Review of: "Is the Observational Dark Energy Universe Completely a Coincidence?"

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Potential competing interests: No potential competing interests to declare.

Dear Editor,

I have reviewed the manuscript titled \emph{“Is the Observational Dark Energy Universe Completely a Coincidence?”} by Angela Chen. The paper proposes a novel model suggesting that the universe's observed accelerated expansion could stem from time flow variations among different patches of spacetime, rather than invoking the anthropic principle or additional dark energy components. Below, I provide both technical comments and deep questions that may help refine the manuscript and clarify certain theoretical implications.

\section*{My Comments and Questions for the Author}

\textbf{1.} The author employs Raychaudhuri’s equation to connect relative acceleration among universe patches to a negative pressure term in Einstein’s equation. However, the derivation in Eq. (10), particularly the assumptions leading to $\delta\theta$ and $\delta\alpha$, would benefit from more clarification. Could the author provide more intermediate steps or assumptions made, especially where non-trivial congruence is introduced?

\textbf{2.} The model predicts that high-redshift observations should display a variance in time-flow consistent with high $\sigma^2(\alpha)$ values. Yet, the manuscript primarily discusses qualitative implications. Could the author include quantitative estimates or constraints on $\sigma^2(\alpha)$ based on current high-redshift data, especially JWST findings for supermassive black holes and early galaxies?

\textbf{3.} Equation (25) is intriguing in suggesting that dark energy scales with$\rho_m a^{-3}$ in high-redshift regimes. However, this implies a critical dependency on initial conditions. How does the model ensure consistency with both low and high-redshift measurements of the cosmological constant? Could the author also elaborate on potential deviations from the Friedmann equation in this framework?

\textbf{4.} The author suggests that $\alpha \sim 1/\tau$ in Eq. (13), thereby linking the cosmological constant’s decay with cosmic age. Could this dependency affect predictions in the early universe? Specifically, how does the author reconcile this with constraints from cosmic microwave background measurements on Ω_Λ?

\textbf{5.} Given the emphasis on time dilation as a source of dark energy, it would be valuable for the author to contrast this framework with the standard ΛCDM model explicitly. In particular:

$$R_{ab} - \frac{1}{2} R g_{ab} + \alpha^2 g_{ab} = T_{ab}$$

How does this relation alter the evolution of matter and radiation, particularly when considering the scale factor's impact on α?

I recommend including references (arXiv) such as:

- 2406.18095v1
- 2304.05807v4
- 0812.4005v1
- 1709.02384v2
- 1201.2110v2
- 2305.10815v1
- 2410.14492v1
- 2312.05948v2
- 1902.05365v2

Sincerely,