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NON EQUILIBRIUM THERMODYNAMICS BY VACUUM ENERGY MOMENTUM TENSOR OF INTERACTING QUANTUM FIELDS AND LIVING CELLS

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Abstract

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From the theory and experiment to day it's known the vacuum as a ground state of the quantum field. It is not just "nothing" but has a rich structure, which determines its possible seeing or virtual excitations, the particle spectrum. At the molecular level with thermodynamic behaviour is considered by any electromagnetic quantum field that the additional boundaries as by the Casimir effect changes the energy of the vacuum and then it depends from the distance between the boundaries, the two parallel, perfectly conducting square plates (side L, distance d, L>d), moved inertial to each other, so that the so-called Casimir force can be calculated theoretically. The Casimir force for electromagnetic field has been measured with great accuracy, proving at its best the physical reality and non-triviality of the quantum vacuum.

Also during phase transitions (e.g. the contributions of the living cells environmental "freeze-drying" and vacuum sublimation for intracellular and extracellular ice formation after sublimate condensation and the following vitrification of the living cells (Tsvetkov et al., 2004, 2005, 2006, 2007) the possible elementary excitations of the fields and therefore the quantum vacuum energy change in a well-defined calculable way. Furthermore, the presence of a positively charged atomic nucleus changes the vacuum energy and thereby affects the atomic energy spectra.

Changes of the vacuum energy produce measurable physical effects. However, its absolute value affects only the gravitational field. It knows that only the quantum vacuum field and the gravitational field influence the living cells at the nano-physical dimensional molecular distance. A even though the absolute value of the vacuum energy cannot be determined. But gravity depends on this absolute value in exactly the same way as it depends on the so-called cosmological constant. The cosmological term is exactly equivalent to a vacuum energy. Vacuum energy and the cosmological constant cannot be distinguished by any experiment and are therefore physically equivalent. The gravitational field, which defines the metric and curvature of space-time, is determined by the sum of all forms of energy and momentum. By symmetry reasons, the so-called energy momentum tensor of the vacuum must be of a form such that its pressure is exactly the negative of its energy density or from the analysis of the linear partial differential equation this local entities of the energy momentum tensor must fulfil kinematical conditions. If the energy density of the vacuum is positive, its pressure is thus necessarily negative. For the temperatures T' < T (Mitter and Robaschik, 1999) the external pressure by the thermodynamic behaviour of the electromagnetic quantum field with a Casimir effect is reduced in comparison with the standard situation (T' =

T). Therefore it is expected the existence of a certain distance d_0, at which the Casimir attraction is compensated by the net radiation pressure.

The freedom to add a cosmological constant corresponds to the freedom to choose the absolute scale of the vacuum energy and both of them should be chosen so that they cancel each other and have no net observational consequence, also gravitationally. We hoped, that a consistent theory of quantum gravity, once found, would tell us how to do this in detail and to understand better the so-called third low of the thermodynamics.

From a great interest is the so-called problem of the connection between the second low of the thermodynamics also the entropy and the time arrow.

Three-privileged direction of time must enter the theory: one in logic (for the time ordering of predicates in history or by the definition of the causality in the time products of the field operators in the interacting quantum field in the S-matrix theories by Bogolubov, N.N.) one for decoherences (as an irreversible process, e.g. scattering processes and the fulfilness of the localisation condition), and the familiar one from the thermodynamics. The three of them must necessarily coincide. The most interesting aspect of these result is certainly that the breaking of time reversal symmetry is not primarily dynamically but logical or that is connected with kinematical conditions between physically measured entities as by deep inelastic scattering and a matter of interpretation at least from the present point.

