

Incompleteness, Entropy and Unification

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Math and experiments form the basis of physics. However mathematical models and experimental data need also a correct consistent interpretation. Interpretation means understanding of physics and can include logic, philosophy, historical experience etc. In 1931 Gödel proved two theorems which state that a mathematical system cannot be complete and internally consistent by itself. [1] This result seemed not so significant for physics when it was possible to supplement math with experiments and add new confirmed axioms to mathematical models. Now the experimental study is much more difficult and the question about physical meaning of the mathematical incompleteness becomes relevant. We know that every theoretical model is an approximation and by definition suffers from a lack of accurate information about conditions. Missing information, as well as information itself, can cause uncertainty and, as a consequence, entropy. Demonstrating some incompleteness math seems to take entropy into account a priori. Of course, math can deal with pure abstractions but it was founded on the patterns of the physical reality and should obey them. The human mind still surpasses AI and one of the reasons is that it can use experience in solving non-computable problems. The ability to make wrong assumptions and to select the most appropriate solution for the given conditions based on experience is a natural mechanism of the human mind compensating for uncertainty and adapting to entropy increase. Physics, apparently, obeys a similar pattern. Unfortunately, pure math cannot solve all its problems. At the same time, entropy itself may have a clearer physical meaning which could help in understanding some relevant specific problems.

There are many problems in physics that could be hypothetically related to entropy: dark matter and dark energy in cosmology, UV divergences and vacuum energy in QFT, entanglement and measurement in QM etc. Some problems are known from the classical physics, e.g. the problem of electromagnetic mass, described by Feynman.[2] Also in thermodynamics and statistical physics there is a problem with the theory of the first order phase transitions. The three-body problem in mechanics makes the evolution of deterministic systems unpredictable. In 1961 E. Lorenz studied the unpredictability in fluid dynamics and discovered the butterfly effect which symbolizes the chaos theory now. [1] But first chaos appeared in the kinetic theory of gases as an assumption of uncorrelated velocities of particles. Boltzmann used the molecular chaos to overcome Loschmidt's paradox and to explain the entropy increase in time-symmetric dynamical systems before he postulated time asymmetry. Since the mid 19th century entropy has been playing an important role in physics. Nevertheless, I argue that it is still underestimated and not understood well enough.

The notion "entropy" was proposed by Clausius in 1860 but the concept of dissipation of energy and the second law was described in 1824 by Carnot who associated heat with falling water in accordance with the caloric theory.[3] Later Boltzmann gave the statistical definition of entropy as a measure of the number of possible microstates. In 1948 Shannon introduced the concept of information entropy which states that increased information causes increased uncertainty. Nevertheless the thermodynamic entropy was the first concept and seems to be the most underestimated. Actually it is a pure abstraction, what may be the result of a mechanical approach to heat processes. Thermodynamics itself remains the only theory with a corpuscular-mechanical interpretation. Other classical theories such as gravity and electrodynamics are field theories which seem to be more consistent with the trend of modern physics. Maybe it is not quite correct to attribute heat processes only to mechanical collisions at the molecular level. Temperature and pressure characterize the state of the Universe even at the moment of Big Bang. It means that temperature and pressure can be more fundamental phenomena which don't emerge from the mechanical impacts of particles. Let us assume that thermodynamics may have a wrong interpretation.

Historically there were two main hypotheses about the nature of heat: fluid and corpuscular [3]. The corpuscular hypothesis underlies the mechanical theory and classical thermodynamics. The fluid hypothesis represented heat as a kind of substance - heat fluid. The caloric theory which dominated until the mid of 19th century was based on the fluid hypothesis. Dalton described heat as: “elastic fluids built from particles of matter with a far-reaching atmosphere of caloric (heat)...” [3]. Like the electron surrounding the core, each atom of the substance had to be surrounded by the elastic atmosphere of heat. During heating, the atmosphere should increase in size, causing an increase in the repulsive forces between particles and creating pressure. In this form, the caloric theory did not deny atomism and to some extent was close to a field theory, especially its concept of the caloric aether. It could combine both hypotheses but its weakest point was the heat conservation law. According to this law the amount of heat should be conserved even if the system produces work. Similar law remains in the form of the continuity equation of heat flow in the thermal conduction theory [2]. This law was refuted when Joule and Mayer proved that a system doing work loses heat equal to the work performed. Joule supported the mechanical theory but Mayer had his own idealistic approach which gave birth to the energetic theory. Proponent of this theory Ostwald called the results of the kinetic model “.. conclusions from an unproven postulate ..”[4]. However, the idealistic concepts of Ostwald and Mach, who denied atoms, were not so effective in contrast to the statistical approach of Boltzmann and Gibbs. The advances seemed to prove the validity of the mechanical theory but the mathematical model of thermodynamics can allow an alternative interpretation, e.g. field interpretation. A huge part of the mechanical theory was taken from the caloric theory, e.g.: concept of heat and entropy, heat capacity, gas laws, equation of state of ideal gas, Carnot theorem etc. Thermodynamics developed in parallel with electromagnetism where the fields proposed by Faraday and the mathematical model created by Maxwell resolved many problems and led to the QFT. In thermodynamics, there were no convincing experiments that could demonstrate heat phenomena as interactions of molecules by force fields and not by mechanical impacts. One can assume that heat phenomena can combine the kinetic motion and the action of fields. The conjugated values temperature, pressure, volume can work to some extent similar to the conjugated electricity and magnetism. A field interpretation of thermodynamics may lead to an underlying theory of the fundamental level the same way as the field theory of electromagnetism has led to the quantum level and QFT.

