The Dependence of Hall Conductance Quanta on the Fundamental Frequency of the Atomic Level

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Abstract

Dynamic model of elementary particles (DM) has allowed looking at many physical phenomena from a new point of view. This model was developed in the framework of a new philosophical approach to foundations of physics - dialectical. As all-embracing, the dialectical philosophical approach surpasses formal logical with its limited capabilities dominated currently in modern physics. In this paper, the nature of quanta observed in the Hall conductivity is elucidated with use of new fundamental parameters characteristic of the DM and taking into account the shell-nodal atomic model developed herewith. The primary fundamental parameters of the DM are fundamental frequency of exchange (interaction) at the atomic and subatomic levels, ω_e, which is unknown yet fundamental parameter for modern physics, and an elementary quantum of the rate of the exchange, *e*.

1. Introduction

The discovery in 1982 by Störmer and Tsui [1] of additional fractional quantized resistance values at measurement the Hall conductivity in extremely pure semiconductor samples, in strong magnetic field, has come as a great surprise.

In 1983 Laughlin [2] have succeeded in explanation of the result in terms of new quantum states of matter. He put forward a theory according to which the fractional quantum Hall effect is caused by the capture of an odd-number of fundamental units of magnetic flux by each electron, as opposed to a single unit of flux in the integer quantum Hall effect.

According to his theory, the low temperature and the powerful magnetic field compel the electron gas to condense to form a new type of quantum fluid. Since electrons are most reluctant to condense, they first, in a sense, combine with the "flux quanta" of the magnetic field. Particularly for the first steps discovered by Störmer and Tsui, the electrons each capture three flux quanta, thus forming a kind of composite particle with no objection to condensing.

With this, the quantum Hall effect (QHE) plateaux are formed when the Fermi energy lies in a gap of the density of states. The difference is the origin of the energy gaps. While in the integer effect gaps are due to magnetic quantization of the single particle motion, in the fractional effect the gaps arise from collective motion of all the electrons in the system.

Laughlin’s theory, based on his imaginary quantum-mechanical fluid of a new form and on a many body wave function, predicted that the elementary excitations involve pseudo-particle charge carriers with charges that are fractions of the electronic charge.

As a result, in spite of difficulties in explanation of a series of details, we have a first more or less well abstract-mathematical description of this phenomenon. However, it should be stressed, the latter does not quite mean that this theory is true and uniquely possible, and that we have obtained perfect understanding of the effect. The study of so-called fractional charges (or quasiparticles of fractional charges) and so-called fractional statistics are regarded as active fields of research till now. Actual measurements of the Hall conductance have been found to be integer or fractional multiples of e^2/h to nearly one part in a billion. This is why the resistance unit h/e^2 is used in resistance calibrations worldwide, and as an extremely precise independent determination of the fine-structure constant, a quantity of fundamental importance in quantum electrodynamics. Thus, the fractional quantum Hall effect remains a major topic of research, experimental and theoretical, in low-temperature condensed matter physics.

Precise measurements have shown that an accuracy of quantization of the Hall conductivity does not depend on experimental conditions and parameters of samples such as: their size, influence of boundaries, a degree of perfection of crystal structures (impurities and defects), a type of crystals, temperature, the strength of a measuring current, and etc.

It means that the nature of the integer and fractional quanta observed in the Hall conductivity is defined by only fundamental parameters of matter characteristic of the atomic level. According to the DM, such a parameter is the *fundamental frequency of exchange* (interaction) *of the atomic and subatomic levels*, ω_e. Our studies have shown that all physical phenomena that have been already analyzed herein are quite well explained when we take into account this fundamental parameter.

We assume that the fractional quantum conductance observed in the Hall effect (just like the integer quantum conductance) must be explained independently of accounting the magnetic field by dealing generally with quantum behavior of the electric charge transfer in the sample at the atomic level. In this regard, the quantum Hall effect must help in elucidating many important aspects of not only quantum but also atomic physics, especially, in view of new results obtained in the last 13 years in this field. We mean, first, a discovery of an internal structure of atoms due to a new (shell-nodal, molecule-like) atomic model [3]; second, the last observation of GHE at room temperature in graphene - a single layer of carbon atoms tightly packed in a hexagonal crystal lattice [4].

