$SU(2) \times U(1)$ model" (see, e.g., Refs. [10, 18]), the hot big bang model (see, e.g., Refs. [6-12]) and "the SUSY GUT transition" (see, e.g., Ref. [7]), used in Refs. [1-5], which are the fundamental basis of this work.

The "dark energy" was not introduced a priori in the ΛCDM model. This dark energy is based on the convincing experimental observation of the expansion of the universe by Hubble because by this discovery Einstein' cosmological constant Λ, introduced by him to get a static universe, has obtained a Renaissance via the quantum field theory as vacuum energy density (negative pressure), which in the works [1, 2] was thus connected with the cosmological "constant" and the dark energy as variable quantities. This work supports once more this hypothesis [1, 2] by the transition to a time-dependent vacuum energy density or cosmological "constant" in the eternal cyclic evolution of the total (massless and massive) universe and anti-universe. This assumption is confirmed by discovery of the present accelerated cosmic expansion [7], defined as the corresponding "present dark energy" [1, 2].

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References

[1] H. Strusny, *Big bang (by sterile neutrino decay) and quantum gravity in universe and corresponding anti-universe*, Hadronic Journal **42**, 383 (2019)

[2] H. Strusny, *Universe (particles) and anti-universe (antiparticles) as well as vacuum energy density or cosmological "constant" including quantum gravity*, Hadronic Journal **41**, 95 (2018)

[3] H. Strusny, *The role of light neutrinos and SUSY GUT particles as well as heavy and sterile neutrinos in the universe*, Hadronic Journal **40**, 375 (2017)

[4] H. Strusny, *From particle-defined cosmological parameters or heavy neutrinos to the "joint" origin of dark matter and dark energy by sterile neutrino types*, Hadronic Journal **40**, 255 (2017)
[5] H. Strusny, *The significance of the neutrinos and the magnetic monopoles for the universe*, Hadronic Journal **40**, 13 (2017)
[6] H. Mo, F. van den Bosch, and S. White, *GALAXY FORMATION AND EVOLUTION*, (Cambridge University Press, Cambridge, UK, 2010).
[7] K. Olive *et al.* [Particle Data Group], Chin. Phys. C**38**, 090001 (2014), [http://pdg.lbl.gov]
[8] S. Weinberg, *Cosmology* (Oxford University Press, New York, 2008)
[9] A. Unsöld and B. Baschek, *The New Cosmos*, (Springer, Berlin, Heidelberg, New York, 2005), 5th ed.
[10] J. Beringer *et al.* (Particle Data Group), Phys. Rev. D**86**, 010001 (2012), [http://pdg.lbl.gov]
[11] M. Treichel, *Teilchenphysik und Kosmologie* (Springer-Verlag, Berlin, Heidelberg, 2000)
[12] P. A. R. Ade et al., (Planck Collaboration I. and XVI.):
Planck 2013 results. I. Overview of products and scientific results, Astron. & Astrophys. **571**, A1 (2014), [arXiv.1303.5062v1];
Planck 2013 results. XVI. Cosmological parameters, Astron. & Astrophys. **571**, A16 (2014), [arXiv.1303.5076v1]
[13] E. Bulbul, M. Markevitch, A. Foster, R. K. Smith, M. Loewenstein and S. W. Randall, ApJ **789**, 13 (2014), [arXiv:1402.2301v2]
[14] J. D. Anderson, P. A. Laing, E. L. Lau, A. S. Liu, M. M. Nieto, and S. G. Turyshev, Phys. Rev. D**65**, 082004 (2002)
[15] H. Dittus and C. Lämmerzahl, Physik Journal **5**, 25 (2006)
[16] M. Tanabashi et al. [Particle Data Group], Phys. Rev. D**98**, 030001 (2018) and 2019 update [http://pdg.lbl.gov]
[17] R. Beck, Astrophys. Space Sci. Trans. **5**, 43 (2009)
[18] K. Fujikawa and R. E. Shrock, Phys. Rev. Lett. B**45**, 963 (1980)
[19] G. A. Krasinsky and V. A. Brumberg, Celest. Mech. & Dyn. Astron. **90**, 267 (2004)

[20] A. G. Riess et al., arXiv:1604.01424v3[astro-ph.CO],
[https://www.space telescope.org/news/heic1908/], 25 April 2019
[21] K. P. Singh, Turk. J. Phys. **34**, 173 (2010)
[22] A. Boyarsky, O. Ruchayskiy, D. Iakubovskyi, and J. Franse
Phys. Rev. Lett. **113**, 251301 (2014), [arXiv:1402.4119]
[23] T. E. Jeltema and S. Profumo, Mon. Not. R. Astron. Soc. **450**, 2143 (2015),
[arXiv:1408.1699]
[24] J. M. Cline and A. R. Frey, Phys. Rev. D**90**, 123537 (2014),
[arXiv:1410.7766]
[25] S. K. Kang and A. Patra, arXiv:1412.4899
[26] D. A. Iakubovskyi, Adv. Astron. Space Phys. **6**, 3 (2016)