Are Dark Matter, Dark Energy and Inflation a Construction of ` Spacetime by Matter?

Stuart Kauffman Sept 2024

This is the third in a set of articles. All take non-locality as fundamental. All require that matter constructs spacetime. All are testable. The first is a theory of quantum gravity proposing that sequential actualization of four mutually entangled particles constructs successive three-dimensional Minkowski space-like slices that constitute a four - dimensional Minkowski spacetime. *This construction is a Dark* Energy. The second builds on this and the unexpected discovery that the particles of SU(3) x SU(2) x U(1) are capable of a collective autocatalysis that construct a universe by driving Cosmogenesis, Baryogenesis and Inflation. Dark Energy has a Hubble Scale.

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This third article derives the consequences: Matter constructs spacetime locally proportional to its fourth root. This proposal appears to unite Dark Matter, Dark Energy, and Inflation. ***The proposal that matter to its fourth root constructs spacetime predicts that older galaxies rotate faster than younger galaxies of the same mass.*** **The predictions are confirmed at 7.5 sigma.** ***Dark Energy*** **may be a slow construction of spacetime by low density matter throughout the universe.** ***Cold Dark Matter*** **may be a more rapid construction of spacetime by matter clumped in galaxies and galactic clusters. The theory predicts a** ***Hubble Tension*** **that is the difference between the slower and faster rates of constructing spacetime.**

THE LAMBDA CDM STANDARD MODEL OF COSMOGENESIS AND ITS TENSIONS

The standard model of Cosmogenesis, based on General Relativity, is the Lambda CDM model. Lambda is Einstein's Cosmological Constant, in favor with the discovery of the accelerating expansion of the universe. This expansion is due to Dark Energy, estimated at 69% of the energy budget of the universe. Lambda is the favored theory for Dark Energy. We do not know the physics of Dark Energy.

Cold Dark Matter, CDM, has been proposed for decades to account for the excess rotation velocities of galaxies beyond that which General Relativity alone can explain. Cold Dark Matter is assumed to be some form of particle that does not interact with ordinary matter, via some coupling to Gravity. No Cold Dark Matter particles have been identified. We do not know the physics of Dark Matter.

TENSIONS

The Hubble Tension: Measure of the rate of expansion of the universe, the Hubble Constant, Ho, determined for the early universe from the Cosmic Microwave Background, CMB, is Ho = 67.8 Km/sec/Mpc. Ho for the late universe is estimated at Ho = 73.4 Km/sec/Mpc. The current statistical significance of this tension is 5.0 sigma.

The James Webb Space telescope has raised a second alarm. "Impossible Galaxies" with 10^{10} solar masses existed only 350 to 400 million years after the Big Bang. It is not known how such galaxies could have formed so quickly. In addition, the radii of these galaxies are only 10% that of later galaxies of the same mass, and rotate too slowly.

Nonlocality as fundamental:

If nonlocality is fundamental, no theory that requires locality can be fundamental.

Therefore, General Relativity and Minkowski Spacetime cannot be fundamental. They require locality.

String theory cannot be fundamental. It requires locality.

Loop Quantum Gravity cannot be fundamental. It requires locality.

The AdS/CFT duality cannot be fundamental – CFT lives on a D -1 surface, so it requires locality. And the Holographic Principle cannot be fundamental. It requires locality.

The AdS/CFT duality is the major way to map from a quantum field theory with no geometry to a geometry. If Non-locality is fundamental

Quantum Gravity if Nonlocality is Fundamental

If we start with nonlocality, we must explain locality – spacetime.

Nonlocality is N entangled coherent particles from SU(3) x SU(2) x U(1).

Therefore, if we start from nonlocality, locality – spacetime - must emerge from matter.

Matter must “somehow” construct spacetime…This construction can be a Dark Energy

Lambda, the Cosmological Constant, cannot be correct.
Lambda **asserts that spacetime itself, without matter, can construct more spacetime.** ***Then Lambda cannot be Dark***

Quantum Gravity if Nonlocality is Fundamental

Stuart Kauffman Entropy (2022), 24, (4),

i. Non locality consists in N entangled coherent particles in Hilbert Space.

ii The von Neumann Entropy, VNE, for each pair of entangled particles, is sub-additive and fits the triangle inequality so is a real number *distance* between 0 and ln N, the number of entangled particles.

Iii. Thus, this is a Metric in Hilbert Space with no geometry.

