TGD view of the paradoxical findings of the James Webb telescope

October 25, 2023

Matti Pitkänen

orcid:0000-0002-8051-4364.
email: matpitka6@gmail.com,
url: http://tgdtheory.com/public_html/,
address: Rinnekatu 2-4 A 8, 03620, Karkkila, Finland.

Abstract

It seems the findings of the James Webb telescope are bound to force a revolution in cosmology and perhaps in astrophysics in general. The very early cosmology looks surreal in the conceptual framework of the standard cosmology and one might speak of time paradox. Most distant galaxies are visible before the time of reionization in which the universe should have become transparent to radiation. The physical ages of cosmologically youngest stars and galaxies can be dramatically higher than they should be. In particular, globular star clusters, which are very old formations, are found. The abundances of various atoms vary inside galaxies and star clusters although they should not. Complex hydrocarbons (PAHs) are present and appear in regions where there are no stars of star formation but not in the regions where there is star formation. Obviously, these findings challenge many basic assumptions of recent day physics, in particular the notion of time. I have discussed the general TGD based explanation of these paradoxical findings already earlier, and in this article I will consider the new findings.

1 Introduction

It is fair to say that the findings of the James Webb telescope are bound to force a revolution in cosmology and perhaps in astrophysics in general. A mass extinction of the fashionable theories, which have dominated the theory landscape during the last 4 decades, seems unavoidable.

The view of the very early cosmology provided by the James Webb telescope looks surreal in the conceptual framework of the standard cosmology. Most distant galaxies are visible before the time of reionization in which the universe should have become transparent to radiation. The physical ages of cosmologically youngest stars and galaxies can be dramatically higher than they should be. In particular, globular star clusters, which are very old formations, are found. One might speak of a time paradox.

The James Webb telescope can detect the detailed structure of individual galaxies and even star clusters. The abundances of various atoms vary inside galaxies and globular star clusters although they should not. Complex hydrocarbons (PAHs) are present and appear in regions where there are no stars of star formation but not in the regions where there is star formation [?]

Obviously, these findings challenge several basic assumptions of recent day physics, in particular the notion of time. I have discussed the general TGD based explanation of these paradoxical findings already earlier [L13, L11], and in this article I will consider the new findings.

The conceptual framework involves geometric and number theoretic views complementary to each other. Geometric view relies on the TGD view of space-time a a 4-surface in $H = M^4 \times CP_2$

obeying holography and on zero energy ontology (ZEO), which replaces standard ontology and predicts that the arrow of time changes in the counterparts of ordinary state function reductions.

The number theoretic view of TGD [L2, L3], which is complementary to the geometric view of TGD, predicts a hierarchy of phases of ordinary matter labelled by effective Planck constant $h_{eff} = nh_0$, where n corresponds to the dimension of an extension of rational associated with the polynomial with integer coefficients determining region of space-time as 4-surface in M^8 and by $M^8 - H$ duality in $H = M^4 \times CP_2$ [L8, L9]. In particular, gravitational quantum coherence is predicted in astrophysical scales. Gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$, originally introduced by Nottale [E1], quantifies this notion [L12].

The emerging TGD view of cosmology and astrophysics is discussed in various articles [L4, L5, L11, L14, L15].

2 The findings of the James Webb telescope concerning very yearly Universe

The list of the discoveries of the James Webb telescope is rather impressive (`rb.gy/8gjh2`). There is also a popular article "12 amazing James Webb Space Telescope discoveries across the universe" (`rb.gy/rdj0c`). The list includes discoveries related to galaxies and globular star clusters in the very early universe, star formation, exoplanets, in particular hot Jupiters, protoplanets, and brown dwarfs.

The Youtube video (see `rb.gy/j52ux`) in LAB360 with the title "James Webb Telescope Detects more than 700 Galaxies at the Edge of Our Universe" summarizes some of the basic findings of the James Webb telescope concerning the very early Universe.

2.1 Summary of the findings of the James Webb telescope

The existence of more than 700 galaxies a few hundred million years after BB is in sharp conflict with the standard Big Bang Model although it is consistent with the cosmic expansion. Distance measurements indeed use cosmic redshift to deduce the distances of the galaxies. In any case, the James Webb telescope is profoundly shaking the foundations of cosmology. It seems that one can safely forget the standard story about the formation of stars and galaxies and also inflation as the generally accepted story of what happened before that.

In the standard picture, the epoch of reionization starts 1 billion years after the BB as the fog of gas is cleared by reionization so that photons can propagate. No signals hould arrive from the epoc preceding reionization. These 700 galaxies should not be there since they are too young, existing 370-500 million years after BB.