The nature of quantization in the Hall conductance (the resistance quantum) is uncovered in this paper as an internal feature of atomic structures, without accounting an influence of external magnetic fields. It is a new approach which has become possible due to reconsideration of basic concepts of modern physics started in 1996 by the author (with L. Kreidik) [3] in order to conform them to dialectical logic and philosophy. As a result of the reconsideration, the new concepts were fully developed and generalized currently in dialectical physics (that is the physics which is based on dialectical philosophy and logic) [5].

We use here new fundamental parameters discovered in the framework of the DM [6]. We rest also on the shell-nodal atomic model [7, 8] of dialectical physics [3, 5]. The two primary fundamental parameters are: (1) the *fundamental frequency of the atomic and subatomic levels*, ω_e; and (2) an *elementary quantum of the rate of mass exchange*, *e*, of the dimensionality $g \times s^{-1}$. The first parameter was completely unknown for modern physics up to 1996, the year of publishing the book "*Alternative Picture of the World*" [3]. The second parameter was/is known as the electron charge, but its nature and true value (and hence, true dimensionality) were unknown till now. Both above parameters were introduced for the first time in the reference book; and they were considered in detail further, mainly in [5].

The more general notion of exchange, instead of interaction, as the notion naturally inherent in the DM, is also used in the paper.

2. The fundamental quantum of specific resistance and the spectrum of specific resistances

One of the main fundamental parameters of the Dynamic Model of Elementary Particles (DM) [5, 6, and 9] is a fundamental frequency (or a fundamental time number) of the atomic and subatomic levels, ω_e:

$$\omega_e = \frac{e}{m_e} = 1.869162505 \times 10^{18}\ s^{-1}, \tag{2.1}$$

where $e = 1.702691627 \times 10^{-9}\ g \times s^{-1}$ is the electron charge (an elementary quantum of the rate of mass exchange), and $m_e = 9.109382531 \times 10^{-28}\ g$ is the electron mass.

The fundamental wave radius $\lambda\!\!\!^{-}_e$, corresponding to the fundamental frequency ω_e, is equal to

$$\lambda\!\!\!^{-}_e = \frac{c}{\omega_e} = 1.603886538 \times 10^{-8}\ cm, \tag{2.2}$$

where $c = 2.99792458 \times 10^{10}\ cm \times s^{-1}$ is the basis speed of exchange of matter-space-time at the atomic and subatomic levels (the speed of light c is equal to the above speed).

The fundamental radius $\lambda\!\!\!^{-}_e$ and the time number ω_e, as a circular frequency, show their worth everywhere. The fundamental wave radius defines average atomic diameters and, hence, average distances (lattice parameters) in ordered material structures (crystals). The fundamental frequency ω_e defines, in particular, the quantum of specific resistance of atomic spaces. Let us consider this feature in more detail.

Ohm’s law in a differential form is presented as

$$j = \frac{1}{S}\frac{dq}{dt}, \tag{2.3}$$

or

$$j = \frac{1}{\rho_e}E = \sigma_e E. \tag{2.4}$$

In a spherical field of the *H*-atom, the “electric” current density, *i.e.*, the density of current of mass exchange, j, is

$$j = \frac{\omega_e e}{4\pi r^2}. \tag{2.5}$$

The latter can be rewritten in the following form

$$j = \varepsilon_0 \omega_e \frac{e}{4\pi\varepsilon_0 r^2} = \frac{1}{\rho_e}E. \tag{2.6}$$

where $\varepsilon_0 = 1\ g \times cm^{-3}$ is the absolute unit density.

Thus, going down to the atomic level, we have arrived at a minimal (boundary) value of specific resistances, and actually, at the *fundamental quantum of specific resistance*

$$\rho_e = \frac{1}{\varepsilon_0 \omega_e} = \frac{m_e}{\varepsilon_e e} = 5.349991157 \times 10^{-19}\ \mu_0 \times s, \tag{2.7}$$

where $\mu_0 = 1/\varepsilon_0\ cm^3 \times g^{-1}$.

From this it follows that the *fundamental quantum of specific resistance* ρ_e is a magnitude inversely proportional to the product of the fundamental frequency of exchange at the atomic (and subatomic) levels, ω_e, and the unit density of matter, ε_0, at this (basis) level.

The dimensionality of ρ_e, expressed through the absolute units of matter-space-time (*g*, *cm*, and *s*), has the form

$$[\rho_e] = \left[\frac{1}{\varepsilon_0 \omega_e}\right] = \frac{1}{\frac{g}{cm^3} \times \frac{1}{s}} \quad \text{or} \quad [\rho_e] = \frac{cm^3}{g/s} \tag{2.7a}$$

from which it follows the physical meaning of ρ_e.

