The Cosmology and the Uncertainty Principles: A New Road to the Quantum Gravity

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Abstract

We introduce the ansatz that universe size and age are the maximal spatial and temporal uncertainty, respectively within the uncertainty principles. This allows us to derive a relationship between Planck's constant and the Hubble's constant. Accordingly, we obtain numerical value of the minimum momentum and energy uncertainty, which are locally experimentally verifiable. A new approach to unifying quantum mechanics and cosmology/General Relativity, i.e. Quantum Gravity is given.

Keywords: *FRW Universe, Hubble's Constant, Planck's Constant, Uncertainty Principles, Quantum Gravity, Quantum Mechanics, Cosmology*

Uncertainty principles have been explored in cosmological context, to determine minimum length and time scales [1 arXiv]. Here we explore their relationship for determining cosmological parameters, such as the size of the cosmological horizon and the age of the universe.

One can ask the question, if the maximum uncertainty in the position, $(\Delta x)_{max}$ in the position-momentum uncertainty principle [2 Feynman] -

$$\Delta x \Delta p \quad \geq \hbar \tag{1}$$

can be extended to cosmological proportions. Finite distance of Cosmological Horizon, suggests that maximum Spatial Uncertainty $(\Delta x)_{max}$ is the diameter *D* of the Cosmological Horizon

$$(\Delta x)_{max} = D \geq \hbar/(\Delta p)_{min} \tag{2}$$

where, $(\Delta p)_{min}$ is the minimum uncertainty of momentum. Analogously, the question can be asked, whether, in the time-energy uncertainty principle

$$\Delta E \Delta t \quad \geq \hbar \tag{3}$$

the maximum Temporal Uncertainty $(\Delta t)_{max}$ be the age *T* of the Universe [Weinberg, Narlikar]-

$$(\Delta t)_{max} = T \geq \hbar/(\Delta E)_{min} \tag{4}$$

where, $(\Delta E)_{min}$ is the minimum uncertainty of energy. While $(\Delta x)_{max}$ and $(\Delta t)_{max}$ are of Cosmological proportions, the $(\Delta p)_{min}$ and $(\Delta E)_{min}$ are of local microscopic and experimentally measurable quantities. Since,

$$T = H_0^{-1} \tag{5}$$

where, H_0 is the Hubble's constant, so we have,

$$H_0^{-1} \geq \hbar/(\Delta E)_{min} \tag{5}$$

And,

$$(\Delta E)_{min} \geq \hbar H_0 \tag{6}$$

Given numerical value of $\hbar$ and H_0 , (in mks units),

$$\hbar = 4.16328 \times 10^{-33} \tag{7}$$

$$H_0 = 2.26537 \times 10^{-18} \tag{8}$$

we have,

$$(\Delta E)_{min} = 2.389 \times 10^{-52} \text{ Joules} \tag{9}$$

This implies that energy states with a difference $(\Delta E)_{min}$ would be indistinguishable. Using,

$$(\Delta E)_{min} = h\upsilon \tag{10}$$

this corresponds to the following frequency of a photon,

$$\upsilon = 3.60545 \times 10^{-19} \text{ Hertz} \tag{11}$$

Atomic electron transition levels, having energy difference $(\Delta E)_{min}$ or less, will be indistinguishable. An experimentally determined value of $(\Delta E)_{min}$ will give an independent estimate of the age of the universe and Hubble's constant.

Now we apply these consideration to the hypertoroidal spacetime, with S^3xS^1 topology, Cosmology for this topology of spacetime, has been developed by Segal [5] and Guillemin [6]. Finite size of the S^3 universe suggests that the maximum spatial uncertainty should be $(\Delta x)_{Max}=2\pi R_{Univ}$, where R_{Univ} *is* the radius of the universe. It follows from the Position-Momentum uncertainty principle $\Delta x\Delta p \geq h/2\pi$, that there exists a minimum uncertainty in the momentum - i.e., $(\Delta p)_{Min}=h/(2\pi)^2R_{Univ}$. Similarly, the finite duration T of the S^1 Time Cycle, suggests that the maximum temporal uncertainty is $(\Delta t)_{Max}=T$. It follows from the Time-Energy uncertainty principle $\Delta E\Delta t \geq h/2\pi$, that there exists a minimum uncertainty in the energy - i.e., $(\Delta E)_{Min}=h/2\pi T$. These consideration suggest the following conclusions - (1) Quantum states with $\Delta E\leq(\Delta E)_{Min}$ and $\Delta p\leq (\Delta p)_{Min}$ will be indistinguishable, (2) It should be possible to determine radius of the finite S^3 universe, i.e., $R_{Univ}=h/[(2\pi)^2(\Delta p)_{Min}]$, by locally measuring $(\Delta p)_{Min}$, and (3) Determine duration of the universe's time cycle, $T=h/2\pi(\Delta E)_{Min}$, by locally measuring $(\Delta E)_{Min}$. As a cosmological curiosity, for the ancient Mayan calendar of the 5000 years time cycle of the S^1 topology of time, one obtains the prediction $(\Delta p)_{Min}= 2.23 \times 10^{-53}$ *kg m/s*; and $(\Delta E)_{Min}= 6.68 \times 10^{-45}$ *Joules.*

Hubble's constant

Klein Gordon equation

Dirac Equation

References

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