Addendum to viXra 2004.0634

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In this brief addendum we clarify the interpretation of the Gaussian Random Walk model of spacetime introduced in viXra: 2004.0634.

As conjectured in [1], at energies near or exceeding the Fermi scale (M_{EW}), conventional space and time coordinates turn into *statistical entities* and create dynamic conditions falling outside the effective framework of Quantum Field Theory. In particular, the scaling of coordinates (X) near or above M_{EW} is determined by the following probability distribution

$$P(X,L) = X^{-\tau_X}\Phi(X/X_c), \quad X >> 1, \ L >> 1 \tag{1}$$

$$X_c = L^{D_X}, \quad L >> 1 \tag{2}$$

The contribution of the cutoff function Φ becomes negligible when X falls far below its cutoff value or $L \to \infty$, that is,

$$\Phi(X/X_c) = const., \quad X << X_c \text{ or } L \to \infty \tag{3}$$

The key hypothesis of [1] is that the limit (3) of the power-law (2) reproduces the probability distribution of *Gaussian random walks*. Our goal here is to further elaborate on this point following the philosophy of the Renormalization Group program.

Consider a generic random walk in (2+1) spacetime dimensions having a constant step size commensurate with the magnitude of X. The probability distribution of this process replicates the power-law described by (1)-(3), namely [2]

$$P(\mathbf{X}) = \frac{1}{4\pi} X^{-2} \delta(|\mathbf{X}| - X) \tag{4}$$

where

$$\mathbf{X} = (X_0, X_1, X_2) \tag{5}$$

Next, proceed to constructing the probability distribution for the coarse-grained step

$$\mathbf{X}' = \sum_1^n \mathbf{X}_i \tag{6}$$

in which $n >> 1$ is the overall number of steps. The coarse-grained probability distribution in $D \geq 2$ dimensions can be derived through the cumulant expansion method [2]. The result in the 3+1 spacetime reads

$$P(\mathbf{X}') = \frac{1}{(2\pi n \sigma_0)^2} \exp(-\frac{|\mathbf{X}'|^2}{2n\sigma_0^2}) \tag{7}$$

which represents a standard Gaussian probability distribution with fractal dimension $D_{RW} = 2$.

The takeaway point of this discussion is that, in the limit of exceedingly long random walks consisting of statistically independent steps, processes of the type (4) are reducible to Gaussian Random Walks. This is to say that space and time coordinates evolve according to the *same probabilistic rules* at large energies, graciously blending into the four-dimensional continuum of relativistic physics near or below M_{EW} .

There is another way of phrasing this result. Assume that space and time *are not* integrated into spacetime but rather treated as individual random variables above M_{EW} . In this case, the fractal dimensions of space and time are unequal ($D_{RW} = 1$ for time in one dimension and $D_{RW} = 2$ for two or three dimensional space). As a result, the locality principle expressed by (9) in [1] fails to hold because (10) is no longer equal to one. The unavoidable conclusion is that space and time *must* be joined into a single entity, the Minkowski spacetime of Special Relativity.

References

1. https://vixra.org/pdf/2004.0634v4.pdf

Alternative site:

https://www.prespacetime.com/index.php/pst/article/view/1680/1608

2. Creswick, R. J., Farach H. A., Poole C. P. "Introduction to Renormalization Group Methods in Physics", John Wiley & Sons, 1992.