A solution of two galactic anomalies in the TGD framework

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Abstract

Initial mass function (IMF) is used in the modelling of the galaxies. IMF would be the initial distribution of stellar masses as a given galaxy started to evolve about 10-13.6 billion years ago. It would be very natural to assume that the IMF is universal and the same for all galaxies, and this has indeed been done. The candidate for a universal IMF has been determined from the data related to the Milky Way and its satellites. There are however several candidates for the galactic IMF. It has been however found that the IMF depends on the distance of the galaxy from Earth and that the IMFs tend to concentrate on larger stellar masses. The dependence of MF on this distance is in conflict with the standard view about time assuming that the geometric past is fixed.

Zero energy ontology (ZEO) of TGD suggests a solution to the paradox. TGD Universe is quantum coherent also in astrophysical scales and "big" state function reductions (BSFRs) reversing the arrow of time occur for stars making them blackholes. This is the case also for Kerr-Newman rotating blackholes. Also quasars as white holes become galactic blackholes with an arrow of time opposite to that for a distant environment. ZEO implies that the geometric past and thus the IMF of the galaxy changes in the sequence of BSFRs. A simple argument based on the fact that massive stars have shorter age shows that the IMF for large distances from Earth indeed is concentrated on larger stellar masses.

The TGD based solution of the satellite galaxy problem relies on the TGD view about galactic dark matter: dark energy and dark matter reside at long cosmic strings which can form tangles at which the flux tubes thicken and liberate energy forming the ordinary galactic matter. The orbits of the stars around the cosmic string are helical orbits in a plane orthogonal to the string and in special case planar orbits. The velocity curve is flat without further assumptions. The preferred planes could correspond to planar minimal surfaces with 3-D E^3 projection.

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1 Introduction

Two anomalies related to the physics of galaxies are discussed. The first strange finding is that the initial mass function of galaxies depends on distance from the observer [E2]. The newest anomaly of cold dark matter models is that the stars of the satellite galaxies of bigger galaxies tend to rotate around the host galaxy in planar orbits rather than along random orbits as halo models predict.

1.1 Can the the initial mass function of galaxies really depend on distance from the observer?

In learned about new very interesting findings related to distant galaxies from a popular article "*New discovery about distant galaxies: Stars are heavier than we thought*" (see `https://cutt.ly/UJdEG2G`. The article tells of the work done by astrophysicists in Niels Bohr Institute, Denmark by A. Sneppen et al.

The article "*Implications of a Temperature-dependent Initial Mass Function. I. Photometric Template Fitting*" [E2] provides a technical description of the work (`https://cutt.ly/SJdEZik`). The abstract of the article gives an overall view of the findings.

> *A universal stellar initial mass function (IMF) should not be expected from theoretical models of star formation, but little conclusive observational evidence for a variable IMF has been uncovered. In this paper, a parameterization of the IMF is introduced into photometric template fitting of the COSMOS2015 catalog. The resulting best-fit templates suggest systematic variations in the IMF, with most galaxies exhibiting top-heavier stellar populations than in the Milky Way. At fixed redshift, only a small range of IMFs are found, with the typical IMF becoming progressively top-heavier with increasing redshift. Additionally, subpopulations of ULIRGs, quiescent and star-forming galaxies are compared with predictions of stellar population feedback and show clear qualitative similarities to the evolution of dust temperatures.*

Here is how I understand the basic notions and reported findings appearing in the article.

1. Initial mass function IMF used in the modelling of the galaxies is the key notion. IMF would be the initial distribution of stellar masses as galaxy started to evolve. The ages of galaxies between 10-13.6 billion years so that they formed very early. It would be very natural to assume that IMF is universal and same for all galaxies, and this has been indeed done. The candidate for a universal IMF has been determined from the data related to Milky Way and its satellites. There are however several candidates for the galactic IMF.

2. The finding of the group is that IMF is not universal and tends to concentrate towards higher masses for distant and therefore younger galaxies. The proposed IMF is parametrized by using a temperature like parameter T_{IMF}, interpretable as the temperature when the galaxy was formed.