Namely ρ_e, being the magnitude inversely proportional to the rate of mass exchange, *g/s*, per the unit volume of atomic (basis) space, cm^3, characterizes by itself the fundamental quantum of volume deformation of the atomic (basis) space at the unit rate of wave mass exchange of the space.

The objective measures of resistance of 1Ω and charge of $1C$ [5] are, respectively:

$$1\Omega = \frac{10^9}{4\pi c_0^2 \varepsilon_0}\, cm^{-1} \times s = 8.854187817 \times 10^{-14}\, \mu_0\ cm^{-1} \times s \tag{2.8}$$

and

$$1C = 1A \times s = \frac{c_0 \sqrt{4\pi}}{10}\, g \times s^{-1} = 1.062736593 \times 10^{10}\, g \times s^{-1}, \tag{2.9}$$

where $c_0 = 2.99792458 \times 10^{10}$.

Hence, the quantum of *specific electron resistance* is defined by the measures:

$$\rho_e = 6.042328514 \times 10^{-6}\, \Omega \times cm, \tag{2.10}$$

or

$$\rho_e = 5.685628951 \times 10^{-15}\, m^3 \times C^{-1}. \tag{2.11}$$

An average specific resistance of a series of metals at 273 *K* is congruent with the fundamental quantum (2.11). Let us show it.

The rate of exchange in a spherical field is

$$v = \frac{v_1}{Z^*_{r,n}}, \tag{2.12}$$

where

$$z^*_{r,n} = \frac{z_{r,n}}{z_{r,1}}, \tag{2.13}$$

and $z_{r,n}$ are roots of Bessel radial functions. The subscript *r* indicates the order of the Bessel functions, and *n* indicates the number of the root. Therefore, the mass rate of exchange is presented by the ratio

$$q = \frac{e}{Z^*_{r,n}} \tag{2.14}$$

and the specific electron resistance as

$$\rho_e = \frac{1}{\varepsilon_0 \omega_e} = \frac{m_e}{\varepsilon_0 e} z^*_{r,n} = 6.042328514 \times 10^{-6} z^*_{r,n}\ \Omega \times cm. \tag{2.15}$$

A theoretical spectrum of specific resistances of some metals, obtained by Eq. (2.15), in comparison with the experimental data is presented in Table 2.1.

We see the well agreement of both presented data that confirms the validity of a new theoretical concept, realized in the framework of the DM, taken here as the basis for the derivation.

For the radial function of the order $r = \frac{1}{2}$, the wave number $z^*_{r,n} = n$ and

$$\rho_e = \frac{1}{\varepsilon_0 \omega_e} = \frac{m_e}{\varepsilon_0 e} n = 6.042328514 \times 10^{-6} n \ \ \Omega \times cm \qquad (2.16)$$

where n = 1, 2, 3, …

Table 2.1. The specific resistances, theoretical and experimental, of some metals ($\rho_e, 10^{-6}\ \Omega \times cm$).

$z^*_{r,n} = \frac{z_{r,n}}{z_{r,1}}$	Element	Theory *Eq.* (2.15)	Experiment [12]
1	19 *K*	6.04	6.1
	28 *Ni*		6.14
$j^*_{2\frac{1}{2},2} = 1.578$	76 *Os*	9.54	9.5
$j^*_{2,2} = 1.639$	78 *Pt*	9.9	9.81
	46 *Pd*		9.77
2	73 *Ta*	12.08	12.4
$j^*_{1,2} = 1.831$	50 *Sn*	11.07	11.15
	37 *Rb*		11.29
$j^*_{2\frac{1}{2},3} = 2.138$	90 *Th*	12.92	13
$j^*_{2,3} = 2.263$	25 *Cr*	13.68	14.1
$j^*_{2\frac{1}{2},4} = 2.692$	41 *Nb*	16.27	16.1
$j^*_{1,4} = 3.477$	92 *U*	21.02	21
3	23 *V*	18.13	18.2
$j^*_{1\frac{1}{2},4} = 3.13$	75 *Re*	18.92	18.9
	82 *Pb*		19.2
$j^*_{1,5} = 4.299$	33 *As*	25.98	26
5	72 *Hf*	30.21	30
	38 *Sr*		30.3
$j^*_{1,7} = 5.94$	5 *B*	35.9	36