Iv. To convert from potentia in Hilbert space to spacetime, I postulate sequential actualization to Events. NOW is recovered among potentia, for when one actualizes, amplitudes change.

v. This converts a flowing time in Hilbert Space to a sequential set of atemporal Events.

iv. A linear mapping from metric in Hilbert Space with no geometry to classical spacetime geometry among the discrete atemporal events via sequential actualizations.

v. Complete Graphs and Faithful Lorentzian Manifolds . We recover

At the Classical Level this is a net rate of construction by Matter of Spacetime that scales as Kex $M^{1/4}$ (Kex is in m^3/sec/gram)

The Central Proposal:

A Construction of Spacetime by Matter can unite Dark Matter and Dark Energy as the same construction. A *slow* exponential construction of spacetime by *dilute* matter *is* a Dark Energy.

The Central Tension:

Dark Energy is an expansion of spacetime. Dark Matter models a centripetal acceleration toward galactic centers. Can an expansion of spacetime also yield a centripetal acceleration toward galactic centers?

The surprising answer seems to be YES. Dark Matter can be seen instead as an Expanding Ricci soliton surrounding galaxies and

TO DEMONSTRATE:

1) This quantum construction of spacetime by matter, QCST, explains galactic rotations curves.

2) QCST also explains the Baryonic Tully Fisher Relation.

3) Therefore, this quantum construction of spacetime by matter can hope to replace *Dark Matter* with respect to galactic rotation curves.

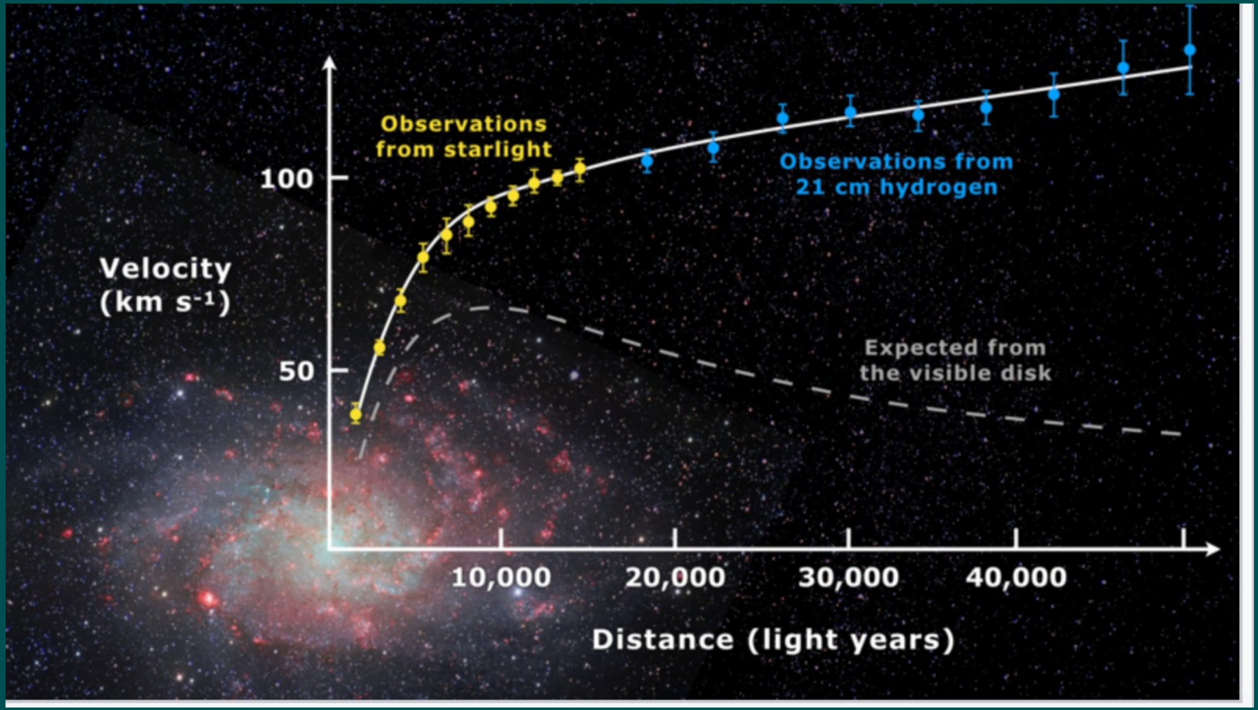


Figure 1

The unexpected flat radially distal high rotation velocities observed but not accounted for by General Relativity.

The vertical gap between the expected curve and the observed curve is the "Missing Matter" needed to fit Kepler's laws.