According to the mechanical interpretation pressure is created by elastic collisions of molecules and e.g. it is precisely the mechanical impacts drive the pistons of heat engines. But if we simulate collisions of a molecule with a piston in a real situation we can prove that the kinetic theory cannot work physically (see Appendix). The theory contradicts the laws of mechanics on which it is actually based. There is no doubt that thermodynamics can give right predictions mathematically but they are far from being accurate, especially in real gases. The results of the historical experiments proving the kinetic model also allow another interpretation. For example, in the Joule's experiment on expansion of an ideal gas into vacuum the theoretical process of free expansion was replaced by throttling. The throttling process requires a pressure difference, which is created by prior work on the system. The work was stored in the form of the pressure difference and gave the molecules additional kinetic energy during throttling. It is impossible to judge by this experiment whether the temperature of the ideal gas changes during the theoretical free expansion when work is not done. Besides, volume is a natural independent variable in the equations for internal energy, e.g.: $U = U(T, V)$, $U = U(V, P)$, $U = U(S, V)$

In order to prove the possibility of the field interpretation we need to replace the mechanical action of molecules by the action of their force fields. The field energy which is formed during volume increase can be associated with irreversible latent heat by analogy with the latent heat in real gases. Classical heat Q in the continuity equation can be replaced by total heat Q_{tot} including kinetic heat Q_U , irreversible latent heat Q_V and reversible latent heat Q_P in real gases:

$$\partial Q_{tot} / \partial t + \nabla \cdot q_{tot} = 0$$

The equation can express the local conservation law for total heat and is valid also for expanding systems performing work. By analogy with the total heat internal energy of the system can also consist of: kinetic energy E_k , potential energy E_p , field energy E_S . In accordance with the provided arguments, the kinetic energy of molecules during the expansion of gas cannot be turned directly into external work. It remains inside the system, being transformed into the energy of fields or irreversible latent heat. The external work can be considered as a macroscopic effect of the internal energy transformation and not as the converted heat itself. In modern physics, particles are excitations of their quantum fields and interactions are realized by means of gauge fields, e.g. the photon is a compensating field which manifests the local gauge invariance. One can assume that the supposed force field around a neutral gas molecule can be also a compensating field which manifests local energy invariance or local symmetry. An increase in the volume of the field should compensate for a decrease in temperature. In this case the external work performed by the system can be considered as a requirement of global energy invariance or global symmetry, described by the first law of thermodynamics. Such modifications entail a change in traditional ideas about the law of conservation of energy which may describe only a part of a general regularity. The proposed principle of energy invariance combines the first and the second laws of thermodynamics considering entropy as compensating fields. The classical first law says that energy of action must be conserved and the second law states that in all irreversible processes entropy should increase. If we assume that entropy is a physical field then the total energy-mass of the system including work should increase with its expansion.

The proposed concept allows one to describe thermodynamic processes basically with two main parameters: temperature as a charge or potential and entropy as a compensating field. The nature of the field around the molecules can be described only hypothetically. However, in order for the gas particles to be electrically neutral, the fields around them must interact by forces of a more fundamental nature than electromagnetic ones. The movements of gas molecules can obey the same statistical laws as in the kinetic model. To understand the physical picture, we can draw an analogy with liquid. Almost the same way as water molecules move, touching each other by the boundaries of their electron clouds, the gas molecules can move, being in contact by the boundaries of their force fields. The repulsive forces of the fields around the molecules can be proportional to the kinetic energy. Then the action performed by the mechanical impacts of molecules in the classical theory can be attributed to the force fields around the molecules and the basic equations of the ideal gas can be valid also for the proposed model. According to the formula of the statistical entropy $k \ln W$ the Boltzmann constant can be considered as a mathematical coefficient expressing a constant value of entropy: $P = nkT = nTS_{const}$

