
An extended interpretation of the thermodynamic theory, including an additional energy associated with a decrease in mass

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Abstract: Although its practical efficiency is unquestionable, the thermodynamic tool presents a slight inconsistency from the theoretical point of view. After exposing arguments which explain this opinion, a suggestion is put forward to solve the problem. It consists of linking the mass-energy relation $\pm\Delta mc^2$ to the laws of thermodynamics. This combination results in a clarification of the theory and opens a bridge between thermodynamics and gravitation. It is shown that the submicroscopic consideration, which is based on the cellular concept of the real physical space when the space is treated as the tessellation lattice, indeed strongly supports the idea of a variation in mass in thermodynamic processes.

Keywords: thermodynamics; entropy; matter waves; inertons; gravitation; relativity; quantum mechanics.

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Jean-Louis Tane is a Retired Scientist whose speciality is geology that he taught during more than 30 years at Joseph Fourier University, Grenoble, France, and during three years at the University of Marrakech, Morocco. Most of his papers deal with geologic topics, particularly the problem of the origin of spilitic rocks, yet one of his courses concerned the use of thermodynamics in geochemistry. His interest for physics has been confirmed recently, by the writing of several papers suggesting a link between thermodynamics and relativity. They have been published, between 2000 and 2004 in the *Journal of Theoretics*.

1 Statement of the problem

Following typical thermodynamic courses (see, e.g., Fermi, 1937; Atkins and de Paula, 2002; Nordstrom and Munoz, 1986; Anderson and Crerar, 1993) let us consider the

experimental context of an isolated system composed of two parts separated by a mobile piston. We assume that part 1 contains a gas whose initial pressure is P_1 while part 2 is a vacuum. If the piston, previously locked, is released, the gas expands into the whole system and the thermodynamic

interpretation usually given to the process is based on the two following equations

$$dU = dQ + dW, \quad (1)$$

$$dU = TdS - PdV, \quad (2)$$

whose significance and mutual relations are well known. A more conventional method of writing equation (1) would be $dU = \delta Q + \delta W$, but the simplified and general transcription adopted here has no influence on the discussion presented below. Note that the usual reasoning tends to focus attention on the gas for which it is successively written:

$dQ = 0$ (since the gas cannot exchange heat with the vacuum);

$dW = 0$ (since, by definition, $dW = -P_{\text{ext}}dV$, where P_{ext} is the pressure external to the gas, i.e., the pressure $P_{\text{ext}} = 0$ of the vacuum and dV the change in volume of the gas);

$dU = 0$ (being the sum $dQ + dW$);

then owing to the equality $dU = 0$, we have $dS = (P/T)dV$ (where the three quantities P , T and dV are positive and hence dS is positive too).

On this basis, it is implicitly admitted that the relation $dU = 0$ is true not only for the gas, but equally for the whole system, defined as isolated. It is precisely upon this point that an important and interesting problem arises.

To be rapidly convinced of this reality, let us imagine an experimental context identical to the one just considered, except that instead of being vacuum, part 2 would contain a gas whose initial pressure is P_2 . In such a case, applying equation $dW = -P_{\text{ext}}dV$ to part 1 and part 2 leads to the doublet of equations:

$$dW_1 = -P_2dV_1,$$

$$dW_2 = -P_1dV_2.$$

Noting that $dV_2 = -dV_1$, we get for the whole system

$$dW = dV_1(P_1 - P_2). \quad (3)$$

Since dV_1 is positive when $P_1 > P_2$ and negative when $P_1 < P_2$, equation (3) shows that dW is always positive and reaches the value zero only when $P_1 = P_2$. In other words, we are facing the fact that the disappearance of the pressure gradient within the system is accompanied by an additional energy whose origin is inside this system.

The process examined just before (expansion of a gas in vacuum), corresponds to the particular case for which $P_2 = 0$ in equation (3), so that dW has a positive value, not a zero value as previously recalled and classically accepted. This is the indication that the vacuum plays an important role in the calculation. When equation $dW = -P_{\text{ext}}dV$ is applied to it, P_{ext} corresponds to the pressure of the gas and dV to the decreasing volume of the vacuum, which can be noted as dV_{vacuum} . Accordingly, dW_{vacuum} has a positive value and represents at the same time dW_{system} , given that dW_{gas} is zero.

Transposing these results in equation (1), and applying it to the whole system, we see that the only condition to obtain $dU_{\text{system}} = 0$ is that dQ_{system} should be negative. Such a

condition is not compatible with one of the fundamental laws of thermodynamics (sometimes called the law of heat exchange), which relies on the idea that an exchange of heat between two parts 1 and 2 of an isolated system is described by the relation $dQ_2 = -dQ_1$. At the scale of the whole system, this relation leads to the conclusion

$$dQ = dQ_1 + dQ_2 = 0. \quad (4)$$

where dQ_1 and dQ_2 represent the change in heat for the gas and the vacuum.

As will be explained further, it is highly probable that the true value of dQ is not zero but positive. At the present stage of the discussion, combining the idea that dQ is not negative with the fact, already noted, that dW is positive provides a sufficient condition to conclude that dU is itself positive. Hence, there is really something not clear in the usual concept of thermodynamics, which is based on the idea that the internal energy change dU for an isolated system obeys the double equation

$$dU = dQ + dW = 0. \quad (1b)$$

2 A suggestion to solve the problem

We have seen in Section 1 that the disappearance of the pressure gradient within an isolated system is accompanied by a creation of energy inside this system. Previously we (Tane, 2000, 2001, 2002, 2003, 2004) did a preliminary analysis of the problem and proposed a way to solve it. Now let us elucidate all the aspects of the problem in detail.

We can give to this energy created inside the system under study, the designation dW_{int} , in order to distinguish it from the energy dW_{ext} that (in the more general case of a nonisolated system) corresponds to the exchange of work between the system and its surroundings. With these designations, dW takes the significance

$$dW = dW_{\text{ext}} + dW_{\text{int}}. \quad (5)$$

The condition $dW_{\text{ext}} = 0$ means that the system is isolated (in the classical sense given to this concept in thermodynamics). The condition $dW_{\text{int}} = 0$ means that there is no pressure gradient (i.e., no irreversibility of pressure) within this system. Contrary to dW_{int} which, as already seen, obeys the relation

$$dW_{\text{int}} \geq 0 \quad (6)$$

the value of dW_{ext} can be positive or negative, depending on whether the system receives work or gives work in its exchanges with the surroundings.

If the system we are considering is not isolated but only closed, the work dW exchanged with its surroundings (and whose precise designation is dW_{ext}) is given, as recalled above, by the classical expression $dW = -P_{\text{ext}}dV$. If we are under conditions of reversibility, i.e., if $P_{\text{ext}} = P_{\text{int}}$, this relation becomes $dW = -P_{\text{int}}dV$. Observing that P_{ext} can always be written $P_{\text{ext}} = -P_{\text{int}} + P_{\text{int}} + P_{\text{ext}}$, we get the general expression

$$dW = -P_{\text{int}}dV - (P_{\text{ext}} - P_{\text{int}})dV, \quad (7)$$

which means

$$dW_{\text{irr}} = dW_{\text{rev}} + dW_{\text{int}}, \quad (8)$$

that is

$$dW_{\text{irr}} = dW_{\text{ext}} + dW_{\text{int}}. \quad (9)$$

Each term of equations (8) and (9) has the same value and significance as the corresponding term of equation (7). An important point to be noted is that $dW_{\text{ext}} = dW_{\text{rev}}$.