Key words: causality and locality conditions, localisation, quantum vacuum, energy momentum tensor, freezing-drying, living cells

Introduction

The study of the damage produced by freezing-drying and/or low temperature is important in a variety fields (Belaus and Tsvetkov, 1985; Zwetkov, 1985, Tsvetkov at al., 1989), of which here are some examples: In medicine, surgeons would like to be able to cryopreserve organs for transplants. To date, however, the cryopreservation of large organs (except blood) has very poor success rate. Blood and sex cells are routinely frozen and thawed for later use but even then, in many cases, the cellular survival rates are unacceptably low. Cryopresevation is also important or endangered species. Frost damage is an important agronomic concern: if farmers can get a crop into the ground before the last frost, then they have a longer growing season and a greater yield. Damage in seeds during drying may also be agronomical and ecological important. Because of the impact of temperature on all reaction of the living cell, and by the moved genetic elements in the genome the so-called insertion sequences and transposons, adaptation and mutation to fluctuations in temperature is possibly the most common response researched. Freeze-drying is also important in the food industry.

Main Results

By calculation of the Casimir effect from great importance is the defined infinite sequence of the causal ordered events points in the Mnkowski space time without accumulative event point obtained by hyperbolical turns and reflections on the two mirrors which one if parallel inertial moved to the other at rest. Also it is to be possible to define the so-called time arrow then by this case the Minkowski space-time is no more Couchy finite compact. For the considerations of the evolutions of the interactions between the quantum fields and the living cells and insertion sequences or transposons in the genome and the quantum fields and the classical external fields in the environment of the living cells that make possible to consider the so called kinetic leap effect of the vitrification by the living cells at low temperature by the help of impulse partial differential equations in Banach spaces also the so called microlocal analysis and the change of the vacuum energy by the phase transition.

At the first we take the infinite sequences of the causal ordered reflecting event point without accumulative event point in the Minkowski space-time and so also defined the time arrow

$y^{\mu}_{-2(n - \frac12(j-1))}$, $y^{\mu}_{-2(n - \frac12 j)}$, $y^{\mu}_{2(n - \frac12 j)}$, $y^{\mu}_{2(n - \frac12(j+1))}$,

and the point $x^{\mu} = (ct, \bar{x})$ between the plates,

so that $t \in (t_{-2(n - \frac12 j)}, t_{2(n - \frac12 j)}]$, $n = 0,1,2, ...,$

$j = 0,1,2, ..,2n$ for $x^3 \in (0, \lambda v t_0)$, or $x^3 \in (\lambda v t_0, L)$

and $L = vt_0$, $0 < \lambda < 1$, with $t \in (t_{2(n - \frac12 j)},$

$t_{-2(n - \frac12(j-2))}]$, $n = 0,1,2, ..., j = 0,1,2, ..,2n,$

where $\mu = 0,1,2,3$, and n is the reflecting number of the event point y_0 from the Minkowski space-time at the time $t = t_0$ between the plate at the rest and the inertial parallel moved plate with the constant velocity v.

$y^{\mu}_{-2(n - \frac12(j-1))}$, $y^{\mu}_{-2(n - \frac12 j)}$, $y^{\mu}_{2(n - \frac12 j)}$, $y^{\mu}_{2(n - \frac12(j+1))}$,

and the point $x^{\mu} = (ct, \bar{x})$ between the plates,

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$j = 0,1,2, ..,2n$ for $x^3 \in (0, \lambda v t_0)$, or $x^3 \in (\lambda v t_0, L)$

and $L = vt_0$, $0 < \lambda < 1$, with $t \in (t_{2(n - \frac12 j)},$

$t_{-2(n - \frac12(j-2))}]$, $n = 0,1,2, ..., j = 0,1,2, ..,2n,$

Further we can defined by the distinguishing marks "l" = left and "r" = right the following relations between the point x between the plates and the reflecting see events points from the infinite sequence points without accumulative events point in the Minkowski space

$^{l}\tilde{x}^{\mu} = x^{\mu} + (y^{\mu}_{2(n-\frac12 j)}/y_0^2)((xy_{2(n-\frac12 j)})^2 - x^2y_0^2)^{\frac12} - (xy_{2(n-\frac12 j)})\,(y^{\mu}_{2(n-\frac12 j)}/y_0^2) = x^{\mu} + y^{\mu}_{2(n-\frac12 j)}((xy_{2(n-\frac12 j)})/y_0^2)((1 - x^2y_0^2/(xy_{2(n-\frac12 j)})^2)^{\frac12} - 1) = x^{\mu} + y^{\mu}_{2(n-\frac12 j)}f$ for $t \in (t_{2(n - \frac12 j)}, t_{-2(n - \frac12(j-2))}]$ and