The entropy change $k \ln W_2/W_1$ can be associated with two processes: the first is related to change in volume and the second to change in temperature. With an increase in temperature of the system the number of the microstates W should increase. In this case the increase in entropy can be associated with the increase in useless movements of particles. This entropy can be called heat entropy S_U . The role of the Boltzmann's constant k can play here the heat capacity c_v of a single particle:

$$\Delta S_U = c_v N_A \ln \frac{T_2}{T_1} = C_V \ln \frac{T_2}{T_1}$$

Here we can use a simplified analogy with the definition of mechanical work: $\delta W = \vec{F} ds$. The temperature can be compared with the force, and the particle displacements with the entropy change. But abstractly the heat entropy can be represented as a compensating field denoting useless movements of particles. The useless work of the particles in total can be defined as kinetic heat: $\delta Q_U = T dS_U$.

With an increase in the distance between the gas particles the number of the microstates W should also increase. This increase in entropy can be directly associated with the increase in volume of the system:

$$\Delta S_V = k N_A \ln \frac{V_2}{V_1} = R \ln \frac{V_2}{V_1}$$

With an increase in volume of the system its temperature transforms into the volume entropy S_V . This process can be described as the conversion of the kinetic heat Q_U to the irreversible latent heat Q_V or kinetic energy E_k to field energy E_S . As an external result of this transformation the work W is produced. The volume entropy determines the main physical meaning of the thermodynamic entropy. The heat entropy is a kind of an intermediate form. Theoretically, the heat entropy should disappear as soon as the system reaches the absolute zero temperature. But in real gases, the kinetic energy of molecules can go also into the potential energy, because the electromagnetic forces break the symmetry. The potential field S_P can be opposed to the entropic field S_V . The latent heat in real gases can be called reversible latent heat Q_P in comparison with the irreversible latent heat Q_V in ideal gases.

The classical definition of the universal gas constant R determines it as the work of one mole of an ideal gas in an isobaric process with an increase in temperature by 1K. For temperature $T = 1K$, we can write down: $R = PdV = TdS = 1 \cdot dS = S_{const}^V$. So the gas constant R can be the volume entropy. This result corresponds to the idea that the Boltzmann's constant k can be considered as a definite constant value of the entropy: $R = k N_A$, $k = S_{const}$. The heat capacity for 1K is mathematically equal to the heat entropy: $C_V = TdS = 1 \cdot dS = S_{const}^U$. Then the equation of state for the ideal gas $PV = RT$ (for 1 mole) can be written as: $PV = TS_{const}^V$

The classical equation for thermodynamic entropy is: $\Delta S = \int_1^2 \frac{\delta Q}{T} = C_V \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1}$

The term with C_V determines the heat entropy ΔS_U and the term with R the volume entropy ΔS_V .

For the adiabatic process the change in entropy is: $\Delta S = R \ln \frac{V_2}{V_1} - C_V \ln \frac{T_2}{T_1} = \frac{\delta W}{T} - \frac{\delta Q}{T} = \Delta S_V - \Delta S_U = 0$

It clearly shows that the absence of entropy change in the adiabatic process is caused by the compensation for a decrease in heat entropy with an increase in volume entropy. As a result the total entropy does not change. Such a representation removes the contradictions of zero entropy change in the adiabatic processes. The classical entropy S is an abstract generalized concept which includes the heat entropy and the volume entropy only mathematically. As a result the classical theory does not take into account an increase in volume entropy and field energy in heat processes.

For the isothermal process, the entropy change is: $\Delta S = R \ln \frac{V_2}{V_1} = \frac{\delta W}{T} = \Delta S_V$

In the isothermal process, all the heat supplied to the system is converted into the irreversible latent heat Q_V and the volume entropy ΔS_V increases. This process is accompanied by the external work.

For the isochoric process: $\Delta S = C_V \ln \frac{T_2}{T_1} = \frac{\delta Q}{T} = \Delta S_U$

In the isochoric process, all the heat supplied to the system goes to an increase in the internal heat energy, which is accompanied by an increase in the heat entropy S_U .

For the isobaric process: $\Delta S = C_V \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1} = \Delta S_U + \Delta S_V = \Delta S_{tot}$

In the isobaric process, part of the supplied heat increases the internal heat energy and, as a result, the heat entropy. Another part is converted into energy of fields, which is accompanied by external work. Both heat entropy S_U and volume entropy S_V increase. Classical theory doesn't recognize the role of the volume in the change of entropy. Lack of separation of the classical entropy in types led to the conclusion that entropy changes only during heat transfer, and remains unchanged with a volume change. However in the isobaric process, a change in entropy includes both types and in the adiabatic process an increase in volume entropy is compensated by a decrease in heat entropy.

