Measuring Cosmological Parameters by Using Uncertainty Principles in the $S^3 \mathrm{x} S^1$ Space-Time

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Abstract

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., $(\Delta p)_{Min}=h/(2\pi)^2 R_{Univ}$. 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 $(\Delta E)_{Min}$.

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In context of quantum mechanics and uncertainty principles - one can ask the question, what could be the maximum spatial and temporal uncertainty. Arguably, the maximum spatial uncertainty cannot be larger than the size of the universe - for a static S^3 universe. For an expanding universe, the uncertainty should have the particle horizon as the maximum spatial uncertainty. For a cyclic universe, the temporal uncertainty cannot be larger than the duration of the time cycle. Segal [1] has extensively studied cosmology on S^3xS^1 space-time (S^3 space and S^1 time) - in which both the spatial factor as well as the temporal factor are finite. His motivation is to develop cosmology on the spatial part of the Einstein Cylinder (S^3xR^1). He introduces S^1 times and uses the Uni-energy operator to arrive at cosmological red-shift of distant galaxies. Guillemin [2], develops periodicity for particles propagating along the null geodesics - with the null geodesics being closed curves.

Finite size of the S^3 universe suggests that the maximum spatial uncertainty should be -

$$(\Delta x)_{Max}=2\pi R_{Univ}, \qquad (1)$$

where R_{Univ} *is* the radius of the universe. It follows from the Position-Momentum uncertainty principle

$$\Delta x \Delta p \geq h/2\pi, \qquad (2)$$

that there exists a minimum uncertainty in the momentum - i.e.,

$$(\Delta p)_{Min}=h/(2\pi)^2 R_{Univ}. \qquad (3)$$

Similarly, the finite duration T of the S^1 Time Cycle, suggests that the maximum temporal uncertainty is -

$$(\Delta t)_{Max}=T \qquad (4)$$

It follows from the Time-Energy uncertainty principle,

$$\Delta E \Delta t \geq h/2\pi \qquad (5)$$

that there exists a minimum uncertainty in the energy - i.e.,

$$(\Delta E)_{Min}=h/2\pi T \qquad (6)$$

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.,

$$R_{Univ} = h/[(2\pi)^2 (\Delta p)_{Min}] \tag{7}$$

by locally measuring $(\Delta p)_{Min}$, and

(3) Determine duration of the universe's time cycle,

$$T = h/2\pi(\Delta E)_{Min} \tag{8}$$

by locally measuring $(\Delta E)_{Min}$.

References

1. I.E. Segal :*Mathematical Cosmology and Extra-Galactic Astronomy,* Cambridge University Press, 1984.
2. V. Guillemin: *Cosmology in 2+1 dimensions, cyclic models and deformations of M(2,1)*, Princeton University Press, (1989).