Follow up Comments on "Dimensional Regularization as Mass Generating Mechanism (v1)"

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Abstract

The purpose of this document is to disseminate reviewers' comments and author's replies on the preprint posted at [1] and [2].

Key words: Dimensional Regularization, fractal spacetime, particle masses, Standard Model.

Reviewer 1 (Benjamin Grinstein):

"Ervin Goldfain's article Dimensional Regularization as Mass Generating Mechanism presents a brief review of regularization of relativistic quantum field theory in 4 space-time dimensions using the example of a single real scalar field with self-interaction $g\Phi^4$. It displays the computation of the divergent contributions to the 1-loop 2- and 4-point functions when rendered finite by two different regularization schemes: Pauli-Villars (PV) and dimensional regularization (DR).

The paper then argues as follows: the two regularization schemes should give the same physical results, regardless of what regularization method is used. This assumption is incorrect. For any finite value of the regulator there are distinctly different observable predictions of the two regulators. For example, finite mass of the PV regulator fields implies the presence of particles with corresponding mass that, depending on how the theory is fully defined, may introduce non-causal phenomena, or violate covariance, or give a non-unitary scattering S-matrix [1]. The only way around these difficulties is to take the limit $\Lambda_{UV}^2 \to \infty$ in the PV case and $\varepsilon \to 0$ in DR. The infinities that result from this limit are dealt with by using field and parameter renormalization, a by now standard procedure in defining any quantum field theory [2].

The relationship (16) in the paper, that $\varepsilon << 1$, is content free. As one needs to take the limit $\varepsilon \to 0$ as one renormalizes, it is clear that $\varepsilon << 1$ holds. None of the claims that follow equation (16) are actually consequences of (16). There is no justification given for any of these claims. The references are all to papers by the same author, and inspection of some of them reveals both that there is no connection to the claim of the present paper, nor is there proper justification to the results in them.

Refs.

[1] T. D. Lee and G. C. Wick, “Negative Metric and the Unitarity of the S Matrix,” Nucl. Phys. B 9 (1969) 209.

T. D. Lee and G. C. Wick, “Finite Theory of Quantum Electrodynamics,” Phys. Rev. D 2 (1970) 1033.

R. E. Cutkosky, P. V. Landshoff, D. I. Olive and J. C. Polkinghorne, Nucl. Phys. B 12, 281 (1969). N. Nakanishi, Phys. Rev. D 3, 811 (1971).

T. D. Lee and G. C. Wick, Phys. Rev. D 3 (1971) 1046.

N. Nakanishi, Phys. Rev. D 3, 3235 (1971)

[2] See eg, M.E.Peskin and D.V.Schroeder, ``An Introduction to quantum field theory,'' Addison-Wesley, 1995, ISBN 978-0-201-50397-5

***Author's reply (Ervin Goldfain*):**

"Thank you for the review.

Let me say from the outset that I disagree with your characterization of the preprint.

You are invoking technicalities that, although factually true, miss entirely the rationale of my arguments. While it is true that dimensional deviations $\varepsilon \neq 0$ lead to manifest non-causality, covariance or unitarity violations, the underlying premise of the preprint is that relation (16) describes a *nonintegrable/complex dynamic regime* that is asymptotically compliant with the consistency requirements mandated by perturbative Quantum Field Theory.

Contrary to your dismissive assessment, the preprint references several contributions where the (direct or indirect) use of (16) leads to unforeseen insights and possible solutions to the host of open issues challenging the Standard Model. Below is a list of representative examples,

1. https://iopscience.iop.org/article/10.1209/0295-5075/82/11001

2. Available at the following site:

https://www.ingentaconnect.com/contentone/asp/qm/2014/00000003/00000003/art00012

3. https://www.worldscientific.com/doi/10.1142/S0218127408020756

4. https://www.researchgate.net/publication/343426044

5. https://www.researchgate.net/publication/343425962

6. https://www.researchgate.net/publication/361099344

7. https://www.researchgate.net/publication/368287653

8. https://www.researchgate.net/publication/364294648

9. https://www.researchgate.net/publication/361644297

10. https://www.researchgate.net/publication/357093467

11. https://www.researchgate.net/publication/357093456

12. https://www.researchgate.net/publication/349476440

13. https://www.researchgate.net/publication/344417174

14. https://www.researchgate.net/publication/343686626

15. https://www.researchgate.net/publication/344036923

Let's agree to disagree.

Reviewer 2 (Alireza Khalili Golmankhaneh):

"The manuscript presents a comprehensive and informative tutorial on the use of Dimensional Regularization (DR) in the context of Relativistic Quantum Field Theory (QFT). The authors successfully convey the significance of DR in dealing with divergences arising from perturbative corrections to Feynman diagrams. The paper introduces the concept of DR and its implementation, and subsequently discusses its potential role in mass generation in particle physics, offering a fresh perspective that reconciles the Higgs model with the minimal fractal topology of spacetime above the Fermi scale.

I recommend rejecting the paper due to the issue with Equation 8, which appears to be meaningless. For instance, when considering a specific value, such as d = 0.3, the expression d^{0.3}k lacks clarity and interpretation.

To further assist the author in understanding the subject matter and potentially addressing this problem, I suggest referring to the following books:

"Brownian motion on the Sierpinski gasket" by M. T. Barlow and E. A. Perkins, published in Probab Theory Rel, 79(4) (1988), pages 543-623.

"Analysis on Fractals" by J. Kigami, published by Cambridge University Press in 2001.

"Harmonic calculus on fractals - a measure geometric approach I" by U. Freiberg and M. Zahle, published in Potential Anal. 16 (2002), pages 265-277.

"Fractal Calculus and its Applications."

Author's reply (Ervin Goldfain):

"Thanks for the feedback.

It looks like you misunderstood the meaning of equations (8) and (13). These are momentum integrals cited in standard textbooks on Quantum Field

Theory. Equation (13) is NOT a fractional integral, but a Dimensional Regularization integral in $\varepsilon = 4 - d$ dimensions, where μ is an arbitrary mass scale whose function is to maintain dimensional consistency.

Introducing fractional differential and integrals in this tutorial is beyond the scope of the paper."

References

1. https://doi.org/10.32388/DW6ZZS

2. https://www.researchgate.net/publication/370670747