Stimulated Topological Condensation of "Vapour Phase" Photons and Possible Implications for Space Power Technology

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Abstract

A quantum topological network model that might allow for the production of energy through the employment of vacuum electromagnetic currents form is based upon foundational principles of topological geometrodynamics (TGD) [Pitkanen, $1995_1, 2$]. Such a production photon-factory would have the capability of drawing upon a seemingly inexhaustible supply of what in TGD formalism is a "vapour phase" of photons. Particularly in the presence of Bose-Einstein condensate photons, it is theoretically possible to convert these "vapour phase" photons into condensed photons that can then be harnessed and transformed into useful kinetic energy by more traditional means. TGD presents a view, similar to certain string models, of space-times as surfaces within an 8-dimensional space H that is a product of Minkowski space future lightcone M^4_+ and a complex projective space CP_2. TGD model allows for topological merging, akin to the condensation process in classical physics, of free elementary particle like 3-surfaces to the background surface of larger size. "Topological evaporation" corresponds to the reverse of this process in which particles go "outside" the classical spacetime. TGD predicts vacuum electromagnetic fields having as their source vacuum gauge currents instead of currents composed of elementary particles. The vacuum gauge currents generate coherent states of photons and the for lightlike vacuum currents the coherent state arises in a resonant-like manner. A presence of Bose-Einstein condensates of photons in a nearby spacetime sheet external to the coherent-state generator would allow for a transfer of photons from that sheet into a vapour phase. The capture of these photons into an electro-mechanical propulsion system may provide a source of energy which can be converted into a form useful for the propulsion and acceleration of a space craft. An emission of coherent light from a region not containing charged particles would be a clear indication of vacuum current presence. Whether this entire process, if it is feasible, could generate enough useful energy for spacecraft propulsion is a major open question. However, it does appear that in the least such a mechanism could provide for some type of quantum communication with storage of information in both phase and intensity of the coherent emf and with the vacuum currents acting as quantum antennae. An examination of certain models known as quantum cellular automata and networks (QCAM, CLAN) (Dudziak, 1993) and synchronized heterogeneous dynamical networks (SHDN (Chinarov, 1998) may provide some further insight into how the suggested stimulated coherent production of photons might be initiated, controlled, and stabilized in an application for space travel or communication.

TOPOLOGICAL GEOMETRODYNAMICS

Topological geometrodynamics provides an alternative (Pitkänen$_1$,1995) approach to the unification of quantum theory and relativity. In this approach (Pitkänen$_1$,1995), there is a fundamental and radical generalization of the concept of 3-space. Spacetime is replaced by a surface of 8-dimensional space $H = M^4_+ \times CP_2$, where M^4_+ is the interior of the future light cone of 4-dimensional Minkowski space and CP_2 is complex projective space with real dimension four. The reasons forcing the use of (the interior of) the future light cone of M^4, denoted by M^4_+, rather than entire Minkowski space, are both mathematical and cosmological, as a matter fact, M^4_+ corresponds to an empty Robertson-Walker cosmology. This space possesses the symmetries of the empty Minkowski space broken only by the presence of the lightcone boundary plus some additional symmetries, namely those of the internal space CP_2. One can identify the isometries of CP_2 (cf. Figure 2. below) having dimension) as color symmetries characteristic for quarks and gluons and the theory becomes unique. It is easy to construct action principles allowing the symmetries of H as symmetries and giving spacetime surface as a solution of the field equations. This means a solution of the so called energy problem of General Relativity since energy now corresponds to time translations of 8-dimensional H rather than of 4-dimensional spacetime as in General Relativity.

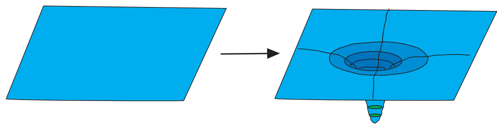

Figure 1: Gravitation makes spacetime curved and leads to a loss of translational symmetries in GRT.