The mass of the galaxy serves as a measure for the age of the galaxy but 6 galaxies with age .5 Gy and 10 times bigger than the Milky Way have been found! This makes one wonder, what will be found when one goes farther back in time?

JW can see galaxies as extended objects with visible structures and this provides a lot of additional information about the composition of these too-early birds.

1. Complex organic molecules, found also in smoke/fog, were found [E5]: this is 1 billion years too early! These molecules, polycyclic aromatic hydrocarbons (PAHs) (`rb.gy/cx75l`), are big molecules, containing hundreds of atoms. What adds to the mystery, is that PAHs were found in regions where there are no stars or star formation but not in regions where stars are forming! PAH world hypothesis states that PAHs have played a key role in prebiotic life leading the emergence of RNAs (`rb.gy/z6vma`).

2. Also the locations of these molecules can be determined by JW in terms of their spectra. The distribution of the molecules is not uniform as one might expect. These galaxies can have the same mass as the Milky Way. The mass serves as a measure for the age of the galaxy but the age of these galaxies, according to standard cosmology, is only 10 percent of that of the Milky Way. This creates a paradox.

3. One particular galaxy, GN-z11 (`rb.gy/gx9fh`) is observed as it existed 13.3 Gy ago.

(a) GN-z11 is found to contain an exceptionally high proportion of nitrogen and abundance of stars.

(b) Birth of globular star clusters (rb.gy/xezay) have been found in GN-z11. This finding is especially paradoxical since they are regarded as very old objects! The compositions of O,N, Na, and Al vary inside globular clusters. These anomalies have been known for a long time rb.gy/8rdew). One however expects that the stars of the cluster should have the same origin and age in the early universe.

(c) Also supermassive stars (rb.gy/o0y36), having masses of few hundred solar masses, have been found in globular clusters. Multiple globular clusters have been found.

2.2 What theoretical implications the discoveries might have?

The findings of the James Webb telescope could be fatal for the fashionable theories related to standard cosmology. Inflationary scenario is the predecessor of radiation dominated cosmology which was once thought to be understood and it is difficult to think that it could survive if the cosmic evolution at the later period differs dramatically from the expectations.

One of the possible victims of the mass extinction of theories is ΛCDM model of cold dark matter, which has been the guiding cosmology for decades. Professor Boylan-Kolchin's paper, "Stress testing CDM with high-redshift galaxy candidates" published in Nature Astronomy [E4] (https://www.nature.com/articles/s41550-023-01937-7) discusses the constraint posed by the James Webb findings. The problem is that both the stellar and galactic masses are limited by the baryonic reservoir and the detected unexpectedly large number of massive stars and galaxies is at the very edge of these limits.

3 TGD explanation of the paradoxical findings of the James Webb telescope about very early Universe

What goes wrong with the standard cosmology? Could TGD inspired cosmology suggest an answer?

3.1 Zero energy ontology

Consider first zero energy ontology (ZEO) and the TGD view of dark matter. TGD suggests that the prevailing view about the notion of time is wrong. TGD forces a new ontology of quantum theory, which I call zero energy ontology (ZEO) [L7].

1. Causal diamond (CD) as a state-determined and dynamical quantization volume has two boundaries and zero energy states are in fermionic degrees of freedom superpositions of pairs of 3-D states asociated with these two.

2. Zero energy states corresponds also to superpositions of space-time surfaces connecting the two boundaries of CD. By the almost deterministic holography implied by the 4-D general coordinate invariance, the space-time analogs 4-D analogs of Bohr orbits of particles as 3-D surfaces. In ZEO, subjective time and geometric time are not the same thing but are strongly correlated. This new ontology solves the basic paradox of quantum measurement theory.

3. There are two kind of state functions reductions (SFRs): "Small" SFRs (SSFRs) corresponding to repeated measurements in Zeno effect and "big" SFRs (BSFRs) corresponding to ordinary SFRs. CD has two kind of boundaries; active and passive. In SSFRs, the active boundary and states at it change whereas the passive boundary and the states at it remain unaffected. This is the counterpart of the Zeno effect: the state changes slighty but the arrow of time is preserved. SSFRs also correspond to weak measurements in quantum optics.

   In BSFRs the arrow of time changes. BSFR occurs when the set of observables measured in SSFR a the active boundary of CD does not commute with those measured earlier at the passive boundary of CD. CD increases in size in a statistical sense during the sequence of SSFRs since the active boundary drifts farther from the passive one. This gives rise to the correlation of subjective time a sequence of SSFRs with geometric time a distance between the tips of CD.