As concerns the exchanges of heat and their relations with the concept of entropy, the usual thermodynamic tool is given by the well known expression

$$dS \geq dQ/T_{\text{ext}},$$

which can be represented in the form

$$dS = dQ/T_{\text{ext}} + dS_{\text{int}}. \quad (10)$$

To be coherent with the reasoning previously adopted, equation (10), which has the dimensionality of entropy, needs to be converted into an equation having the dimensionality of energy, i.e.

$$T_{\text{ext}} dS = dQ + T_{\text{ext}} dS_{\text{int}}. \quad (11)$$

whose significance is

$$dQ = dQ_{\text{ext}} + dQ_{\text{int}}, \quad (12)$$

that is

$$dQ_{\text{irr}} = dQ_{\text{rev}} + dQ_{\text{int}}. \quad (13)$$

Each term of equations (12) and (13) has the same value and significance as the corresponding term of equation (11). We have observed that $dW_{\text{ext}} = dW_{\text{rev}}$ and we also see here that $dQ_{\text{ext}} = dQ_{\text{rev}}$ but this last equality is not a novelty. In the usual concept of the thermodynamic theory, it is an implicit equation whose integration leads to equation (21) that will be used further.

In the same manner as we have introduced a difference between dW_{ext} and dW_{int} in equation (5) and a difference between dQ_{ext} and dQ_{int} in equation (12), we now easily conceive that there is a difference between dU_{ext} and dU_{int} . It can be expressed through the general equation

$$dU = dU_{\text{ext}} + dU_{\text{int}}, \quad (14)$$

which can be better written (as explained later) in the form

$$dU^* = dU_{\text{ext}} + dU_{\text{int}} \quad (15)$$

whose meaning is

$$dU_{\text{irr}} = dU_{\text{rev}} + dU_{\text{int}}. \quad (16)$$

For reasons of homogeneity with equation (15), equations (5) and (12) can be written respectively

$$dW^* = dW_{\text{ext}} + dW_{\text{int}} \quad (17)$$

and

$$dQ^* = dQ_{\text{ext}} + dQ_{\text{int}}. \quad (18)$$

In conventional thermodynamics, dU_{ext} is generally noted as dU . It is to avoid the risk of an additional confusion that the

sum $dU_{\text{ext}} + dU_{\text{int}}$ has been noted as dU^* (and not simply dU) in equation (15). The conceptual difficulty which is often encountered in learning (and teaching) thermodynamics comes from the fact that dU_{int} is not recognised as an energy, so that dU^* and dU_{ext} are not differentiated. Consequently, they are expressed through the same designation dU with the drawback evoked above.

We have just recalled that the term usually noted as dU in thermodynamics corresponds to the one noted as dU_{ext} in equation (15). Concerning the energy quantity dU_{int} and given that it is generated within the system, there is no other solution to explain its origin than as that of a correlated decrease in mass, according to the Einstein mass-energy relation. Since this relation was not known when the laws of thermodynamics have been stated, we can easily conceive that it was not obvious for their authors to imagine such a possibility, all the more that the decrease in mass is generally much too small to be experimentally detectable.

The practical and well known efficiency of the thermodynamic tool is evidently due to the fact that although not identified as an energy, the term dU_{int} is nevertheless taken into account through the concept of the internal component of entropy, usually noted as dS_{int} . We have to note that being a physical reality, dU_{int} is not easy to eliminate. It is certainly for this reason that the art of playing thermodynamics often looks like an acrobatic feat whose objective is to convert dU_{int} into dS_{int} everywhere it appears. For instance, in the study of anomalies in water, we (Zelepukhin et al., 1994; Krasnoholovets et al., 2003) were forced to introduce an additional correction to the Gibbs potential called “the change of the Gibbs potential associated with intermolecular interaction (or the configuration potential)” $G_{\text{in}} = (C_p - S)\Delta T$; this potential definitely introduced a correction into the entropy S of the water system studied.

On the other hand, let us now look at the Einstein mass-energy relation that is classically presented through the expression $E = mc^2$ where c is the speed of light. In the differential form its becomes

$$dE = c^2 dm,$$

which could be preferably written in our case as $dE = -c^2 dm$, since dE is positive when dm is negative and conversely. Transposed in the language of thermodynamics and taking into account the term dU_{int} previously explained, this expression becomes

$$dU_{\text{int}} = -c^2 dm. \quad (19)$$

We have seen above that dU_{int} is the energy created within a system, due to the disappearance of an internal gradient i.e., of an internal irreversibility. Combining this data with the observation, evidenced for a long time by scientists, that every kind of irreversibility generates heat, both the term dW_{int} of equation (5) and the term dQ_{int} of equation (13) can appear as being heat.

The great difference between the theory suggested here and the classical one lies in the origin of the heat, which is linked to irreversibility. In conventional thermodynamics,

this heat is considered as coming from the fact that the energy received by the system from its surroundings, is partly transformed into thermal energy. In our theory, the energetic quantity dU_{int} is considered as resulting from a partial disintegration of mass inside the system. For a better understanding of this difference, a practical and numerical example is examined below.

3 A numerical application of the suggested theory

Let us consider an isolated system composed of two parts 1 and 2, each of them containing liquid water. We suppose that the initial temperature T_1 of part 1 is 293 K (20°C) and that the initial temperature T_2 of part 2 is 333 K (60°C). We know that the evolution of the system consists of an irreversible exchange of heat between the two parts, until they reach the same final temperature T_f . We also know that T_f is given by the relation

$$T_f = (C_1 T_1 + C_2 T_2) / (C_1 + C_2) \quad (20)$$

where C_1 and C_2 are the heat capacities of part 1 and part 2, respectively. To simplify the calculation without reducing its interest, we can assume that the mass of water is the same in each part and choose it in such a way that $C_1 = C_2 = 1$ J. Since $C = 4.18$ J for one gram of water, the mass we have to consider is $1/(4.18) = 0.223$ [g]. Knowing that liquid water is a condensed form of water, we can also note that C designates indifferently C_v and C_p (whose values are quite equal in such a case) and that we make an acceptable approximation in considering that C does not vary significantly with temperature.

Admitting these considerations, the difference between the classical interpretation and the one suggested presently is the following.

3.1 The classical interpretation

Equation (20) gives

$$T_f = (1 \times 293 + 1 \times 333) / (1 + 1) \text{ K} = 313 \text{ K}.$$

From the general relation

$$\Delta Q = C \times (T_f - T_i) \quad (21)$$

where T_i means T_{initial} and having, in the present case, $\Delta U = \Delta Q$ (since $\Delta W = 0$),

we obtain

$$\Delta U_1 = \Delta Q_1 = 1 \times (313 - 293) \text{ J} = 20 \text{ J},$$

$$\Delta U_2 = \Delta Q_2 = 1 \times (313 - 333) \text{ J} = -20 \text{ J}$$

so that, for the whole system

$$\Delta U = \Delta Q = \Delta U_1 + \Delta U_2 = 0.$$

Concerning the entropy change, the general equation is

$$\Delta S = \int_{T_i}^{T_f} \frac{C}{T} dT, \quad (22)$$

which gives

$$\Delta S_1 = \ln(313/293) = 0.066030 \text{ JK}^{-1},$$

$$\Delta S_2 = \ln(313/333) = -0.061939 \text{ JK}^{-1}$$

so that, for the whole system:

$$\Delta S = 0.066030 \text{ JK}^{-1} - 0.061939 \text{ JK}^{-1} = 0.00409 \text{ JK}^{-1}.$$

The important point to keep in mind is that ΔU is zero, while ΔS is positive.