   Here I however encounter a problem in my attempts to understand. I find it difficult to comprehend why T_{IMF}, a parameter that should characterize a galaxy, should depend on the distance of this galaxy from us. This looks nonsensical. Perhaps IMF is not what "initial mass function" suggests. What does one mean with "initial"? Or maybe some very interesting new physics related to the notion of time and aging of the stars is lurking there!

3. High mass stars have a short lifetime and end up to Supernovae unless the star formation creates new ones. Because stellar mass is dominated by low-mass stars, the inferred stellar masses and star formation rates (SFRs) are highly sensitive to the ratio of high-mass to low-mass stars in the IMF. The inferred extinction, metallicity, and other properties depend on the assumed IMF.

In the standard model, star formation is sensitive to the pressure-gravitation balance. The IMF should be sensitive to all variables that can affect it. Article mentions central gravitational potential, existing stellar mass, star formation history, supernova rate, cosmic-ray density and galactic magnetic fields, metallicity, dust density and composition, AGN activity, and the environment and merger history.

All of these are known to vary both between different galaxies at fixed redshift and across different redshifts. According to the authors, it should be expected that the IMF is not universal but rather differs between galaxies and between different epochs for the same galaxy. In particular, the IMF should depend upon the gas temperature of star-forming clouds, with higher-temperature regions producing higher average stellar masses. Because observations of dust even at moderate redshifts find an increase in temperature toward higher redshifts.

4. Authors notice that already in the case of the Milky Way there are several candidates for IMB and that typical stellar mass and star formation rate (SFR) are highly sensitive to IMF. There are also significant degeneracies between the IMF and extinction, metallicity, star formation history, and the age of the stellar population, which makes it very difficult to determine the entire shape of IMF.

5. The group performs a fit to a temperature dependent family of IMFs having initial temperature T_{IMF} as a parameter. What is nice is that for a given redshift, this is found to give only a few candidates for the IMF. The very distant galaxies would be top-heavier (stellar mass would be concentrated towards higher masses) and the fraction of heavier stars would be higher.

The proposal of the authors can be criticized. There is no doubt that the dependence of IMF on the galaxy is a fact but its dependence on the distance of the galaxy from us is in a glaring conflict with the standard view about time evolution, in particular with the basic assumption of the standard ontology stating that our geometric past is fixed.

Initial mass function (IMF) would be the initial distribution of stellar masses as the galaxy started to evolve about 10-13.6 billion years ago. It would be very natural to assume that the IMF is universal and the same for all galaxies, and this has indeed been done. The candidate for a universal IMF has been determined from the data related to the Milky Way and its satellites. There are several candidates for the galactic IMF. It has been however found that the IMF depends on the distance of the galaxy from Earth and that the IMFs tend to concentrate on larger stellar masses. The dependence of MF on this distance is in conflict with the standard view about time assuming that the geometric past is fixed.

Zero energy ontology (ZEO) [L4, L7, L9] [K4] defines the ontology behind TGD based quantum measurement theory and solves the basic paradox of quantum measurement theory. Second key element is the predicted hierarchy of effective Planck constants [L1] labeling phase of ordinary matter behaving like dark matter.

ZEO suggests a solution to the paradox created by the findings. TGD Universe is quantum coherent also in astrophysical scales and "big" state function reductions (BSFRs) reversing the arrow of time opposite to that for the environment occur for stars making them blackholes. This is the case also in GRT for Kerr-Newman rotating blackholes. Also quasars as white holes transform in BSFR to galactic blackholes with an arrow of time opposite to that for a distant environment. ZEO implies that the geometric past and thus the IMF of the galaxy changes in the sequence of BSFRs. A simple argument based on the fact that massive stars are shorter-lived shows that the IMF for large distances from Earth indeed is concentrated on larger stellar masses.

1.2 The satellite plane anomaly of the cold dark matter model

The anomalies of the halo models of galactic matter have been steadily accumulating during years. For instance, it has been found that satellite galaxies of larger galaxies tend to move in planes [E3] whereas the ΛCDM predicts that the orbits are more or less random. Quite generally, ΛCDM fails on short scales.

The TGD based solution of the satellite galaxy problem relies on the TGD view about galactic dark matter: dark energy and dark matter reside at long cosmic strings, which can form tangles at which the flux tubes thicken and liberate energy forming the ordinary galactic matter. The orbits of the stars around the cosmic string are helical orbits in a plane orthogonal to the string and, as a special case, planar orbits. The velocity curve is flat without further assumptions. The preferred planes could correspond to planar minimal surfaces with 3-D E^3 projection.