$^{r}\tilde{x}^{\mu} = x^{\mu} + (y^{\mu}_{-2(n-\frac12 j)}/y_0^2)((xy_{-2(n-\frac12 j)})^2 - x^2y_0^2)^{\frac12} - (xy_{-2(n-\frac12 j)})\,(y^{\mu}_{-2(n-\frac12 j)}/y_0^2) = x^{\mu} + y^{\mu}_{-2(n-\frac12 j)}((xy_{-2(n-\frac12 j)})/y_0^2)((1 - x^2y_0^2/(xy_{-2(n-\frac12 j)})^2)^{\frac12} - 1) = x^{\mu} + y^{\mu}_{-2(n-\frac12 j)}f'$ for $t \in (t_{-2(n - \frac12 j)}, t_{2(n - \frac12 j)}]$,

$n = 0,1,2, ...j = 0,1,2, ..,2n,$

as a light like Minkowski event point and $y^{\mu}2\,(n\text{-}1/2j)$ and $y^{\mu}\text{-}2(n\text{-}1/2j)$ are fixed Minkowski event point described the infinite sequence of the causal ordered events points without accumulative events point.

Further we define by the following relations

$\kappa' x^{\mu} = \tau_j{}^{r}\tilde{x}^{\mu} + \frac12(x + \tau_j{}^{r}\tilde{x})^{\mu} f_{\kappa'}$ with $f_{\kappa'} = \frac12 y_0^{-2} (x\,\tau_j{}^{r}\tilde{x})((1 + 4\kappa'^2x^2y_0^2/(x\,\tau_j{}^{r}\tilde{x})^2)^{\frac12} - 1)$

for $y_{2(n - \frac12 j)}{}^2 = (\frac12\,(x + \tau_j{}^{r}\tilde{x}))^2$,

$t \in (t_{-2(n - \frac12 j)}, t_{2(n - \frac12 j)}]$, $n = 0,1,2, ...,$

$j = 0,1,2, ..,2n$, $\kappa x^{\mu} = \tau_j{}^{l}\tilde{x}^{\mu} + \frac12(x + \tau_j{}^{l}\tilde{x})^{\mu} f_{\kappa}$

with $f_{\kappa} = \frac12 y_0^{-2}\,(x\,\tau_j{}^{l}\tilde{x})((1 + 4\kappa^2x^2y_0^2/(x\,\tau_j{}^{l}\tilde{x})^2)^{\frac12} - 1)$ for $y_{2(n - \frac12 j)}{}^2 = \frac12(x + \tau_j{}^{l}\tilde{x})^2$,

$t \in (t_{2(n - \frac12 j)}, t_{-2(n - \frac12(j-2))}]$,

$n = 0,1,2, ..., j = 0,1,2, ..,2n,$

$\kappa x^{\mu} = \tau_{2n-1}{}^{l}\tilde{x}^{\mu} + \frac12(x + \tau_{2n-1}{}^{l}\tilde{x})^{\mu} f_{\kappa}$ with

$f_{\kappa} = \frac12 y_0^{-2}\,(x\,\tau_{2n-1}{}^{l}\tilde{x})\,((1+4\kappa^2x^2y_0^2/(x\,\tau_{2n-1}{}^{l}\tilde{x})^2)^{\frac12} - 1)$ for $y_1{}^2 = (\frac12(x + \tau_{2n-1}{}^{l}\tilde{x}))^2$,

$t \in (t_{-1}, t_1]$,

so that the following bounded open domains of double cons are defined

$^{r}D = {}^{l}D_{\kappa x,\ \tau j}{}^{r\tilde{}}{}_{x} = V^{+}{}_{\tau j}{}^{r\tilde{}}{}_{x}\ ?\ V^{-}{}_{\kappa x}$ with the basis

$S_{\kappa x,\ \tau j}{}^{r\tilde{}}{}_{x}$ and the axis $[\kappa x^{\mu}, \tau_j{}^{r}\tilde{x}^{\mu}] =$