By analogy with the equivalence of heat and work $\delta Q = \delta W$ one can establish equivalence: $\delta Q_U = \delta Q_V$ as a manifestation of the local energy invariance. Since $\delta W = \delta Q_V$ we get the general equivalence

for ideal gas: $\delta Q = \delta W = \delta Q_U = \delta Q_V$ and the same with energy: $U = W = E_k = E_S$. Internal heat energy U can be supplemented with the concept of the total internal energy U_{tot} which includes field energy. The internal heat energy is equal to the classical internal energy and changes both with heat transfer and change in volume. The total internal energy U_{tot} changes only with heat transfer or mechanical actions without volume change, e.g. with friction. Any real process of converting kinetic energy into field energy is accompanied by work and can be described by total enthalpy H_{tot} . The total enthalpy H_{tot} combines the global and the local energy invariance:

$$H_{tot} = U_{tot} + PV; \quad dH_{tot} = \delta Q_{tot} + VdP$$

According to the energy invariance principle, which combines the first and the second laws, the amount of total energy can increase due to the energy of fields. However it does not affect the phenomenological mathematical result of energy transformations:

$$dU_{tot} = \delta Q_{tot} - \delta W; \quad dU_{tot} = TdS_{tot} - PdV$$

According to the second law of thermodynamics not all heat can be converted into work due to entropy increase. Therefore, part of the internal heat energy must remain in the system in the form of the kinetic heat Q_U until the conditions are changed to the absolute zero temperature in a vacuum.

The classical principle of non-decreasing entropy has here a clear physical meaning. In the absence of intermolecular attraction forces, the processes become irreversible, since the ideal gas cannot spontaneously return to its original state and the entropy of an isolated system invariably increases. However, the regularity of non-decreasing thermodynamic entropy has both physical and statistical nature. The missing element responsible for the spontaneous increase in entropy in time symmetrical dynamics can be added now to the gas model in the form of force fields around particles. They increase in volume as the system expands and make processes with gases physically irreversible. Thus, the proposed interpretation substantiates the fact of the irreversibility in time and can actually solve the paradox of “the arrow of time”.

The third law of thermodynamics describes entropy near absolute zero temperature. The heat entropy will tend to zero as the system approaches the absolute zero temperature. The volume entropy in this case may tend to zero or increase depending on the distance between molecules. The first option is when the particles are approaching each other and form a solid state. The second option is the formation of a degenerate gas. In the first case the volume entropy like the heat entropy will tend to zero but the second option is also possible under certain conditions. For example, to get a Bose-Einstein condensate, the concentration of molecules is reduced to prevent their convergence and cluster formation. With the concentration decrease, the distances between the molecules increase, and a part of the kinetic energy of the molecules passes into the energy of their entropic fields. Approaching the absolute zero, the particles appear at the lowest energy level, and their fields merge into one common field, forming a singular quantum state. The volume entropy of a degenerate gas should approach its maximum value when approaching absolute zero. This process can be described by the modified equation of the first law or by the Gibbs-Duhem equation. According to the equations, during a complete thermodynamic expansion, the kinetic heat is converted to the entropic fields and tends to zero. The heat entropy will decrease to the minimum or also to zero:

$$dU_{tot} = \delta Q_{tot} - \delta W = \delta Q_V; \quad U_{tot} = E_k - W = E_S; \quad S_{tot}dT - VdP = S_V$$

So the internal heat energy of a degenerate gas is converted to the entropic field energy $E_S = (T)S_V$ or irreversible latent heat $\delta Q_V = (T)dS_V$. Close to the absolute zero temperature a kind of the phase transition occurs and the system passes from the molecular to the fundamental level demonstrating also emergent quantum effects. The heat charge dissipates in entropic fields and the thermodynamic interaction is transformed into separate kinetic interactions of elementary quanta-oscillators of the fields

which can also have their kinetic charges and compensating fields. The general regularity of energy transformations can be depicted as follows: $T \rightarrow S_V + W$

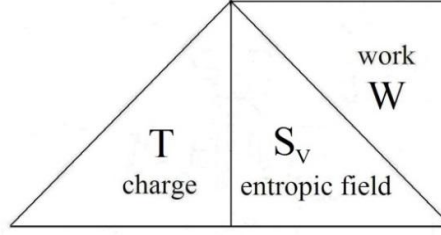


Fig.1: Energy triangle

The heat charge usually includes heat entropy, e.g.: $E_k = TS_U$, $E_k \rightarrow E_S + PV$; $\delta Q_U \rightarrow \delta Q_V + PdV$.

