Some comments on an idea of Stephen Adler: a frame dependent cosmological constant.

Johan Noldus*

August 27, 2018

Abstract

In the context of DICE2018, S. Adler launched the interesting idea of an effective observer dependent cosmological constant. We discuss this suggestion in the context of covariant quantum mechanics.

1 Discussion.

As is well known, the vacuum energy of a quantum field contributes to the value of the effective cosmological constant. We have generalized this idea to quantum theory on a curved spacetime with physical regularization parameters giving definite meaning to the Feynman diagrams as well as the entire Dyson series. Herein, the expectation value of the energy momentum tensor of a free "field", more accurately a Bi-Field, is given by the expression

$$\langle 0|T_{\mu\nu}(x)|0\rangle = \lim_{y\to x}\left(\partial_\mu\partial_{\nu'}W(x,y) - \frac{1}{2}g_{\mu\nu'}(x,y)\left(g^{\alpha\beta'}(x,y)\partial_\alpha\partial_{\beta'}W(x,y) - m^2W(x,y)\right)\right)$$

where $W(x,y)$ is the suitably regularized Wightman function with no singularity structure on the lightcone. Therefore, the latter expression vanishes identically and procures for a zero, ontological, cosmological term.

Our quantum theory is objective and the ambiguity in the Wightman function resides in parameters coupling to *physical* and in particular geometrical, local, quantities. This is in sharp contrast to the usual choice of a nonstationary observer in standard quantum field theory where global foliations in a globally hyperbolic spacetime are mandatory and a particle interpretation is opaque and detector dependent. Indeed, "particles" do not exist any more in that language and semiclassical, ad-hoc detector models are mandatory, to achieve a relational interpretation without any realist ontology apart from the field itself. No such thing happens in generally covariant quantum theory where a particle, as an irreducible concept, has a firm meaning independent of the context of an observer. The latter comes afterwards and it is in this light that we shall discuss some effective models giving rise to an oberver dependent illusion of a

*email: johan.noldus@gmail.com, Relativity group, department of mathematical analysis, University of Gent, Belgium.

free Bi-Field induced cosmological constant amongst other geometrical entities.

More in particular, let γ be a wordline in eigentime parametrization and pick a moment of observation t; then, with $\delta, \epsilon > 0$ we may posit that

$$\langle 0|T^{\delta,\epsilon}_{ab}(\gamma(t))|0\rangle = \mathcal{R}\left[\partial_a \partial_\mu \sigma(\gamma(t),\gamma(t-\delta))\partial_b \partial_{\nu'}\sigma(\gamma(t),\gamma(t-\delta-\epsilon))\langle 0|T^{\mu\nu'}(\gamma(t-\delta),\gamma(t-\delta-\epsilon))|0\rangle\right]$$

is the relevant observed quantity where

$$\langle 0|T^{\mu\nu'}(x,y)|0\rangle = \left(\partial_\mu \partial_{\nu'} W(x,y) - \frac{1}{2}g_{\mu\nu'}(x,y)\left(g^{\alpha\beta'}(x,y)\partial_\alpha \partial_{\beta'} W(x,y) - m^2 W(x,y)\right)\right)$$

and $\sigma(x,y)$ is Synge's function. $\mathcal{R}$ indicates the real part of a complex number and ∂_a is a shorthand for $e^\mu_a(z)\partial^z_\mu$ in $z = \gamma(t)$. This real tensor is nonsymmetrical and depends upon a delay time δ and observation time ϵ in the past of observer time t. For regular spacetimes and wordlines with observation times δ, ϵ small with regard to metric fluctuations and the total worldline acceleration, we may write that

$$\langle 0|T^{\delta,\epsilon}_{ab}(\gamma(t))|0\rangle := \Lambda^{\delta,\epsilon}(R(\gamma(t)))\eta_{ab} + \alpha^{\delta,\epsilon}R_{ab}(\gamma(t)) + \beta^{\delta,\epsilon}V_a(t)V_b(t) + \ldots$$

where $V^\mu(\gamma(t)) = \frac{d}{dt}\gamma^\mu(t)$ is the normalized tangent to the worldline and assymetrical contributions require third order derivatives involving the worldline acceleration vector. Those simulate an Unruh effect and reproduce a kind of density matrix formula; indeed, in the operational language of Bi-Fields

$$\langle 0|_{t-\delta} \neq \langle 0|_{t-\delta-\epsilon}$$

and

$$T^{\delta,\epsilon}_{ab}(\gamma(t)) := \sum_i A^{\delta,\epsilon}_{i;a}(t-\delta)B^{\delta,\epsilon}_{i;b}(t-\delta-\epsilon)$$

where A, B are Hermitian operators on local, isomorphic, Hilbert spaces. In general, $\beta^{\delta,\epsilon}$ is an extremely small locally Lorentz violating parameter which depends upon the regularization procedure which is physically neglegible and simulates a dust contribution associated to the observer worline. The Ricci term, in case it is positive, simulates lensing effects of energy momentum and one would expect $\alpha^{\delta,\epsilon}$ to be positive due to Einstein's equations. An Unruh term is procured by

$$\kappa^{\delta,\epsilon}V_{(a}(\gamma(t))A_{b)}(\gamma(t))$$

whereas the assymetric combination would be associated to rotational effects of the acceleration vector with regard to the parallel transported vierbein.