3.2 The new suggested interpretation

By integration, equation (11) leads to an expression, which can be written

$$T_{\text{ext}}^* \Delta S = \Delta Q + T_{\text{ext}}^* \Delta S_{\text{int}}, \quad (23)$$

whose meaning is

$$\Delta U^* = \Delta U_{\text{ext}} + \Delta U_{\text{int}}.$$

In equation (23), T_{ext}^* represents the average external temperature that can be calculated as follows:

for part 1, its value is

$$T_{\text{ext}}^* = T_2^* = \Delta Q_2 / \Delta S_2 = -20 / (-0.061939) \text{ K} = 322.89 \text{ K},$$

for part 2, its value is

$$T_{\text{ext}}^* = T_1^* = \Delta Q_1 / \Delta S_1 = 20 / (0.066030) \text{ K} = 302.89 \text{ K}.$$

Contrary to T_1 and T_2 , which are varying both in space and in time, T_1^* and T_2^* can be seen as *space-time parameters*, whose values are constant for the process we are considering. In a more general way, this peculiarity appears as a characteristic of T_{ext}^* .

The terms ΔQ_1 , ΔQ_2 , ΔS_1 and ΔS_2 having the numerical values already calculated in Section 3.1, when applying equation (23) to part 1 and part 2, we get successively:

for part 1:

$$\Delta U_1^* = T_{\text{ext}2}^* \Delta S_1 = 322.89 \times 0.066030 \text{ J} = 21.32 \text{ J},$$

$$\text{so that: } \Delta U_{\text{int}1} = \Delta U_1^* - \Delta U_{\text{ext}1} = 21.32 \text{ J} - 20 \text{ J} = 1.32 \text{ J};$$

for part 2:

$$\Delta U_2^* = T_{\text{ext}1}^* \Delta S_2 = 302.89 \times (-0.061939) \text{ J} = -18.76 \text{ J},$$

so that:

$$\Delta U_{\text{int}2} = \Delta U_2^* - \Delta U_{\text{ext}2} = -18.76 \text{ J} - (-20) \text{ J} = 1.24 \text{ J};$$

for the whole system:

$$\Delta U_{\text{int}} = \Delta U_{\text{int}1} + \Delta U_{\text{int}2} = 1.32 \text{ J} + 1.24 \text{ J} = 2.56 \text{ J},$$

$$\Delta U_{\text{ext}} = \Delta U_{\text{ext}1} + \Delta U_{\text{ext}2} = 20 \text{ J} - 20 \text{ J} = 0,$$

$$\text{so that } \Delta U^* = \Delta U_{\text{ext}} + \Delta U_{\text{int}},$$

$$\text{i.e., } \Delta U^* = 0 \text{ J} + 2.56 \text{ J} = 2.56 \text{ J}.$$

The essential point is that the value $\Delta U_{\text{ext}} = 0$ corresponds to the fact that the whole system is defined as isolated.

The value $\Delta U_{\text{int}} > 0$ corresponds to the fact that the evolution of this system (disappearance of an internal temperature gradient) is accompanied by an increase in energy whose value is 2.56 J and whose corresponding decrease in mass (according to the Einstein mass-energy relation) is

$$dm = -2.56/(3 \times 10^8)^2 \text{ kg} = -2.84 \times 10^{-17} \text{ kg} \quad (24)$$

Although this latter value is evidently too small to be detectable experimentally, it appears as the logical inference of the reasoning adopted.

4 The concept of free energy in the suggested theory

The concept of free energy, introduced by Gibbs, is of great usefulness in the thermodynamic study of chemical reactions. It is generally noted G and defined by the well known equation

$$G = U + PV - TS \quad (25)$$

whose differential form is

$$dG = dU + d(PV - TS). \quad (26)$$

The point to be careful about when considering G in the light of the new suggested theory is that dU , in equation (26), corresponds to dU_{ext} that can itself be written as

$$dU_{\text{ext}} = T_{\text{int}}^* dS - P_{\text{int}}^* dV \quad (27)$$

whose meaning is $dU_{\text{ext}} = dU_{\text{reversible}}$, or as

$$dU_{\text{ext}} = T_{\text{ext}}^* dS - P_{\text{ext}}^* dV + c^2 dm \quad (28)$$

whose meaning is $dU_{\text{ext}} = dU^* - dU_{\text{int}}$, i.e.,

$$dU_{\text{ext}} = dU_{\text{irr}} - dU_{\text{int}},$$

so that

$$dU_{\text{ext}} = dU_{\text{rev}}.$$

Thus we see that equation (28) is really coherent with equation (27).

Taking into account these considerations, the whole meaning of equation (26) can itself be understood through two equivalent interpretations:

4.1 The first interpretation

$$dG = T_{\text{int}}^* dS - P_{\text{int}}^* dV + d(PV - TS), \quad (29)$$

that is

$$dG = T_{\text{int}}^* dS - P_{\text{int}}^* dV + P_{\text{ext}}^* dV + V dP_{\text{ext}}^* - T_{\text{ext}}^* dS - S dT_{\text{ext}}^*$$

where P_{ext}^* and T_{ext}^* are constant (as already seen for T_{ext}^* in the Section 3.2), so that $dT_{\text{ext}}^* = 0$ and $dP_{\text{ext}}^* = 0$. Consequently,

$$dG = (T_{\text{int}}^* - T_{\text{ext}}^*) dS + (P_{\text{ext}}^* - P_{\text{int}}^*) dV. \quad (30)$$

4.2 The second interpretation

The second interpretation is equivalent to the first one, but using dU_{ext} as defined by equation (28)

$$dG = T_{\text{ext}}^* dS - P_{\text{ext}}^* dV + c^2 dm + d(PV - TS), \quad (31)$$

which (after the same treatment as that already done), is reduced to

$$dG = c^2 dm. \quad (32)$$

Both equations are the same but the first transcription gives the formula to calculate dG (equation (29)), while the second shows that dG is correlated to a change in mass (equation (32)).

For a practical example of the use of these equations, let us come back to the exchange of heat between the two parts of the isolated system previously considered and to the interpretation presented in the Section 3.2.

We are in a situation for which dV is negligible, so that equation (30) is reduced to

$$dG = (T_{\text{int}}^* - T_{\text{ext}}^*) dS. \quad (33)$$

Having noted above that T_{int}^* and T_{ext}^* are constants (referring to the process we are considering), the difference $T_{\text{int}}^* - T_{\text{ext}}^*$ is a constant too and, consequently, the integration of equation (33) leads to

$$\Delta G = (T_{\text{int}}^* - T_{\text{ext}}^*) \Delta S. \quad (34)$$

By applying equation (34) to part 1 and part 2 successively, we get

$$\Delta G_1 = (302.89 - 322.89) \times 0.066030 \text{ J} = -1.32 \text{ J},$$

$$\Delta G_2 = (322.89 - 302.89) \times (-0.061939) \text{ J} = -1.24 \text{ J},$$

so that, for the whole system, $\Delta G = \Delta G_1 + \Delta G_2 = -2.56 \text{ J}$.

This result being the same (with an inversion of sign) as the one obtained in the Section 3.2, we see that ΔG is effectively equivalent to $-\Delta U_{\text{int}}$.

In the case of a chemical reaction, the negative value of ΔG corresponds to the disappearance, within the system, of a gradient in chemical potential. This peculiarity is a well known data of the classical theory. The complementary information we obtain now is that the negative value of ΔG is accompanied by a decrease in mass.