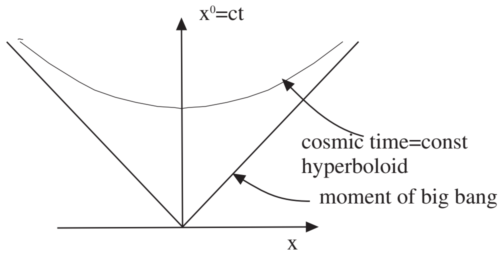

Figure 2: Geometry of the future lightcone M^4_+.

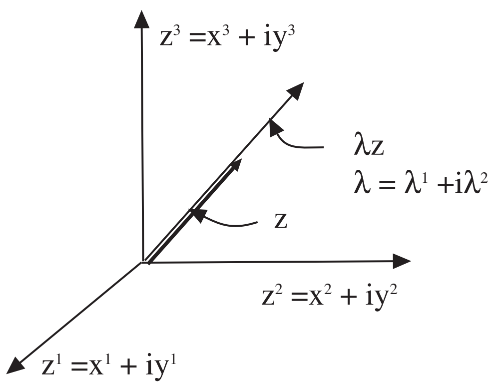

Figure 3: CP_2 as a complex projective space of real dimension 4.

Sub-manifold geometry leads to a natural geometrization of gauge fields and quantum numbers. Induction procedure for the metric means that distances in spacetime surface are measured using the meter sticks of the imbedding space. In the case of gauge fields induction means that parallel translation is performed using the parallel translation defined by the spinor connection of the imbedding space. The requirement of electroweak gauge structure fixes the space S uniquely to $S = CP_2$. Also the geometrization of known elementary particle quantum numbers results.

One can enter up with TGD also as a generalization of the old fashioned hadronic string model by generalizing the description of hadrons as strings having quarks at their ends with the description of particles as small 3-surfaces X^3 containing quantum numbers at their boundaries. This leads to a topological explanation of the family replication phenomenon and makes it possible to explain the known elementary particle quantum numbers in terms of H-geometry. The TGD resulting from the generalization of string is however quite different from the TGD resulting as a solution of the energy problem of GRT.

The only manner to unify these two TGD:s is provided by a generalization of the spacetime concept. The macroscopic spacetime with matter is identified as a many-sheeted surface with hierarchical structure. There are sheets glued on larger sheets glued on larger sheets..... Each sheet has outer boundary and material objects are identified as spacetime sheets. Gluing is performed by topological sum operation connecting different spacetime sheets by very tiny wormholes with size of order CP_2 radius. Wormholes reside near the boundaries of a given spacetime sheet and they feed various gauge fluxes to the larger spacetime sheet (external world from the view point of the smaller spacetime sheet). Elementary particles correspond to so called CP_2 type extremals, which have Euclidian metric and negative finite action and have very much the same role in TGD as blackholes in GRT.

Also 'vapour phase', i.e. small particle like surface residing (at least part of the time) outside the macrosocopic spacetime surface are possible, and are the counterpart of the Baby Universies of GRT. The requirement that gauge and gravitational fluxes are conserved on the boundaries of 3-surface implies that classical gauge charges and gravitational mass of the vapour phase particle vanish. There is no reason for the vanishing of the inertial four-momentum although one can consider the possibility that the rest masses of the vapour phase elementary particles vanish in accordance with the idea that topological condensation gives rise to the massivation of the elementary particle. One could argue that quantum gauge charges of topologically evaporated CP_2 type extremals cannot be identified as gauge fluxes and therefore can be nonvanishing. This problem does not however affect recent considerations.

In TGD framework spacetime can be therefore regarded as a manysheeted surface. The distances between parallel sheets are extremely small, of the order of CP_2 size $R \sim 10^4$ Planck lengths. Sheets have a finite size and outer boundary and form a hierarchical structure ordered by the typical size of the sheet. A spacetime sheet is identified as a geometric representation of a material object so that 'matter' (in the sense of 'res extensa') reduces to spacetime topology in TGD and interactions between particles can be be understood topologically. Elementary particles correspond to surfaces with size of order R, which have suffered topological condensation ('gluing' by topological sum contact) to a larger spacetime sheet.

