Newton's constant as a conversion factor

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Abstract

A lineelement in a prior flat embedding space is formulated, bringing together spacetime, the gravitational field and - as an exemplaric case - a nongravitational scalar. As a consequence, even pure propagation is nonlinear, what however is supressed by the tremendous value of the vacuum energy density. The universe is reckognized as a torus in nongravitational degrees of freedom, in space and in time.

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The three dimensionful fundamental constants appear in strikingly different ways in the current theoretical framework. There is the velocity of light, whose role is ultimately transparent at least if spacetime is flat and if the indefiniteness of the metric is left to another story. It is the prototype of a conversion factor mediating a rotation (or, more precisely a boost) symmetry. I shall set it unity throughout in the following. Then there is Planck's constant $\hbar$ in the role of a conversion factor from the volume element of phase space towards a pure number with thermodynamic meaning. Again, the imaginary unit involved in the sum of states shall be left to another story. Furthermore, there are smaller amounts of actions around, as in the case of the fine structure constant. However, grosso modo the picture remains quite in line with what was learned from the velocity of light. And finally there is Newton's constant G, where nothing fits. In a crazy way, it mediates the maximum possible asymmetry between spacetime and energy-momentum, with the density of the latter regarded as a source of a property of the first.

General Relativity is quantitatively successful at least in some region of the external parameter space. However, its incompatibility with quantization, its sensitivity to the vacuum energy density, its obscure involvement of Newton's constant, and a number of other strange aspects do not weigh less. Something fundamental is wrong, and it may be wise to approach all the problems from a sufficiently opposite way of thinking, unworried by quantitative precision for the time being. There have been numerous attempts to modify the theory of gravity for the said reasons, all of which got stuck somewhere in the middle. Neither are they as accurate as General Relativity, nor do they solve the fundamental problems, the latter obviously because of lack of radicality. But where is the radix of the misery? From a bit of a distance, one can well find a promising candidate for the current erroneous pre-judgement: It is background-independence and the dynamic nature of the metric. But arguments are even more conclusive. In [1] I discuss that background-dependence and prior flat geometry are circumventable logic consequences if the concept of information is regarded under the aspect of reductionism. There I also argue that the experimental verification or falsification of the Unruh effect will bring the fundamental decision.

It is so difficult to implement G as a conversion factor since spacetime x^μ is 4-dimensional in place of being 1-dimensional. So the Lagrangian has dimension energy per 3-volume in place of energy alone. However, there is a quantity usually given the dimension of energy in field theory, that is the (scalar) field itself. The example of a massive complex scalar ϕ will already be sufficient to explain the very essence. $m^2\phi^*\phi$, where m is the mass of the field quantum, is part of the Lagrangian and has dimension energy per 3-volume. So $\phi^*\phi$ has dimension inverse energy per 3-volume, and in fact is inversely proportional to m. This is usually multiplied by $\hbar^3$, what assigns to ϕ the dimension of mass, what seemingly is just a matter of convention. In this context it is worth remembering that there is some peculiar interplay between field and "hidden" trajectories. In classical statistical physics there is equally some interplay between different dimensionalities, in that a 1-dimensional phase trajectory ergodically sweeps out a phase manifold defined from the constants of the motion. This motivates to postulate a line element extending those of flat spacetime

$$\mathrm{d}s^2 = \mathrm{d}x_\mu \mathrm{d}x^\mu - 2G^2\hbar^3 \mathrm{d}\phi^* \mathrm{d}\phi \; , \tag{1}$$

where the indices are raised and lowered by means of the Minkowski metric and the sign convention is such that ϕ is spacelike. I left the dimensionality of the field as it was originally and rather wrote out the factor $\hbar^3$ explicitely.

In terms of real variables, the above is the line element of a 6-dimensional flat space. The two field equations $\phi(x^\mu)$ and $\phi^*(x^\mu)$ define a 4-dimensional submanifold $\mathcal{M}$ whose volume element $\mathrm{d}V$ is given by $\sqrt{|\det g|}\mathrm{d}^4x$, with the induced hermitian metric $g_{\mu\nu} = \eta_{\mu\nu} - 2G^2\hbar^3\partial_\mu\phi^*\partial_\nu\phi$. Because of the background, opposite to General Relativity the simplest ansatz for the action is sensible. $\mathcal{M}$ is regarded as a stationary manifold with the Lagriangian being the volume factor up to a multiplicative constant

$$L = -\frac{1}{G^2\hbar}\sqrt{|\det g|}\ . \qquad (2)$$

This is well known from membrane theory, except of the physical interpretation of the manifold. Applied to the above, this yields $L = -\frac{1}{G^2\hbar}\sqrt{1 - 2G^2\hbar^3\partial_\mu\phi^*\partial^\mu\phi} \approx -\frac{1}{G^2\hbar} + \hbar^2\partial_\mu\phi^*\partial^\mu\phi$. As a conclusion, the world factually is nonlinear even at the level of pure propagation in flat spacetime, while this effect is supressed by the tremendous value of the vacuum energy density, which is one Planck mass per Planck volume. This is satisfactory, since the linearity of propagation - the meritorious it may have been for the development of theoretical physics - is absolutely not understandable from the viewpoint of unification of all physical concepts.