The fact that conventional thermodynamics does not take into account the decrease in mass, which is linked to a chemical reaction, is probably the reason why it is not of common use in the study of nuclear reactions, which are effectively characterised by a change in mass. It seems that this difficulty disappears when the enlarged concept suggested here is substituted to the classical one.

After this preliminary consideration based on macroscopic thermodynamics, we will now examine the problem from the submicroscopic point of view.

5 Submicroscopic consideration

5.1 Space structure and quantum mechanics

Let us turn now to the microscopic consideration of a dynamic system. What has to be proved is the realistic mass exchange between the system studied and the ambient space. Obviously orthodox quantum mechanics cannot solve the problem, because it treats the mass of a quantum system as an invariable classical parameter. At the same time relativistic experiments demonstrate that the mass is not a constant, but changes with the system's velocity. This means that something is wrong in our comprehension of the fundamentals, namely: there is no connection between conventional quantum physics and relativity.

Very recently, a rigorous mathematical theory of the real physical space has been developed by Bounias and Krasnoholovets (2003a, 2003b, 2003c). The theory shows that the real space represents a mathematical lattice, called *the tessellattice*, packed with elementary cells whose size can be estimated as the Planck one, $\sim 10^{-35}$ m. The tessellattice represents a degenerate space-time, i.e., in this case all cells (in other words, balls) are degenerated.

A particed cell provides a formalism describing the elementary particles proposed in Krasnoholovets and Ivanovsky (1993), Krasnoholovets (1997). In this respect, mass is determined by a fractal reduction of volume of a cell, while just a reduction of volume as in degenerate cells, which was initially postulated in Krasnoholovets and Ivanovsky (1993), Krasnoholovets (1997, 2000a), is not sufficient to provide mass (because a dimensional increase is a necessary condition Bounias and Krasnoholovets, 2003b). Accordingly, if V_o is the volume of an absolutely free cell, then the reduction of volume resulting from a fractal concavity is the following: $V^{\text{part}} = V_o - V_{\text{frac}}$. The mass m of a particed cell is a function of the fractal related decrease of the volume of the ball:

$$m \propto \frac{1}{V^{\text{part}}} (e_v - 1)_{e_v-1} \quad (35)$$

where (e) is the Bouligand exponent, and $(e_v - 1)$ the gain in dimensionality given by the fractal iteration; the index v at the Bouligand exponent specifies the possible fractal concavities affecting the particed ball (Bounias and Krasnoholovets, 2003b). The moment of junction allows the formalisation of the topological characteristics of what is called *motion* in a physical universe. It is the motion that was referred to by deBroglie as the major characteristic determining physics. While an identity mapping denotes an absence of motion that is, a null interval of time, a nonempty moment of junction stands for the minimal time interval. In our understanding, there is no minimal spatial 'point' at all; only instants that, basically, do not reflect timely features.

Now let us consider the motion of a particed cell in the tessellattice. Clearly the massive particed cell cannot move without contact with ambient cells. Such interaction creates excitations in the tessellattice called *inertons*

(Krasnoholovets and Ivanovsky, 1993; Krasnoholovets, 1997), because the excitations carry inert properties of the particle and they represent a substructure of the particle's matter waves. As has been shown (Krasnoholovets and Ivanovsky, 1993; Krasnoholovets, 1997) inertons spread from the particle down to a distance

$$\Lambda = \lambda c / v \quad (36)$$

where λ can be called the free path length of the particle, or the particle's spatial amplitude, v , is the particle's velocity and c is the velocity of inertons, which may be associated with the speed of light (if we deal with the charged system). Then Λ plays the role of the free path length of the particle's cloud of inertons.

A detailed theory of submicroscopic mechanics developed in real physical space has been constructed in Krasnoholovets and Ivanovsky (1993), Krasnoholovets (1997, 2000a, 2000b, 2002a). The theory has allowed us to completely clarify fundamental notions of quantum physics; the theory has introduced short range action that automatically means the introduction of a new kind of carriers – inertons, – which thus become carriers of the quantum mechanical interactions.

It has been argued that a deformation coat, or a crystallite, is formed around a created particle in the tessellattice space. The size of the crystallite in which cells are deformed is associated with the Compton wavelength of the particle $\lambda_{\text{com}} = h/mc$; the role of the crystallite is to shield the particle from the degenerate space. The mechanics constructed is exemplified by elementary excitations of the surrounding space, i.e., inertons, which accompany the moving particle. The motion of the particle has been studied, starting from the Lagrangian (it is simplified here)

$$L = g_{ij} \dot{X}^i \dot{X}^j + \frac{1}{2} \sum_l \tilde{g}_{ij}^{(l)} \dot{x}_{(l)}^i \dot{x}_{(l)}^j - \sum_l \frac{\pi}{T_l} \delta_{ij} [X^i \dot{x}_{(l)}^j + v_0^i x_{(l)}^j] \quad (37)$$

Here the first term describes the kinetic energy of the particle, the second term depicts the motion of the ensemble of inertons and the third term characterises the interaction between the particle and its inertons. X^i , \dot{X}^i are components of the particle coordinate and the velocity; $x_{(l)}^i$ and $\dot{x}_{(l)}^i$ are components of the l th inerton coordinate and the velocity; g_{ij} and $\tilde{g}_{ij}^{(l)}$ are mass tensors of the particle and its l th inerton; v_0^i are components of the initial velocity of the particle (here $i = x, y, z$); π/T_l is the frequency of scattering of the particle by the l th inerton; δ_{ij} is the Kroneker symbol.

In the so called relativistic case, when v_0 approaches to the velocity of light c , the initial Lagrangian has been chosen in the classical form

$$L = -mc^2 \sqrt{1 - v_0^2 / c^2} \quad (38)$$

in which the following transformation has been made

$$v_0^2 \rightarrow [g_{ij} \dot{X}^i \dot{X}^j + F(X, x, \dot{x}, v_0)] / g \quad (39)$$

where the function F is similar to the second and third terms in expression (equation 37).

The Euler-Lagrange equations written for the particle and inertons allow one to obtain paths of the particle and its inertons (Krasnoholovets and Ivanovsky, 1993; Krasnoholovets, 1997, 2000a). The solutions to the equations of motion show that the particle oscillates along its path, namely, the particle's velocity changes periodically from v_0 to zero during a spatial interval λ , which exactly coincides with the deBroglie wavelength of the particle. Thus the value of $\lambda = h/mv_0$ determines the spatial period of the oscillatory moving particle.

Furthermore the relationship $\lambda = v_0 T$ holds, where hereinafter, $1/T$ is the frequency of scattering of the particle by its inerton cloud. A cloud of inertons oscillates around the particle and the cloud's range periodically changes from zero to $\Lambda = cT$. These two relationships result in relation (equation 36).

Thereby the motion of a particle is deterministic and features the deBroglie's relationships

$$E = h\nu, \quad \lambda = h/mv_0 \quad (40)$$

where in our case

$$E = mv_0^2/2 \text{ and } m = m_0/(1 - v_0^2/c^2)^{-1/2}.$$

The transition to Schroedinger's and Dirac's quantum mechanics is ensured by the transition to typical initial classical Hamiltonians, which are used to start the formalisms. Relationships (equation 40) enable one to derive the Schroedinger equation and in this case the wave ψ function, which is an abstract characteristic in the conventional formalism, gains in importance in the field of inertia of the particle. The field of inertia is located in the range covered by the amplitude of the particle's inerton cloud Λ , which signifies that the wave ψ function formalism cannot be employed beyond this range limited by the amplitude Λ .