DARK MATTER was invented to constitute the Missing Matter.

No Dark Matter particles have yet

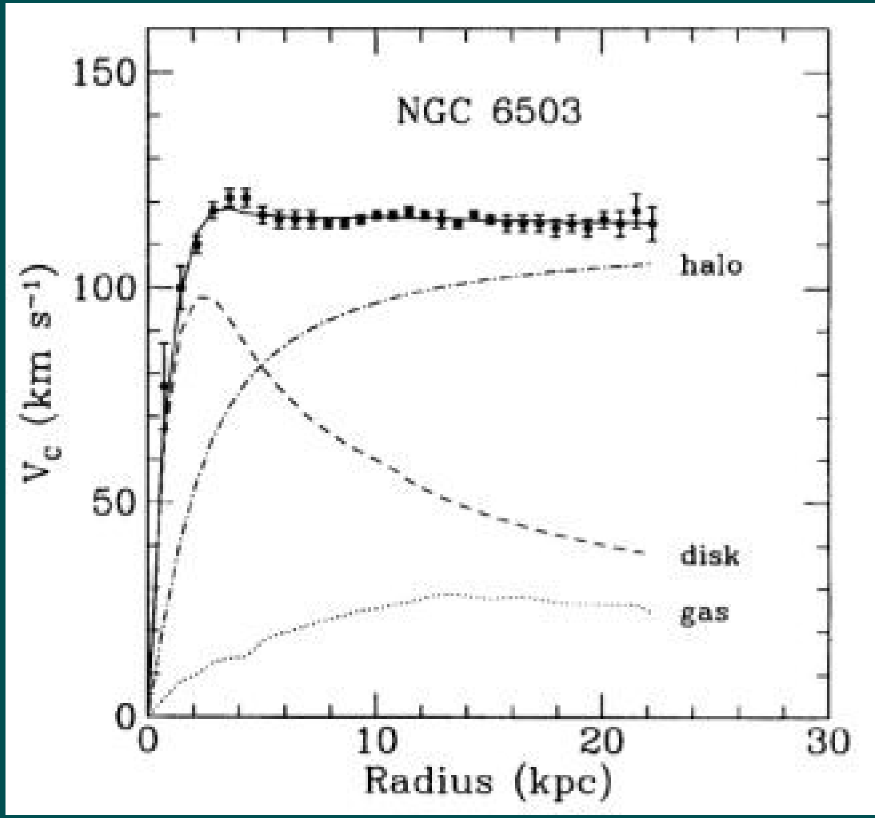
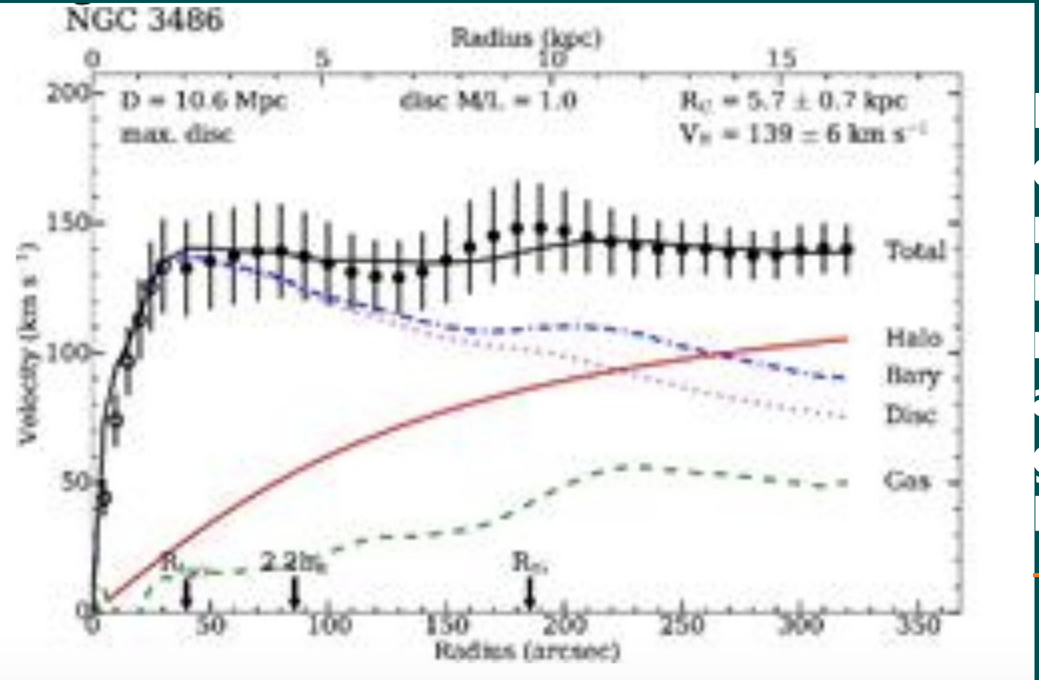


Figure 2a

Radial distribution of the dark matter halo needed in addition the the radial distribution of baryonic matter (disc plus gas) to account for the flat distal galaxy curves by General Relativity itself.