According to the proposed concept, the missing energy-mass of the Universe and the missing mass of galaxies can be considered as irreversible latent heat or entropic fields arising from the thermodynamic transformations. These fields appeared as a residual heat effects and can be considered as degenerated forms of particle fields like Bose-Einstein condensate [6],[8] or superfluids [5],[7]. Space fabric itself could be formed by fields of dissipated scalar particles as a result of transition of the hot Universe to a gaseous state. Thermodynamics of dark energy and dark matter can be described by analogy with black holes mechanics. [9] The observable vacuum energy E_λ and the observable missing mass of galaxies M_{DM} can be associated with work by analogy with work terms ΩdJ and ΦdQ in the first law for black holes. Then the energy of vacuum as dark energy dE_{DE} and the energy-mass of dark matter dE_{DM} are:

$$dM_{BH} = \frac{\kappa}{8\pi} dA + \Omega dJ + \Phi dQ; \quad dE_{DE} = \delta Q_V + dE_\lambda; \quad dE_{DM} = \delta Q_V + dM_{DM}$$

There are reasons to believe that the proposed energy invariance principle is valid not only for the thermodynamic interactions. With a decrease in the action energy of an electromagnetic wave the volume of its field can increase. The action energy may well pass into the increase of the field or electromagnetic mass. This explanation can eliminate the problem of the energy disappearance of the red-shifted electromagnetic wave in the expanding space-time. Here we can draw an analogy with the process of gas expansion into a void. Thus, the proposed principle of the local energy invariance can supplement the principle of the local gauge invariance. The photon itself can be represented as an ensemble of quantum pulses generated by vibrations. So the proposed regularity can be extrapolated to the fundamental level of energy. It can describe almost any energy transformation with two parameters: charge or potential and entropy as a compensating field. The energy can be considered as a product of these two parameters and the work as an external result of the transformations. Basically we can suppose that energy at the fundamental level can also consist of charge and entropy. The charge can be considered in this case as a higher or lower potential of the fundamental background field. The compensating fields should provide local conservation and external work should provide global conservation of energy. Based on the proposed concept, we introduce a thermodynamic interaction at the molecular level, which can complement the existing model of the four main interactions. The heat charge can be considered as a density concentration of the interacting quanta-oscillators of the field which dissipates with volume increase. The separate interactions between elementary oscillators can be called kinetic interactions. Such oscillators presumably form the space itself and the fields of all particles. It is natural to assume a fractal like structure of fields where the fields of individual molecules determine the behavior of macroscopic systems and the fields of separate quanta-oscillators determine the behavior of the molecular fields. We can also assume that counterintuitive effects of quantum mechanics observed in the experiments can have a secondary emergent character. [10] Quantum mechanics can emerge from the dynamics of the fundamental level. [11] Thus, electromagnetic quantum fluctuations of vacuum and pulses in the form of virtual particles can be also generated by collective vibrations of the elementary oscillators.

The energy of the elementary kinetic oscillator should obey the local energy invariance. Since this is supposedly the fundamental level, the action energy of the oscillator cannot be dissipated. The kinetic charge passes into the potential field and goes back. At the same time the elementary oscillator is not an isolated system, therefore, its vibrations should have an effect on other oscillators or do some work which is also action energy. Thus, the general pattern of energy transformations is violated at the fundamental level, since the action energy will increase due to the external work. In this case, work will not be compensated by a loss of the action energy and it can be called free work W_F : $T_k \rightleftharpoons S_p + W_F$. This pattern can be considered also as a possible mechanism of emergence. The validity of this concept can be proved even at the molecular level in a thought experiment (see Appendix).

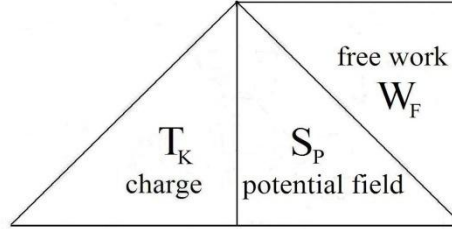


Fig.2: Energy triangle with free work

The free work of the kinetic oscillators forms new energy-mass, which increases the total volume of space if not balanced by the opposite energy of gravity: $dE_{KI} + \delta W_F$, $dE_{KI} = \sum T_K dS_p$. Such a transformation is possible because the symmetries don't work in the oscillating space-time foam. Thus dark energy can be a result of violating energy conservation. [12] The proposed pattern may explain the accelerated expansion of the Universe and dark energy increase: in voids of the intergalactic space gravitational fields become too weak and the kinetic oscillators produce free work increasing dark energy.

