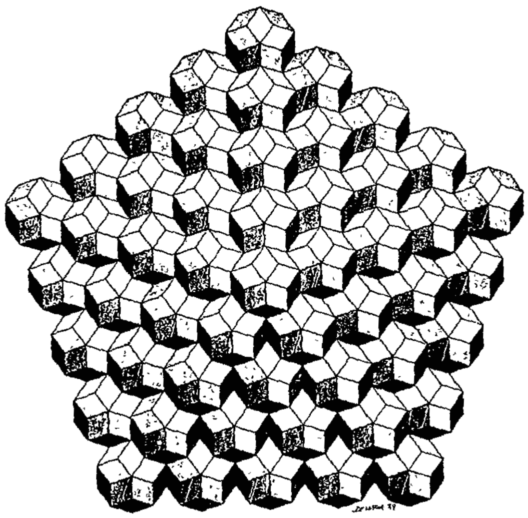
Symmetry of STRUCTURE

an interdisciplinary Symposium

Abstracts

II.



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Does a factlike origin of time asymmetry violate the validity of the time symmetric conservation law of energy ?

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1. The factlike origin of the second law of thermodynamics.

Attempts to base asymmetry of time on the second law of thermodynamics are numerous although this law is the most controversial one established in the 19th century. This controversy is due to the paradox which is implied by the second law. Indeed, the time asymmetry of irreversible behaviour cannot be reconciled with the time symmetry of the laws governing the mechanics of the underlying elementary particles.

Even the most fundamental approach of reconciliation of the two types of time symmetry is recently published by Prigogine in 1980 (Prigogine, 1980). He assignes a micro status to entropy and establishes a new complementarity between reversible and irreversible evolution.

Reversible evolution is identified by mechanical observables while he identifies irreversible evolution by thermodynamical observables. We queried Prigogine's assertions (Verstraeten, 1987, 1988, 1989). Particulary we argued against Prigogine's concept on micro entropy density operator on philosophical as well as physical grounds.

Moreover, we emphasize the factlike base of the second law of thermodynamics. To give evidence for this assertion we return to Carnot's arguments which generated Carnot's General Axiom. According to this axiom the Carnot engine produces work at maximum efficiency and the coefficient linking the absorbed heat and the produced work is the same for all bodies. The Carnot process does not depend solely on the system itself, yet the surroundings (furnace and refrigerator) are also involved. A Carnot process for a body B may be defined as a simple cyclic process which units heat at the one and only one hotness h^- and absorbs a positive amount of heat at the one and only one hotness h^+, which is hotter than h^-. Hotness h corresponds to a corresponding real value of temperature ϑ so that for the intrinsicely ordered hotness h_1 and h_2 with ordering $\succ$ which we read as "hotter than" :

$$h_1 \succ h_2 \leftrightarrow \vartheta(h_1) > \vartheta(h_2) \quad (1)$$

Consequently the Carnot cycle contains two isothermal branches corresponding to the emission and absorbtion of heat, and two adiabatic branches.

According to the latent heat theory, the transmitted heat dC during the time interval dt is written in differential form.

$$dC = Q\,dt = \Lambda_V dV + K_V d\vartheta \quad (2)$$

Λ_V : the latent heat or transmitted heat at constant temperature

K_V : the specific heat or transmitted heat at constant volume.

According to Euler's theorem Q has an integrating factor f locally, where f is continuous and positive. Applying Euler's theorem on (2), the time derivative of a function $\mathcal{H}_f(V,\vartheta)$ is given by

$$\dot{\mathcal{H}}_f = Q/f = (\Lambda_v \dot{v} + K_v \dot{\vartheta})/f \qquad (3)$$

When f is identified with the temperature ϑ we reach Clausius' expression for the entropy. As long as the Carnot cycle is conceivable in terms of volume, temperature, latent heat and specific heat, so will be the entropy.

For a Carnot cycle with a furnace and a refrigerator of which the temperature differs only by an infinitesimal amount, the produced work ΔL is

$$\Delta L = F(\vartheta + \Delta\vartheta, \vartheta)\, C^+ \qquad (4)$$

with $C^{\pm} = \oint \frac{Q \pm |Q|}{2}\, dt$

(the contour integral is integrated along the isotherms and adiabats of the considered Carnot cycle). As already mentioned F does not depend on the particularity of the body. When we use the universal form $F = J\Delta\vartheta/\vartheta$ (Truesdell-Bharatha, 1977) and the expression (3) for the entropy :

$$\Delta L = J\Delta\vartheta \oint \mathcal{H}_\vartheta \qquad (5)$$

Then

$$\Delta L = J(\vartheta^+ - \vartheta^-) \oint d\mathcal{H}_\vartheta \qquad (6)$$

or

$$\Delta L = J(1 - \vartheta^-/\vartheta^+)\, C^+ \quad \text{if} \quad C^+/\vartheta^+ = C^-/\vartheta^- \qquad (7)$$