3.1.1 Hierarchy of dark matters as $h_{eff} = nh_0$ phases of ordinary matter

TGD also predicts quantum coherence in arbitrarily long scales and gravitational quantum coherence corresponds to the longest, even astrophysical, coherence scales since gravitational interaction has infinite range and is unscreened [L12]. The gravitational Planck constant introduced by Nottale [E1] characterizes the monopole flux tubes connecting astrophysical objects. Along these flux dark gravitons mediating gravitational interaction and also other dark particles propagate. This has important implications in TGD inspired biology since the gravitational magnetic bodies of Sun, planets and perhaps even Moon become key plaryes in TGD inspired quantum biology.

TGD leads also to a view of dark energy identified as classical energy assignable to string like objects that I call cosmic strings. Their thickening to monopole flux tubes lead to vision about the formation of galaxies, stars and planets differing in many respects dramatically from the standard view [L4, L5, L11, L14, L15]. In particular, galactic dark matter would be associated with long cosmic strings formed as thickenings of the cosmic strings to monopole flux tubes.

The change of arrow of time in BSFR implies dramatic effects even in astrophysical scales. Even astrophysical objects can live forth and back in geometric time. The ageing in the physical sense occurs in both directions of geometric time so that the physical age is total time spent in this moving forth and back. Since the passive boundary is stationary, the physical ageing in ZEO is faster than ageing in the standard ontology.

3.2 TGD view of the anomalies

Consider now a slightly more detailed the explanation of the various anomalies.

3.2.1 Time anomalies

Consider first the time anomalies.

1. ZEO explains stars and galaxies older than the Universe.
2. ZEO also predicts the variation of the ages of galaxies and stars in the very early Universe. Since galaxies and stars can be born at different periods in this life forth and back in geometric time, they can have different ages in the sense of ZEO. This explains why the abundances of atoms associated with the stars of star clusters are found to vary. The life forth and back in time also explains the appearance of globular star clusters, which are very old and are not possible in standard cosmology.

3.2.2 PAHs in the very early Universe

What about PAHs, which appear in the regions where star formation does not occur and do not appear in the region containing stars?

1. The TGD view of nuclear physics, originally inspired by the findings about "cold fusion", and based on the notion of dark nuclei, identified scaled up analogs of ordinary nuclei, leads to a model of prestellar evolution based on dark fusion (explaining also "cold fusion" [L6, L1, L10]).

   "Dark" means that the nucleons of these nuclei have non-standard values of Planck constant $h_{eff} = nh_0$. In the number theoretic vision of TGD, integer n has interpretation as the dimension of extension of rationals associated with the polynomial with integer coefficients, which defines the space-time region [L8, L9, L16].

2. Dark fusion generates dark nuclei as sequences of dark protons at monopole flux tubes having size scale of electron Compton length. Their binding energy is much smaller than the binding energy of the ordinary nuclei. Dark nuclei can therefore transform to ordinary nuclei and liberate most of the nuclear binding energy in the process, this give rise to "cold fusion".

The temperature of the dark fusion region increases in the process and eventually reaches the temperature at which ordinary nuclear fusion can start.

Even chemistry and complex molecules can emerge before the ordinary nuclear fusion is ignited. This could explain the presence of PAHs, in particular their presence in regions, where there is no star formation or stars.

3. James Webb telescope has also found complex organic molecules, such as methanol and ethanol, in pre-stellar ice in the molecular cloud Chamaeleon I located 630 light year away (`rb.gy/d3q0s`). Contrary to expectations, this finding suggests that many star and planetary systems developing in Chamaeleon I contain molecules in a fairly advanced chemical state. This would indicate that the presence of precursors to prebiotic chemicals in planetary systems is a typical outcome of star formation rather than a peculiarity of our solar system.

   In the TGD framework, dark fusion could produce heavier elements before the ignition of the ordinary nuclear fusion and lead also to a development of complex chemistry [L1, L10]. This could resolve some mysteries related to the abundances of nuclei such as the origin of nuclei heavier than Fe and also the anomalous abundances of some lighter nuclei. Also objects like brown dwarfs (`rb.gy/41kp5`), called planets , which failed to become stars, could have emerged in this way. James Webb has also identified numerous protostars, which have not yet reached the ignition temperature (`rb.gy/6hsax`): they could be similar objects. TGD however suggests that planets could have formed by an explosion throwing out an outermost layer of the stellar magnetic body as a magnetic bubble consisting of monopole flux tubes carrying dark matter, which would then transform to ordinary matter in a process starting with dark fusion [L14, L15].