Elementary particles can also topologically evaporate: vapour phase particles are 'outside' the macroscopic spacetime and analogous to the Baby Universies of General Relativity. An argument based on the conservation of Newtonian gravitational flux and gauge fluxes on the boundaries suggests that vapour phase particles have vanishing gravitational mass and gauge charges whereas inertial mass (or at least four-momentum) should be nonvanishing: this implies a breaking of Equivalence Principle for such particles.

In principle there is energy and momentum transfer between various spacetime sheets and also between spacetime sheets and 'vapour phase'. Assuming that Einstein's equations of GRT hold true, one can calculate the energy transfer from a given spacetime sheet to other sheets and to vapour phase. One can also construct a model for various particle transfer processes by assuming that standard interactions cause evaporation and condensation. In the case of a single spacetime sheet this means that each elementary particle species is effectively doubled corresponding to vapour phase- and condensate states. In each vertex of the

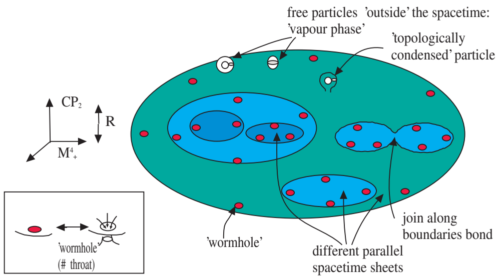

Figure 4: Topological condensate and vapour phase: two-dimensional visualization.

Feynmann diagram both vapour phase and condensate states can occur with appropriate amplitudes. Also the classical gauge fields associated with the condensate can affect the condensation or evaporation and again appropriately generalized standard interaction vertices are assumed.

A futher purely TGD:eish phenomenon, deriving from the induced gauge field concept, is the existence of genuinely classical gauge fields, in particular electromagnetic and gravitational fields having standard couplings to the quantum fields. Unlike in classical electrodynamics, vacuum emfs can have nonvanishing divergence identifiable as a vacuum gauge current rather than as a current consisting of elementary particles. The presence of the vacuum gauge currents makes possible a generation of coherent states of photons: each Fourier component of the vacuum gauge field generates its own coherent state. A purely TGD:eish prediction are so called 'massless extremals' representing nonlinear em waves with associated lightlike vacuum currents for which the coherent state is generated in resonant-like manner. Thus lightlike vacuum currents can act as as ideal quantum antennas (Pitkänen$_{1,3}$).

In complete analogy with the stimulated emission and absorption, the presence of the BE condensate of photons (large number of photons in given Fourier mode) at some other spacetime sheet than the one creating the coherent state, implies a stimulated transfer of photons between this spacetime sheet and vapour phase.

The first application coming into mind is quantum communication with information stored in both the phase and the intensity of the coherent emf and lightlike vacuum currents serving as quantum antennas. The second application would be a mechanism of energy production based on the sucking of photons from the coherent state of vapour phase to condensate containing BE condensate of photons. The necessary prequisites for the mechanism are as follows:

a) There exist a region of spacetime containing classical gauge fields with nonvanishing lightlike vacuum em current generating coherent photons. Lightlikeness implies resonance and would lead to large density of photons in the vapour phase.

b) There is a device capable of inducing topological condensation of the vapour phase photons. The device in question could be smaller spacetime sheet containing BE condensate of photons in some Fourier modes of the quantized photon field.

b) There exists a mechanism for transferring the condensed photons away from the device so that a continuous flux of energy from the vapour phase becomes possible.

Since charged elementary particles are massive, they cannot give rise to coherent, macroscopic lightlike currents. Hence the emission of coherent light from a spacetime region not containing charged particles (the absence of emission and absorption lines, brehmstrahlung radiation, etc.) would be a signature of the vacuum currents. Also the lightlikeness of this current could serve as a signature in laboratory length scales (microtubules (Pitkänen$_1$,1995,Pitkänen$_3$,1996).

At best, the stimulated topological condensation of photons might be capable of generating sufficient release of energy that can be harnessed to be useful in the operation of a large interstellar or beyond-solar-system missions. The second possibility is quantum communication already mentioned. At worst, the energy density of the photons in the vapour phase might be of the same order of magnitude as the energy density of the microwave background or even smaller. Even in this case the mechanism might however provide a direct test of the TGD:eish spacetime picture.