We can further assume that the kinetic and gravitational interactions can form a group with a broken symmetry at the fundamental level. In order to explain the observed phenomena the action of the kinetic oscillators should be balanced by an opposite effect, e.g. also in the form of hypothetical gravitational oscillators. If the kinetic oscillator can be abstractly represented as a two-dimensional potential hill of the field, then the gravitational oscillator should correspond to the potential well. But we can usually observe only the results of the vibrations of the oscillators which gravitate as any energy. This concept might clear up the idea of negative mass [13] which can be detected only at the fundamental level, although some effects of it can be observed at low temperatures or even in the usual vaporization processes.

The gravitational oscillator supposedly creates a zone of the low potential in the field pulling it to this point like a hole. The energy transformations of the gravitational oscillators can be similar to the kinetic oscillators: $M_G \rightleftharpoons S_p + W_F$. According to the local energy invariance, each gravitational oscillator forms its own compensating inertial field S_p . The inertial fields in sum generate gravitational fields of objects in accordance with the requirement of global energy invariance. The gravitational and inertial fields of objects can be associated with entropic fields [14] but with gravitational entropic fields. The formation of a black hole occurs, when the kinetic oscillators are squeezed away between the gravitational oscillators and the broken symmetry is violated again: $dM_{BH} = dM_{QG} + \delta W_F$; $dM_{QG} = \sum M_G dS_p = \kappa/8\pi dA$. Free work of the extruded kinetic oscillators forms accretion discs, jets and the observed radiation. Black holes can play the role of separators for the oscillators and no information loss occurs in them. They generate gravitational entropy but restrain the thermodynamic entropy. We can assume that the energy of the gravitational oscillator can correspond to the Planck mass m_{pl} , and the energy of the kinetic oscillator to the Planck energy \hbar . Approaching the fundamental level, the Planck mass in the Newton's constant: $G = \hbar c/m_{pl}^2$ remains fixed [15] but G collapses to zero decoupling gravitational and kinetic interactions. Finally the field becomes discrete consisting of oscillators with Planck mass m_{pl} and oscillators with

Planck energy \hbar that, in general, obey the main equivalence: $E = M$. The Newton's constant G and the observed cosmological constant λ are the resulting coefficients of the fundamental interactions but in the case of the cosmological constant the balance is biased towards the kinetic interactions: $dE_{DE} = (dE_{KI} + dM_{QG}) + dE_\lambda$ where $dE_{KI} + dM_{QG} = \delta Q_V$. Gravitational fields can be contrasted with the dark energy fields but considered as perturbations of the background field itself like sound waves in gases. [16]

The joint free work of the oscillators can form the binding energy-mass of the dark matter fields dM_{DM} where the energy of the kinetic oscillators is balanced by the energy of the gravitational oscillators: $dE_{DM} = (dM_{QG} + dE_{KI}) + dM_{DM}$.

Dark energy, dark matter, quantum vacuum, baryonic matter, black holes can be considered as different states of the background field depending on the force of gravity and the forces of the emergent quantum interactions. For example, the electromagnetic vacuum energy: $dE_{EM} = \rho_V dV + dE_A + dE_\gamma$ [17] can also be added to the energy of the background field: $dE_{EV} = (dM_{QG} + dE_{KI}) + dE_{EM}$.

In the baryonic matter, the joint work of oscillators manifests itself in all kinds of movements of constituents. The movements of oscillators form heat charge of the thermodynamic interaction (TD) and charges of the strong (CH) and electroweak (EW) interactions at the quantum level.

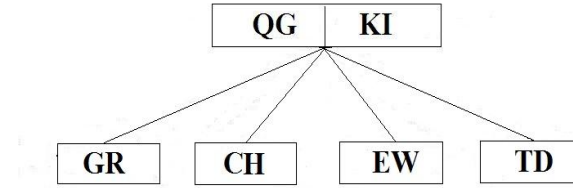


Fig.3: Unification of interactions

$$E_{UN} = (M_{QG} + E_{KI}) + W_F, \quad W_F = E_{GR} + E_{CH} + (E_{EM} + E_{WK}) + E_{TD}$$

E_{UN} - energy of the Universe, M_{QG} - energy of gravitational oscillators, E_{KI} - energy of kinetic oscillators

Ultimately, quantum-gravitational (QG) and kinetic interactions (KI) may lead to the initial interaction. A spontaneous symmetry violation could be the reason of the formation of the interactions with the broken symmetry and opposite forces. The Universe itself can be the result of the violation of the energy balance. A number of gravitational oscillators formed clusters, e.g. black holes, and a part of the gravitational energy turned out to be bound. The equivalent energy of kinetic oscillators was released and formed inflatonic fields and heat charge of the Big Bang.