3.2.3 How signals from the period preceding the reionization are possible at all?

One reason is that there was a reionization. TGD also allows us to consider the possibility that the signals arrive as dark photons along monopole flux tubes of a cosmic flux tube network acting as an analog of the nervous system. Also in the TGD based model of the brain, dark photon signals propagating between the central nervous system and magnetic body play a key role.

I have considered the findings of James Webb telescope from the TGD point of view in [L13, L11]). The TGD view of cosmology and astrophysics is discussed in various articles [L4, L5, L11, L14, L15].

3.3 About the identification of the Schrödinger galaxy

The latest mystery related created by the observations of James Webb telescope is so called Schrödinger galaxy [E2] (see this and this).

It has been found that the determination of the redshift $1 + z = a_{now}/a_{emit}$ gives two possible space-time positions for the Schrödinger galaxy CEERS-1749 a_{now} *resp.* a_{emit} corresponds to the scale factor for the recent cosmology *resp.* cosmology when the radiation was emitted. Note that for not too large distances the recession velocity β satisfies the Hubble law $\beta = HD$. The nickname "Schrödinger galaxy" comes from the impression that the same galaxy could have existed in two different times in the same direction.

Accordingly, CHEERs allows two alternative identifications: either as an exceptionally luminous galaxy with $z \sim 17$ or as a galaxy with exceptionally low luminosity with $z \sim 5$. Both these identifications challenge the standard view about galaxy formation based on ΛCDM cosmology.

1. The first interpretation is that CHEERS is very luminous, much more luminous than the standard cosmology would suggest, and has the redshift $z \sim 17$, which corresponds to light with the age of 13.6 billion years. The Universe was at the moment of emission $t_{emit} = 220$ million years old.

   In the TGD framework, the puzzlingly high luminosity might be understood in terms of a cosmic web of monopole flux tubes guiding the radiation along the flux tubes. This would also make it possible to understand other similar galaxies with a high value of z but would not explain their very long evolutionary ages and sizes. Here the zero energy ontology (ZEO) of TGD could come in rescue [L17, L14, L15].

2. Another analysis suggest that the environment of the CHEERS contains galaxies with redshift $z \sim 5$. The mundane explanation would be that CHEERS is an exceptionally dusty/quenched galaxy with the redshift $z \sim 5$ for which light would be 12.5 billion years old.

   Could TGD explain the exceptionally low luminosity of $z \sim 5$ galaxy? Zero energy ontology (ZEO) and the TGD view of dark matter and energy predict that also galaxies should make "big" state function reductions (BSFRs) in astrophysical scales. In BSFRs the arrow of time changes so that the galaxy would become invisible since the classical signals from it would propagate to the geometric past. This might explain the passive periods of galaxies quite generally and the existence of galaxies older than the Universe. Could the $z \sim 5$ galaxy be in this passive phase with a reversed arrow of time so that the radiation from it would be exceptionally weak.

TGD seems to be consistent with both explanations. To make the situation even more confusing, one can ask whether two distinct galaxies at the same light of sight could be involved. This kind of assumption seems to be unnecessary but one can try to defend this question in the TGD framework.

1. In the TGD framework space-times are 4-surfaces in $M^4 \times CP_2$. A good approximation is as an Einsteinian 4-surface, which by definition has a 4-D M^4 projection. The scale factor a corresponds to the light-cone proper time assignable to the causal diamond CD with which the space-time surface is associated. a is a very convenient coordinate since it has a simple geometrical interpretation at the level of embedding space $M^4 \times CP_2$. The cosmic time t assignable to the space-time surface is expressible as $t(a)$.

2. Astrophysical objects, in particular galaxies, can form comoving tessellations (lattice-like structures) of the hyperbolic space H^3, which corresponds to $a = constant$, and thus $t(a)$ constant surfaces. The tessellation of H^3 is expanding with cosmic time a and the values of the hyperbolic angle η and spatial direction angles for the points of the tessellation do not depend on the value of a. The direction angles and hyperbolic angle for the points of the tessellation are quantized in analogy with the angles characterizing the points of a Platonic solid and this gives rise to a quantized redshift.