Radial distribution of the dark matter halo, red curve needed in addition the the radial distribution of baryon matter (disc plus gas) to account for the flat distal galaxy curves by General Relativity itself.

Figure 2b

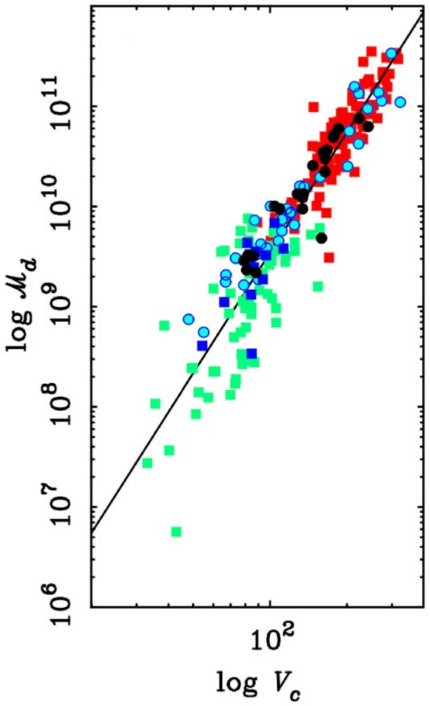
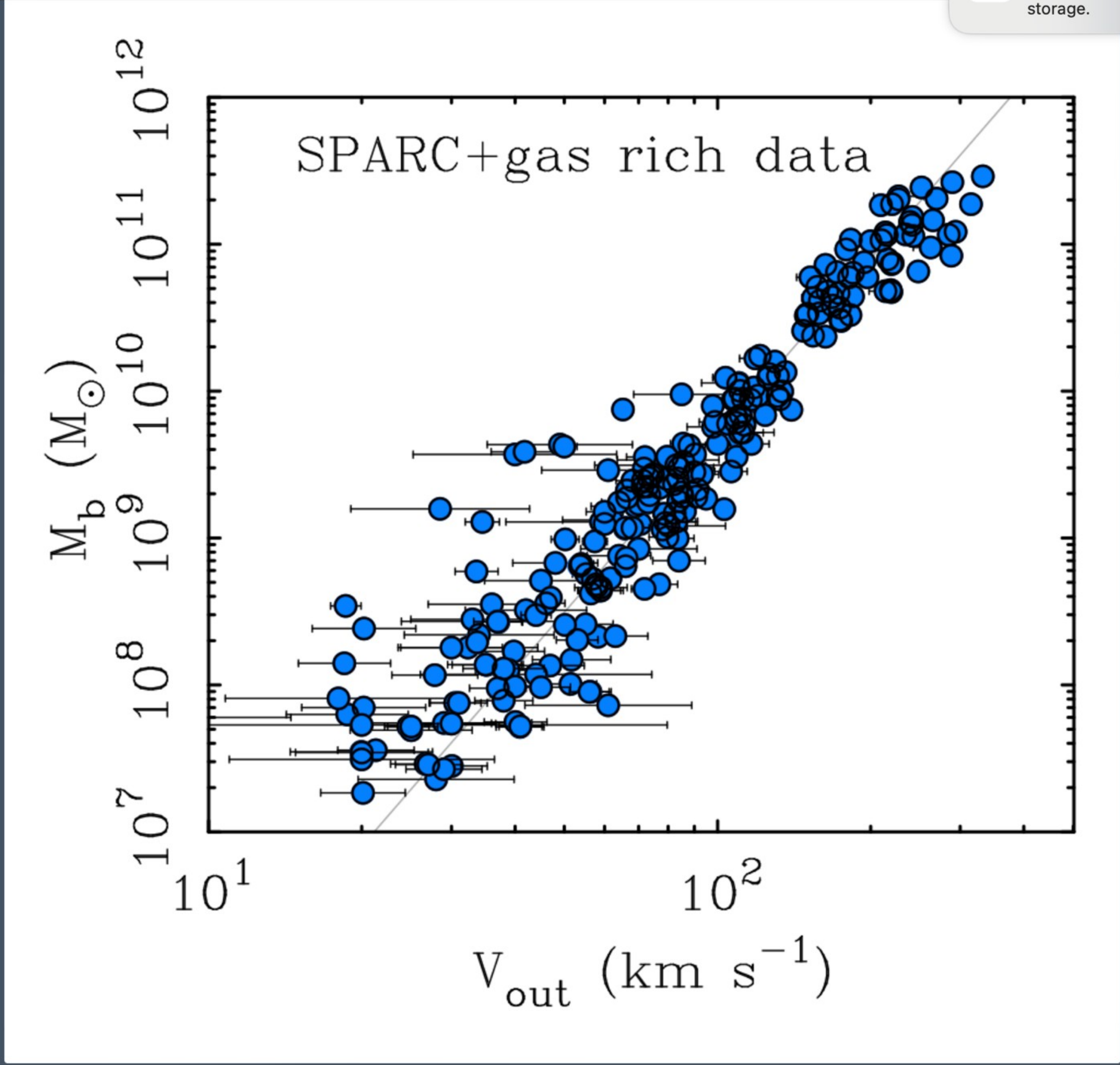