3. The fundamental quantum of electron resistance and the spectrum of fundamental resistances

The fundamental quantum of specific resistance defines also the *fundamental quantum of resistance*. Let an elementary length be $l = 2\pi r$, where r is some wave radius. Then, in a spherical field, the quantum of resistance is

$$R_e = \rho_e \frac{l}{S} = \frac{1}{\varepsilon_0}\frac{m_e}{e}\frac{2\pi r}{4\pi r^2} = \frac{2\pi m_e}{e^2}\frac{er}{4\pi\varepsilon_0 r^2} = \frac{2\pi m_e v r}{e^2}, \qquad (3.1)$$

where

$$\frac{e}{4\pi\varepsilon_0 r^2} = v \qquad (3.2)$$

is the speed-strength.

In the spherical field $vr = v_0 r_0 = const$, where v_0 and r_0 are the Bohr speed and radius, respectively. Hence,

$$R_e = \frac{2\pi m_e v_0 r_0}{e^2} = \frac{h}{e^2} = 2.285514295 \times 10^{-9}\mu_0\, cm^{-1} \times s, \qquad (3.3)$$

or

$$R_e = \frac{h}{e^2} = 25812.80567\ \Omega, \qquad (3.4)$$

where h is the Plank constant.

Thus, the *fundamental quantum of resistance* R_e is a magnitude depended on the fundamental quantum of the rate of mass exchange e, at the atomic (basis) level, and hence, on the fundamental frequency, ω_e, just like ρ_e, because they are fundamentally related between themselves (see (3.1) and (2.1)).

The dimensionality of R_e, expressed through the absolute units of matter-space-time (*g*, *cm*, and *s*), has the form

$$[R_e] = \frac{cm^2}{g/s}. \qquad (3.4a)$$

Hence R_e, being the magnitude inversely proportional to the rate of mass exchange, *g/s*, per the unit area of atomic (basis) space, cm^2, characterizes by itself the fundamental quantum of areal deformation of the atomic (basis) space at the unit rate of wave mass exchange of the space.

In the cylindrical field of exchange, the *quantum of resistance* is found on the basis of the following conditions: $r_n = r_0 z^*_{r,n}$ and $l = 2\pi r_0 z^*_{r,n}$. In this case $S = \pi r_n^2$, and an elementary quantum of the mass rate of exchange (electron charge) is defined by the expression $e = \pi r_0^2 \varepsilon_0 v_0$ [6]. As a result, we arrive at

$$R_e = \rho_e \frac{l}{S} = \frac{1}{\varepsilon_0}\frac{m_e}{e}\frac{2\pi r_0 z^*_{r,n}}{\pi (r_0 z^*_{r,n})^2}\frac{v_0}{v_0} = \frac{h}{e^2}\frac{1}{z^*_{r,n}}. \qquad (3.5)$$

For the cylindrical function of the order $r = \frac{1}{2}$, the characteristic argument is $z^*_{r,n} = n$, and the simplest spectrum of resistances will be presented by the following expression:

$$R_e = \frac{h}{e^2}\frac{1}{n}. \tag{3.6}$$

Note, the stabilization of Hall resistance (in the Hall quantum effect) is found at the values satisfying the fundamental spectrum of resistances (3.5).

A cross-section *S*, in the cylindrical field, can be presented by a system of elementary channels with the sections $S_n = n\pi r_0^2$ and $r_m = r_0 z^*_{p,m}$. In such a case

$$R_e = \frac{h}{e^2}\frac{z^*_{p,m}}{n}. \tag{3.7}$$

If $p = \frac{1}{2}$, then $z^*_{p,m} = m$, and we arrive at the *spectrum of fundamental resistances*

$$R_e = \frac{h}{e^2}\frac{m}{n}. \tag{3.8}$$

This spectrum is known as a *fractional quantization* in the Hall conductivity.

4. The quantum of specific proton resistance

The proton (*H*-units) motion in semiconductors is incorrectly interpreted in contemporary physics through a theory of the "hole" (positive) conductivity. According to shell-nodal atomic model, atoms along with principal nodes, filled with nucleons, have empty collateral nodes [5, 7, 8, 10, 11]. The wave motion of *H*-units in atomic space is realized through collateral nodes, where nucleons got into are in nonequilibrium state there. Accordingly, the quanta of ***specific electron resistance*** ρ_e must be supplemented with the quanta of ***specific proton resistance*** ρ_p.