2 TGD based explanation for the dependence of IMF on distance

What could be the TGD based interpretation of the strange findings? Could the cosmic string model for the formation of galaxies and stars [L2, L3, L8] predict the time evolution of the galactic mass distribution by assuming a universal IMF? The paradoxical finding challenges the standard view about time: could zero energy ontology (ZEO) [L4, L7, L9] implying radical revision of this notion, be involved in an essential manner?

2.1 Cosmic string model for the formation of astrophysical objects

Consider first the cosmic string model for the formation of galaxies, stars, planets and and also smaller objects [**?**]

1. Cosmic strings would be the fundamental objects. Their string tension is determined by CP_2 length scale determining their energy density identifiable as dark energy and Kähler magnetic energy. Also ordinary and dark particles in the TGD sense can contribute to the density of energy. Galaxies are assumed to be tangles of a long cosmic string at which the cosmic string has thickened to a monopole flux tube with reduced string tension. The flat velocity spectrum of stars rotating around the cosmic string is flat and the value of the velocity is dictated by the string tension. Therefore galactic dark matter as a halo is replaced with the energy density of the long cosmic string containing galaxies as its tangles: this explains the linear structure formed by galaxies.

2. The energy of the cosmic strings would have been liberated as ordinary matter: this is completely analogous to the formation of ordinary matter in the decay of the inflaton field in inflation models. The seeds of stars can be identified as sub-tangles of galactic flux tubes analogous to spaghettis. This hierarchy of tangles inside tangeles inside... tangles continues to short length scales, even biomolecules, atomic nuclei, and hadrons would be this kind of tangles. The already existing ordinary matter could condense around these seeds.

   The conservative guess is that this analog of inflation was significant only during the very early stages of star formation when no stars existed yet and only the transformation of dark energy to ordinary matter could give rise to stars.

   The flux tube tangle would thicken and generate stellar objects as subtangles. The farther the star is, the younger the galaxy is. Massive stars as supernovas die soon and the mass function shifts to lighter stellar masses.

3. New massive stars are not formed after the galactic cosmic string tangle and galactic blackhole-like entity reaches a maximal size: one could say that the galaxy dies. After this star formation could happen as a condensation process around tangles serving as seeds as in the standard model and would give rise to stars, planets, and even smaller objects. The development of the flux tube containing the tangles would determine galactic evolution.

4. Note that a quasar identified as a galactic blackhole-like object would be there from the beginning and feed mass to its environment. In the spirit of ZEO, I have proposed that it is the TGD analog of white hole and a time reversed version of a blackhole-like object. Instead of sucking matter inside it it would spew matter outside, essentially energy of cosmic string, out which gives rise to the galactic matter.

   BSFR means death in a universal sense and in a well-defined sense, a blackhole is a dead object. Could blackhole be a time reversal of a white hole as quasar. BSFR changes the arrow of time and the radiation produced by blackhole would travel to the geometric past: nothing would come out from the perspective of the observer in the future! This what ordinary blackholes indeed look like. Could blackhole-like entities have an arrow of time, which is opposite to that of the environment? As a matter of fact, this would not be new! Also in GRT, Kerr-Newman solutions representing rotating blackholes have an arrow of time opposite to that of a distant environment [?]. I have discussed Kerr-Newman blackholes in the appendix of [K2].

Both galactic blackholes and stellar blackholes would be dead and time reversed quasars and "live" in a reversed time direction. Also ordinary blackholes would "live" in the opposite direction of time.

2.2 The interpretation of IMF and T_{IMF} in the TGD framework

What could be the interpretation of the IMF in the TGD framework? Does the parameter T_{IMF} appear naturally? Since the formation of galaxies and stars would be a process analogous to inflation, it would seem that the gravitational condensation around seeds defined by the flux tube tangles dominates except in very early times. Hence it would seem that the interpretation in terms of IMF which depends on T_{IMF} must make sense in the TGD framework. This is not possible without a new view about time provided by zero energy ontology (ZEO).