TOPOLOGICAL CONDENSATION OF PHOTONS AS A METHOD OF ENERGY EXTRACTION?

There are three principle issues that must be considered. First is the matter of topological condensation. If this process does occur, there must be a kinetic model that would allow for the transfer of photon energy that can result in energy exchange with a macroscopic device such as an engine or drive system. The second issue concerns the amount of such photon exchange that could occur within a given volume of interstellar or even solar domain space. It may be that the conjectured process can generate realistically only such a modest amount of useable energy that it is not practical. The third issue concerns what practical mechanism could be employed, assuming a positive answer to the first two concerns, for controlling the use of this condensate energy. The first issue, i.e. mathematical modelling of the quantum antenna and topological condensation of photons, was discussed in [Pitkänen and Dudziak$_2$] in detail and here only a brief summary of results of this discussion will be given.

Massless Extremals

The so called massless extremals describe nonlinear waves propagating with light velocity and are a crucial element in the model to be represented. The characteristic feature is the presence of nonvanishing lightlike vacuum gauge currents not possible in ordinary QED by the fact that free Maxwell action represents free field theory.

Let $k = (k^0, k^3, 0, 0)$ be a light like vector of M^4 and $u = u(m^1, m^2)$ be an arbitrary function of Minkowski coordinates m^1 and m^2 in the plane ortogonal to the direction 3-vector $(k^3, 0, 0)$ associated with k. Denote by s^n the n:th coordinate of CP_2 and by $v = k \cdot m$ the Minkowski inner product of the wave vector k and $M4^4$ coordinate m. The surfaces defined by the map

$$s^n = f^n(v, u) , \quad (1)$$

where f^n and u are arbitrary functions, define massless extremals. They describe the propagation of massless fields in the direction of k: the fields are periodic with period $\lambda = 2\pi/k^0$ so that only k and its integer multiples are possible wavevectors. The polarization associated with various induced gauge fields depends on the position in (m^1, m^2)-plane and is in the direction of the gradient of u. Field equations involve tensor contractions of energy momentum tensor and gauge current. These are proportional to kk and k respectively and vanish by the lightlikeness of k. Linear superposition holds true only in a restricted sense since propagation direction is fixed and polarization direction in each (m^1, m^2)=const plane is fixed.

What is remarkable that these solutions are not solutions of the ordinary Maxwell equations in vacuum: gauge current densities are in general nonvanishing(!) and proportional to the light like four-momentum k. As a consequence, also lightlike electromagnetic current is in general (but not necessarily) present. The interpretation of the em current J as electron current is impossible and the correct interpretation as vacuum current is possible for induced gauge fields. The presence of the vacuum current implies that massless extremals act as quantum antennae in the sense that each Fourier component of the vacuum current, equivalent to an oscillating external force coupled to a harmonic oscillator, generates a coherent state of photons (coherent state is an eigenstate of the photonic annihilation operators). Since photons have lightlike 4-momenta, it is intuitively obvious that the coherent state is generated in resonance like manner for a lightlike current.

A Model For The Transfer Of Photons And Energy Between Vapour Phase And Condensate

In ordinary QED classical gauge fields can have only ordinary charged particles as their sources. In TGD genuine vacuum currents are possible. The coupling of the quantum field to the classical em field with a nonvanishing vacuum source implies the generation of a coherent state of photons such that each Fourier component present in the classical gauge current gives rise to an eigenstate of the corresponding photonic annihilation operator. In case of lightlike vacuum currents allowed by TGD, the coherent state is generated in resonant-like manner so that lightlike vacuum current acts as an ideal quantum antenna.

If one introduces a second spacetime sheet, which contains BE condensate of photons for some modes of the photon field, a stimulated topological condensation of the vapour phase photons to this spacetime sheet occurs. This effect could be used to extract energy from the vapour phase.

