Support for the TGD view of dark matter from condensed matter physics

November 22, 2022

Matti Pitkänen

Email: matpitka6@gmail.com.
http://tgdtheory.com/public_html/.
Recent postal address: Rinnekatu 2-4 A 8, 03620, Karkkila, Finland.

Abstract

Three condensed matter findings, difficult to understand in the standard framework and providing support for the TGD view of dark matter, are discussed. The first discovery is that the antiprotons in hybrid matter-antimatter atoms do not seem to interact with the surrounding matter. A possible TGD based explanation is that the antiproton is dark and resides at a magnetic flux tube.

The second finding might be called invisible magnetic fields. In TGD their identification could be as magnetic fields associated with monopole flux tubes, which are not possible in Maxwellian electrodynamics.

The third finding is that vanadium-oxide VO_2 is able to have memories about electric currents and can be said to learn. Dark valence electrons, proposed to explain strange disappearance of valence electrons in transition metals induced by heating, could explain the finding and also why the conductivity of VO_2 is 10 times higher than expected on the basis of the Wiedemann Franz law.

Contents

1 Introduction

TGD [L24, L33] identifies space-time at the fundamental level as a 4-surface in $H = M^4 \times CP_2$. TGD involves geometry and number theory as complementary approaches to physics and there is an analogy for Langlands duality [L30].

$M^8 - H$ duality [L12, L13] is the TGD counterpart of Langlands duality. A rational polynomial P defines a 4-surface in M^8, which has an interpretation as the analogy of momentum space. The roots of P define a set of 3-D mass shells in $M^4 \subset M^8$ analogous to 8-D momentum space, and one can assign to it a 4-surface of H by a holography based on the condition that the normal space of

4-surface is associative. The associativity makes it possible to map this 4-surface $M^8 - H$ duality to a space-time surface in H as a minimal surface with singularities analogous to frames of a soap film [L26].

P defines an algebraic extension of rationals to which one can assign a Galois group acting as a number theoretic symmetry group [L17, L18, L19, L16]. For cognitive representations, the momentum components of virtual particles are assumed to be algebraic integers. Galois confinement in its simplest form states that the total momenta for physical states have components, which are ordinary integers.

The dimension n of the extension, serving as a measure for algebraic complexity, is identified in terms of effective Planck constant $h_{eff} = nh_0$ and the phases of ordinary matter with $h_{eff} > h$ behave like ordinary matter and would reside at monopole flux tubes giving rise to magnetic body. Note that one must distinguish between galactic dark matter which could be also dark energy residing at cosmic strings possibly thickened to flux tubes.

The ramified primes of the extension are identified as what I have called p-adic primes [K2] [L34] assigned with a given space-time sheet of the many-sheeted space-time and defining the p-adic size scale of the sheet and also characterizing elementary particles. p-Adic length scale hypothesis as a part of p-adic thermodynamics, states that primes near powers of 2, or possibly of more general small primes, define physically preferred scales and in this way provides a quantitative formulation of the fractality. The possible origin of p-adic length scale hypothesis is considered in [L30].

TGD predicts fractal Universe and can explain unexpected findings that are emerging in all scales using the same basic mechanisms. This includes findings in elementary particle physics, nuclear physics [L11, L3, L15], atomic and molecular physics and chemistry [L5, L4, L21, L35], physics of condensed matter [L23] [K3, K4, K6], biology [L31, L9, L32, L20] and neuroscience [L14, L28], galaxy formation and cosmology [L8, L10, L25, L27, L29].

In this article three condensed matter findings, difficult to understand in the standard framework and providing support for the TGD view of dark matter, are discussed. The first discovery is that the antiprotons in hybrid matter-antimatter atoms do not seem to interact with the surrounding matter. A possible TGD based explanation is that the antiproton is dark and resides in a magnetic flux tube. The long term storage of antimatter might be a possible technological implication.

The second finding is the discovery of invisible magnetic fields. In TGD their identification could be as magnetic fields associated with monopole flux tubes, which are not possible in Maxwellian electrodynamics.