1. Zero energy ontology (ZEO) [L4, L7, L9] suggests a radical interpretation for the dependence of IMF on the distance of the galaxy from us. In ZEO, the stars of the galaxy evolve by state function reductions (SFRs) occurring in stellar and even longer scales. This is due to the hierarchy of effective Planck constants predicted by number theoretical vision of TGD involving the notion of $M^8 - H$ duality [L5, L6]) and adelic physics [L1]. ZEO predicts that both "big" and "small" SFRs (BSFRs and SSFRs) are possible.

2. In the BSFR, the arrow of geometric time changes and BSFRS can change even in astrophysical scales. This could explain the observation of stars which are older than the Universe [L3]. A given star would make BSFRs and in this manner evolve forth and back in the geometric time and become physically older but the center of mass time coordinate for the causal diamond (CD) of the star would not shift to the geometric future so that aging as it is usually understood would not take place.

   The size L of the CD is expected to increase in the process and could define as its inverse a parameter analogous to $T_{IMF} = \hbar_{eff}/L$.

3. The stellar BSFRs could explain the nonsensical looking dependence of the IMF on the distance of the galaxy from us. These stars of these very old galaxies would experienced would have made a large number of BSFRs. By universal evolution [L1] they would be at a high evolutionary stage and can be said to be repret old stars, stars older than the Universe. Star would have transformed to a blackhole and back to a white hole serving as a seed for the formation of a new star. The massive stars would have disappeared as supernovas and the mass distribution of these stars defining the IMF would shift towards lighter masses. Also the temperature would decrease for these stars determining IMF, which would imply the paradoxical looking decrease of T_{IMF} with the increasing cosmic distance.

3 TGD based explanation of the satellite plane anomaly of the cold dark matter model

The satellite galaxies of larger galaxies tend to move in a plane around the host as described in the review article [E3] whereas the ΛCDM predicts that the orbits are more or less random. The article gives illustrations showing the concentration around the planes for the Milky Way, Andromeda, and Centaurian. The plane of satellites is approximately orthogonal to the plane of the host galaxy in all cases.

Quite generally, ΛCDM fails on short scales. The success in long scales is understandable in the TGD framework since the approximation of the mass density of cosmic strings by a continuous mass density is good in long scales.

3.1 Why planar orbits are preferred?

TGD predicts [L2, L3, L8] a fractal network of very massive long cosmic strings which can locally thicken to flux tubes: this thickening involves transformation of dark energy and possible dark matter of cosmic string to ordinary matter giving rise to galaxies and other structures. Also stars would have thickened flux tube tangles inside themselves. The model finds support from the observation that galaxies form long strings as found decades ago (Zeldowich was one of the discoverers [E4]).

The TGD based model predicts the formation of planes in which objects in various scales move. The prediction is fractal: this applies to planets around stars, stars around galaxies, satellite galaxies around larger galaxies,....

This model explains the satellite plane anomaly and also the earlier anomalies if the galaxies are associated with the long "cosmic strings" predicted by TGD [K1]. They create a strong gravitational potential giving rise to a radial force in the plane orthogonal to the cosmic string. The motion along the string is free whereas the planar motion is rotation. The velocity spectrum is flat as required by the flatness of the galactic velocity spectrum. In the simplest model cosmic string is the carrier of galactic dark matter and dark energy. No dark matter halo and no exotic dark matter particles are needed.

Helical orbits are the most general orbits. If a concentration of matter occurs to a plane, it tends to catch objects moving freely in the direction of string to its vertical gravitational field and planar sheets such planetary systems, spiral galaxies, and the planar systems formed by satellite galaxies can form.

The first guess is that the satellite galaxies move in the plane of the host galaxy. The plane is however approximately orthogonal to the plane of the host in the 3 cases illustrated in [E3].

1. I have proposed that the intersections of nearly orthogonal cosmic strings could induce the thickening to flux tubes and transformation of the dark energy of flux tubes to ordinary matter starting to rotate in the planes defined by the intersecting cosmic string.

2. These intersections are unavoidable for strings like objects in 4-D space-time and would occur at discrete points. In the collision of cosmic strings, these points would define the nucleus of the host galaxy, say the Milky Way. The satellite galaxies would be assignable to the plane defined by the second colliding cosmic string, which would take the role of stars in the plane of the host galaxy.

