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On the Necessity of the Existence of the Cosmological Scales

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Abstract
An interesting interpretation of the role of the cosmological scales may give rise to the necessity of their existence.

Keywords: Quantum Uncertainty, Cosmological Scales, Hawking Particles.

Addendum

The previous article gave rise to some direct implications, another implication under an interesting interpretation is the following: the energy-time uncertainty and corresponding momentum-space uncertainty are given by

$$\Delta E \Delta t \geq \frac{\hbar}{2} \qquad \Delta p_R \Delta R \geq \frac{\hbar}{2} \tag{1}$$

We will treat the uncertainty ΔpR as the momentum of the in-going Hawking particle [1]. The total energy of the Hawking particle / anti-particle pair is zero, we only utilize the energy and momentum of one of the two particles; the in-going one with a borrowed energy

$\Delta E = E_H =$ $\Delta E = E_H = \frac{\hbar c}{\lambda}$, with $\lambda \sim R \sim \frac{1}{\hbar c}$, that is the wavelength λ of the in-going Hawking particle is of order R such that

$$\Delta p_R = p_H = \frac{\hbar}{\lambda} \sim \frac{\hbar}{R} \sim \hbar^2 c \tag{2}$$

It is now clear that if we interpret the cosmic event horizon R as a quantum uncertainty in position ΔR, that is

$$R \stackrel{!}{=} \Delta R \sim \frac{1}{\hbar c} \tag{3}$$

We may satisfy the quantum uncertainty.
For the energy-time uncertainty we arrive at

$$\Delta E = E_H = \frac{\hbar c}{\lambda} \sim \frac{\hbar c}{R} \sim \hbar^2 c^2 \sim \Lambda_{FLRW} \tag{4}$$

$$t \stackrel{!}{=} \Delta t \sim \frac{R}{c} \sim \frac{1}{\hbar c^2} \tag{5}$$

This suggests a relationship between the energy of the in-falling Hawking particle at the boundary and the energy due to virtual vacuum fluctuations internally. Again, we observe that we satisfy the quantum uncertainty.

Conclusions

We have saw that if we were to interpret the cosmological scales as quantum uncertainties in space and time they satisfy the quantum uncertainty together with the vacuum energy. The possibility of non-existence, that is the case where R = ΔR = t = Δt = 0 is inconsistent with the quantum uncertainty, and is therefore non-physical. Therefore, under this interpretation, one may say that the existence of the cosmological scales is necessary because the scales have to satisfy quantum uncertainty together with the vacuum. And, consequently, that the observable universe may exist because it is borrowed from the vacuum itself through the uncertainty principle.

References

1. Eide, A. C. (2022). On Virtual Scalar Fields in a Conformally Flat FLRW Spacetime.