Scientific Research Publishing

Journal of Applied Mathematics and Physics, 2025, 13(6), 2128-2136
https://www.scirp.org/journal/jamp
ISSN Online: 2327-4379
ISSN Print: 2327-4352

The Upsilon Equation in $R_H = ct$ Cosmology—A Summary of Recent Progress

Eugene Terry Tatum[1], U. V. S. Seshavatharam[2]

[1]Independent Researcher, Bowling Green, KY, USA
[2]Honorary Faculty, I-SERVE, Hitech City, Hyderabad, India
Email: ett@twc.com, seshavatharam.uvs@gmail.com

How to cite this paper: Tatum, E.T. and Seshavatharam, U.V.S. (2025) The Upsilon Equation in *RH* = *ct* Cosmology—A Summary of Recent Progress. *Journal of Applied Mathematics and Physics*, **13**, 2128-2136.
https://doi.org/10.4236/jamp.2025.136119

Received: May 16, 2025
Accepted: June 27, 2025
Published: June 30, 2025

Copyright © 2025 by author(s) and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/
Open Access

Abstract

This paper provides a brief historical summary of recent progress made with respect to the Upsilon constant linkage between the time-dependent Hubble parameter and the time-dependent cosmic temperature. We discuss how our original $R_H = ct$ variant model, called Flat Space Cosmology (FSC), has evolved, including how it has recently been used as an approach to resolving the Hubble tension, to extend the cosmic age to alleviate the early galaxy formation problem, and to provide highly useful Friedmann equations in thermodynamic form. A new and tantalizing cosmic rotation resolution of the Hubble tension using FSC is also briefly discussed, including whether it could also explain "dark energy" observations.

Keywords

Upsilon Constant, Hubble Constant, CMB Temperature, Flat Space Cosmology, Black Hole Cosmology, $R_H = ct$ Model, Thermodynamic Friedmann Equations, Cosmic Age, Early Galaxy Formation Problem, Cosmic Rotation, Dark Energy, Hubble Tension

1. Introduction and Background

Following an early publication of the Planck satellite survey findings [1], we put together a model of black hole cosmology in 2015 and published it under the title of "The Basics of Flat Space Cosmology" [2]. This "FSC model" variant of $R_H = ct$ linear expansion treats the universe from inception as if it were a steadily growing and adiabatically expanding black hole, wherein its spherical cosmic horizon always translates outward at the speed of light c with respect to a centrally located imaginary observer. Following such key assumptions, the model Hubble parameter H_t as well as its angular velocity parameter ω_t is always defined as c/R_t wherein

R_t is the cosmic radius at any time t. As with most other black hole models, the ratio of total cosmic Hubble mass M_t to R_t follows the Schwarzschild formula and equals $c^2/2G$ at any time t, as one might expect for a cosmic black hole. Furthermore, the cosmic temperature formula at any time t follows:

$$\left.\begin{array}{l} k_B T_t \cong \dfrac{\hbar c^3}{8\pi G\sqrt{M_t M_{pl}}} \cong \dfrac{\hbar c}{4\pi\sqrt{R_t R_{pl}}} \\ \begin{cases} M_t \cong \left(\dfrac{\hbar c^3}{8\pi G k_B T_t}\right)^2 \dfrac{1}{M_{pl}} & \text{(A)} \\ R_t \cong \dfrac{1}{R_{pl}}\left(\dfrac{\hbar c}{4\pi k_B}\right)^2 \left(\dfrac{1}{T_t}\right)^2 & \text{(B)} \\ R_t T_t^2 \cong \dfrac{1}{R_{pl}}\left(\dfrac{\hbar c}{4\pi k_B}\right)^2 & \text{(C)} \\ t \cong \dfrac{R_t}{c} & \text{(D)} \end{cases} \end{array}\right\} \tag{1}$$