Relying on Ohm's law in a differential form for the nucleon current (*i.e*., for the current of *H*-units),

$$j_p = \frac{E_p}{\rho_p} \quad \text{or} \quad I_p = \frac{E_p}{\rho_p}S \tag{4.1}$$

let us define the specific proton resistance.

According to the DM, the nucleon strength is the speed of motion, *i.e*., $E_p = v$; hence,

$$\rho_p = \frac{v}{I_p}S \tag{4.2}$$

Assuming that an elementary quantum of current is equal to

$$I_p = \omega e, \tag{4.3}$$

and sections of a tube of current in this case are

$$S = \pi(\lambda\!\!\!^{-}_e z_{r,n})^2 \tag{4.4}$$

the spectrum of specific nucleon resistances is presented in the following form:

$$\rho_p = \frac{v}{\omega e}\pi ƛ_e^2 z_{r,n}^2. \tag{4.5}$$

Since

$$\frac{v}{\omega} = r = ƛ_e z_{r,n} \tag{4.6}$$

we obtain

$$\rho_p = \frac{\pi ƛ_e^3 z_{r,n}^3}{e}. \tag{4.7}$$

This expression is referred to the oscillatory level of motion, *i.e.*, to the level of superstructure. At the basis level, $v = c$ and $\omega = \omega_e$, hence

$$\frac{v}{\omega} = \frac{c}{\omega_e} = ƛ_e \tag{4.8}$$

Therefore, the specific nucleon resistances of the basis ρ_{pc} have the form

$$\rho_p = \frac{\pi ƛ_e^3 z_{r,n}^2}{e}. \tag{4.9}$$

If an elementary channel of exchange is defined by the wave fundamental radius $ƛ_e$ ($z_{r,n} = 1$), *i.e.*, the processes occur in the wave zone, then the quantum of specific proton resistance of both basis and superstructure will be equal to

$$\rho_p = \frac{\pi ƛ_e^3}{e} = \frac{\pi ƛ_e^3}{\omega_e m_e} = 7.612634088 \times 10^{-15}\ cm^3 \times g^{-1} \times s, \tag{4.10}$$

or

$$\rho_p = 8.597777961 \times 10^{-2}\ \Omega \times cm = 8.090221375 \times 10^{-11}\ m^3 \times C^{-1} \tag{4.11}$$

The quantum ρ_p (4.10) is significantly more than the quantum of specific electron resistance ρ_e (2.11) (see also (2.7)). Comparing the both quanta of specific, proton and electron, resistances, we obtain the following relationship

$$\rho_p = \frac{\pi ƛ_e^3 \varepsilon_0}{m_e}\rho_e = \zeta \rho_e, \tag{4.12}$$

where the coefficient of proportionality ζ has the fundamental value

$$\zeta = \frac{\pi ƛ_e^3 \varepsilon_0}{m_e} = 14229.24613 \tag{4.13}$$

It can serve as a measure of the bond of a nucleon in the external atomic shell.

5. The electron and nucleon currents and the Hall effect

Experimentally, the separation of the electron and proton currents in conductors is not a simple problem. However, to a definite extent, the Hall effect solves it through an introduction of a conductor in a magnetic field B directed perpendicularly to the current (Fig. 5.1).

The condition of a steady-state transversal potential difference U_H is defined by the following equalities for the electron and nucleon components, respectively:

$$eE_{ez} = \frac{v_{ex}}{c} eB, \qquad eE_{pz} = \frac{v_{px}}{c} eB. \tag{5.1}$$

Assuming at the field levels that $v_{ex} = E_{ex}$ and $v_{px} = E_{px}$ and performing the transformations,

$$\Delta U_{ez} = E_{ez} a = \frac{E_{ex}}{c} aB = \rho_e \frac{j_e}{c} aB = \rho_e \frac{j_e ab}{cb} B = \rho_e \frac{I_e}{cb} B, \tag{5.2}$$

we obtain an expression for the electron potential difference

$$\Delta U_{ez} = \rho_e \frac{\Gamma_e}{b} B, \tag{5.3}$$

where

$$\frac{I_e}{c} = \Gamma_e \tag{5.4}$$

is the electron circulation.

