THE METHUSELAH STAR PARADOX: THE AGE OF THE UNIVERSE AS AN OBSERVER-DEPENDENT CONFIGURATION

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ABSTRACT

The paradox of the star HD 140283 (the Methuselah star), whose central age estimate (14.46 ± 0.8 Gyr [4]) exceeds the age of the Universe according to the Planck mission (13.787 ± 0.020 Gyr [5]), is examined. Different dating methods yield estimates ranging from 12 to 14 Gyr [6, 7, 8]. It is shown that within the Observer-Dependent Theory of Everything (ODTOE) [1] this spread is not a measurement error but reflects the difference of observation operators $\hat{O}_i$ applied to a single field of potential states Ψ: each method produces its own configuration $R_i = \hat{O}_i(\Psi)$. Three resolution mechanisms are proposed: retrocausality (Hawking–Hertog top-down cosmology [10] as a consequence of ODTOE Statement 4), time as the iteration index of the map Φ (rather than a coordinate), and structural incompleteness ($S < 1$ per Statement 3). It is shown that the "age of the Universe" is a configuration whose lifetime is determined by the coherence of the observer collective: $T_U = T_0/(1 - S_U)^n$ [1].

Keywords: Methuselah star, HD 140283, age of the Universe, observer-dependence, ODTOE, retrocausality, structural incompleteness.

I. INTRODUCTION

The star HD 140283, located in the constellation Libra at a distance of approximately 200 light-years from Earth, represents one of the most persistent chronological anomalies in modern astrophysics. In 2013, the team of Bond et al. [4], using Hubble Space Telescope fine guidance sensor data, estimated the star's age at 14.46 ± 0.8 Gyr. The age of the Universe according to the Planck mission is 13.787 ± 0.020 Gyr [5]. The central estimates yield a discrepancy of approximately 660 Myr: the object appears older than the space containing it.

Subsequent re-evaluations using various methods produced a spread: 12.0 ± 0.5 Gyr (CHARA interferometry and MESA models, Tang and Joyce, 2021) [6], 14.2 ± 0.4 Gyr (asteroseismic analysis, 2025) [8], and 12 to 14 Gyr depending on chemical abundances (Guillaume et al., 2024) [7]. A spread of two billion years for a single object is not the error of any individual measurement.

Standard cosmology resolves the paradox by refining uncertainties: within the error bars, there is formally no contradiction. This approach places the problem

within the uncertainty band but does not explain why different methods systematically diverge.

The goal of this paper is to show that the Observer-Dependent Theory of Everything (ODTOE) [1] offers three complementary resolution mechanisms based on the axiom of observer-dependence, the iterative nature of time, and structural incompleteness.

II. THE PROBLEM IN ODTOE TERMS

II.1. Axiom (A) and observer-dependence of age

The ODTOE axiom [1] states: the observer constitutes the observable, and the result of any experiment depends on the observer:

$$R = \hat{O}(\Psi) \tag{A.1}$$

The age of a star is not a property of the star itself but an element of the configuration R generated by the act of observation. The dating method (spectroscopy, parallax, asteroseismology) is the choice of a specific operator $\hat{O}_i$. Each method generates its own configuration $R_i = \hat{O}_i(\Psi)$. The two-billion-year spread is a consequence of the difference between observation operators acting on the same field of potential states.

II.2. The age of the Universe as a collective observation configuration

The value of 13.8 Gyr is a configuration R_U stabilized by the collective observation of the scientific community. By Postulate P5 [1], the collective probability is determined by the superposition of individual beliefs:

$$P_{\text{coll}}(E) = 1 - \prod_{i=1}^{m}(1 - B_i^k) \tag{P5.1}$$

The high coherence S of the scientific community regarding the ΛCDM model provides the configuration with a long lifetime according to formula P3.1 [1]:

$$T(C) = \frac{T_0}{(1-S)^n} \tag{P3.1}$$

This stability is a property of observer coherence, not a property of the Universe itself. Anomalous objects such as HD 140283 are points where the configuration inertia $I(C)$ weakens and an alternative configuration emerges.

III. THREE RESOLUTION MECHANISMS

III.1. Retrocausality

ODTOE formalizes Wheeler's self-excited circuit [9] and Hawking–Hertog top-down cosmology [10] through Statement 4 [1]: the fixed point of self-observation $\Psi^* = \Phi(\Psi^*)$ closes a loop in which the past and the present mutually condition each other.

The Universe does not have an absolute beginning from which time can be counted linearly. The self-observation map $\Phi(\Psi) = \iota(\hat{O}_\Psi(\Psi))$ determines the causal structure retrospectively: the observer in the present selects the cosmological history compatible with its current state.

HD 140283 and the Universe are observed by the same observer but through different operators: $\hat{O}_{\text{star}}$ (spectral analysis, parallax) and $\hat{O}_{\text{universe}}$ (cosmic microwave background, ΛCDM model). The paradox arises not in reality but at the point of incompatibility between two operators.