wherein T_t is the time-dependent cosmic temperature, M_{pl} is the Planck mass, and R_{pl} is our "Planck radius", which we define as the Schwarzschild radius of the original Planck mass black hole, equal to two Planck lengths, $2l_p$. All other symbols are the well-known physical constants. One can readily see that the top equation is much like the Hawking black hole temperature formula, with the exception that the mass and radius terms in the denominators are geometric mean terms, which we believe must follow for a growing and expanding (as opposed to static or steady state) black hole cosmology. However, one should realize that M_t of the original Planck mass cosmic epoch equals M_{pl}, which reduces the geometric mean terms of the top equation to those of Hawking's black hole formula. Furthermore, as clearly demonstrated in our original 2015 publication, our model mass and energy density formulae reduce to $3H_t/8\pi G$ and $3H_t c^2/8\pi G$, respectively, at all times t. Thus, the FSC model, as a direct result of its growing black hole assumptions, is *always* at the Friedmann critical density; hence, the model name 'Flat Space Cosmology' seems appropriate.

One can readily see from such a model that c/R_t not only represents the time-dependent model Hubble parameter but could also represent the time-dependent angular velocity ω if we can further assume that the model also has approximate light-speed rotation at the expanding horizon. The following derivations come from the same 2015 FSC paper:

$$\left.\begin{array}{l} \to RT_R^2 \cong \dfrac{1}{R_{pl}}\left(\dfrac{\hbar c}{4\pi k_B}\right)^2 \cong 1.0272646\times 10^{27}\ \text{m}\cdot\text{K}^2 \\ \text{and}\quad \dfrac{T_R^2}{\omega_R} \cong \dfrac{c}{R_{pl}}\left(\dfrac{\hbar}{4\pi k_B}\right)^2 \cong \omega_{pl}\left(\dfrac{\hbar}{4\pi k_B}\right)^2 \\ \Rightarrow \dfrac{\omega_R}{T_R^2} \cong \dfrac{1}{\omega_{pl}}\left(\dfrac{4\pi k_B}{\hbar}\right)^2 \cong 2.918356766\times 10^{-19}\ \text{K}^{-2}\cdot\text{sec}^{-1} \end{array}\right\} \tag{2}$$

Here it is only necessary for the reader to see that the term on the bottom left is also consistent with a time-dependent Hubble parameter H_t divided by the square of its time-dependent cosmic temperature, T_t^2 (*i.e.*, H_t/T_t^2). And, if we were to represent the bottom right constant with the Latin symbol for Upsilon ($\mho$), we could rearrange the bottom equation as:

$$H_t = \mho T_t^2 \tag{3}$$

Equation (3) is what we now refer to as the "Upsilon Equation". The importance of this relation is that, in our particular linear $R_H = ct$ variant model, the Hubble parameter can now be seen as a cosmic thermodynamic parameter which can be directly linked to the time-dependent cosmic temperature, including, for example, the Cosmic Microwave Background (CMB) temperature, in a remarkably simple way. Another way to demonstrate this important relationship is by showing once again some of the derived FSC 'quantum cosmology' formulae published in 2018 [3]:

$$R \cong \frac{\hbar^{3/2}c^{7/2}}{32\pi^2 k_B^2 T^2 G^{1/2}} \qquad R_0 \cong \frac{\hbar^{3/2}c^{7/2}}{32\pi^2 k_B^2 T_0^2 G^{1/2}} \tag{4}$$

$$H \cong \frac{32\pi^2 k_B^2 T^2 G^{1/2}}{\hbar^{3/2}c^{5/2}} \qquad H_0 \cong \frac{32\pi^2 k_B^2 T_0^2 G^{1/2}}{\hbar^{3/2}c^{5/2}} \tag{5}$$

$$t \cong \frac{\hbar^{3/2}c^{5/2}}{32\pi^2 k_B^2 T^2 G^{1/2}} \qquad t_0 \cong \frac{\hbar^{3/2}c^{5/2}}{32\pi^2 k_B^2 T_0^2 G^{1/2}} \tag{6}$$

$$M \cong \frac{\hbar^{3/2}c^{11/2}}{64\pi^2 k_B^2 T^2 G^{3/2}} \qquad M_0 \cong \frac{\hbar^{3/2}c^{11/2}}{64\pi^2 k_B^2 T_0^2 G^{3/2}} \tag{7}$$

$$Mc^2 \cong \frac{\hbar^{3/2}c^{15/2}}{64\pi^2 k_B^2 T^2 G^{3/2}} \qquad M_0c^2 \cong \frac{\hbar^{3/2}c^{15/2}}{64\pi^2 k_B^2 T_0^2 G^{3/2}} \tag{8}$$