Figure 2: Baryonic Tully Fisher Relation (BTFR): total baryonic disk mass of galaxies against the rotation velocity V_c. Circles and squares represent the data derived from [138](red), [139](black), [137, 142] (green), [140](light blue) and [141] (dark blue). The black solid line shows an unweighted linear fit. The figure is reproduced from [125].

Figure 3a

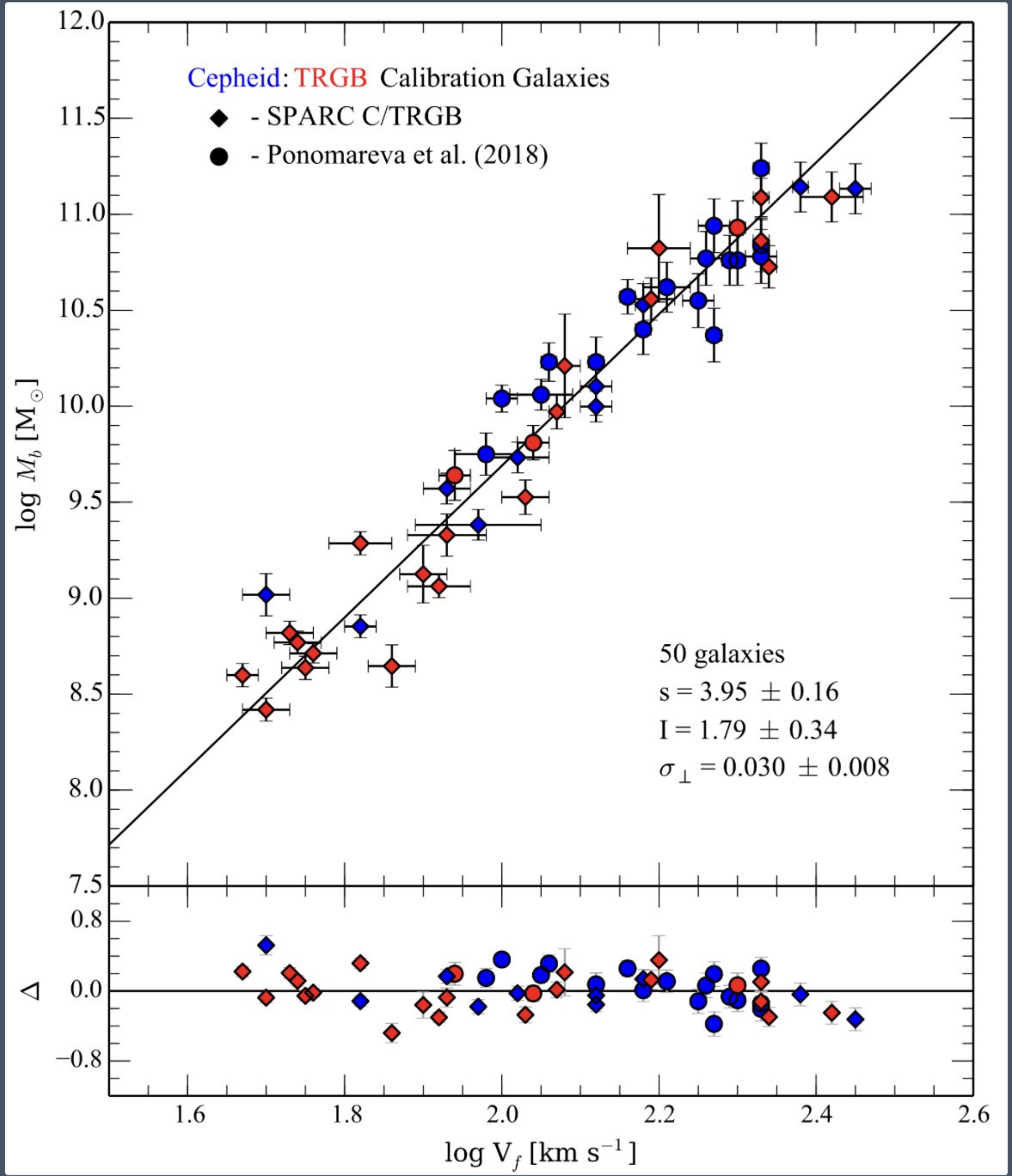
THE BARYONIC TULLY FISHER RELATION



Baryonic mass (stars plus gas) as a function of the rotation speed measured at the outermost detected radius.

Figure 3b

THE BARYONIC TULLY FISHER RELATION



The Baryonic Tully-Fisher relation calibrated with 50 galaxies with direct distance determinations from either the Tip of the Red Giant Branch method (23) or Cepheids (27).

THE BARYONIC TULLY FISHER RELATION

Figure 3c

DERIVING THE BARYONIC TULLY FISHER RELATION:

QCST requires a construction of spacetime by matter at a *rate* proportional to matter, *M ^ 1/4th power*. Therefore, the *total* spacetime constructed is the *Integral* of the rate of construction over the lifetime of the galaxy.

The QCST theory can hope to explain and derive the empirical Baryonic Tully Fisher Relation, figures above and below.

The BTFR is that maximal rotation velocity, V, scales as V^4 proportional to Baryonic Matter, M. Thus, maximal rotation velocity, V, scales as M ^ *1/4th*

In order to derive the empirical Baryonic Tully Fisher Relation, QCST must yield a construction of spacetime such that it equals the *increased tangential rotation velocity* at each radius, and that it increases monotonically with radius from the galactic center. In addition, the QCST theory must account for the power law scale 4 of the BTFR with respect to galactic mass.