Besides, it is important to emphasise that in the case of a many particle system (for instance, a solid) the role of the spatial amplitude λ of a particle, i.e., its deBroglie wavelength, plays the amplitude of oscillations δg of the particle that vibrates in the vicinity of its equilibrium position. Below we will use this fact in the analysis of the behaviour of the particle mass in a many particle system.

5.2 Space structure, microscopic mechanics and the phenomenon of gravity

What exactly do inertons, as carriers of the elementary quantum mechanical interaction, transfer? To describe quantum mechanics, we needed to know the inerton's position, velocity, kinetic energy and momentum. In paper Krasnoholovets (2002b) a detailed consideration of the motion of a particle in the tessellattice has been performed. The study has elucidated processes of emission and reabsorption of inertons, which shows that inertons transfer fragments of the particle's mass to the distance Λ from the particle and then the space tessellattice being elastic, returns

inertons to the particle. The value of mass m_{inert} transferred by an inerton has been studied in Krasnoholovets (2001) it has been argued that m_{inert} falls within the range around 10^{-85} kg to 10^{-45} kg.

The mass of an inerton is specified by its own dynamics (Krasnoholovets, 2002b) and, therefore, the Lagrangian equation (37) should be supplemented by additional terms. Namely, a moving particle and its inerton cloud metamorphose every half a period, i.e., $\lambda/2$ and $\Lambda/2$, respectively: The particle cell and ambient cells involved in the inerton cloud periodically change, due to the periodic character of the motion of the particle, from the deformed state to the tension state. In other words, the mass (a local characteristic of the tessellattice) is periodically converted to the rugosity of the tessellattice (a collective property of cells enfolded in the inerton cloud). Therefore, keeping in mind that the availability of the mass in a particle means the total mass of the particle jointly with its inerton cloud, the mass part of the particle's Lagrangian becomes

$$L = \frac{1}{2}\dot{\mu}^2 + \frac{1}{2}\dot{\xi}^2 - c\mu\nabla\bar{\xi} \quad (41)$$

Here $\mu = m(\vec{r}, t)/m_0$ is the current dimensionless mass of the {particle + inerton cloud}-system; $\bar{\xi} = \bar{\xi}(\vec{r}, t)$ is the current dimensionless value of the rugosity of the tessellattice in the range covered by the system. Geometrically the rugosity $\bar{\xi}$ depicts the state in which the tessellattice cells in the region covered by the inerton cloud do not have any volumetric deformation (i.e., the cells become massless), but are slightly shifted from their equilibrium positions in the tessellattice along the particle vector velocity \vec{v} . This characteristic of the rugosity also embraces the state of inflation of cells, especially the particle cell. The moving particle periodically changes its state from deformed (the mass state) to inflated and shifted (the tension state); this conversion occurs after passing the section $\lambda/2$, beginning with the initial starting point that has to be specified by the mass state. In physical language, the rugosity manifests itself as the tension of space. The last term in expression (41) introduces the conversion of the mass state to the tension state where c is the rate of this conversion, i.e., the velocity of inertons.

Proceeding to the Euler-Lagrange equations for variables μ and $\bar{\xi}$ we have to use them in the form

$$\partial/\partial t(\partial L/\partial \dot{q}) - \delta L/\delta q = 0$$

where $\delta L/\delta q$ is the functional derivative

$$\frac{\delta L}{\delta q} = \frac{\partial L}{\partial q} - \frac{\partial}{\partial x} \frac{\partial L}{\partial(\partial q/\partial x)} - \frac{\partial}{\partial y} \frac{\partial L}{\partial(\partial q/\partial y)} - \frac{\partial}{\partial z} \frac{\partial L}{\partial(\partial q/\partial z)}.$$

The equations for m and $\bar{\xi}$ obtained from equation (41) are the following

$$\partial^2 \mu / \partial t^2 - c\nabla\dot{\bar{\xi}} = 0, \quad (42)$$

$$\partial^2 \bar{\xi} / \partial t^2 - c \nabla \dot{\mu} = 0 \quad (43)$$

The availability of the radial symmetry allows the solutions to equations (42) and (43) in the form of standing spherical waves (Krasnoholovets, 2002b), which exhibit the dependence $1/r$; in particular, the solution for the mass is (Krasnoholovets, 2002b)

$$m(r, t) = m_0 \frac{l_{\text{Plank}}}{r} \left| \cos\left(\frac{\pi r}{2\Lambda}\right) \right| \left| \cos\left(\frac{\pi t}{2\tilde{T}}\right) \right|. \quad (44)$$

The solution for the rugosity/tension ξ , which in the case of the radial symmetry becomes a scalar variable, is

$$\xi(r, t) = \xi_0 \frac{\Lambda}{r} \left| \sin\left(\frac{\pi r}{2\Lambda}\right) \right| \left| \sin\left(\frac{\pi t}{2\tilde{T}}\right) \right|. \quad (45)$$

In expressions (equations 44–45) the variable r satisfies the inequalities $l_{\text{Plank}} \leq r \leq \Lambda$.

Newton's gravitational law immediately follows from expression (equation 43). Indeed, at $r \ll \Lambda$, $t \gg T$ and $v^2/c^2 \ll 1$ we obtain

$$m(r) \cong l_{\text{Plank}} m_0 / r. \quad (46)$$

This relation shows the degree of deformation of the space around the particle. Then multiplying both parts of expression (equation 46) by a factor $-G/l_{\text{Plank}}$ where G is the Newton's constant of gravitation, we obtain the so called potential gravitational energy, or Newton's gravitational potential, of the object in question

$$U(r) = -Gm_0/r \quad (47)$$

where the Newton's constant simple plays the role of a dimensional coefficient.

5.3 The mass of a particle in a many particle system

So far we have treated the behaviour of a stationary moving quantum system. However, if the system in question consists of a huge number of particles (e.g., a gas, a solid and so on), the Lagrangians equations (37) and (41) must be complemented by terms including the interaction between particles. Let us focus on the modified Lagrangian (equation 40), which should help us to arrive exactly at the changes in the behaviour of the system's mass, revealed in the aforementioned thermodynamic analysis,

$$L_{\text{mass}} = \sum_{\bar{n}} \left(\frac{1}{2} \dot{\mu}_{\bar{n}}^2 + \frac{1}{2} \dot{\xi}_{\bar{n}}^2 - c \dot{\mu}_{\bar{n}} \nabla \bar{\xi}_{\bar{n}} - \frac{\pi}{2} \sum_{\bar{n}'} \chi_{\bar{n}\bar{n}'} \dot{\mu}_{\bar{n}} \bar{\xi}_{\bar{n}'} \right) \quad (48)$$

The parameter $\chi_{\bar{n}\bar{n}'}$ throws into engagement, the mass of one particle described by the radius vector \bar{n} with the tension of the tessellattice generated by the other particle, depicted by the radius vector \bar{n}' ; in other words, $\chi_{\bar{n}\bar{n}'}$ is the scattering frequency of the rate of mass $\dot{\mu}_{\bar{n}}$ of the \bar{n} particle by the nonhomogeneity of space caused by the rugosity $\bar{\xi}_{\bar{n}'}$ of the \bar{n}' -particle.