One should pay particular attention to Equations (4) and (5). Using our model Hubble parameter definition, one can divide the speed of light c by the radius formulae in (4) to arrive at the Hubble parameter equations of (5), wherein the left equation is the generic time-dependent formula, and the right equation is the formula using the current CMB temperature. Using the 2009 Fixsen CMB temperature of 2.72548 K [4] as T_0, for example, the right equation of (5) gives a current Hubble constant value of 66.89 km/s/Mpc after conversion of S.I. units (s^{-1}) to the conventional km/s/Mpc units. See again [3] for details.

With respect to the current paper, it is only important to recognize that the Hubble parameter equations in (5) are also Upsilon equations, which can be reduced to $H_t = \mho T_t^2$ and $H_0 = \mho T_0^2$, respectively. As has been derived in a different way, in reference [5], Upsilon is a compound constant with the following value:

$$\mho \cong \frac{k_b{}^2 32\pi^2 G^{1/2}}{c^{5/2}\hbar^{3/2}} \cong 2.91845601\times10^{-19} \pm 0.00003279\times10^{-19}\ \text{s}^{-1}\cdot\text{K}^{-2} \tag{9}$$

This is the same ratio of constants as seen in Equations (5). Notice that the value and units of Upsilon are also the same as first given in 2015 [see again relations

(2) above]. For the interested reader, reference [6] summarizes the most important FSC publications as of 2021.

The primary purpose of this paper is to briefly summarize recent progress made in demonstrating the importance of the Upsilon constant and the Upsilon equation in our particular variant of $R_H = ct$ cosmology. These developments will be the subject of the Results section.

2. Results (Recent Progress)

To the best of our knowledge, the first publication to explicitly demonstrate that the top thermodynamic equation of relations (1) above can be independently derived using the Stefan-Boltzmann Law is the paper of Haug & Wojnow [7]. This was an important development, because the Stefan-Boltzmann Law applies only to perfect or near-perfect black body spectra, such as the CMB spectrum. Thus, it would be expected that the thermodynamics of a black hole cosmology model should rigorously adhere to the Stefan-Boltzmann Law throughout its adiabatic expansion. This is true of the FSC model of nature's presumed most perfect black body, a cosmic black hole, but does not appear to be the case in the current standard model of cosmology known as ΛCDM.

Another important recent development for the FSC model came with the publication by Haug & Tatum [8] of a proposed solution to the Hubble tension problem. This publication describes in explicit detail how the thermodynamic assumptions of the 2015 FSC model can be used to derive cosmological redshift-vs-distance equations which have been used to *match* the full distance ladder of the PantheonPlusSH0ES supernova redshift database. This powerful mathematical approach making use of FSC has been referred to as the Haug & Tatum Cosmology (HTC) model in order to emphasize its utility in evaluating the Hubble tension. HTC has also been used to extract the current NIST CODATA value of the Planck length from the Union2 supernova redshift database [9]. HTC applied to the full distance ladder of the Union2 supernova redshift database also supports a more realistic current cosmic age of 14.6 billion years [10]. This extension of the cosmic age by about 800 - 820 million years (in comparison to the ΛCDM model) perhaps fits better with JWST observations of "mature" galaxies in the early universe [11], as well as with age estimates [12] [13] of the Milky Way galaxy star HD 140283, also known as the "Methuselah star".