$y_{2(n - ½j)}{}^{\mu} f_{\kappa}$,

$^{l}D = {}^{r}D_{\kappa' x,\ \tau j}{}^{l\tilde{}}{}_{x} = V^{+}{}_{\tau j}{}^{l\tilde{}}{}_{x}\ ?\ V^{-}{}_{\kappa' x}$

with the basis $S_{\kappa' x,\ \tau j}{}^{l\tilde{}}{}_{x}$ and the axis

$[\kappa' x^{\mu}, \tau_j{}^{l}\tilde{x}^{\mu}] = y_{-2(n - ½j)}{}^{\mu} f_{\kappa'}$.

We can consider f_k as a solution of the differential equation

$w_j{}^{-1} d_t f_{\kappa} = \kappa^2 x^2/[(x\ \tau_j{}^{l}\tilde{x}) + y_0{}^2 f_{\kappa}] - f_{\kappa}$

where $(x\,t_j l x^{l\sim}) + y02f_k$ is the linear term who decries the hyperboloid given in the Minkowski space time by x^2 to the light con in the same space-time and $\kappa = s_j/w_j$

where s_j is the rate of the see quantum scalar wave field system with great time of the relaxing and strong interacting, e.g. epigenetic interactions and w_j is the rate of the virtual quantum scalar wave field system with the shot time of the relaxing and weak interacting, e.g. quantum vacuum interactions in the cells, e.g. Casimir effect.

For $d_t f_{\kappa} = 0$ also in the stationary case we have

$\kappa^2 x^2/[(x\ \tau_j{}^{l}\tilde{x}) + y_0{}^2 f_{\kappa}] - f_{\kappa} = 0,$

$f_{\kappa}[(x\ \tau_j{}^{l}\tilde{x}) + y_0{}^2 f_{\kappa}] - \kappa^2 x^2 = 0,$

$y_0{}^2 f_{\kappa}{}^2 + (x\ \tau_j{}^{l}\tilde{x}) f_{\kappa} - \kappa^2 x^2 = 0,$

$f_{\kappa}{}^2 + y_0{}^{-2}(x\ \tau_j{}^{l}\tilde{x}) f_{\kappa} - y_0{}^{-2}\kappa^2 x^2 = 0$ so that

$f_{\kappa} = ½ y_0{}^{-2}\ (x\ \tau_j{}^{l}\tilde{x})\ ((1+4\ \kappa^2 x^2 y_0{}^2/(x\ \tau_j{}^{l}\tilde{x})^2)^{½} - 1).$

It is to remark that fk and fk,are J 1 for the case Minkowski space-time.

For consideration of the energy momentum tensor of the scalar quantum field it is possible to take the following way of the consideration of the scalar mass field.

$\varphi(\kappa x) = \int dq_{\kappa}\theta(q^0{}_{\kappa})\delta(q_{\kappa}{}^2 - m^2)\ \tilde{\varphi}(q_{\kappa})$

where $\tilde{\varphi}(q_{\kappa}) = \exp[iq_{\kappa}\kappa\ x]\ \varphi(q_{\kappa})$

and $(\partial_{\kappa x}{}^2 - m^2)\ \varphi_{m_{\kappa}}(\kappa\ x) = 0,$

$\varphi(q_{\kappa}) = \int d\kappa x\theta(\kappa x^0)\delta((\kappa x)^2 - \kappa^2 x^2)\ \tilde{\varphi}(\kappa x),$

$\tilde{\varphi}(\kappa x) = \exp[-iq_{\kappa}\kappa x]\varphi(\kappa x),$

$(\partial_{q_{\kappa}}{}^2 - \kappa^2 x^2)\varphi(q_{\kappa}) = 0$ and

$q_{\kappa}{}^2 = \kappa^{-2} x^{-2}$ can be considered as a squared 4-impulse vector in Minkowski impulse space lying on the mass hyperboloid of the "matter" scalar field.