The Euler-Lagrange equations of motion constructed on the basis of the Lagrangian (equation 46) are the following

$$\dot{\mu}_{\bar{n}} - c \nabla \dot{\xi}_{\bar{n}} - \frac{\pi}{2} \sum_{\bar{n}'} \chi_{\bar{n}\bar{n}'} \bar{\xi}_{\bar{n}'} = 0, \quad (49)$$

$$\ddot{\xi}_{\bar{n}} - c \nabla \dot{\mu}_{\bar{n}} - \frac{\pi}{2} \sum_{\bar{n}'} \chi_{\bar{n}\bar{n}'} \dot{\mu}_{\bar{n}'} = 0. \quad (50)$$

Equations (49) and (50) allow us to derive the following equation describing the behaviour of the mass

$$\begin{aligned} \dot{\mu}_{\bar{n}} - c^2 \nabla_{\bar{n}}^2 \mu_{\bar{n}} + \frac{\pi}{2} c \nabla_{\bar{n}} \mu_{\bar{n}} \sum_{\bar{n}'} \chi_{\bar{n}\bar{n}'} - \frac{\pi}{2} C \sum_{\bar{n}'} \chi_{\bar{n}\bar{n}'} \\ - \frac{\pi}{2} c \sum_{\bar{n}'} \chi_{\bar{n}\bar{n}'} \nabla_{\bar{n}'} \mu_{\bar{n}'} + \left(\frac{\pi}{2}\right)^2 \sum_{\bar{n}, \bar{n}'} \chi_{\bar{n}\bar{n}'} \chi_{\bar{n}\bar{n}'} \mu_{\bar{n}'} = 0 \end{aligned} \quad (51)$$

where C is a constant. In the first crude approximation, equation (51) can be simplified to

$$\dot{\mu}_{\bar{n}} - c^2 \Delta \mu_{\bar{n}} - c^2 \Delta \mu_{\bar{n}} + \frac{\pi}{2} \chi^2(n) \mu_{\bar{n}} \approx C_{\bar{n}}, \quad (52)$$

where Δ is the Laplace operator, $\chi^2(n) = \sum_{\bar{n}, \bar{n}'} \chi_{\bar{n}\bar{n}'} \chi_{\bar{n}\bar{n}'}$ and $C_{\bar{n}} = C \sum_{\bar{n}'} \chi_{\bar{n}\bar{n}'}$; below, we put $C = 0$, because $C \neq 0$ will introduce in the solution, a term that describes an incessant inflation/disappearance of the total mass of the system of particles in question. Thus setting $C_{\bar{n}} = 0$ in equation (52) and allowing the periodic solution in time, equation (52) is reduced to

$$\Delta \mu_{\bar{n}} - \frac{\omega_{\bar{n}}^2 - (\pi/2)^2 \chi^2(n)}{c^2} \mu_{\bar{n}} = 0. \quad (53)$$

On the assumption of the radial symmetry of each particle, the solution to equation (53) becomes similar to expression (equation 44), namely

$$m_{\bar{n}}(r, t) = \frac{l_{\text{Plank}}}{r} m_0 \left| \cos(K_{\bar{n}} r) \right| \left| \cos(\Omega_{\bar{n}} t) \right| \quad (54)$$

where we come back to the dimension mass variable and denote the proper cycle frequency of the particle oscillation and the corresponding wave vector as follows

$$\Omega_{\bar{n}} = \omega_{\bar{n}} \sqrt{1 - \chi^2(\bar{n}) \tilde{T}_{\bar{n}}^2}, \quad K_{\bar{n}} = k_{\bar{n}} \sqrt{1 - \chi^2(\bar{n}) \tilde{T}_{\bar{n}}^2}. \quad (55)$$

Here we designated $\omega_{\bar{n}} = \pi / 2\tilde{T}_{\bar{n}}$ and $k_{\bar{n}} = \pi / 2\Lambda_{\bar{n}}$.

Thus equations (52) and (53) show that the mass of the particle induces the mass field $m(r, t)$ in the ambient space, which obeys the law of standing spherical waves (equation 54). This mass distribution generates the tension of space $\xi(r, t)$, which also adheres to the same law of standing spherical wave equation (45), though it oscillates in the counterphase.

5.4 An additional mass

Solution (53) shows that the union of particles in a many particle system lowers their energy, because $\hbar \tilde{\omega} < \hbar \omega$

(hereinafter we omit the index \bar{n}). Besides, the mass field around each particle in the system becomes more concentrated. This is obvious from the difference between mass amplitudes written for a system's particle and a free particle

$$\left(\frac{l_{\text{Planck}}}{r} m_0 |\cos(Kr)| - \frac{l_{\text{Planck}}}{r} m_0 |\cos(kr)| \right)_{r \ll \Lambda} \quad (56)$$

$$\propto m_0 \chi^2 \tilde{T}^2 / 2r > 0.$$

This is a typical phenomenon known as the defect of mass (especially in the nuclear physics), though so far the phenomenon has not been studied in such a broad sense.

Let us investigate how the system of particles will behave when external conditions, namely, thermodynamic parameters, change. Evidently, any alteration in the system's parameters affects proper particle parameters, such as the value of the particle velocity v , the spatial amplitude of the velocity oscillation (the deBroglie wavelength) λ and the amplitude of the particle's inerton cloud Λ . The three given parameters are concerned with the period of the particle oscillation \tilde{T} (Krasnoholovets and Ivanovsky, 1993; Krasnoholovets, 1997, 2000a):

$$\tilde{T} = \Lambda / c = \lambda / v. \quad (57)$$

At the same time it is this characteristic \tilde{T} that enters expression (equation 56). This automatically means that any change in thermodynamic parameters will immediately change v , λ and Λ , which in turn must influence the value of \tilde{T} in the solution for the mass distribution (equation 54). Therefore, the change between two equilibrium states of thermodynamic parameters signifies the appearance of the difference in the value of mass amplitude of the particle's inerton cloud, which for states 1 and 2 can be written as (when the inequality $K_1 r \ll 1$ holds)

$$\begin{aligned} \frac{m_0}{r} &= (|\cos(K_2 r)| - |\cos(K_1 r)|) \\ &\approx \frac{m_0}{r} \left[\cos\left(k_1 \sqrt{1 - \chi^2 (\tilde{T}_1 + \delta\tilde{T})^2} r\right) - \cos\left(k_1 \sqrt{1 - \chi^2 \tilde{T}_1^2} r\right) \right] \\ &\approx \frac{m_0}{r} \chi^2 \tilde{T}_1 \delta\tilde{T} \end{aligned} \quad (58)$$

Thus the value of mass, which is carried by inertons from the particle's inerton cloud at the rearrangement of the system, can be crudely estimated as $\delta m = m_0 \chi^2 \tilde{T}_1 \delta\tilde{T}$, or in the explicit form

$$\delta m = \chi^2 h^2 \delta v / (m_0 v^5), \quad (59)$$

(we take into account, the deBroglie wavelength of the particle $\lambda = h / (m_0 v)$, where h is Planck's constant, and relations (57), which give $\tilde{T}_1 = h / (m_0 v^2)$ and $\pm \delta\tilde{T} = \mp h \delta v / (m_0 v^3)$). Then for the system of N particles, the value of the mass, which the system emits or acquires at its thermodynamic rearrangement, will become

$$\Delta m = \chi^2 h^2 N \delta v / (m_0 v^5). \quad (60)$$

Let us now come back to the example considered in Section 3. If we divide the mass, 2.23×10^{-4} kg, of the water specimen by the mass of water molecule, $m_0 \approx 3 \times 10^{-26}$ kg, we obtain the number of molecules in the specimen, $N \approx 0.74 \times 10^{22}$.