The gravitational field cannot couple as a tensor, else the universe would be rather curvy. But a clear alternative becomes visible when the mass of the scalar field is introduced via the modification $\phi \to \hat{\phi} = \phi + \imath\sqrt{\frac{G}{\hbar}}m\int\phi A_\mu \mathrm{d}x^\mu$, where A is a vector with dimension of a pure number. By the mechanism familiar from electrodynamics (see, for example [2]), this firstly yields the coupling of A to the vector current defined from ϕ, and secondly comes the mass term $-m^2A^2\phi^*\phi$. It is highly plausible that the mass term originates from interaction with something external, like the potential term of a harmonic oscillator comes from the interaction with the spring. Furthermore, it is plausible that the mass term is not a constant but depends on the value of A^2. And finally, the vector coupling is plausible as the gravitational one.

Different from electrodynamics, there is no request for a conserved current to make the construction sensible. Relevant rather is the conservation of the entire stress-energy, which is trivial in terms of g if the gravitational field A equally is introduced as another dimension. For this, there is an ultimate possibility: The gravitational field and the angles underlying spacetime are a pair of action-angle variables $z^\mu = A^\mu e^{\imath\alpha^\mu}$, where locally $\sqrt{G\hbar}(A\mathrm{d}\alpha)^\mu \cong \mathrm{d}x^\mu$. In the line element (1) real spacetime is replaced by this complex variables $\mathrm{d}x_\mu \mathrm{d}x^\mu \rightarrow 2G\hbar \mathrm{d}z^*_\mu \mathrm{d}z^\mu$. In [1] I argue that cartesian coordinates are prior, what implies that any deviation already encodes a physical fact. To prefer a point in embedding space is the minimum requirement to differ the universe from empty prior embedding space. The polar coordinates around the preferred point in any subspace of conjungate variables reflect the topology. In terms of real coordinates, the embedding space (exemplarily including the complex scalar field from above) is 10-dimensional, while 6 embedding equations $A^\nu(\alpha^\mu); \phi(\alpha^\mu); \phi^*(\alpha^\mu)$ define $\mathcal{M}$, which remains 4-dimensional. Equally, L remains proportional to the volume of $\mathcal{M}$.

As a conclusion, the universe is a torus. The nongravitational dimensions are seen from outside, so the torus structure is not directly visible. The spacelike 3-sections have topology of a 3-torus and furthermore the sections at constant cosmic time are intrinsically flat apart from higher order deviations. For time, the situation is not so clear, however it is quite plausible that time is a torus as well. This brings the by far most natural explanation for information loss: The trajectory is wound around in time, that means the mapping of the curve parameter into time is many to one. The winding number is not encoded in the value of time, rather it is encoded in the spatial position, since the trajectory goes through entire space ergodically.

What regards quantiziation, it is not yet enough that gravitational field and (the angles behind) spacetime are pairs of action-angle variables. The algebra is larger, as is well known from string theory where an uncertainty relation of the kind $\delta x \geq \frac{\hbar}{\delta p} + G\delta p$ is suggested. All this shall be treated elsewhere in connection with the role of G as a measure of excentricity in phase space.

A consistency check shall clarify whether the vacuum term remains dominant in the Lagrangian. The expression $\frac{1}{G^2\hbar} N \frac{m_f}{R_{univ}} A^2$, where N is the number of quanta present and -R_{univ} is the spatial radius of the universe, shall be compared to unity. Far away from any source, $A^2 = 1$ is the necessary boundary condition because of the mass term. However, any component of A is of order of magnitude of the cosmic radius. With the square of any such component inserted, the term is order of magnitude $G\frac{m_f N}{R_{univ}}$. With the mass arbitrarily close to the Planck mass, this remains small as long as the number of quanta is substantially less than $\frac{R_{univ}}{m_f}$. Such a limit is plausible from the current theory of gravitation, where for a black hole the mass is proportional to the radius rather than to its third power.

References

[1] Vones 1

[2] Itzykson-Zuber