

Three Routes to the Dynamics of Continuous Spacetime Dimensions

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Abstract

This brief report is a bird-eye view of the paths leading to the concepts of *evolving fractal spacetime* and *continuous dimensionality*, far beyond the range of Effective Field Theory.

Key words: complex dynamics, continuous spacetime dimensions, dimensional fluctuations, Physics beyond Effective Field Theory, primordial cosmology.

Cautionary remark: The reference section mainly includes our own contributions in order to stimulate independent exploration and unbiased analysis.

- *Complex dynamics* (CD) of collective systems with many degrees of freedom is characterized by non-linear, dissipative and non-local interactions between components, by the emergence of instability and chaos, the tendency to self-organize and adapt, to generate unforeseen outcomes and patterns, to unfold on multiple scales, display memory effects and an endless game of cooperation and competition [1 - 2].
- Implementing CD in theoretical physics requires use of unconventional tools such as the analysis of chaos and multifractal geometry, non-extensive statistics, self-organized criticality, and fractional dynamics.

Here are few examples of settings where CD is fully applicable:

- **Far-from-equilibrium physics** of collective systems with many degrees of freedom [3 - 6].
- The onset of **decoherence** and transition from quantum to classical behavior in field theory [7].

- The nearly universal existence of **nonintegrable phenomena** and the subsequent transition to chaos [8 - 10].

There are essentially *three routes* linking CD to the continuous and evolving dimensionality of spacetime far above the electroweak scale, namely:

- 1) **Dimensional Regularization** procedure of Quantum Field Theory [11 - 12].
- 2) The emergence of **nontrivial fixed points** in the Renormalization Group theory of phase transitions [12].
- 3) **Hamiltonian Chaos** in the phase-space of nonintegrable systems and the corresponding onset of fractal spacetime [13 - 14].

The last two decades have consistently shown that both CD and evolving spacetime dimensionality can lead to key developments in high-energy theory, statistical physics, self-organized systems, fractional dynamics, astrophysics and cosmology, fluid physics, plasma physics and condensed matter.

References:

1. <https://www.geios.com/read/HC9S30>
2. <https://www.researchgate.net/publication/344227402>
3. Hinrichsen, H., (2000), Non-equilibrium critical phenomena and phase transitions into absorbing states, *Advances in Physics*, 49(7), pp. 815–958.
<https://doi.org/10.1080/00018730050198152>
4. Lübeck, S., (2004), Universal scaling behavior of non-equilibrium phase transitions, *International Journal of Modern Physics B* 2004 18:31, pp. 3977-4118, <https://doi.org/10.1142/S0217979204027748>
5. Nicolis, G., (2012), *Foundations of Complex Systems; Emergence, Information and Prediction*, 2nd Edition, <https://doi.org/10.1142/8260>
6. Täuber, U., (2014), *Critical Dynamics: A Field Theory Approach to Equilibrium and Non-Equilibrium Scaling Behavior*, Cambridge University Press 978-0-521-84223-5.

7. <https://plato.stanford.edu/entries/qm-decoherence/>
8. <https://www.qeios.com/read/5LHA8S>
9. <https://www.researchgate.net/publication/380075915>
10. Gutzwiller, M. C., (1990), Chaos in Classical and Quantum Mechanics, Springer-Verlag, ISBN 0-387-97173-4.
11. <https://doi.org/10.32388/DW6ZZS>
12. <http://dx.doi.org/10.13140/RG.2.2.21554.99524/2>
13. <https://doi.org/10.32388/7ZYVDB>
14. <https://doi.org/10.32388/0KXQIL>