The value of 'quantum' velocity v can be derived in the following way. From the relationship $h v = m_0 v_0^2 / 2$, where one should put $v = 1/2 \tilde{T}$ (Krasnoholovets and Ivanovsky, 1993; Krasnoholovets, 1997, 2000a), we obtain $v_0 = 1490$ m/s at $v = 10^{14} \text{ s}^{-1}$ that is the typical value for water molecules. The temperature introduces a disturbance in v_0 , which can be estimated from the relationship $(3/2) k_B T = (1/2) m_0 v_{\text{th}}^2$, namely, the thermal velocity $v_{\text{th}} = \sqrt{3 k_B T / m_0}$; the difference between these characteristics exactly corresponds to the correction δv in expression (60). Numerical values for this parameter are the following: $v_{\text{th}}^{(\text{initial})} = 64$ m/s for normal (initial) conditions and $v_{\text{th}}^{(\text{equilib})} = 66$ m/s at the equilibrium temperature 313 K. Therefore, the value of v in expression (60) becomes $v = v_0 + v_{\text{th}}^{(\text{initial})} = 1554$ m/s and $\delta v = v_{\text{th}}^{(\text{equilib})} - v_{\text{th}}^{(\text{initial})} = 2$ m/s.

Although χ is a fitting parameter, we can evaluate it as well. Indeed, in the Lagrangian equation (48) χ plays the role of a frequency at which particles, together with their inerton clouds, exchange by local deformations and tensions of space. In the system of identical particles which is being treated here, the frequency $1/\tilde{T}$ can be called fundamental and hence one can expect that $\chi \propto 1/\tilde{T}$, though as it follows from equation (55), $\chi \ll 1/\tilde{T}$. Since particles in the system are specified by velocities v and c , we may suggest that the following combination exactly represents the parameter χ :

$$\chi = v / (\tilde{T} c). \quad (61)$$

Setting for the velocity of inertons, carriers of quantum mechanical and gravitational interactions, $c = 2.46 \times 10^{10}$ m/s, we obtain from expression (60): $\Delta m = 2.84 \times 10^{-17}$ kg. This estimate checks well with the result (24) obtained in the framework of the thermodynamic analysis stated above.

6 A system of particles in an external dynamic mass field

6.1 The behaviour of the particle mass

If the system of particles under consideration falls within an external mass field, the Lagrangian equation (48) must be supplemented by one more term that describes the interaction of the field with masses inside the system. What can produce such mass field? In paper (Krasnoholovets and Byckov, 2000) this question has been discussed in detail:

Any moving object induces its own inerton field in the ambient space, which transfers mass, and hence a test material object (a particle or a system of particles) must undergo the influence of this inerton (mass) field. Evidently, the conditions of interaction should be written by analogy with the last term in the Lagrangian equation (48), namely, the given Lagrangian is supplemented by the term

$$\frac{\pi}{2} \sum_{\bar{n}} \chi_{\bar{n}}^{\text{ext}} \dot{m}_{\bar{n}} \dot{\xi}^{\text{ext}}. \quad (62)$$

Then instead of equation (52) we obtain the equation

$$\ddot{\mu}_{\bar{n}} - c^2 \Delta \mu_{\bar{n}} + \frac{\pi}{2} \chi^2(n) \mu_{\bar{n}} - \frac{\pi}{2} \chi_{\bar{n}}^{\text{ext}} \dot{\xi}^{\text{ext}} \approx 0. \quad (63)$$

The solution to equation (63) can be written as follows

$$m_{\bar{n}}(r, t) = \frac{l_{\text{Planck}}}{r} m_0 |\cos(K_{\bar{n}} r)| |\cos(\Omega_{\bar{n}} t)| \\ + (-1)^{\lfloor t/2\pi/\Omega^{\text{ext}} \rfloor} \frac{\chi_{\bar{n}}^{\text{ext}} \xi_0^{\text{ext}} \Omega^{\text{ext}}}{R^{\text{ext}}} |\sin(K^{\text{ext}} R^{\text{ext}})| |\cos(\Omega^{\text{ext}} t)|. \quad (64)$$

here R^{ext} is the mean distance from the external origin of the mass field to the system studied and Ω^{ext} is the mean frequency of oscillations of the external mass field.

Thus expression (64) shows that particles in the system affected by an external mass field become more weight.

6.2 A specific example, quantum mechanics and simulation

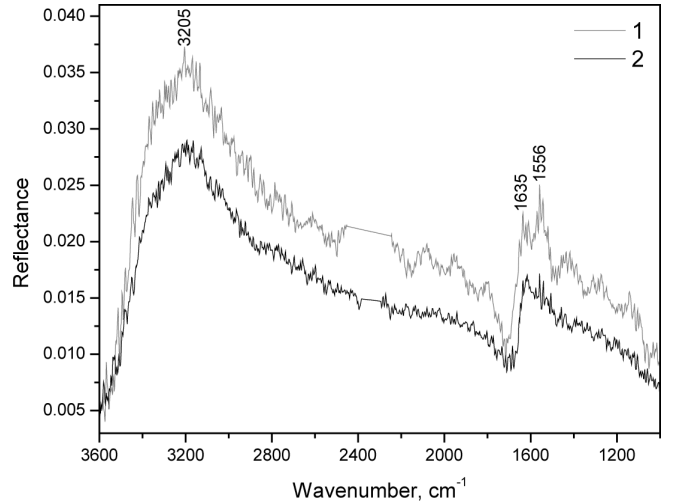
It is interesting to examine how the increase in the particle mass can be treated in the framework of the orthodox quantum mechanical approach. Let us simulate the behaviour of the aqueous solution of hydrogen peroxide affected by a technology developed in 1986, called Teslar, a tiny chip inserted into a quartz wristwatch; this Teslar chip has recently been studied by the Krasnoholovets' research team (Krasnoholovets et al., 2004).

The Teslar wristwatch developed 18 years ago is a special chip, which neutralises two currents (or cancels out two flows of electromagnetic field) and generates a low frequency, scalar wave due to this reaction of neutralisation. That was the hypothesis of the authors of the invention. The hypothesis was tested in a number of ways in the late 1980s, including using in vitro analysis of rat nerve cells and human immune cells, in which noradrenaline uptake into nerve cells was inhibited by as much as 19.5% more than in controls and lymphocyte proliferation increased by as much as 76% over controls (Rein, 1989, 1988). Additional reports – using electrodermal screening procedures, which measure the conductivity of acupuncture points, – suggested that when a Teslar watch is worn on the left wrist there are dramatic improvements in the energy level readings of most organs (Morley, 1991). Because of

such reports and the desire to further understand the physics of the Teslar technology, additional scientific studies have been commissioned.

In Figure 1 we show typical infrared spectra recorded from aqueous solutions of hydrogen peroxide. The spectra demonstrate that the Teslar watch suppresses the vibration of molecules in the solution under consideration and, in particular, strongly freezes vibrations of O–H bonds, which is especially seen in the vicinity of the maximum $3,400 \text{ cm}^{-1}$. We suppose that the Teslar chip can strongly affect a significantly nonequilibrium system and the hydrogen bond is a good marker for the observation of changes in the system studied.

Figure 1 IR-RAS spectra of H_2O_2 solution just after pouring it in the cuvette. 1 (upper curve): the sample did not undergo the influence of the Teslar watch; 2 (lower curve): the sample was affected by the Teslar watch



From the viewpoint of the theory stated above, we may conclude that the solution acquires an additional mass radiated by the Teslar watch. However, the means of conventional quantum mechanics do not allow any similar explanation. What exactly can quantum mechanics propose?