(Applying the theory of latent heat for the isothermal absorbtion)

When $\int_{\vartheta^+} d\mathcal{H}_\vartheta > C^+/\vartheta^+$ then the produced work is less than the produced with maximum efficiency and hence there is a dissipation. This results in the second law of thermodynamics

$$\oint d\mathcal{H}_\vartheta \geq 0 \qquad (8)$$

The universality of F or J in (4) is an immediate corollary of the principle of the non-existence of the perpetuum mobile extended to the domain of thermodynamics according to Mach (Mach, 1986). So any engine can produce either at maximum

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efficiency or at less efficiency. But by the fact of the non existence of the perpetuum mobile, equation (8) can never be $\oint d\mathcal{H}_\vartheta < 0$ because then the efficiency should be higher than that of the Carnot cycle. Hence the non decrease in entropy is factlike and not lawlike.

2. Does the factlike origin of the asymmetry of time generate a paradox ?

The second law of thermodynamics encouraged some scientists to search for a lawlike foundation of the asymmetry of time and the arrow of time (see for a good survey Grünbaum, 1973,VIII). The first section makes it clear that they were searching invain as this law is just a fact and so is asymmetry of time. A complete and concise survey of the factlike foundation of time asymmetry is given by Costa de Beauregard yet we assigne our approach a particular position in the scope of the mentioned factlike foundation. Indeed, nearly all factlike approaches are based on statistical arguments. Therefore we refer to Reichenbach's branch systems (Reichenbach, 1956), which are branched off the mother system. The entropy of the branchpoint is in most non equilibrium cases very low so that entropy can only increase. In most equilibrium cases the entropy is non decreasing. Grünbaum formulated an ameliorated version of Reichenbach's branch systems. He disconnected the link made by Reichenbach between local time asymmetry of a branch system and the time asymmtry of the Universe (Grünbaum, 1973, p 260). However we query both approaches because they are so little "physical factlike". This concept means that one event govered by physical laws is assigned a physical significance by its actuality only. A physical event is actual when it can be measured according to a physical experimental method.

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Branch systems are not actual, yet they are mental constructions which permit to predict the future of all germane systems with some probability. As Grünbaum (P 253-260) and de Beauregard (chapter 3.4.2) decided outright, branch systems do not permit retrodiction because there is no system before the branch off. The non existence of the system means that it is not actual but we go further : even after the branch off the system is not actual because nobody can tell us how the system is sufficiently defined. Moreover, how can we physically determine the adjective "most" ? By taking a sample at a particular point of time ?
Did the above mentioned authors realize that the particularity of that point of time was only generated by the mental decision that the asymmetry of time was the product of a mental fact not by a physical fact. ? Nevertheless this foundation of the time asymmetry has one advantage : it does not violate the validity of any physical conservation law which presupposes time symmetry.

Our approach of time asymmetry is physical factlike because the non existence of a heat engine with an efficiency to produce work exceeding the Carnot engine is physically relevant if and only if there is an actual physical fact either to support the above mentioned principle or to violate it by an opposite fact.

Does such physical fact generate a paradox between the involved time asymmetry and the time symmetry which is a prerequisite of the first law of thermodynamics ? We examine this problem in the third section.

3. Violation of the first law ?

The first law of thermodynamics essentially links mechanical quantities (mass, action on the environment), which are spatially localizable at any point of time to heat which is not localizable in space. The latter is only known by the mechanical work into which it can be converted. Consequently the validity of this law is controlled directly or indirectly by mechanical quantities which make part of the scope of the mechanics of time symmetric processes. Moreover, another set of time symmetric processes is involved, namely the set containing all reversible processes which identify the body or the set of bodies of which the energy is conserved. With Bridgman (Bridgman, 1961,p 122-125 and p 188-191) we prefer to use the term recoverable and irrecoverable processes instead of reversible and irreversible processes. It is clear that the processes to recover the identity of the examined body are different from the processes controlling the validity of the first law. In the opposite case the first law would be just a definition of the system and could not be falsified. Hence there should not be a first law.

The time of the mentioned recoverable processes is symmetric. Indeed, the time symmetry is a prerequisite for identification and conservation, because onehas to be able to compare the body at yhe two extremities of the time interval wherein the processes are engineered.

