_m \qquad \text{or} \qquad I=\frac{1}{2\pi i}\int_0^{2\pi} I_m e^{i\varphi/2}d\varphi=\frac{2}{\pi}I_m \tag{10}$$

In the expression (10), the amplitude I_m of the elementary current is

$$I_m=\left(\frac{dq}{dt}\right)_m=\omega_0 e=\frac{2\pi e}{T_0}, \tag{11}$$

where ω_0 is the angular frequency of the fundamental tone of the electron orbit. Thus, substituting (11) into (10), we obtain

$$I=\frac{4e}{T_0}. \tag{12}$$

or, as $T_0=2T_{orb}$,

$$I=\frac{2e}{T_{orb}}. \tag{13}$$

Other options to derive an average value of current generated by an individual electron moving in a circular orbit are presented in [1]. They all give the same magnitude defined by the formula (13), but not by (4). The definition of electric current and the relevant problem of electron spin are analyzed in detail in the fundamental book "*Atomic Structure of Matter-*

Space" (2001) [2]. It's quite comprehensive book in which all the questions that just might be are analysed, and their solutions are presented. In particular, a small fragment of the book, namely paragraphs 9 and 10 of Chapter 9 (from 453 to 494 pages), which examines the concept of current, is available online on the internet in PDF format [3].

Thus, a problem of the average current was solved by the authors of [2], an error in (4) was corrected. The resulting formula for the circular current (13) differs by the multiplier 2 from the erroneous formula (4). Unfortunately, the latter is still remained in physics for the explanation of the Einstein-de Haas measurement data and other phenomena...

Substituting the average value of current (13) into (3), we arrive at the correct formula for the orbital magnetic moment of an electron (logically, physically and mathematically conditioned), which at anybody can no longer call doubts.

$$\mu_{orb} = \frac{I}{c} S = \frac{2e}{cT_{orb}} \pi r_0^2 = \frac{\upsilon_0}{c} e r_0 . \quad (14)$$

Accordingly, the ratio of the orbital magnetic moment (14) to its mechanical moment (the moment of its orbital momentum, $\hbar = m_e \upsilon_0 r_0$), taking into account the sign (the opposite direction of moments), is equal to

$$\frac{\mu_{orb}}{\hbar} = -\frac{\upsilon_0 e r_0}{c m_e \upsilon_0 r_0} = -\frac{e}{m_e c} . \quad (15)$$

The resulting ratio of the moments, the theoretical derivation of which was given above, coincides with the ratio of the moments (the gyromagnetic ratio) (1) obtained in Einstein-de Haas and Barnett experiments.

CONCLUSION

The true absolute value of the intrinsic magnetic moment of an electron bound in an atom (that have not been considered here) is negligible compared to the relatively huge value ascribed to it at half the orbital magnetic moment (and called the Bohr magneton). What is its precise value and how it was calculated one can find in [4].

We have shown here, hope it was made clear and convincingly enough, that if 100% trust the experimental results, theorists should be first to find an obvious mistake in the formula used by them for the calculation of electric current generated by an individual electron moving on the Bohr orbit, but did not engage in fantasy. The strength of electric current I is the only variable physical quantity (calculated according to its definition) that determines the magnitude of the magnetic moment at constant values of *c* and *S* (see Eq. (3)).

In the mathematical formulation of the definition of electric current accepted in physics for the particular case, which is the motion of a single charge along a closed path, one had to be careful and think (for good reason there is a saying: "look before you leap, cut once"). It is an elementary logical task, cope with it and school children and students, but it has never been put forward for consideration, although this task is fundamentally important and, moreover, good for the development of logical thinking of physicists.

It seems simple, "as the rake", but for some reason, the problem under consideration was not resolved by theorists at that time. Apparently, so necessary revision was not taken into account because of their firm belief in validity and universality of the formula (4). Therefore, to get out of the situation with which they were faced owing to the result (2), theorists preferred to follow the trodden path of their predecessors and put forward the postulate about the allegedly existing in reality an intrinsic mechanical moment of the electron, which was called then an electron spin. Namely to find the missing half in the calculations, resulted in the ratio (2), to fit the latter to the experimental ratio (1), they groundlessly **ascribed** to the electron, in addition to its real fundamental (intrinsic) properties, such as mass and charge, a virtual (mythical) and, therefore, an unreal “fundamental characteristic” property, **spin**. As a consequence, it appeared at once the mythical **electron spin magnetic moment** associated (conjugated) with the mythical spin, the absolute value of which was called the **Bohr magneton**, μ_B:

$$\mu_{spin} \equiv \mu_B = \mu_{orb,theor} = \frac{\upsilon_0}{2c} e r_0 \qquad (16)$$

With the help of a mythical spin magnetic moment, theoreticians "closed the gap" in their calculations of the gyromagnetic ratio (2). Thus, the "lost" (in their calculations) half of the orbital magnetic moment of the electron, bound in an atom, was called by theorists the electron spin magnetic moment. Then this "lost" orbital half (under the name of spin magnetic moment or the Bohr magneton) was fastened to the half of the orbital magnetic moment (5) that they received theoretically:

$$\mu_{e,theor} = \mu_{orb,theor} + \mu_{spin} = \frac{\upsilon_0}{2c} e r_0 + \frac{\upsilon_0}{2c} e r_0 = \frac{\upsilon_0}{c} e r_0 \qquad (17)$$

Put together the two halves, actually, of the same orbital magnetic moment, have been named the **total magnetic moment** of an electron in an atom, $\mu_{e,theor}$. As a result of such an obvious and explicit fitting, the complete coincidence with the experimentally obtained gyromagnetic ratio (1) was achieved:

$$\frac{\mu_{e,theor}}{\hbar} = \frac{\mu_{orb,theor} + \mu_{spin}}{\hbar} = \frac{\mu_{e,\exp}}{\hbar} = -\frac{e}{m_e c} \qquad (18)$$

It was an epoch-making error; it marked the beginning of the present spinmania in physics, which continues to this day. Unfortunately, if to say honest, in result of such an explicit blunder, physics has taken the wrong way. At the present time, modern physics cannot exist without the notion of spin. Apparently, to someone, it was truly necessary to discard the humanity in his cognition of nature to centuries ago, directing physics in a wrong direction to create a virtual reality: driving physics in a dead end, to hinder the development of our civilization. Consciously or not, but in this kind of virtual (absurd) creations of the 20th century, many eminent theoretical physicists of that time took part...

As was noted, the relatively enormous absolute value of $\hbar/2$ was attributed to electron spin that is comparable with the value of electron's angular orbital moment. With this, it is believed that an existence of the intrinsic mechanical moment, spin, of the electron of such a magnitude was confirmed experimentally. However, where is the direct evidence? Where are experiments to determine the spin **on free electrons**, but not on the electrons which bound to atoms? They are not.

Thus, we see that explaining a series of phenomena observed experimentally, physicists, using the mythical (fabricated, postulated) concepts such as the electron spin, considered here, or like virtual particles of quantum electrodynamics (that will be discussed further in Part 3), draw a distorted picture of reality. In fact, they create virtual, mythical world (science fiction).

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