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If follow the laws of quantum mechanics , it turns out that the vacuum energy density at the Big Bang emerged as a result of the decoherence of the quantum state of the universe. Perhaps our universe emerged due to the destruction of the state of quantum entanglement of the physical vacuum .

Consider the limit entanglement entropy theory on the surface. (Holographic principle) .

$$S_{En} = \frac{A}{4l_p^2}, \quad l_p^2 = \frac{G\hbar}{c^3}$$

In the case of three-dimensional space , the density of entanglement entropy per unit volume will be limited to a certain value.

$$s_{\max} = \frac{dS_{En}}{dV} \quad (bit/m^3)$$

We use the condition that physical entropy (the opposite is information) in a certain volume is not transmitted above the speed of light .

$$V = \frac{4\pi}{3}R^3 \quad A = 4\pi R^2 \quad c\Delta t = R$$

$$\frac{dS_{En}}{dV} = \frac{1}{2l_p^2 c\Delta t}$$

Then with the help of the Heisenberg uncertainty relation and the holographic principle possible to estimate the distribution of energy to the maximum entropy of entanglement in the physical vacuum .

$$\Delta E\Delta t \geq \frac{\hbar}{2}$$

Evaluation of energy uncertainty for the maximum entropy of entanglement is as follows .

$$\Delta E \geq \hbar c l_p^2 \frac{dS_{En}}{dV}$$

It turns out that 1 bit of entropy of entanglement per unit volume has a certain minimum energy to vacuum .

$$E_0 = \hbar c l_p^2 \frac{dS_{En}}{dV}$$

Thus, the physical vacuum in a state of quantum entanglement is entitled to their own material . In this state the physical vacuum has its own energy and mass , as well as should have a local density .

$$\rho_{VAC} = \frac{dE_{VAC}}{dV} = E_0 \frac{dS_{En}}{dV}$$

After some substitutions , the formula for the self-energy density of the vacuum in a state of entanglement entropy .

$$\rho_{VAC} = \hbar c l_p^2 \left(\frac{dS_{En}}{dV} \right)^2$$

As can be seen from this formula , the square of the quantum entanglement entropy density determines the magnitude of the energy density of physical vacuum . Thus , the vacuum state in the destruction of quantum entanglement is material itself .

Now with the help of this formula we consider the evolution of the universe at the very beginning , that is, during the Big Bang . As can be seen from this formula vacuum energy density occurs when there is an initial entanglement entropy . The initial entropy always remained a mystery to cosmology . However, remember the definition of entropy of entanglement in quantum mechanics .

$$S_{En} = -p_{\alpha\beta} Tr\left(p_{\alpha\beta}\right)$$

The entropy of entanglement occurs when a quantum system interacts with the environment . This phenomenon is known as decoherence .

$$\Psi = c_\alpha \Psi_\alpha + c_\beta \Psi_\beta \rightarrow \begin{pmatrix} \Psi_\alpha \\ \Psi_\beta \end{pmatrix}$$

Therefore , if you follow the laws of quantum mechanics , it turns out that the vacuum energy density at the Big Bang emerged as a result of the decoherence of the quantum state of the universe. Perhaps our universe emerged due to the destruction of the state of quantum entanglement of the physical vacuum .

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