The proposed concept of energy transformations is fundamentally different from the classical paradigm. According to the classical theory, energy cannot be generated and must be conserved in constant total amount. A closed thermodynamic system of gas at the molecular level is usually presented as a box with jumping and colliding balls exchanging kinetic energy. However, such a concept no longer corresponds to the cosmological observations. According to the proposed model a constant process of generating kinetic and gravitational energy at the fundamental level occurs. This energy can be neutralized by an opposite interaction and converted into a binding energy, or can pass to other levels, and ultimately dissipate due to an increase in entropy. In cyclic reversible processes the amount of action energy in a system stabilizes and remains constant. The generated energy is compensated by the dissipated energy. It creates the observable picture that can be only simplistically described by reversible mechanical processes, e.g. the kinetic model of gases. But in the absolute sense any process of energy transformations is irreversible in accordance with the principle of "arrow of time". Thus, the classical paradigm of energy conservation can be replaced by the concept of dynamical balancing of the energy continuously generated at the fundamental level.

Conclusion

The mathematical incompleteness can have a physical explanation. Entropy doesn't afford us to create complete and internally consistent mathematical models. Total order is not possible neither in nature nor in math but it is possible to reduce uncertainty supplementing math with other methods of cognition. The example, that a deeper knowledge of thermodynamic entropy can reduce incompleteness in physics, is not a coincidence because the role of entropy in energy transformations is hard to overestimate. The Universe and nature can be created by a broken balance of energies and forces. Absolute energy is not conserved and constantly generates new conditions and entropy. Prevailing attraction forces make for us an illusion of the deterministic predictability but as soon they weaken and the dynamical balance becomes unstable the evolution can take an unpredictable course. Even in deterministic systems there is always a possibility of an exponential increase in entropy causing imbalance or even chaos. It is naïve to think that we will ever be able to create a supercomputer like Laplace's demon giving accurate predictions for everything, but who knows. In any case the accumulated experience and a combination of methods can afford us to keep on expanding our knowledge of nature and our world which are very unstable dynamical systems as we know.

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Appendix

Thermodynamics as a classical field theory

One can assume that the field interpretation of thermodynamics can be written in the language of the classical field theory. As the basis one can take the theory of thermal conductivity. Feynman in his lectures on electromagnetism [2] used it to explain the formalism of the field theory. The possibility of applying the Gauss theorem to heat phenomena allows us to continue the analogy with electromagnetism. The coefficient of thermal conductivity depends on the specific heat which denotes a constant value of heat entropy according to the proposed concept. It is logical to assume that the entropy of heat flow can express the same. The heat flow should overcome resistance depending on the structure of the substance which cause dissipation of the kinetic energy. Then the heat flux q can be described as the flux of the kinetic energy q_K :

$$q_K = -\nabla E_K, \quad E_K = TS_U$$

The spherical heat charge is: $G_K = 4\pi r^2 q_K$

One can assume that the inverse square law can be applied here: $F = \frac{G_K G_K}{r^2}$

In accordance with the Poisson equation: $\nabla \cdot q_K = \nabla^2 E_K = 4\pi \rho_K$

The working part of the potential E_K is the temperature T , which creates not only a thermal field, but also a force field of pressure. Thus, the flow of kinetic energy q_K can simultaneously create pressure in the system. With an increase in volume heat goes into a compensating field, since the working part of the heat charge T goes into the volume entropy S_V . Thus, the appearance of the compensating field is the result of the conversion of the kinetic energy E_K . Entropic flow q_S can be defined as:

$$q_S = -\nabla E_S$$

With an increase in the volume of the system, the flow of kinetic energy passes into the flow of entropy: $q_K \rightarrow q_S$. Consequently, the disappearance of the kinetic energy flux ($-\nabla \cdot q_K$) causes the appearance of the entropy flux ($\nabla \cdot q_S$) accompanied by the external work δW :

$$-\nabla \cdot q_K = \nabla \cdot q_S = \frac{\delta W}{\delta t}; \quad \frac{\delta W}{\delta t} = \frac{\delta Q_V}{\delta t} = -\frac{\delta Q_K}{\delta t}$$

Using these relations, one can describe isoprocesses in ideal gas. We denote the external flow of kinetic energy: $\frac{\delta Q_K}{\delta t}$:

$$\text{Adiabatic: } dU = PdV; \quad -\nabla \cdot q_K = \nabla \cdot q_S \left(\frac{\delta W}{\delta t} \right)$$

$$\text{Isothermal: } TdS = PdV; \quad -\frac{\delta Q_K}{\delta t} = \nabla \cdot q_S \left(\frac{\delta W}{\delta t} \right)$$

$$\text{Isochoric: } TdS = dU; \quad -\frac{\delta Q_K}{\delta t} = \nabla \cdot q_K$$

$$\text{Isobaric: } dH = dU + PdV; \quad -\frac{\delta Q_K}{\delta t} = \nabla \cdot q_K + \nabla \cdot q_S \left(\frac{\delta W}{\delta t} \right)$$

The disappearance of the kinetic energy is accompanied by the appearance of the entropic energy-mass. In real gases the disappearance of the kinetic energy is accompanied also by the appearance of the potential energy:

$$q_P = -\nabla E_P$$

This description is far from being accurate and is meant to give a general idea of the concept.