The third finding is that vanadium-oxide VO_2 is able to have memories about electric currents and can be said to learn. Dark valence electrons, proposed to explain strange disappearance of valence electrons in transition metals induced by heating, could explain the finding and also why the conductivity of VO_2 is 10 times higher than expected on the basis of the Wiedemann Franz law. Also now technological implications can be imagined.

2 Three condensed matter findings supporting TGD view of dark matter

The explanation of all three anomalies relies on the notion of magnetic body carrying dark particles as ordinary particles with a non-standard value of effective Planck constant $h_{eff} = nh_0$ [L6, L7, L35, L4].

2.1 A strange behavior of hybrid matter-antimatter atoms in superfluid Helium

I received an interesting link to a popular article "ASACUSA sees surprising behaviour of hybrid matter antimatter atoms in superfluid helium" (`https://cutt.ly/NVIzglw`), which tells of a completely unexpected discovery related to the behavior of antiproton-$^4He^{++}$ atoms in ^4He superfluid. The research article [D5] by ASACUSA researchers Anna Soter et al is published in Nature (`https://cutt.ly/LVIceiB`).

The formation of anti-proton-$^4He^{++}$ hybrid atoms containing also an electron in ^4He was studied both above and below the critical temperature for the transition to Helium superfluid.

The temperatures considered are in Kelvin range corresponding to a thermal energy of order 10^{-4} eV.

Liquid Helium is much denser than Helium gas. As the temperature is reduced, a transition to liquid phase takes place and the Helium liquid gets denser with the decreasing temperature. One would expect that the perturbations of nearby atoms to the state should increase the width of both electron and antiproton spectral lines in the dense liquid phase.

This widening indeed occurs for the lines of electrons but something totally different occurs for the spectral lines of the antiproton. The width decreases and when the superfluidity sets on, an abrupt further narrowing of He^{++} spectral lines takes place. The antiproton does not seem to interact with the neighboring ^{4}He atoms.

Researchers think that the fact that the surprising behavior is linked to the radius of the hybrid atom's electronic orbital. In contrast to the situation for many ordinary atoms, the electronic orbital radius of the hybrid atom changes very little when laser light is shone on the atom and thus does not affect the spectral lines even when the atom is immersed in superfluid helium.

Consider now the TGD inspired model.

1. It seems that either antiprotons or the atoms of ^{4}He superfluid effectively behave like dark matter. For the electrons, the widening however takes place so that it seems that the antiproton seems to be dark. In the TGD framework, where dark particles corresponds $h_{eff} = nh_0 > h$, $h = n_0h_0$ phases of ordinary matter, the first guess is that the antiprotons are dark and reside at the magnetic flux tube like structures.

   The dark proton would be similar to a valence electron of some rare earth atoms, which mysteriously disappear when heated (an effect known for decades) [L5]. Dark protons would indeed behave like a dark matter particle is expected to behave and would have no direct quantum interactions with ordinary matter. The electron of the hybrid atom would be ordinary.

2. Darkness might also relate to the formation mechanism of the hybrid atoms. Antiproton appears as a Rydberg orbital with a large principal quantum number N and large size proportional to N^2. $N > 41$ implies that the antiproton orbital is outside the electron orbital but this leaves the interactions with other Helium atoms. For a smaller value of N the dark proton overlaps the electronic orbital. Note that for $N = 1$, the radius of the orbital is $10^{-3}/8a_0$, $a_0 \simeq .53 \times 10^{-10}$ m, in the Bohr model.

3. The orbital radii are proportional to $h_{eff}^2 \propto (n/n_0)^2$ so that dark orbitals with the same energy and radius as for ordinary orbitals but effective principal quantum number $(n/n_0)N_d = N_{eff}$, are possible. $(n/n_0)N_d = N_{eff}$ condition would give the same radius and energy for the dark orbital characterized by N_d and ordinary orbital characterized by N.

One can consider both dark-to-dark and dark-to-ordinary transitions.