Because the theory must yield an increased *tangential* velocity, I consider a construction of spacetime along a *"line of sight"*. The same process also increases the volume of spacetime constructed.

This requirement is met. QCST creates classical space time via sequential actualization of 4 mutually entangled quantum particles.

i. *Along any line of sight*, so long as matter is present along the line of sight, the total rate of construction of spacetime *increases monotonically* with the distance between any two sites.

ii. Given a large gravitating mass such as a galaxy, so long as matter is present along the pathway, *along any line of sight*, outward from the galactic center of mass, this is a monotonic increase in the rate of construction of spacetime, increasing with the distance, r, between the large center of mass and the site.

iii. The total spacetime constructed is the *integral* of the rate of construction at each radius, r, between the large center of mass and the site over the lifetime of the galaxy.

v. Thus, this total construction of spacetime maps to an v.
***increased tangential rotation velocity* that itself increases monotonically radially outward from the galactic disc.**

vi. The increased tangential rotation velocity scales with a power law of slope 4 with respect to galactic mass, M, because the rate of construction of spacetime scales as Kex $M^{1/4}$.

Conclusion: The QCST theory can hope to fit and explain the Baryonic Tully Fisher Relation. Further work based on Ricci solitons is required, see below.

RICCI SOLITONS :

Ricci solitons concern shrinking or expanding Spacetime. If matter constructs spacetime, Ricci solitons depend upon matter density distributions.