One of the interesting features of the top FSC equation of (1) above is that the geometric mean terms in the denominators suggest an entirely new way to understand the nature of the average cosmic temperature, including the current CMB temperature. A rigorous mathematical approach has recently shown that the evolving CMB temperature could be an evolving geometric mean temperature of the Hawking Hubble sphere temperature (an evolving minimum temperature) and the Planck temperature (the presumed maximum possible temperature within the Hubble sphere) [14]. Thus, the geometric mean terms in the denominators of the FSC cosmic temperature formula might now be understood in an entirely new way than in the past.

A particularly interesting new development with respect to useful applications of the Upsilon equation is that it can also be expressed as:

$$H_t = \mho T_t^2 = \mho T_0^2 \left(1+z\right)^2 \quad (10)$$

wherein Equation (10) incorporates Upsilon with the empirically supported cosmic relation $T_t = T_0(1 + z)$, which is also a fundamental relation in the recent HTC publications referenced above. The Upsilon equation can, therefore, be seamlessly integrated into the cosmological Friedmann equations in place of the Hubble parameter. The novelty of such an approach is that the relatively large uncertainties in the appropriate value of the Hubble parameter, aggravated by the current Hubble tension, can potentially be vastly reduced by incorporating the tightly constrained CMB temperature T_0 or T_t into the Friedmann equations for various cosmological parameters. This approach has resulted in numerous cosmological thermodynamic Friedmann equations incorporating Upsilon [15]. Additional equations incorporating Upsilon can also be seen in the tables of reference [9]. Such equations carry with them the tighter constraints of CMB temperature measurements in comparison to the current constraints with respect to the measured values of the Hubble constant.

Proponents of the ΛCDM model are sometimes willing to dismiss out-of-hand the predictions of various $R_H = ct$ models. To this, we can only suggest that they carefully read the many recent comparison studies made by Melia, a strong proponent of $R_h = ct$ cosmology in comparison to ΛCDM [16]-[22]. Since FSC and HTC are "growing black hole" $R_h = ct$ variants closely aligned with Melia's arguments in favor of such linear expansion models in general, the Melia comparison studies are well worth reading. HTC reference [15] makes a number of strong arguments in support of Melia's work.

3. Discussion

The recent progress in the evolution of the 2015 FSC model occurred soon after publication of the FSC "quantum cosmology" formulae in 2018; see again [3]. It became quite apparent that the Hubble parameter can be directly linked to cosmic temperature in an expanding linear black hole cosmology model using the compound constant now referred to as Upsilon. After 2018, the next major developments were mathematical derivations of the thermodynamic FSC relation (1) using *either* the Stefan-Boltzmann Law for black bodies *or* the completely novel geometric mean mathematical approach. These developments in the last few years not only appear to support the foundational nature of the FSC thermodynamic relation (1), but also support current suggestions made by cosmologists in recent years that our universe has many features not unlike those of a growing black hole [23]-[33].

New studies in support of a black hole origin and character of our universe have come very recently to our attention. The first of these is the *observational* report of significant galactic rotation anisotropy by Shamir [34]. Shamir suggests several possible explanations for his findings. These are broadly divided into two categories: the physics of galaxy rotation (which we will not further consider herein); or an anomaly in the large-scale structure of the universe. Within the latter category remains the possibility that the universe has, or had, an axis of rotation, such as can be found in theories of black hole cosmology. FSC is one such model listed by Shamir. A second study in possible support of a rotating black hole-like universe, by Szigeti *et al.* [35], is a *theoretical* approach to the current Hubble tension problem. It asks the question whether cosmic rotation could solve the Hubble tension. Tantalizingly, their Fig. 2 appears to indicate (at the top of this figure) that a value of "$H_0(\omega_0)$ = 66.89" with narrow constraints could explain the apparent tension between the H_{CMB} and H_{SNe} values of 67.4 +/− 0.5 and 73.01 +/− 1.07 km/s/Mpc, respectively. Of note, we refer the reader to Equation (5) of our 2015 rotating and growing black hole FSC model paper (see again [2]), wherein $H_0(\omega_0)$ derived from our assumptions was reported to be 66.89 km/s/Mpc. Since this is exactly the $H_0(\omega_0)$ value calculated by Szigeti *et al.*, our 2015 FSC model appears to offer a fairly simple *cosmic rotation* explanation for the Hubble tension problem. Furthermore, one wonders if the mysterious 'dark energy' manifests from an inertial force (*i.e.*, a "pseudo-force") produced by cosmic rotation. We eagerly await the results of similar studies concerning the subjects of cosmic rotation and the fundamental nature of dark energy.