1. The minimal change of the effective principal quantum number N_{eff} in dark-to-dark transitions would be n/n_0 and be larger than one for $n > n_0$. There is evidence for $n = n_0/6$ found by Randel Mills [D2] discussed from the TGD view in [L2]. In this case one would have effectively fractional values of N_{eff}. One can also consider a stronger condition, $h_{eff}/h = m$, one has $mN_d = N$. The transitions would be effectively between ordinary orbitals for which ΔN_{eff} is a multiple of m. This could be tested if the observation of dark-to-dark transition is possible. The transformation of dark photons to ordinary photons would be needed.

2. Energy conserving dark-to-ordinary transitions producing an ordinary photon cannot be distinguished from ordinary transitions if the condition $(n/n_0)N_d = N_{eff}$ is satisfied.

   The transitions $(37, 35) \to (38, 34)$ and $(39, 35) \to (38, 34)$ at the visible wavelengths $\lambda = 726$ nm and 597 nm survive in the Helium environment. The interpretation could be that the transitions occur between dark and ordinary states such that the dark state satisfies the condition that $(n/n_0)N_d = N_{eff}$ is integer, and that an ordinary photon with $\lambda = h/\Delta E$ is produced. This does not pose conditions on the value of h_{eff}/h.

   If the condition that $(n/n_0)N_d = N_{eff}$ is an integer is dropped, effective principal quantum numbers N_{eff} coming as multiples of n/n_0 are possible and the photon energy has fractional spectrum.

If this picture makes sense, it could mean a new method to store antimatter without fear of annihilation by storing it as a dark matter in the magnetic flux tubes. They would be present in superfluids and superconductors.

2.2 Invisible magnetic fields as a support for the notion of monopole flux tube

Physicists studying a system consisting of a layered structure consisting of alternate superconducting and spin liquid layers have found evidence for what they call invisible magnetic fields. The popular article is published in Scitechdaily (`https://cutt.ly/XVme0Xj`) and tells about research carried out by Prof. Beena Kalisky and doctoral student Eylon Persky in Bar-Ilan University. The research article is published in Nature [D4] (`https://cutt.ly/wVme7pu`).

First some basic notions.

1. The notions of spin liquid and charge-spin separation are needed. Popular texts describe charge separation in a way completely incomprehensible for both layman and professional. Somehow the electron would split into two parts corresponding to its spin and charge. The non-popular definition is clear and understandable. Instead of a single electron, one considers a spin liquid as a many-electron system associated with a lattice-like structure formed by atoms. The neighboring electrons are paired. There are a very large number of possible pairings. In the ground state the spins of electrons of all pairs could be either opposite or parallel (magnetization). Pairing with a vanishing spin is favoured by Fermi statistics.

   If the opposite spins of a single pair become parallel and this state is delocalized, one can have a propagating spin wave without moving charge. If one electron pair is removed and this hole pair is delocalized ,one obtains a moving charge +2e without any motion of spin.

2. When a superconductor of type II is in an external magnetic field with a strength above critical value, the magnetic field penetrates to the superconductor as vortices. Inside these vortices the superconductivity is broken and electrons swirl around the magnetic field. This is how the magnetic flux quanta become visible.

In the layered structures formed by atomic layers of spin liquid and superconductor, magnetic vortices are created spontaneously in the superconducting layers. In the Maxwellian world, magnetic fields would be created either by rotating currents or by magnetization requiring a lattice-like structure of parallel electron spins. In the recent case spontaneous magnetization should serve as a signature for the presence of these magnetic fields.

Surprisingly, no magnetization was observed so that one can talk of "invisible" magnetic field.

In the bilayered structure 4Hb-TaS_2, the superconductivity is anomalous in the sense that the critical temperature is 2.7 K whereas in bulk superconductor 2H-TaS_2 it is .7 K. There is also a breaking of time reversal symmetry closely related t the presence of the magnetic flux quanta. The magnetic flux quanta survive above critical temperature 2.7 K up to 3.6 K and their life time is very long as compared to the electronic time scales (12 minute scale is mentioned). Therefore one can talk of magnetic memory.