The possibility of macroscopic quantum antennae has been explored in cell biology (Pitkänen$_3$,1995, Dudziak, 1993) giving rise to the notion that microtubules of the cytoskeleton may act as coherent quantum antennae with the result of creating an organizing network spanning large regions of cell surfaces and even acting across cell boundaries as in the case of neuronal axons and dendrites. The dynamical scaling symmetry of the massless extremals leads to ask whether something of the sort could be artificially constructed on a massive scale across many meters or kilometers of deep space.

Coherent State Is Generated In Resonant-Like Manner For Lightlike Vacuum Currents

The presence of the vacuum current leads to the generation of coherent state of two modes of coherent photons: vapour phase and condensate. Coherent states states are eigenstates of the photonic annihilation operators and in the estimates for the rate of topological condensation, one can replace $A_\mu(qu,i)$, $i = cond, vap$, with the classical photon field $A_\mu(coh,i)$. This has a classical vacuum current as its source and serves as order parameter for the coherent state. The Fourier component of a vector potential describes the eigenvalue of the annihilation operator part of the photon field is for a given momentum k and polarization direction λ and is given by

$$\begin{aligned} A^\mu(coh,v|\lambda,k) &= \sum_n c(k,k_n)\frac{\lambda_\mu J^\mu(k_n)\lambda^\mu}{k_n^2} \ , \\ exp(-ik\cdot m) &= \sum_n c(k,k_n)exp(-ik_n\cdot m) \ . \end{aligned} \tag{2}$$

Here $c(k,k_n)$ is the Fourier component of the planewave $exp(-ik\cdot m)$ expressed using a discrete planewave basis for the spacetime sheet containing the vacuum current and m denotes Minkowski coordinates.

If the classical vacuum current is associated with a 'massless extremal', any current is lightlike. This implies resonance for those frequencies for which the photon wave vector corresponds to a wave vector appearing in the vacuum current. The resonance is smoothed out by the finite spatial size of the spacetime sheet containing the lightlike vacuum current. At the limit of an infinitely large spatial size for the spacetime sheet, one obtains infinitely large amplitudes since one has $k_n^2 = k^2 = 0$ at this limit.

The Mechanisms For Energy Release From The Vapour Phase

The stimulated condensation of the photons from the vapour phase can be used to extract energy from the vapour phase. A continuous removal of the topologically condensed photons from the region of the topological condensation replaces kinetic equilibrium with a dynamical flow equilibrium and vapour phase photons are sucked from vapour phase (or from other space time sheets) to a given spacetime sheet. The absorption of photons requires a device containing BE condensates of photons for some photon modes and the possibility to transfer the condensed photons away in order to establish flow equilibrium.

The maximum differential energy transfer rate in a state containing $N(k,\epsilon)$ photons in mode (k,ϵ) is given by

$$\frac{dP_{max}}{d\Omega} = \omega \frac{dR}{d\Omega} \tag{3}$$

Here $dR/d\Omega$ is the differential rate for topological condensation of photons in given mode with the direction of wave vector k in solid angle $d\Omega$. ω denotes the frequency of the photon.

In case that coherent photons are emitted by massless extremal characterized by wave vector k in the direction of z-axis, having length L and volume V, the diffential condensation rate is given by the expression

$$\begin{array}{l} \frac{dR(k,\lambda,n)}{d\Omega} = \frac{\pi}{2}\omega_n L^2 |M(k,\lambda|^2 (N(k,\lambda)+1)^2 \ , \\ M(k,\lambda) = i\sum_{\lambda_1}\int d^3k_1 J(\omega_n,k_T^1)c(k^1,k)X(k_1,\lambda_1) \ , \\ X(k_1,\lambda_1) = \frac{exp(ik_z^1 L)-1}{ik_z^1 L} p\cdot e_{\lambda_1} e_{\lambda_1}\cdot e_{\lambda} \ , \\ c(k_1,k_2) = \int_{V_2} dV_2 exp\left[i(k_1-k_2)\cdot m\right] \ . \end{array} \tag{4}$$

$J(\omega_n,k_T^1)$ is the Fourier component of the coefficient of J of the light like vacuum current $J(t-z,x_T)p^\mu$,$p^\mu = (1,1,0,0)$. The overlap integral $c(k_1,k_2)$ carries information about the geometry of the spacetime sheet associated with the 'device'. $e_\lambda(k)$ denotes polarization vectors in two directions ortogonal to the vector k. n refers to the frequency $\omega_n = n\pi/L$ of the lightlike vacuum current. The remaining factor X is a purely 'kinematic' factor. From this expression it is clear that resonance indeed occurs and at the limit $L\rightarrow\infty$ the rate for condensation diverges as L^2.