This prerequisite does not beware the body for simultaneous irrecoverable processes. So is a breakdown of the equality (3) the cause of a heat-work conversion at a rate less than the maximum Carnot rate and consequently the system does not return automatically to its initial thermodynamical state.

This phenomenon is purely factlike because we can only formulate necessary conditions of this evolution and not sufficient ones (equation 7). But it does not prevent us to control the validity of the first law, because this irrecoverable evolution evolues in the scope of thermodynamics while the body is defined in terms of recoverable processes. Upon this definition the termal properties are subjoined.

We conclude that the first law of thermodynamics is an extension of the similar law in mechanics so that there is also accounted for non localizable forms of energy. The second law is no restriction of the first law yet a restriction on the efficiency of the heat-work transition only. The first law is general for all bodies while the restriction of the second law imposes constitutive restrictions for evolutions of particular bodies for which no sufficient reason exists. This local anisotropy of time evolution of the thermal properties of the body does not contratict the time symmetry of the recoverable processes which identify the body as long as these processes reduce the actual state of the body to the initial fiducial state. The thermodynamics adduces information to the body yet the additional information produces only necessary conditions for the internal evolution of the body. Hence we conclude that the factlike origin of the asymmetry of time involves a gain of information about a particular body but a loss of knowledge about its internal organization.

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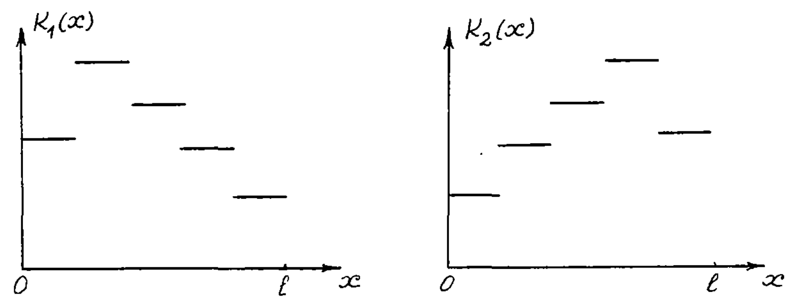
We have to determine function $K(x)$, given by the set n, K_j, x_j, $j=1,\dots,n$, and having the physical meaning of hydroconductivity coefficient in geology or relation of heatconductivity to heatcapacity of structure in the theory of heattransform. Let us consider the value $\ell>0$ (ℓ is stable), function $\mu(t)$, which is known, and additional boundary condition

$$u(x,t)\Big|_{x=0} = \varphi(t), \quad t>0.$$

The set of solutions of the formulated inverse problem in the case of function $\mu(t)$ beeing smooth, consists of two elements $K_1(x)$ and $K_2(x)$, axisymmetrical to $x=\ell/2$. The illustration of such case is given in the figure:



So, the analysis of experimental data on the basis of formulated model is associated with preferability of the only one of two symmetrical solutions to be taken as a corresponding one.

This question is solved by taking into account the additional assumptions of the character of the solution $K(x)$ we are looking for (that is: monotonous, restricted on some segments and etc.)

Just the same problems, connected with the analysis of various symmetrical configurations are typical for the whole class of hyperbolical type equation problems, describing wave processes of deformation and dynamic fracture of fiber reinforced composites. These wave processes form the basis for acoustic emission phenomenon modelling - effective method of nondestructive control, used for diagnostics of composite materials and constructions.

We have to determine function $k(x)$, given by the set n, k_j, x_j, $j=1,\dots,n$, and having the physical meaning of hydroconductivity coefficient in geology or relation of heatconductivity to heatcapacity of structure in the theory of heattransform. Let us consider the value $\ell>0$ (ℓ is stable), function $\mu(t)$, which is known, and additional boundary condition

$$u(x,t)\big|_{x=0} = \varphi(t), \quad t>0.$$

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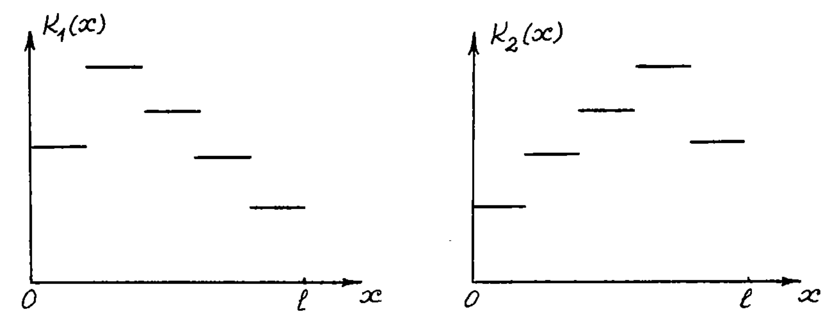

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