The proposal is that a spin liquid state known as a chiral spin liquid is created and that the invisible magnetic field associated with the chiral spin liquid penetrates to the superconductor as flux quanta.

Could TGD explain the invisible magnetic fields?

1. TGD predicts what I called monopole flux tubes, which have closed, rather than disk-like , 2-D cross sections and carry monopole flux requiring no current nor magnetization to generate it.

   This is possible only in the TGD space-time, which corresponds to a 4-surface in 8-D space $H = M^4 \times CP_2$, but not in Minkowski space or in general relativistic space-time in its standard form. The reason is that the topology of the space-time surface is non-trivial in all scales.

   The possibility of closed monopole flux tubes without magnetic monopoles, is one of the basic differences between TGD and Maxwell's theory and reflects the non-trivial homology of CP_2.

2. Monopole flux tubes solve the mystery of why there are magnetic fields in cosmic length scales and why the Earth's magnetic field B_E has not disappeared long ago by dissipation [L1].

3. Electromagnetic fields at frequencies in the EEG range corresponding to cyclotron frequencies have quantal looking effects on brains of mammalians at the level of both physiology and behavior. The photon energies involved are extremely low.

   In the TGD based quantum biology they can be understood in terms of cyclotron transitions for "dark" ions with a very large effective Planck constant $h_{eff} = nh_0$ in a magnetic field of .2 Gauss, which is about 2/5 of the nominal value .5 Gauss of the Earth's magnetic field B_D. The proposal is that B_E involves a monopole flux contribution about $2B_E/5$ [K1].

   The estimate for the invisible magnetic field was .1 Gauss so that the numbers fit nicely.

The findings suggest that the spin liquid phase atomic layer involves the monopole flux tubes assignable to the Earth's magnetic field and orthogonal to the layer. They would not be present in the superconducting layer but would penetrate from spin liquid to the superconductor.

2.3 VO_2 can remember like a brain

The following comments were inspired by a popular article (`https://cutt.ly/lNHzBYa`) with the title "Scientists accidentally discover a material that can remember like a brain". These materials can remember the history of its physical stimuli. The findings are described in the article "Electrical control of glass-like dynamics in vanadium dioxide for data storage and processing" published in Nature [D3] (`https://cutt.ly/cNHyMMa`).

The team from the Ecole Polytechnique Federale de Lausanne (EPFL) in Switzerland did this discovery while researching insulator-metal phase transitions of vanadium dioxide (VO_2), a compound used in electronics.

1. PhD student Mohammad Samizadeh Nikoo was trying to figure out how long it takes for VO_2 to make a phase transition from insulating to conducting phase under "incubation" by a stimulation by a radio frequency pulse of 10 μs duration and voltage amplitude $V = 2.1$ V. Note that the Wikipedia article talks about semiconductor-metal transition. The voltage pulse indeed acted like a voltage in a semiconductor.

2. As the current heated the sample it caused a local phase transition to metallic state in VO_2. The induced current moved across the material, following a path until it exited on the other side. A conducting filament connecting the ends of the device was generated by a percolation type process.

3. Once the current had passed, the material exhibited an insulating state but after incubation time t_{inc}, which was $t_{inc} \simeq .1\mu$s for the first pulse, it became conducting. This state lasted at least 10,000 seconds.

   After applying a second electrical current during the experiment, it was observed that t_{inc} appeared to be directly related to its history and was shorter than for the first incubation period .1 μs. The VO_2 seemed to remember the first phase transition and anticipate the next. One could say that the system learned from experience.

Before trying to understand the finding in the TGD framework, it is good to list some basic facts about vanadium and vanadium-oxide VO_2 or Vanadium(IV) oxide (`https://cutt.ly/yNHhahk`).