4. Summary and Conclusion

This paper has shown how the 2015 FSC model variant of $R_H = ct$ cosmology has evolved since its inception. An important recent development has included derivations of the relevant "quantum cosmology" formulae of Equations (4) through (8), including what is now referred to as the Upsilon formula of Equation (10). It now appears that the current accepted value of the Upsilon compound constant was first correctly calculated in 2015. Rapid progress in the last couple of years has included the following: independent Stefan-Boltzmann Law and geometric mean derivations of the FSC cosmic temperature formula; derivations of useful cosmological redshift-vs-distance FSC formulae; Haug & Tatum's use of multiple supernova redshift databases to offer several possible solutions to the Hubble tension and to extend the cosmic age to alleviate the early galaxy formation problem; use of the Upsilon formula of Equation (10) to create highly useful Friedmann type equations in thermodynamic form; application of the FSC Hubble parameter and angular velocity formulae to suggest that the rotating and growing black hole 2015 FSC model could potentially explain the respective observational and theoretical rotational studies reported recently by Shamir and Szigeti *et al.* In addition, we wonder if our rotational model could offer a possible explanation for what is currently referred to as "dark energy". In summary, it appears to us that a rotating and growing black hole variant $R_H = ct$ cosmology model, such as 2015 FSC with its recent developments, can better offer the above possible solutions and explanations, in comparison to ΛCDM cosmology. Nevertheless, we fully agree that more robust observational evidence is needed to convincingly demonstrate our model's validity and its superiority over ΛCDM.

5. Dedications and Acknowledgements

This paper is dedicated to Stephen Hawking and Roger Penrose for their groundbreaking work on black holes and their possible application to cosmology. Dr. Tatum would also like to thank Rudolf Schild of the Harvard-Smithsonian Center for Astrophysics for his support and encouragement in developing this subject. Author Seshavatharam is indebted to professors Padma Shri M. Nagaphani Sarma, Chairman, Shri K.V. Krishna Murthy, founder Chairman, Institute of Scientific Research in Vedas (I-SERVE), Hyderabad, India and Shri K.V.R.S. Murthy, former scientist IICT (CSIR), Govt. of India, Director, Research and Development, I-SERVE, for their valuable guidance and great support in developing this subject. Finally, both authors would also like to thank Professor Espen Gaarder Haug for his continued interest in, and suggested improvements of, our FSC model.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Planck Collaboration (2014) Planck 2013 Results. XVI. Cosmological Parameters. *Astronomy & Astrophysics*, **571**, Article No. E1. https://doi.org/10.1051/0004-6361/201425195

[2] Tatum, E.T., Seshavatharam, U.V.S. and Lakshminarayana, S. (2015) The Basics of Flat Space Cosmology. *International Journal of Astronomy and Astrophysics*, **5**, 116-124. https://doi.org/10.4236/ijaa.2015.52015

[3] Tatum, E.T. (2018) Why Flat Space Cosmology Is Superior to Standard Inflationary Cosmology. *Journal of Modern Physics*, **9**, 1867-1882. https://doi.org/10.4236/jmp.2018.910118

[4] Fixsen, D.J. (2009) The Temperature of the Cosmic Microwave Background. *The Astrophysical Journal*, **707**, 916-920. https://doi.org/10.1088/0004-637x/707/2/916

[5] Tatum, E.T., Haug, E.G. and Wojnow, S. (2024) Predicting High Precision Hubble Constant Determinations Based on a New Theoretical Relationship between CMB Temperature and H_0. *Journal of Modern Physics*, **15**, 1708-1716. https://doi.org/10.4236/jmp.2024.1511075

[6] Tatum, E.T. and Seshavatharam, U.V.S. (2021) Flat Space Cosmology—A New Model of the Universe Incorporating Astronomical Observations of Black Holes, Dark Energy and Dark Matter. Universal Publishers.