It will be necessary for the mechanism responsible for this photon removal process to maintain continuity through some type of charging mechanism. There are several designs for ion-drive engines fueled by either fission or fusion sources. The same type of ion drive mechanism could be fed instead by the flow of photons from the topological condensation process. What specific mechanism is at the output end of this channel is not the critical element; rather, the question which needs further investigation including development of an experimental approach is whether or not such a drive system could be adequately fed by the vacuum currents.

There is another issue which concerns the effect on evaporation and condensation rates due to the presence of a massive object such as a spacecraft moving at a constant or near-constant velocity. Even if such a craft were composed of several dispersed units, it might have a disturbance on the thermal equilibrium sufficient to alter the entire condensation process. This is a matter for further investigation.

EXPERIMENTAL VERIFICATION-SOME POSSIBLE TESTS

Evidence For Many-Sheeted Spacetime Concept?

Many-sheeted spacetime has some indirect cosmological evidence.
a) Since spacetime sheet is curved, it takes longer time for a topologically condensed photon to propagate from point A to B along the lightlike geodesics of spacetime surface than for vapour phase photons propagating along the lightlike geodesics of the imbedding space. Many-sheetedness implies the possibility of several light velocities and this could serve as a signature of manysheetedness even in laboratory length scales. This would require the re-investigation of a possible dependence of the light velocity on length scale.
b) In cosmological scales each spacetime sheet possesses its own Hubble constant (this is due to different mass density in various spacetime sheets). This could explain the problem of two Hubble constants (see the chapter 'TGD and cosmology' of (Pitkänen$_1$,1995)).
c) The recent evidence (Perlmutter *et al*,1998) for the increase of Hubble constant at short distances could

be regarded as an evidence for many sheeted spacetime. Light coming from nearby sources propagates along smaller spacetime sheets, possessing larger mass density and larger Hubble constant than the light from distant sources having to propagate along large spacetime sheets.
d) Vapour phase photons could propagate from regions beyond cosmological horizon. This could explain why some stars seem to be older than the Universe (see the chapter 'TGD and cosmology' of (Pitkänen$_1$,1995)).

Test For The Concept Of The Lightlike Vacuum Currents

In (Pitkänen$_1$,1995, TGD,Pitkänen$_3$,1996) it has been suggested that microtubules and other linear structures in biological macromolecular assemblies might act as quantum antennas and that this property is fundamental for the ability of biosystems to function as macroscopic quantum systems. The mechanism would be based on the presence of classical lightlike vacuum currents associated with some microtubular spacetime sheet. The resonance phenomenon would enchance the interaction with laser light and also the interaction between different microtubules. The demonstration that biophotons of Popp (Popp *et al*,1981) can be regarded as resulting from light like vacuum currents associated with microtubules or linear molecules (such as DNA), would provide a strong support for the concept.

If one has somehow detected astrophysical emf and found it to have (perhaps light like) gauge current as its source and there is no evidence for the ordinary charged matter in the region in question (no emission or absorbtion lines, no brehmstrahlung) then one could argue that genuine vacuum gauge current is in question. Note that macroscopic lightlike (or nearly lightlike) currents consisting of ordinary charged matter are rather unprobable.

Future Directions

The design of satisfactory and reproducible experimental verification is certainly a necessary goal for the validation of the TGD model and its extension to condensed matter and biophysics as well as particle physics. However, there is much that remains yet to be accomplished first through mathematical and also computational modelling and simulation. More important still is the primary need to engender more dialogue and interaction of these concepts withing the broader physics community and to lead toward this state has been the principal goal of this introductory exposition.

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