1. Vanadium is a transition metal, which has valence shells d^3s^2. It is known that the valence electrons of transition metals can mysteriously disappear, for instance in heating [L5]. The TGD interpretation [K5] would be that heating provides energy making it possible to transform ordinary valence electrons to dark valence electrons with a higher value of h_{eff} and higher energy. In the recent case, the voltage pulses could have the same effect.

2. VO_2 forms a solid lattice of V^{4+} ions. There are two lattice forms: the monoclinic semiconductor below $T_c = 340$ K and the tetragonal metallic form above T_c. In the monoclinic form, the V^{4+} ions form pairs along the c axis, leading to alternate short and long V-V

distances of 2.65 Angström and 3.12 Angström. In the tetragonal form, the V-V distance is 2.96 Angström. Therefore size of the unit cell for the monoclinic form is 2 times larger than for the tetragonal form. At T_c IMT takes place. The optical band gap of VO_2 in the low-temperature monoclinic phase is about 0.7 eV.

3. Remarkably, the metallic VO_2 contradicts the Wiedemann Franz law, which states that the ratio of the electronic contribution of the thermal conductivity (κ) to the electrical conductivity (σ) of a metal is proportional to the temperature. The thermal conductivity that could be attributed to electron movement was 10 % of the amount predicted by the Wiedemann Franz law. That the conductivity is 10 times higher than expected, suggests that the mechanism of conductivity is not the usual one.

   Semiconductor property below T_c suggests that a local phase transition modifying the lattice structure from monoclinic to tetragonal takes place at the current path in the incubation.

One can try to understand the chemistry and unconventional conductivity of VO_2 in the TGD framework.

1. Vanadium could give 4 valence electrons to O_2: 3 electrons d^3:sta and one from s^2. In the TGD Universe, the second electron from s^2 could become dark and go to the bond between V^{4+} ions in the VO_2 lattice and take the role of conduction electron.

2. This could explain the non-conventional character of conductivity. In the semiconductor phase, an electric voltage pulse or some other perturbation, such as impurity atoms or heating, can provide the energy needed to increase the value of h_{eff}. Electric conductivity could be due to the transformation of electrons to dark electrons possibly forming Cooper pairs at the flux tube pairs connecting V^{4+} ions or their pairs. The current would run along the flux tubes as a dark current.

3. In a semi-conducting (insulating) state, the flux tube pairs connecting V^{4+} ions would be relatively short. The voltage pulse inducing a local metallic state could provide the energy needed to increase h_{eff} and thus the quantum coherence scale. This would be accompanied by a reconnection of the short flux tube pairs to longer flux tube pairs serving as bridges along which the dark current could run.

   One can also consider U-shaped closed flux tubes associated with V^{4+} ions or ion pairs, which reconnect in IMT to longer flux tubes. The mechanism would be very similar to that proposed for the transition to high temperature superconductivity [K3, K4, K6].

Experimenters suggest a glass type behavior.

1. Spin glass corresponds to the existence of a very large number of free energy minima in the energy landscape implying breaking of ergodicity. A system consisting of regions with varying direction of magnetization is the basic example of spin glass. In the recent case, decomposition to metallic and insulating regions could define the spin glass.

2. TGD predicts the possibility of spin glass type behavior and leads to a model for spin glasses [L22]. The quantum counterpart of spin glass behavior would be realized in terms of monopole flux tube structures (magnetic bodies) carrying dark phases of the radinary particles such as electrons serving as current carries in the metallic phase.The length of the flux tube pair would be one critical parameter near T_c. Quantum criticality against the change of h_{eff} increasing the length of the flux tube pair by reconnection would make the system very sensitive to perturbations.

3. These phases are highly sensitive to external perturbations and represent in TGD inspired theory of consciousness higher levels with longer quantum coherence scale and number theoretical complexity measured by the dimension $n = h_{eff}/h_0$ of the extension having interpretation as a kind of IQ. These phases would receive sensory information from lower levels of the hierarchy with smaller values of n and control them.

   The large number of free energy minima as a correlate for number theoretical complexity would make possible the representation of "sensory" information as "memories".