   A tessellation for stars making possible gravitational diffraction and therefore channelling and amplification of gravitational radiation in discrete directions, could explain the recently observed gravitational hum [L18],

   These tessellations could also explain the mysterious God's fingers [E3], discovered by Halton Arp, as sequences of identical look stars or galaxies of hyperbolic tessellations along the line of sight [**?**, **?**]. Maybe something similar is involved now.

This raises two questions.

1. Could two similar galaxies at the same line of sight be behind Schrödinger galaxy and correspond to the points of scaled versions of the tessellation of H^3 having therefore different values of a and hyperbolic angle η? The spatial directions characterized by direction angle would be the same. Could one think that the tessellation consists of similar galaxies in the same way as lattices in condensed matter physics? The proposed explanation for the recently observed gravitational hum indeed assumes tessellation form by stars and most stars are very similar to our Sun. [L18].

   The obvious question is whether also the neighbours of the $z \sim 5$ galaxy belong to the scaled up tessellation. The scaling factor between these two tessellations would be $a_5/a_{17} = 17/5$. Could it be that the resolution does allow to distinguish the neighbors of the $z \sim 17$ galaxy from each other so that they would be seen as a single galaxy with an exceptionally high luminosity? Or could it be that the $z \sim 5$ galaxy is in a passive phase with a reversed arrow of time and does not create any detectable signal so that the signal is due to $z \sim 17$ galaxy.

2. Could one even think that the values of hyperbolic angles are the same for the two galaxies in which case the $z \sim 5$ galaxy could correspond to $z \sim 17$ galaxy but in the passive phase with an opposite arrow of time? The ages of most galaxies are between 10 and 13.6 billion years so that this option deserves to be excluded. Could the hyperbolic tessellation explain why two similar galaxies could exist at the same line of sight in a 4-dimensional sense?

   This option is attractive but is actually easy to exclude. The light arriving from the galaxies propagates along light-like geodesics. Suppose that a light-like geodesic connects the observer to the $z \sim 17$ galaxy. The position of the $z \sim 5$ galaxy would be obtained by scaling the H^3 of the older galaxy by the ratio $a(young)/a(old)$. Geometrically it is rather obvious that the geodesic connecting it to the observer cannot be lightlike but becomes space-like. If one approximates space-time with M^4 this is completely obvious.

Consider now more precisely the conditions posed by the light-likeness of the geodesic representing the arriving photon.

1. Let us assume that the light from the distant galaxy moves along a light-like geodesic of X^4. The equation for the light-like geodesic line reads as $dt^2 - a^2(t)sinh^2(\eta)d\eta^2 = 0$. From this one can solve $cosh(\eta)$ as

$$cosh(\eta) - 1 = 2sinh^2(\eta/2) = \int_{t_{emit}}^{t_{now}} dt/a(t)) \quad .$$

2. It is convenient to look at what happens when the space-time surface X^4 is approximated with M^4. This gives $a = t$ and the differential equation can be solved:

$$sinh(\eta/2) = \sqrt{ln(\sqrt{\frac{a_{now}}{a_{emit}}})} \quad .$$

   The quantized value of η for the point of the tessellation fixes the ratio a_{now}/a_{emit} and therefore of a_{emit}. Already this is highly non-trivial. Since the functions appearing on both sides are monotonically increasing, only a single value of a_{emit} is possible for a given value of η. Therefore the strong option cannot be true as already the intuitive argument made clear.

3. During the matter dominated era lasting from $t_0 = 47,000$ years to $t_{end} = 9.8$ billion years, the condition

$$a(t) = a_{end}(\frac{t}{t_{end}})^{2/3} \quad .$$

   After that standard model assumes de Sitter Universe with an accelerating expansion with

$$a(t) \propto a_{end}exp(H_0(t - t_{end}) \quad .$$

   Here one has $H_0 = \sqrt{\Lambda/3}$, where Λ is cosmological constant and $H_0 \simeq 70.88$ kms^{2}Mpc^{-1} is the Hubble constant. Hubble time corresponds to $t_H = H_0/c \simeq 13.79$ billion years. Therefore the ratio t_{now}/t_H equals to 1 with percent accuracy. This gives $a(t) \simeq a_{end}exp((t - t_{end})/t_{now})$.

