A Note on the Coincidence Between the Rydberg Energy Scale and the Total Energy of the Observable Universe

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Abstract

This note reports a striking numerical coincidence observed at the current cosmological epoch ($z \approx 0$). We observe that the product of the total number of photons in the observable universe (N_γ) and the Rydberg ionization energy of hydrogen (E_R) approximates the estimated total mass-energy of the observable universe ($E_{univ} \approx 10^{71}$ J). While this relationship may be a temporal coincidence, the precision of the match suggests a phenomenological scaling of interest to cosmological heuristic models.

1 Introduction

The search for relationships between the microscopic scales of quantum mechanics and the macroscopic scales of cosmology has a long history in theoretical physics. Large Number Hypotheses often seek to identify scaling laws that connect these distinct domains. This note documents a specific numerical resonance between the energy scale of atomic stability (the hydrogen atom) and the total energy budget of the observable cosmos.

2 The Calculation

2.1 The Atomic Scale

We utilize the Rydberg energy (E_R), which represents the ionization energy of the hydrogen atom in its ground state ($n = 1$). This is the fundamental energy scale for baryonic matter stability.

$$E_R = 13.6057 \text{ eV} \tag{1}$$

$$E_R \approx 2.179 \times 10^{-18} \text{ Joules} \tag{2}$$

2.2 The Cosmic Scale

The total information content of the universe is approximated by the total number of photons (N_γ) within the particle horizon. This is derived from the Cosmic Microwave Background (CMB) density and the volume of the observable universe.

Using standard Planck 2018 cosmological parameters:

- CMB Photon Density (n_γ): ≈ 411 cm^{-3}

- Comoving Radius (R_H): $\approx 4.4 \times 10^{26}$ m

- Observable Volume (V_u): $\approx 3.56 \times 10^{80}$ m^3

The total photon count is:

$$N_\gamma = n_\gamma \times V_u \approx 1.46 \times 10^{89} \tag{3}$$

2.3 The Scaling Relation

We compute the product (E_{calc}) of the cosmic photon count and the atomic energy unit:

$$E_{calc} = N_\gamma \times E_R \tag{4}$$

$$E_{calc} \approx (1.46 \times 10^{89}) \times (2.179 \times 10^{-18} \text{ J}) \tag{5}$$

$$E_{calc} \approx 3.18 \times 10^{71} \text{ Joules} \tag{6}$$

3 Comparison and Conclusion

Current cosmological estimates for the total mass-energy of the observable universe (based on the critical density and volume) yield a value in the range of:

$$E_{univ} \approx 2.7 \times 10^{71} \text{ Joules} \tag{7}$$

The calculated value $(3.18 \times 10^{71}$ J) and the expected value $(2.7 \times 10^{71}$ J) align within the same order of magnitude.

We conclude that:

$$E_{univ} \approx N_\gamma E_R \tag{8}$$

Whether this relation implies a fundamental holographic constraint on the vacuum energy or merely represents a transient numerical coincidence of the current epoch remains an open question. However, the alignment of these two vastly different scales—atomic and cosmic—is sufficiently precise to warrant documentation.

Acknowledgements

References

[1] Planck Collaboration. (2020). "Planck 2018 results. VI. Cosmological parameters". *Astronomy & Astrophysics*, 641, A6.