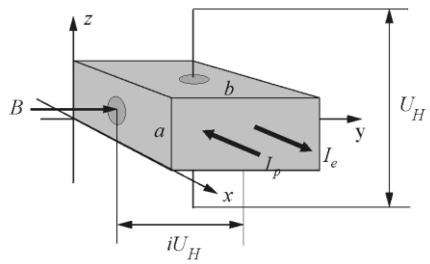

Fig. 5.1. The voltages and currents in the Hall effect; U_H is the transversal potential Hall voltage, iU_H is the transversal kinetic Hall voltage, I_e is the electron current, I_p is the proton current; a and b are the transversal dimensions of a plate.

Analogously, an expression for the nucleon potential difference has the form

$$\Delta U_{pz} = \rho_p \frac{\Gamma_p}{b} B. \tag{5.5}$$

The sum of these voltages defines the total potential ("electric") Hall voltage:

$$\Delta U_H = \rho_H \frac{\Gamma}{b} B, \tag{5.6}$$

where

$$\Gamma = \Gamma_e + \Gamma_p \tag{5.7}$$

is the total magnetic circulation, and

$$\rho_H = \frac{\rho_e \Gamma_e + \rho_p \Gamma_p}{\Gamma} \tag{5.8}$$

is the total specific electron-nucleon resistance, referred to as the Hall coefficient R_H; *i.e.*,

$$\rho_H \equiv R_H. \tag{5.9}$$

Usually, the Hall voltage is represented in the form

$$\Delta U_H = R_H \frac{I_m B_m}{b} \tag{5.10}$$

where the subscript m indicates the "current" and induction in a magnetic system of units, although actually (it follows from the DM), $I_m = \frac{I}{c} = \Gamma$ is the circulation of the dimensionality $g \times s^{-1} \times cm^{-1}$.

When $\rho_e \Gamma_e \ll \rho_p \Gamma_p$ and $\Gamma_e \ll \Gamma_p$, then

$$R_H = \rho_p = 8.597777961 \times 10^{-2}\ \Omega \times cm = 8.090221375 \times 10^{-11}\ m^3 \times C^{-1} \tag{5.11}$$

For a series of metal spaces (see Table 5.1), the positive Hall effect (the specific proton resistance) within mean temperature insignificantly differs from the quantum of the wave zone, defined by the equation (5.11) (see also (4.11)).

Table 5.1. The Hall coefficients [12]

Metal	T, K	$R_H, 10^{-11} m^3 \times C^{-1}$
Be	290	+7.7
Mn	297	+8.4
Nb	273	+8.8
Ta	273	+9.7
V	293	+7.9

If the current has mainly a nucleon character, it is very simple to define the relation between the Hall coefficient and the specific nucleon resistance. In this case, Eq. (5.6) must be presented in the form

$$U_H = R_H \frac{\Gamma_p B}{b} = R_H \frac{I_p B}{cb}, \tag{5.12}$$

where

$$\Gamma_p = \frac{I_p}{c} \tag{5.13}$$

is the nucleon circulation. Substituting I_p by the equality $I_p = \frac{E_p ab}{\rho_p}$, originated from Ohm's law (see (4.1)), we have

$$U_H = R_H \frac{E_p aB}{\rho_p} \frac{1}{c} \tag{5.14}$$

But at the field level, as follows from (5.1), where $v = E$,

$$E_H = \frac{1}{c} E_p B \tag{5.15}$$

Hence,

$$U_H = R_H \frac{E_H a}{\rho_p} \, . \tag{5.16}$$

And because $E_H a = U_H$, we arrive at

$$U_H = R_H \frac{U_H}{\rho_p} \qquad \text{and} \qquad R_H = \rho_p . \tag{5.17}$$

The kinetic "imaginary" ("magnetic") Hall voltage, perpendicular to the potential one (shown in Fig. 5.1), is equal to the following obvious relationship

$$iU_H = iE_H a \tag{5.18}$$

6. Conclusion

The DM has allowed looking at many physical phenomena from a new point of view. This model was developed in the framework of all-embracing dialectical approach to foundations of physics which is a new philosophical basis for physics. The latter will replace in future the formal logic approach of limited capabilities dominated currently in modern physics.

The nature of integer and fractional quanta observed in the Hall conductance is uncovered in this paper on the basis of the aforementioned dialectical approach applied first to foundations of physics. In practice, the new approach is realized through the fundamental parameters first discovered in the framework of the DM and with due regard for the shell-nodal structure of atoms originated from the new approach.