[7] Haug, E.G. and Wojnow, S. (2024) How to Predict the Temperature of the CMB Directly Using the Hubble Parameter and the Planck Scale Using the Stefan-Boltzmann Law. *Journal of Applied Mathematics and Physics*, **12**, 3552-3566. https://doi.org/10.4236/jamp.2024.1210211

[8] Haug, E.G. and Tatum, E.T. (2025) Solving the Hubble Tension Using the Pantheonplussh0es Supernova Database. *Journal of Applied Mathematics and Physics*, **13**, 593-

622. https://doi.org/10.4236/jamp.2025.132033

[9] Haug, E.G. and Tatum, E.T. (2025) Finding the Planck Length from the Union2 Supernova Database in a Way That Appears to Resolve the Hubble Tension. *Journal of Applied Mathematics and Physics*, **13**, 2063-2089. https://www.scirp.org/journal/paperinformation?paperid=143528

[10] Tatum, E.T. and Haug, E.G. (2025) Extracting a Cosmic Age of 14.6 Billion Years from All 580 Supernova Redshifts in the Union2 Database. *Journal of Modern Physics*, **16**, 507-517. https://doi.org/10.4236/jmp.2025.164026

[11] Ferreira, L., Conselice, C.J., Sazonova, E., Ferrari, F., Caruana, J., Tohill, C., *et al.* (2023) The JWST Hubble Sequence: The Rest-Frame Optical Evolution of Galaxy Structure at 1.5 < Z < 6.5. *The Astrophysical Journal*, **955**, Article 94. https://doi.org/10.3847/1538-4357/acec76

[12] VandenBerg, D.A., Bond, H.E., Nelan, E.P., Nissen, P.E., Schaefer, G.H. and Harmer, D. (2014) Three Ancient Halo Subgiants: Precise Parallaxes, Compositions, Ages, and Implications for Globular Clusters. *The Astrophysical Journal*, **792**, Article 110. https://doi.org/10.1088/0004-637x/792/2/110

[13] Guillaume, C., Buldgen, G., Amarsi, A.M., Dupret, M.A., Lundkvist, M.S., Larsen, J.R., *et al.* (2024) The Age of the Methuselah Star in the Light of Stellar Evolution Models with Tailored Abundances. *Astronomy & Astrophysics*, **692**, L3. https://doi.org/10.1051/0004-6361/202451782

[14] Haug, E.G. and Tatum, E.T. (2024) The Hawking Hubble Temperature as the Minimum Temperature, the Planck Temperature as the Maximum Temperature, and the CMB Temperature as Their Geometric Mean Temperature. *Journal of Applied Mathematics and Physics*, **12**, 3328-3348. https://doi.org/10.4236/jamp.2024.1210198

[15] Haug, E.G. and Tatum, E.T. (2025) Friedmann Type Equations in Thermodynamic Form Lead to Much Tighter Constraints on the Critical Density of the Universe. *Discover Space*, **129**, Article No. 6. https://doi.org/10.1007/s11038-025-09566-y

[16] Melia, F. and Shevchuk, A.S.H. (2011) The $R_h = ct$ Universe. *Monthly Notices of the Royal Astronomical Society*, **419**, 2579-2586. https://doi.org/10.1111/j.1365-2966.2011.19906.x

[17] Melia, F. (2012) Cosmological Redshift in Friedmann-Robertson-Walker Metrics with Constant Space-Time Curvature. *Monthly Notices of the Royal Astronomical Society*, **422**, 1418-1424. https://doi.org/10.1111/j.1365-2966.2012.20714.x