$\varphi_t(q_{\alpha_{\kappa}}) = \int d^4 y_{2(n - ½j)}\theta(y^0{}_{2(n - ½j)})$

$\delta(y_{2(n - ½j)}{}^2 - x\ \tau_j{}^{l}\tilde{x})\tilde{\varphi}(y_{2(n - ½j)}),$

$\tilde{\varphi}(y_{2(n - ½j)}) =$

$\exp[-iq_{\alpha_{\kappa}} y_{2(n - ½j)}]\varphi(y_{2(n - ½j)}),$

$(\partial_{q_{\alpha_{\kappa}}}{}^2 - x\ \tau_j{}^{l}\tilde{x})\varphi_t(q_{\alpha_{\kappa}}) = 0,$

$\varphi(y_{2(n - ½j)}) = \int d^4\xi\ \delta(\xi - y_{2(n - ½j)})\ \varphi(\xi)$

with $\varphi(\xi)$ and $\pi^{+}(\xi)_{\xi^0 = t+0} =$

$\partial_{\xi^0}\varphi(\xi)_{\xi^0 = t} + \partial_{\xi^3}\varphi(\xi)$ also solution of impulse wave equation in Banach space and $x\ \tau_j{}^{l}\tilde{x} = ct\ \|\tilde{\mathbf{x}}\|(1\text{-}v/c)$

where $v = |\mathbf{x}|\cos(\mathbf{x}, \tilde{\mathbf{x}})/t$.

For the non-local operator Wick's product is to be given

$:\varphi(q_{\kappa})\ \varphi(q_{\kappa'}): = (2\pi)^{-4}\int d\kappa x\ d\kappa' x$

$\exp[-iq_{\kappa}\kappa x - iq_{\kappa'}\kappa' x]\ :\varphi(\kappa x)\ \varphi(\kappa' x):$

The energy momentum tensor for the quantum vacuum scalar field the so- called zero point fields also can be defined by

where the non local energy momentum tensor is given by the invariant entities T's and the localization

$$T_{\mu\nu}(q_\kappa, q_{\kappa'}) = (2\pi)^{-4}\int d\kappa x\, d\kappa' x \exp$$

$$[-iq_\kappa \kappa x - iq_{\kappa'}\kappa' x]\, T_{\mu\nu}(\kappa x, \kappa' x)$$

for the $T_{\mu\nu}(\kappa x, \kappa' x)$ is given for κ and κ' going to zero also the microlocality must be proven

where T_0 is the Hamiltonian H of the quantum scalar field and T_i i = 1,2,3 are the pressures

$$T_{\mu\nu}(\kappa x, \kappa' x) = (g_{\mu\alpha} - \kappa x_\mu \kappa x_\alpha\, \kappa^{-2} x^{-2})$$

$$(g_{\nu\beta} - \kappa' x_\nu \kappa' x_\beta\, \kappa'^{-2} x^{-2}) \sum_{n=0}^{\infty} \sum_{j=0}^{2n}$$

$$(g^{\alpha\beta} T_0 + y_{2(n-½j)}{}^{\alpha} y_{2(n-½j)}{}^{\beta} T_1 +$$

$$y_{-2(n-½j)}{}^{\alpha} y_{-2(n-½j)}{}^{\beta}\, T_2 +$$

$$½(y_{2(n-½j)}{}^{\alpha} y_{-2(n-½j)}{}^{\beta} + y_{-2(n-½j)}{}^{\alpha} y_{2(n-½j)}{}^{\beta})\, T_3$$

so that a microlocal condition in the Minkowski space-time will be fulfilled if T's are localized for the vacuum without particles by κ and κ' going to zero and continuum energy momentum spectrum also

For further investigation from the condition of the localization must follow kinematical conditions for the

$$\partial^{\mu}{}_{q_\kappa} T_{\mu\nu}(q_\kappa, q_{\kappa'}) = \partial^{\nu}{}_{q_{\kappa'}} T_{\mu\nu}(q_\kappa, q_{\kappa'}) = 0.$$

invariant T's in the Minkowski space-time if $T_{\mu\nu}(q_\kappa, q_{\kappa'})$ fulfil the locality condition.

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