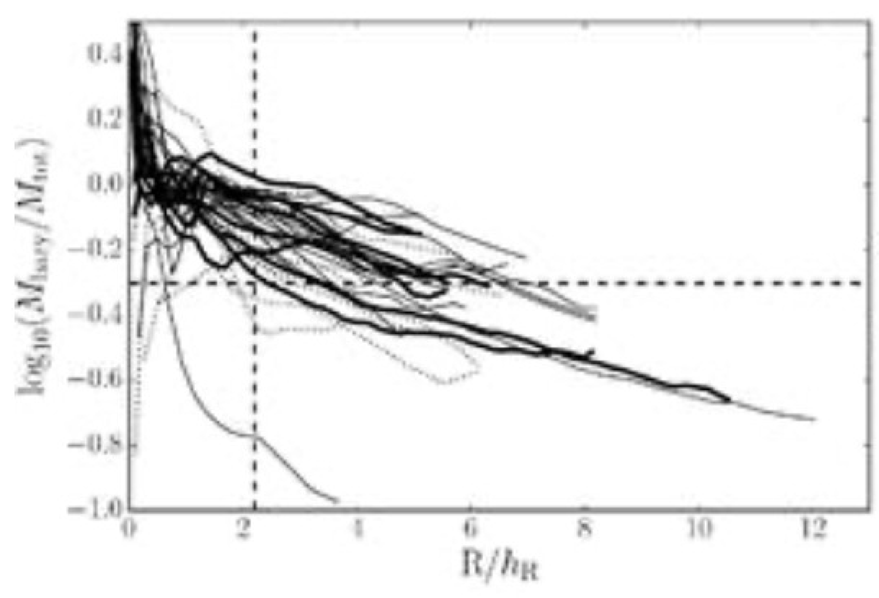


Figure 4a

Radial Baryonic Matter Distribution

Y axis is logarithmic

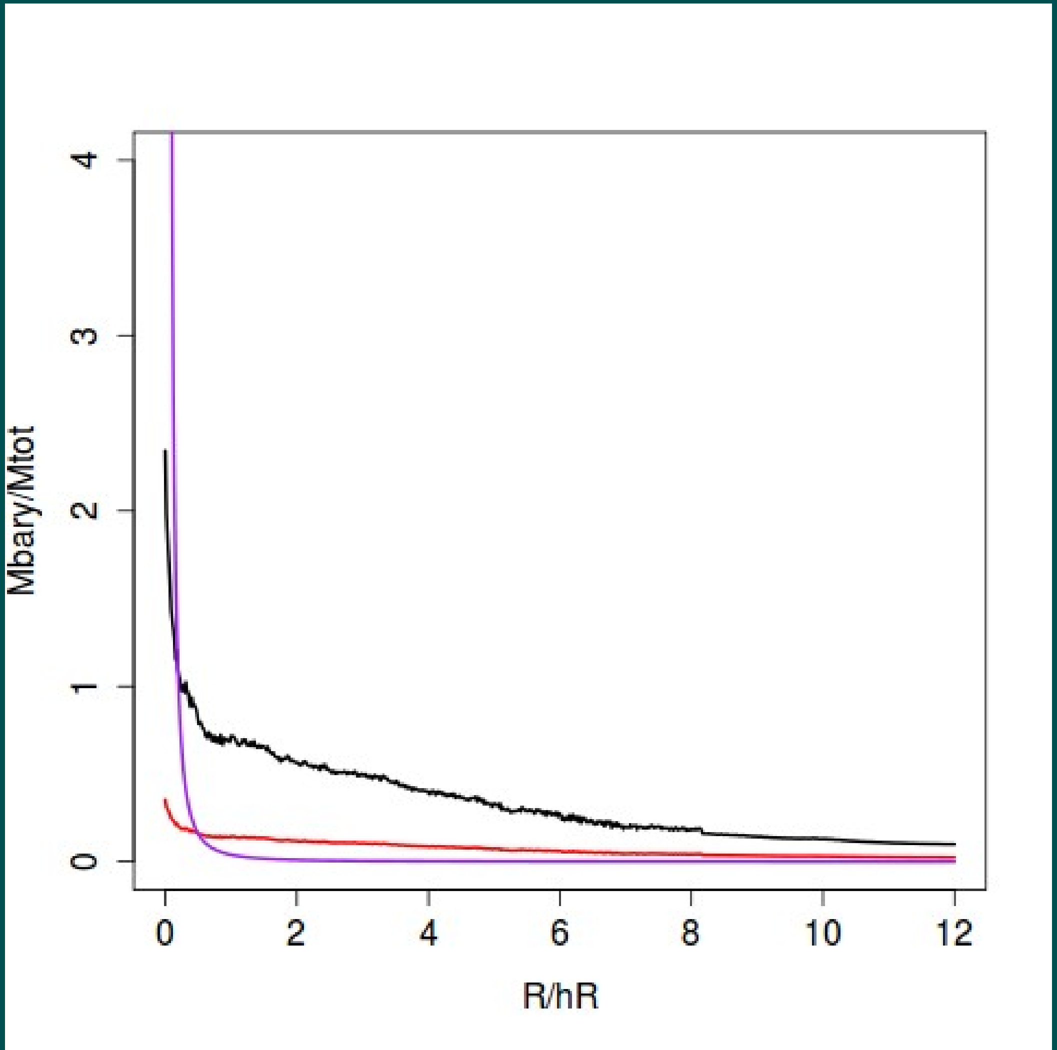


Figure 4b

The Black Curve is the averaged radial distribution of matter in galaxies. T

The Red curve is the ¼ root of the radial matter distribution. The purple

curve is gravitation falling off as 1/r^2.