REFERENCES

Condensed Matter Physics

[D1] Chatterjee S et al. Lifshitz transition from valence fluctuations in YbAl3. *Nature Communications*, 8(852), 2017. Available at: https://www.nature.com/articles/s41467-017-00946-1.

[D2] Mills R et al. Spectroscopic and NMR identification of novel hybrid ions in fractional quantum energy states formed by an exothermic reaction of atomic hydrogen with certain catalysts, 2003. Available at: https://www.blacklightpower.com/techpapers.html.

[D3] Nikoo SN et al. Electrical control of glass-like dynamics in vanadium dioxide for data storage and processing. *Nature Electronics*, 5(9):1–8, 2022. Available at: https://www.nature.com/articles/s41928-022-00812-z.

[D4] Persky E et al. Magnetic memory and spontaneous vortices in a van der Waals superconductor. *Nature*, 2022. Available at: https://arxiv.org/pdf/2206.07730.pdf.

[D5] Soter A et al. High-resolution laser resonances of antiprotonic helium in superfluid ^{4}He. *Nature*, 603:411–415, 2022. Available at: https://www.nature.com/articles/s41586-022-04440-7.

Books related to TGD

[K1] Pitkänen M. Magnetic Sensory Canvas Hypothesis. In *TGD and EEG*. Available at: https:/tgdtheory.fi/pdfpool/mec.pdf, 2006.

[K2] Pitkänen M. Massless states and particle massivation. In *p-Adic Physics*. Available at: https:/tgdtheory.fi/pdfpool/mless.pdf, 2006.

[K3] Pitkänen M. Quantum Model for Bio-Superconductivity: I. In *TGD and EEG*. Available at: https:/tgdtheory.fi/pdfpool/biosupercondI.pdf, 2006.

[K4] Pitkänen M. Quantum Model for Bio-Superconductivity: II. In *TGD and EEG*. Available at: https:/tgdtheory.fi/pdfpool/biosupercondII.pdf, 2006.

[K5] Pitkänen M. Criticality and dark matter: part III. In *Hyper-finite Factors and Dark Matter Hierarchy: Part I*. Available at: https:/tgdtheory.fi/pdfpool/qcritdark3.pdf, 2019.

[K6] Pitkänen M. Comparing Berry phase model of super-conductivity with TGD based model. In *TGD and Condensed Matter*. Available at: https:/tgdtheory.fi/pdfpool/SCBerryTGD.pdf, 2022.

Articles about TGD

[L1] Pitkänen M. Maintenance problem for Earth's magnetic field. Available at: https:/tgdtheory.fi/public_html/articles/Bmaintenance.pdf., 2015.

[L2] Pitkänen M. Hydrinos again. Available at: https:/tgdtheory.fi/public_html/articles/Millsagain.pdf., 2016.

[L3] Pitkänen M. Cold fusion, low energy nuclear reactions, or dark nuclear synthesis? Available at: https:/tgdtheory.fi/public_html/articles/krivit.pdf., 2017.

[L4] Pitkänen M. Does valence bond theory relate to the hierarchy of Planck constants? Available at: https:/tgdtheory.fi/public_html/articles/valenceheff.pdf., 2017.

[L5] Pitkänen M. Mysteriously disappearing valence electrons of rare Earth metals and hierarchy of Planck constants. Available at: https:/tgdtheory.fi/public_html/articles/rareearth.pdf., 2017.

[L6] 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.

[L7] Pitkänen M. Philosophy of Adelic Physics. Available at: https:/tgdtheory.fi/public_html/articles/adelephysics.pdf., 2017.

[L8] Pitkänen M. TGD view about quasars. Available at: https:/tgdtheory.fi/public_html/articles/meco.pdf., 2018.

[L9] Pitkänen M. An overall view about models of genetic code and bio-harmony. Available at: https:/tgdtheory.fi/public_html/articles/gcharm.pdf., 2019.

[L10] Pitkänen M. Cosmic string model for the formation of galaxies and stars. Available at: https:/tgdtheory.fi/public_html/articles/galaxystars.pdf., 2019.