[18] Melia, F. (2013) The $R_h = ct$ Universe without Inflation. *Astronomy & Astrophysics*, **553**, A76. https://doi.org/10.1051/0004-6361/201220447

[19] Melia, F. (2016) The Linear Growth of Structure in the $R_h = ct$ Universe. *Monthly Notices of the Royal Astronomical Society*, **464**, 1966-1976. https://doi.org/10.1093/mnras/stw2493

[20] Melia, F. and López-Corredoira, M. (2016) Alcock-Paczyński Test with Model-Independent BAO Data. *International Journal of Modern Physics D*, **26**, Article ID: 1750055. https://doi.org/10.1142/s0218271817500559

[21] Melia, F. (2023) A Resolution of the Monopole Problem in the $R_h = ct$ Universe. *Physics of the Dark Universe*, **42**, Article ID: 101329. https://doi.org/10.1016/j.dark.2023.101329

[22] Melia, F. (2024) Strong Observational Support for the $R_h = ct$ Timeline in the Early Universe. *Physics of the Dark Universe*, **46**, Article ID: 101587. https://doi.org/10.1016/j.dark.2024.101587

[23] Pathria, R.K. (1972) The Universe as a Black Hole. *Nature*, **240**, 298-299.

https://doi.org/10.1038/240298a0

[24] Easson, D.A. and Brandenberger, R.H. (2001) Universe Generation from Black Hole Interiors. *Journal of High Energy Physics*, **2001**, Article 24. https://doi.org/10.1088/1126-6708/2001/06/024

[25] Christillin, P. (2014) The Machian Origin of Linear Inertial Forces from Our Gravitationally Radiating Black Hole Universe. *The European Physical Journal Plus*, **129**, Article No. 175. https://doi.org/10.1140/epjp/i2014-14175-2

[26] Zhang, T.X. and Frederick, C. (2013) Acceleration of Black Hole Universe. *Astrophysics and Space Science*, **349**, 567-573. https://doi.org/10.1007/s10509-013-1644-6

[27] Popławski, N. (2016) Universe in a Black Hole in Einstein-Cartan Gravity. *The Astrophysical Journal*, **832**, Article 96. https://doi.org/10.3847/0004-637x/832/2/96

[28] Zhang, T.X. (2018) The Principles and Laws of Black Hole Universe. *Journal of Modern Physics*, **9**, 1838-1865. https://doi.org/10.4236/jmp.2018.99117

[29] Gaztanaga, E. (2022) The Black Hole Universe, Part I. *Symmetry*, **14**, Article 1849. https://doi.org/10.3390/sym14091849

[30] Roupas, Z. (2022) Detectable Universes Inside Regular Black Holes. *The European Physical Journal C*, **82**, Article No. 255. https://doi.org/10.1140/epjc/s10052-022-10202-6

[31] Siegel, E. (2022) Are We Living in a Baby Universe that Looks Like a Black Hole to Outsiders? Forbes Archives. https://bigthink.com/hard-science/baby-universes-black-holes-dark-matter/

[32] Lineweaver, C.H. and Patel, V.M. (2023) All Objects and Some Questions. *American Journal of Physics*, **91**, 819-825. https://doi.org/10.1119/5.0150209

[33] Seshavatharam, U.V.S. and Lakshminarayana, S. (2023) A Rotating Model of a Light Speed Expanding Hubble-Hawking Universe. *Physical Sciences Forum*, **7**, Article 43. https://doi.org/10.3390/ecu2023-14065

[34] Shamir, L. (2025) The Distribution of Galaxy Rotation in *JWST* Advanced Deep Extragalactic Survey. *Monthly Notices of the Royal Astronomical Society*, **538**, 76-91. https://doi.org/10.1093/mnras/staf292

[35] Szigeti, B.E., Szapudi, I., Barna, I.F. and Barnaföldi, G.G. (2025) Can Rotation Solve the Hubble Puzzle? *Monthly Notices of the Royal Astronomical Society*, **538**, 3038-3041. https://doi.org/10.1093/mnras/staf446