The behaviour of a quantum system obeys the Schroedinger equation, which in our case can be written as follows

$$i\hbar \frac{\partial \psi(x, t)}{\partial t} = -\frac{\hbar^2}{2m} \frac{d^2 \psi(x, t)}{dx^2} + V(x, t) \psi(x, t) \quad (65)$$

and the initial wave function $\psi(x, t)$ is given as

$$\psi(x, 0) = (2\pi\delta_0^2)^{-0.25} \exp[ip_0 x / \hbar - (x - x_0)^2 / (2\delta_0^2)] \quad (66)$$

Here x_0 , δ_0 and p_0 are the initial position, width and momentum for the wave function of the hydrogen atom, respectively. Figure 2 shows the base state of that hydrogen atom on O–H bonding.

Figure 2 The base state of the hydrogen atom on the O–H bonding

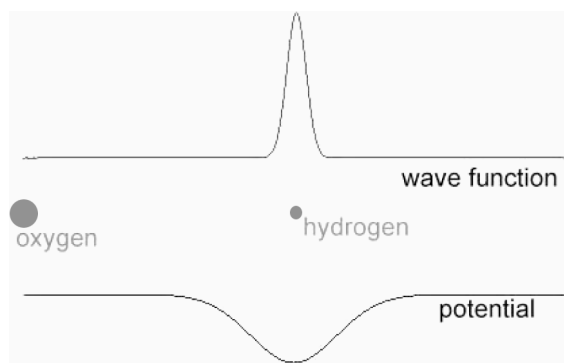
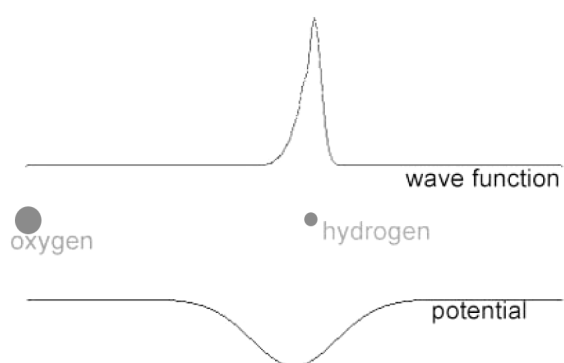


Figure 3 shows the feature of the absolute value of wave function of the hydrogen atom after being irradiated by the infrared beam from FTIR.

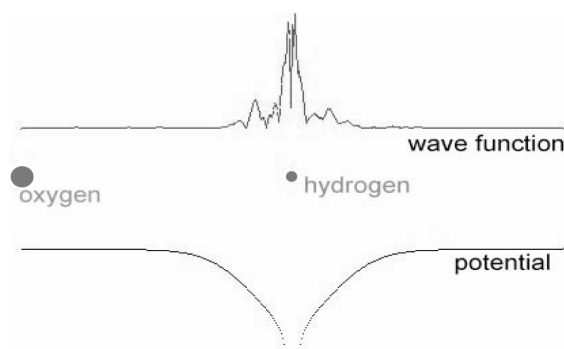
Figure 3 The wave function of the hydrogen atom changes under the IR from FTIR



The wave function of hydrogen atom vibrates right and left absorbing the infrared energy. However, when turning on the Teslar watch, the wave is broken into pieces and the vibration nearly stops, due to the effect of inerton absorption as shown in Figure 4. The absorption of inertons can be modulated in quantum mechanics by introduction of the potential V in equation (65) in the form similar to Newton's equation,

$$V(x,t) = \frac{\alpha}{x} \cos(\Omega t) \quad (67)$$

Figure 4 The wave is broken into pieces and the vibration nearly stops due to the effect of inerton absorption when turning on the Teslar watch



There have been the following choices and parameters that have been tuned in our simulator:

- *Rep. No.* is the number of iterations of the discretised Schrodinger equation
- *IR.p* is the wave length of irradiated IR (the resonant wave length is around 300); *I.pot* is the amplitude of additional potential brought by inertons. It corresponds to the α in our equation with the multiplier: 50,000, for example, the 5,000 for *I.pot* is equivalent to 0.1 for α
- *I.delta* is the coefficient that is used for modifying the additional term in our equation (65) as $(\alpha/x) \times \cos(\Omega t) \Rightarrow (\alpha/(x + I.\delta)) \times \cos(\Omega t)$ to avoid the singularity on $x = 0$
- *J.pot (off/on)* allows us to consider the effect of another O–H bonding. If *J.pot* is on, the distance of these two O–H bondings is turned with the parameter 'another .H'
- *FTIR (off/on)* allows us to treat, whether FTIR is on or off.

As another possibility, we may try to simulate the effect of hydrogen bonding between two water molecules. This time the potential has two valleys, caused by two different O–H bondings, as shown in Figure 5. In this case the feature of vibration of the hydrogen atom is almost the same as the case without considering the other O–H bonding shown in Figure 3. However when reducing the distance between two valleys, i.e., making closer two water molecules, the wave has broken into pieces and the vibration of wave function of hydrogen atom has ceased as shown in Figure 6. This means that O–H bonding no longer absorbs the energy from IR.

Figure 5 Hydrogen bonding between two water molecules

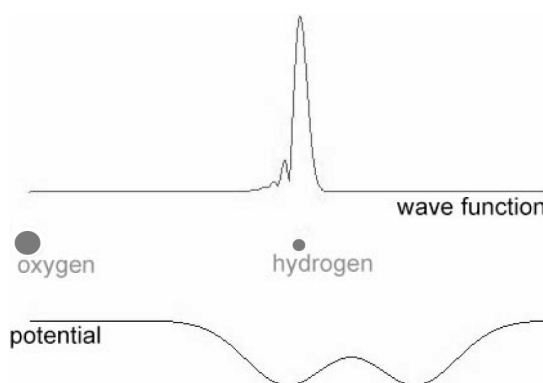
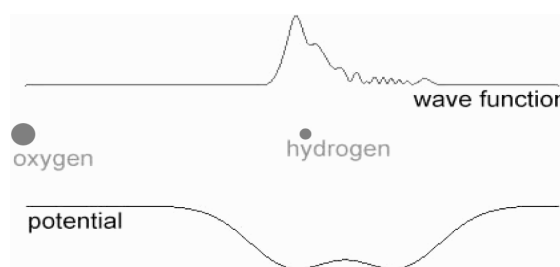


Figure 6 Two water molecules become closer; the wave function has broken into pieces and the vibration of the wave function of the hydrogen atom has ceased



Thus the simulation of the quantum mechanical problem by a classical scheme gives information only on the behaviour of the ψ function and does not clarify the reasons for the potential V that remains purely classical in the nondeterministic quantum equation (65). The submicroscopic concept allows us to account for the origin of the potential V and gives a deeper analysis of the problem.

7 Concluding remarks

Like many scientists who have dealt with thermodynamics, we have often had the impression that thermodynamics is easier to use than to understand. In such a situation, it is of real comfort to discover in books written by other scientists that they have had the same impression. While only two of these books have been referenced here (Nordstrom and Munoz, 1986; Anderson and Crerar, 1993), we would like to express our gratitude to all the authors who have expressed such a concept, which is indubitably of great scientific interest.

In the present paper, by means of both conventional thermodynamic methods and the submicroscopic analysis, we have shown that the change in mass is a general law of evolution of physical systems. The mass exchange is the fundamental property of any physical system, from a system of several canonical particles to that of cosmological objects. Hitherto, the defect of mass has been taken into account only in problems associated with nuclear physics. However, the present research points to the necessity of including the phenomenon of the defect of mass also in tasks typical for condensed matter physics. Besides, the submicroscopic consideration has allowed us to give an estimation of the speed of inertons, carriers of quantum mechanical and gravitational interactions of objects, which has been evaluated as about 2.5×10^{10} m/s.

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