In particular, one of the main fundamental parameters used here (and, generally, used in dialectical physics at the description of all physical phenomena) is the *fundamental frequency of the atomic and subatomic levels*, ω_e, which is still unknown parameter for modern physics. Another discovered parameter is the *fundamental quantum of the rate of mass exchange*, *e*, of the dimensionality $g \times s^{-1}$, known as the electron charge; its nature and, accordingly, the true value and dimensionality were uncovered in the DM.

Radial solutions of the general wave equation (classical, not Schrödinger's) are roots of Bessel functions $z_{r,n}$. They define the spectrum of a possible number, integer or fractional, of the quanta, which are observed under specific conditions (magnetic exposure and extremely low temperature) in the Hall experiment.

All parameters of dialectical physics used in the paper, including the two aforementioned, are put together in Table 6.1.

Table 6.1

Parameter	***Value***	***Dimensionality***
The elementary quantum of the rate of mass exchange (the electron charge), e	$e = 1.702691627 \times 10^{-9}$	$g \times s^{-1}$
The fundamental frequency of the atomic and subatomic levels, ω_e	$\omega_e = \frac{e}{m_e} =$ $1.869162505 \times 10^{18}$	s^{-1}
The fundamental wave radius, $ƛ_e$	$ƛ_e = \frac{c}{\omega_e} =$ $1.603886538 \times 10^{-8}$	cm
The absolute unit density, ε_0	$\varepsilon_0 = 1$	$g \times cm^{-3}$
The speed-strength, $v = E$	$v = E = \frac{e}{4\pi\varepsilon_0 r^2}$	$cm \times s^{-1}$
Roots of Bessel radial functions, $z_{p,q}$	$z_{p,q} = \frac{r_{p,q}}{ƛ}$	
The objective measure of resistance, 1Ω	$1\Omega = \frac{10^9}{4\pi c_0^2} =$ $8.854187817 \times 10^{-14}$	$g^{-1} \times cm^2 \times s$
The objective measure of charge, $1C$	$1C = \frac{c_0\sqrt{4\pi}}{10} =$ $1.062736593 \times 10^{10}$	$g \times s^{-1}$

In the framework of the Dynamic Model of Elementary Particles (DM), we have obtained the formulas and uncovered the nature of the fundamental quanta and corresponding spectra related to electron and proton conductivity of solids; they are put together in Table 6.2.

Table 6.2

Fundamental quanta and spectra	***Formulas***
The fundamental quantum of specific electron resistance	$\rho_e = \frac{1}{\varepsilon_0 \omega_e} = \frac{m_e}{\varepsilon_e e}$
The fundamental quantum of specific proton resistance	$\rho_p = \frac{\pi ƛ_e^3}{e}$

The spectrum of specific electron resistances	$\rho_e = \frac{m_e}{\varepsilon_0 e} z^*_{r,n}$
The spectrum of specific proton resistances	$\rho_p = \frac{\pi ƛ_e^3 z_{r,n}^3}{e}$
The fundamental quantum of resistance	$R_e = \frac{h}{e^2}$
The spectrum of fundamental resistances	$R_e = \frac{h}{e^2}\frac{m}{n}$

We see that the nature of the integer and fractional quanta observed in the Hall conductivity depends on the fundamental parameters of exchange (interaction) on the atomic level: the *fundamental frequency of exchange*, ω_e, and the *quantum of the rate of the exchange*, *e*, presented above. These parameters were unknown till now in modern physics; they were discovered first in the framework of the DM of dialectical physics.

It should be stressed also that modern physics incorrectly interprets the proton motion in semiconductors through the theory of "hole" conductivity. According to the shell-nodal atomic model, atoms resemble elementary nucleon molecules which have, along with principal nodes filled with nucleons, the empty collateral nodes (not considered here). The wave motion of *H*-units in the atomic space is realized through these empty spatial nodes, where nucleons being caught into are, as a rule, in a nonequilibrium state there. Accordingly, the *quantum of specific electron resistance* ρ_e must be supplemented with the *quantum of specific proton resistance* ρ_p as has been shown here. The formula of the ρ_p quantum and the corresponding spectrum of ρ_p are presented in Table 6.2.

Thus, the nature of integer and fractional quanta observed in the Hall conductance (including the resistance quantum) is uncovered in this paper as an internal feature of atomic structures, related to wave exchange (interaction) at the atomic level, without accounting an influence of external magnetic fields and behind Laughlin's theory.

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