[L11] Pitkänen M. Solar Metallicity Problem from TGD Perspective. Available at: https:/tgdtheory.fi/public_html/articles/darkcore.pdf., 2019.

[L12] 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.

[L13] 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.

[L14] Pitkänen M. Could brain be represented as a hyperbolic geometry? Available at: https:/tgdtheory.fi/public_html/articles/hyperbolicbrain.pdf., 2020.

[L15] Pitkänen M. Could TGD provide new solutions to the energy problem? Available at: https:/tgdtheory.fi/public_html/articles/proposal.pdf., 2020.

[L16] Pitkänen M. The dynamics of SSFRs as quantum measurement cascades in the group algebra of Galois group. Available at: https:/tgdtheory.fi/public_html/articles/SSFRGalois.pdf., 2020.

[L17] Pitkänen M. About the role of Galois groups in TGD framework. https://tgdtheory.fi/public_html/articles/GaloisTGD.pdf., 2021.

[L18] Pitkänen M. Does the notion of polynomial of infinite order make sense? https://tgdtheory.fi/public_html/articles/transcendGalois.pdf., 2021.

[L19] Pitkänen M. Galois code and genes. https://tgdtheory.fi/public_html/articles/Galoiscode.pdf., 2021.

[L20] Pitkänen M. Is genetic code part of fundamental physics in TGD framework? Available at: https://tgdtheory.fi/public_html/articles/TIH.pdf., 2021.

[L21] Pitkänen M. Revolution in chemistry. https://tgdtheory.fi/public_html/articles/newchemistry.pdf., 2021.

[L22] Pitkänen M. Spin Glasses, Complexity, and TGD. https://tgdtheory.fi/public_html/articles/sg.pdf., 2021.

[L23] Pitkänen M. TGD and Condensed Matter. https://tgdtheory.fi/public_html/articles/TGDcondmatshort.pdf., 2021.

[L24] Pitkänen M. TGD as it is towards the end of 2021. https://tgdtheory.fi/public_html/articles/TGD2021.pdf., 2021.

[L25] Pitkänen M. TGD view of the engine powering jets from active galactic nuclei. https://tgdtheory.fi/public_html/articles/galjets.pdf., 2021.

[L26] Pitkänen M. What could 2-D minimal surfaces teach about TGD? https://tgdtheory.fi/public_html/articles/minimal.pdf., 2021.

[L27] Pitkänen M. A solution of two galactic anomalies in the TGD framework. https://tgdtheory.fi/public_html/articles/twogalanos.pdf., 2022.

[L28] Pitkänen M. DMT experiences and hyperbolic geometry. https://tgdtheory.fi/public_html/articles/dmthyperb.pdf., 2022.

[L29] Pitkänen M. More anomalies related to the standard model of galaxy formation. https://tgdtheory.fi/public_html/articles/galanomalies.pdf., 2022.

[L30] Pitkänen M. Some New Ideas Related to Langlands Program *viz.* TGD. https://tgdtheory.fi/public_html/articles/Langlands2022.pdf., 2022.

[L31] Pitkänen M. TGD view about water memory and the notion of morphogenetic field . https://tgdtheory.fi/public_html/articles/watermorpho.pdf., 2022.

[L32] Pitkänen M. The realization of genetic code in terms of dark nucleon and dark photon triplets. https://tgdtheory.fi/public_html/articles/darkcode.pdf., 2022.

[L33] Pitkänen M. Trying to fuse the basic mathematical ideas of quantum TGD to a single coherent whole. https://tgdtheory.fi/public_html/articles/fusionTGD.pdf., 2022.

[L34] Pitkänen M. Two objections against p-adic thermodynamics and their resolution. https://tgdtheory.fi/public_html/articles/padmass2022.pdf., 2022.

[L35] Pitkänen M and Rastmanesh R. The based view about dark matter at the level of molecular biology. Available at: https:/tgdtheory.fi/public_html/articles/darkchemi.pdf., 2020.