Physical impossibility of the kinetic model

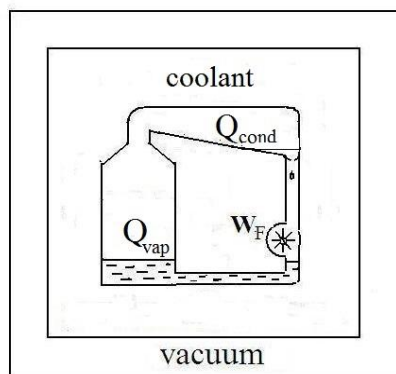
The velocities of the bodies after an elastic collision depend on masses (m_1, m_2) and initial velocities (v_1, v_2):

$$u_1 = \frac{2m_2 v_2 + v_1(m_1 - m_2)}{m_1 + m_2}, \quad u_2 = \frac{2m_1 v_1 + v_2(m_2 - m_1)}{m_1 + m_2}$$

According to the formula the velocity of gas molecules after collisions with the piston should depend on the velocity of the piston. Let us consider the adiabatic compression of an ideal gas. The piston during compression must give an additional energy to the gas molecules, increasing their velocity and the temperature of the gas. A description of this process is given on the first pages of the Feynman lectures [2]. It is compared with a ping-pong ball bouncing from a moving paddle. The ball should pick up speed from the collision and come off with more speed than that with which it struck. Unfortunately this example doesn't take into account the velocity of the paddle before the collision. According to the formula the ping-pong example will work only if the velocity of the paddle is more than the velocity of the ball. Otherwise the change in the speed of the ball after the collision will be not enough, to explain the temperature increase during the adiabatic compression. This process can be also simulated in a low-speed diesel engine. The average piston speed of this engine can be arbitrarily small, since during the adiabatic compression, the temperature of the working fluid must increase in any case. To simplify the calculations, we take the velocity of the piston $v_1 = 1$ m/s, the velocity of the gas molecule $v_2 = 500$ m/s, the mass of the piston $m_1 = 1$ kg and the mass of the gas particle $m_2 = 10^{-6}$ kg. According to the formula we get the velocity after the collision: $u_2 = -501.99$ m/s. The increase in velocity of the molecules after the collisions will be not enough to explain the increase in temperature during the adiabatic compression.

Free work theorem

Let us consider a thought experiment «distiller in vacuum». The device consists of an evaporator, a condenser, a water micro-wheel, a working fluid (water), a coolant (air).



Conditions:

$$T_{vap} = T_{cond}$$

$$\delta Q_{vap} = \delta Q_{cond}$$

Theorem:

Work done by falling water in a reversible thermodynamic cycle of vaporization and condensation is not compensated by heat energy loss:

$$dU_{tot} = \delta Q_{tot} + \delta W_F \text{ or } dU = \delta Q + \delta W_F, \quad dS = 0,$$

According to the Maxwell distribution, fast water molecules should be constantly transformed into vapor molecules even if the temperature is below the boiling point. The mechanism of the statistical distribution can be to some extent compared with the principle of "Maxwell's demon". Only the fastest molecules are released by the forces of intermolecular interaction, and the system, having lost energy, restores the equilibrium with the coolant taking additional heat from it. So when the fast molecules fly out, the temperature decreases, and the equilibrium with the coolant is disturbed. As a result, the kinetic energy of the coolant is transferred to the working fluid, and the process repeats itself spontaneously. In the condenser, the molecules give a part of their kinetic energy to the coolant and become water molecules again. This process of vaporization and condensation is reversible and the heat the system takes from the coolant in the evaporator is completely returned to the condenser. Such an isolated system will never achieve a complete equilibrium, even if the temperatures of the water and the coolant are equal, since the statistical laws will not allow it. Condensed water during its fall can do free work W_F not compensated by the loss of heat. The reversibility of vaporization and condensation means that work on external bodies does not affect the state of the fluid after the process. From a thermodynamic point of view there is no difference whether falling water performs work or not. In both cases, the entropy change in the cycle should be zero. In this case, the external work will be performed by gravity, and the reversible thermodynamic cycle will create the conditions for the release of its energy breaking the general symmetry of the molecular level.