   The colling cosmic strings would be in a very asymmetric position. Why this asymmetry? Could the satellites correspond to circular pieces of cosmic string generated in the collision by reconnections (note the analogy with reconnections of magnetic flux tubes of solar wind occurring during auroras) and generating the matter of the satellite.

   Why only the second cosmic string would have satellites around it? For two separate cosmic strings it is difficult to understand why reconnection would form loops. This process is natural for the two antiparallel strands of a closed U-shaped loop. Cosmic strings indeed form loops.

This model involves two strings. One can also consider a single cosmic string.

1. Cosmic strings are closed in a large enough scale, and the model for quantum biology encourages to consider U-shaped cosmic strings for which the parallel string portions carry opposite magnetic fluxes and can naturally reconnect. The flux tube could self-reconnect and generate loops, possibly assignable to the satellite galaxies. The reconnection process would be fundamental in TGD inspired quantum biology (see for instance [L10]).

2. In the reconnection of the strands carrying opposite magnetic flux would form a section S orthogonal to the long part L of the U-shaped string. Could one assign the host galaxy with L and the satellite galaxies to S? L and S would define nearly orthogonal planes and the satellite galaxies could form around loops created from L by a repeated reconnection and they would rotate around the host in the plane defined by S.

3.2 Is there something that could define galactic planes?

One can wonder whether there is something, which serves as a seed for the concentration of stars around a selected plane, perhaps associated with the boundary of a cell of the honeycomb structure. The collision of two cosmic strings would naturally define two planes of this kind. In the case of a single U-shaped closed string, which looks a more promising option, there is no obvious identification of the plane orthogonal to this object.

1. In the TGD Universe, space-time is a 4-surface in $H = M^4 \times CP_2$ and also membrane like entities are predicted as 4-D minimal surfaces of H having lower-D singularities analogous to the frames of a soap film minimal surface property (and simultaneous extermality with respect to Kähler action) fail but the field equations for the entire action involving volume term and Kähler action are satisfied at the singularities.

2. One can also consider 3-D singularities, which form a tessellation of H^3 at a given moment of cosmic time a and assign it with the honeycomb of large voids. The frame would be a tessellation. The quantization of cosmic redshifts in a given direction, discussed from the TGD viewpoint in [K3], could be seen as evidence for cosmic tessellations having astrophysical objects at their nodes.

   The boundaries of the large cosmic voids form a honeycomb structure and could correspond to a tessellation of H^3. The long U-shaped cosmic strings would be associated with the boundaries of the cells of the honeycomb and perhaps even form a 2-D lattice like structure.

   TGD suggests [L2, L3, L8] a fractal network of very massive long cosmic strings which can locally thicken to flux tubes: this thickening involves transformation of dark energy and possible dark matter of cosmic string to ordinary matter giving rise to galaxies and other structures. Also stars would have thickened flux tube tangles inside themselves. The model finds support from the observation that galaxies form long strings as found decades ago (Zeldowich was one of the discoverers [E4]).

3. The objects $M^1 \times X^2 \times S^1$, where M^1 is time axis, X^2 is a piece of plane of E^2, and S^1 is a geodesic sphere of CP_2, define very simple minimal surfaces carrying no induced Kähler field. The objects X^2
   $timesS^1$ could accompany the boundaries of the honeycomb cells. Universe could be populated by these membrane-like objects. Cell membrane is one important example.

4. Planar or approximately planar objects orthogonal to the cosmic string could tend to gather the matter flowing along helical orbits along the cosmic string. These planes would accompany planetary, galactic, etc... planes and the honeycomb structure could be also seen as a fractal analog of a multicellular structure.

5. Warped planes represent slightly more complex minimal surfaces with 3-D M^4 projection (a thin metal foil or sheet of paper gets warped) for which the plane is deformed but still flat minimal surface. I am not sure whether the "warping" [E1] (`https://cutt.ly/dHoeZKw`) of the outer regions of galactic planes, which has received attention recently (`https://cutt.ly/pHorgcD` and) but has been detected already 1956, is really really warping that is vertical deformation, which depends only single coordinate varying along a straight line (a 2-D plane wave of membrane).

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