4. One obtains for the value of $sinh(\eta/2)$ the expression

$$sinh(\eta/2) = \sqrt{X_{md} + X_{dS}} \quad , X_{md} = \frac{3}{4}t_{end}^{2/3}(t_{end}^{1/3} - t_{emit}^{1/3}) \quad , X_{dS} \simeq \frac{1}{2}\frac{t_{now}}{a_{end}}(1 - exp[-1 + \frac{t_{end}}{t_{now}}]) \quad .$$

A cautious TGD inspired conclusion is that TGD cannot select between $z \sim 17$ and $z \sim 5$ interpretations but that most naturally only one of them is realized. Certainly it is not possible to identify the two galaxies as time= constant snapshots of the same galaxy such that $z \sim 5$ galaxy has a reversed arrow of time and corresponds to the same point of an expanding tessellation of H^3. The identification of the galaxies as different points of an expanding tessellation with different quantized values of the hyperbolic angle η is not excluded but has no explanatory power. One could try to check whether the two galaxies can be identified as scaled variants of some hyperbolic tessellation having a different value of the η.

REFERENCES

Cosmology and Astro-Physics

[E1] Nottale L Da Rocha D. Gravitational Structure Formation in Scale Relativity, 2003. Available at: https://arxiv.org/abs/astro-ph/0310036.

[E2] Naidu RP et al. Schrödinger's Galaxy Candidate: Puzzlingly Luminous at $z \sim 17$, or Dusty/Quenched at $z \sim 5$?, 2023. Available at: https://arxiv.org/pdf/2208.02794.

[E3] Sato H Fang LZ. Is the Periodicity in the Distribution of Quasar Red Shifts an Evidence of Multiple Connectedness of the Universe? *Gen Rel & Grav*, (11), 1985.

[E4] Boylan-Kolchin M. Stress testing ΛCDM with high-redshift galaxy candidates. *Nature Astronomy*, 7:731–735, 2023. Available at: https://www.nature.com/articles/s41550-023-01937-7.

[E5] Woods P. Complex molecules in an early galaxy. *Nature Astronomy*, 7:641, 2023. Available at: https://www.nature.com/articles/s41550-023-02021-w.

Articles about TGD

[L1] Pitkänen M. Cold fusion, low energy nuclear reactions, or dark nuclear synthesis? Available at: https://tgdtheory.fi/public_html/articles/krivit.pdf., 2017.

[L2] Pitkänen M. Philosophy of Adelic Physics. Available at: https://tgdtheory.fi/public_html/articles/adelephysics.pdf., 2017.

[L3] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11, 2017.

[L4] Pitkänen M. TGD view about quasars. Available at: https://tgdtheory.fi/public_html/articles/meco.pdf., 2018.

[L5] Pitkänen M. Cosmic string model for the formation of galaxies and stars. Available at: https://tgdtheory.fi/public_html/articles/galaxystars.pdf., 2019.

[L6] Pitkänen M. Solar Metallicity Problem from TGD Perspective. Available at: https://tgdtheory.fi/public_html/articles/darkcore.pdf., 2019.

[L7] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: https://tgdtheory.fi/public_html/articles/zeoquestions.pdf., 2019.

[L8] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part I. Available at: https://tgdtheory.fi/public_html/articles/M8H1.pdf., 2020.

[L9] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part II. Available at: https://tgdtheory.fi/public_html/articles/M8H2.pdf., 2020.

[L10] Pitkänen M. Could TGD provide new solutions to the energy problem? Available at: https://tgdtheory.fi/public_html/articles/proposal.pdf., 2020.

[L11] Pitkänen M. TGD view of the engine powering jets from active galactic nuclei. https://tgdtheory.fi/public_html/articles/galjets.pdf., 2021.

[L12] Pitkänen M. Comparison of Orch-OR hypothesis with the TGD point of view. https://tgdtheory.fi/public_html/articles/penrose.pdf., 2022.

[L13] Pitkänen M. Some anomalies of astrophysics and cosmology. https://tgdtheory.fi/public_html/articles/acano.pdf., 2022.

[L14] Pitkänen M. Magnetic Bubbles in TGD Universe: Part I. https://tgdtheory.fi/public_html/articles/magnbubble1.pdf., 2023.

[L15] Pitkänen M. Magnetic Bubbles in TGD Universe: Part II. https://tgdtheory.fi/public_html/articles/magnbubble2.pdf., 2023.

[L16] Pitkänen M. New findings related to the number theoretical view of TGD. https://tgdtheory.fi/public_html/articles/M8Hagain.pdf., 2023.

[L17] Pitkänen M. TGD view of the paradoxical findings of the James Webb telescope . https://tgdtheory.fi/public_html/articles/Gersching.pdf., 2023.

[L18] Pitkänen M. The TGD view of the recently discovered gravitational hum as gravitational diffraction. https://tgdtheory.fi/public_html/articles/gravhum.pdf., 2023.