III.2. Time as an iteration index

In ODTOE, time is not a continuous coordinate of spacetime but the iteration index of the map Φ [1]. Each time step is one full cycle of self-observation:

$$\Psi_{n+1} = \Phi(\Psi_n) = \iota(\hat{O}_{\Psi_n}(\Psi_n)) \tag{III.1}$$

The age of an object is the number of iterations n elapsed from some initial configuration. However, the initial configuration is the fixed point Ψ^* itself, not an absolute beginning.

Let n_{star} be the number of self-observation iterations generating the configuration "star HD 140283," and n_{universe} the number of iterations generating the configuration "observable Universe." The paradox $n_{\text{star}} > n_{\text{universe}}$ is resolved if n_{star} and n_{universe} are counted from different fixed points of the hierarchy $\Psi^*_{d-1} \subset \Psi^*_d \subset \Psi^*_{d+1}$ (the principle of recursive self-similarity) [3].

III.3. Structural incompleteness

Statement 3 of ODTOE [1] establishes that absolute coherence $S = 1$ is unattainable — a consequence of the self-referentiality of the strange loop [11] (analogous to Gödel's theorem). A unified, fully self-consistent chronology is impossible. There always exists an informational remainder that does not fit into the closed architecture.

The discrepancy between the star's age and the age of the Universe is the materialization of the structural incompleteness of the current cosmological configuration. This is not an error to be eliminated but a manifestation of a fundamental limitation: no chronological model can close all observations into a self-consistent system, since $S < 1$ always.

IV. THE AGE FORMULA THROUGH ODTOE

IV.1. Age as configuration lifetime

The observed age of the Universe T_U is the lifetime of the configuration C_U (the observed cosmological model):

$$T_U = \frac{T_0}{(1 - S_U)^n} \tag{IV.1}$$

where S_U is the coherence of the observer collective regarding the ΛCDM configuration, and T_0 is the base lifetime at full desynchronization.

Consequence: T_U depends on S_U. As anomalies accumulate (HD 140283, the Hubble tension, the S_8 tension, early galaxies detected by JWST), coherence S_U decreases, and the configuration $T_U = 13.8$ Gyr loses its stability.

IV.2. Age as projection

By analogy with the operator $\hat{O}$ that projects $\mathcal{H} \to \mathcal{C}$ (destroying information about the orthogonal component), the measured age is a projection of the multidimensional state of the field Ψ onto a one-dimensional time scale. The irreversibility of projection means that information about the full state of the configuration is lost with each act of observation.

Different dating methods are different projections, and their results need not coincide, just as projections of a three-dimensional object onto different planes yield different images.

V. CONSEQUENCES AND PREDICTIONS

V.1. Systematic nature of chronological anomalies

If the ODTOE interpretation is correct, analogous chronological anomalies should be detected systematically. Modern cosmology records a number of "tensions": the discrepancy in the determination of the Hubble constant H_0 by different methods, the S_8 discrepancy between CMB data and large-scale structure observations, and the detection of unexpectedly mature galaxies at high redshifts by the James Webb Space Telescope. All these anomalies are manifestations of the incompatibility of observation operators applied to the same field Ψ.

V.2. The age of the Universe is not an invariant

In standard cosmology, the age of the Universe is a fixed quantity. In ODTOE, it is a configuration that depends on observer coherence. As new anomalies are

discovered, S_U will decrease, the number of admissible theories N_{theories} will grow (by formula P6.1 [1]), and the configuration $T_U = 13.8$ Gyr will lose its monopoly status.

VI. DISCUSSION AND LIMITATIONS

1. *Epistemic status.* Observer-dependence of measurement (axiom A), dependence of the result on operator choice, and the impossibility of an absolute chronology ($S = 1$ is unattainable) follow from the ODTOE formalism. The identification of chronological anomalies with the materialization of structural incompleteness is a speculative interpretation. The formalization of the relationship between the number of iterations n and observed time is an open problem.

2. *Operator specification.* The specific form of the operators $\hat{O}_{\text{star}}$ and $\hat{O}_{\text{universe}}$ is not determined in the present work. Their formalization requires a separate study.

3. *Data reproducibility.* The results of [4] were obtained using Hipparcos parallax; Gaia DR3 data may lead to a revision of the distance estimate and, consequently, the age.

4. *Retrocausality.* The mechanism described in Section III.1 is consistent with Hawking–Hertog cosmology [10] but does not yield quantitative predictions beyond qualitative correspondence.

VII. CONCLUSION

The Methuselah star paradox is not a measurement error but a manifestation of the observer-dependence of reality. Within ODTOE, age is not a property of an object but an element of the configuration $R = \hat{O}(\Psi)$, determined by the choice of the observation operator and the coherence of the observer collective.

Three resolution mechanisms complement each other: retrocausality (the past is determined by present observation), time as an iteration index (ages are counted from different fixed points of the hierarchy and need not be comparable), and structural incompleteness (a unified self-consistent chronology is impossible given $S < 1$).

The age of the Universe $T_U = T_0/(1 - S_U)^n$ is a configuration whose stability is determined by observer coherence, not an absolute fact about the cosmos.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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