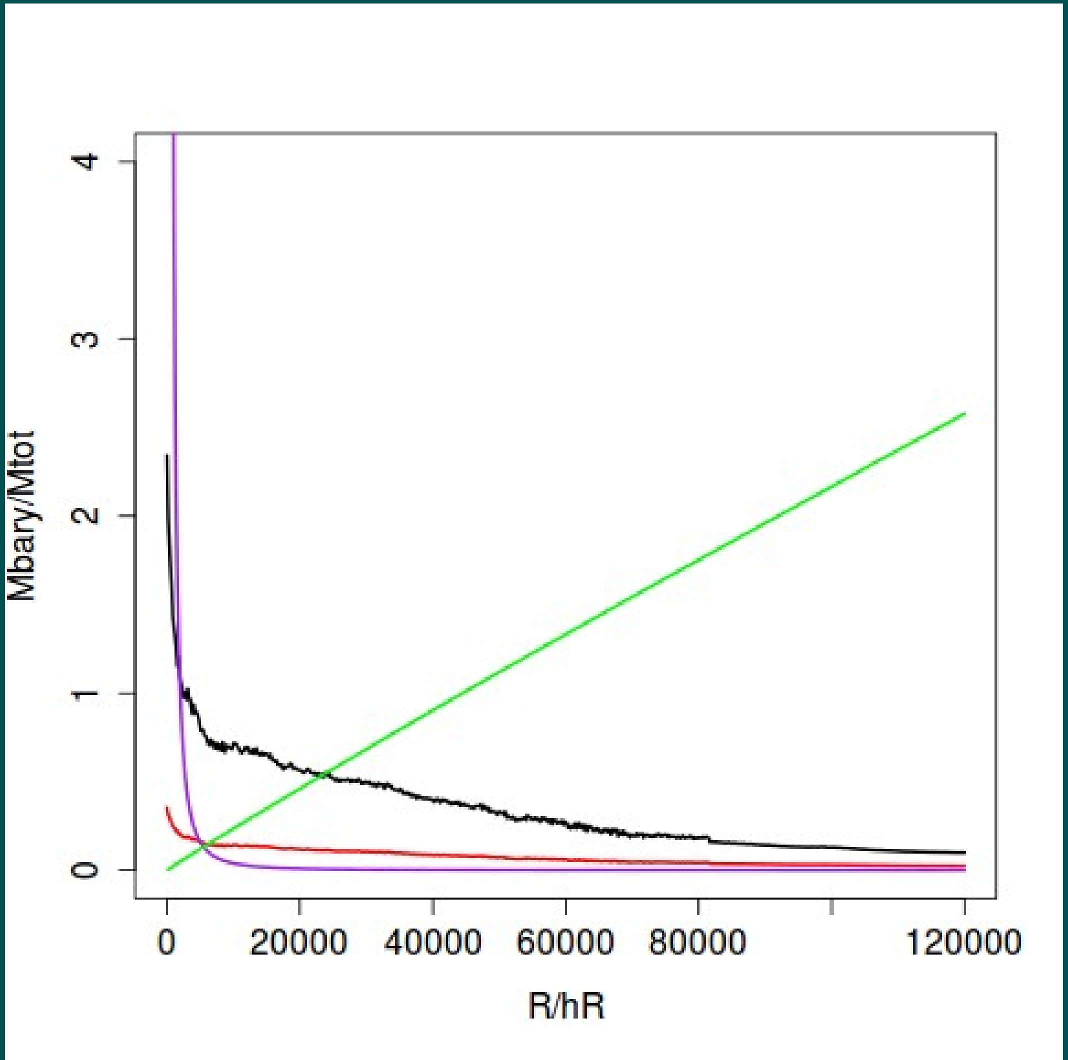


Figure4c

The Red curve is the ¼ root of the radial distribution of baryonic matter.
The Green curve is the integral of the Red curve giving the

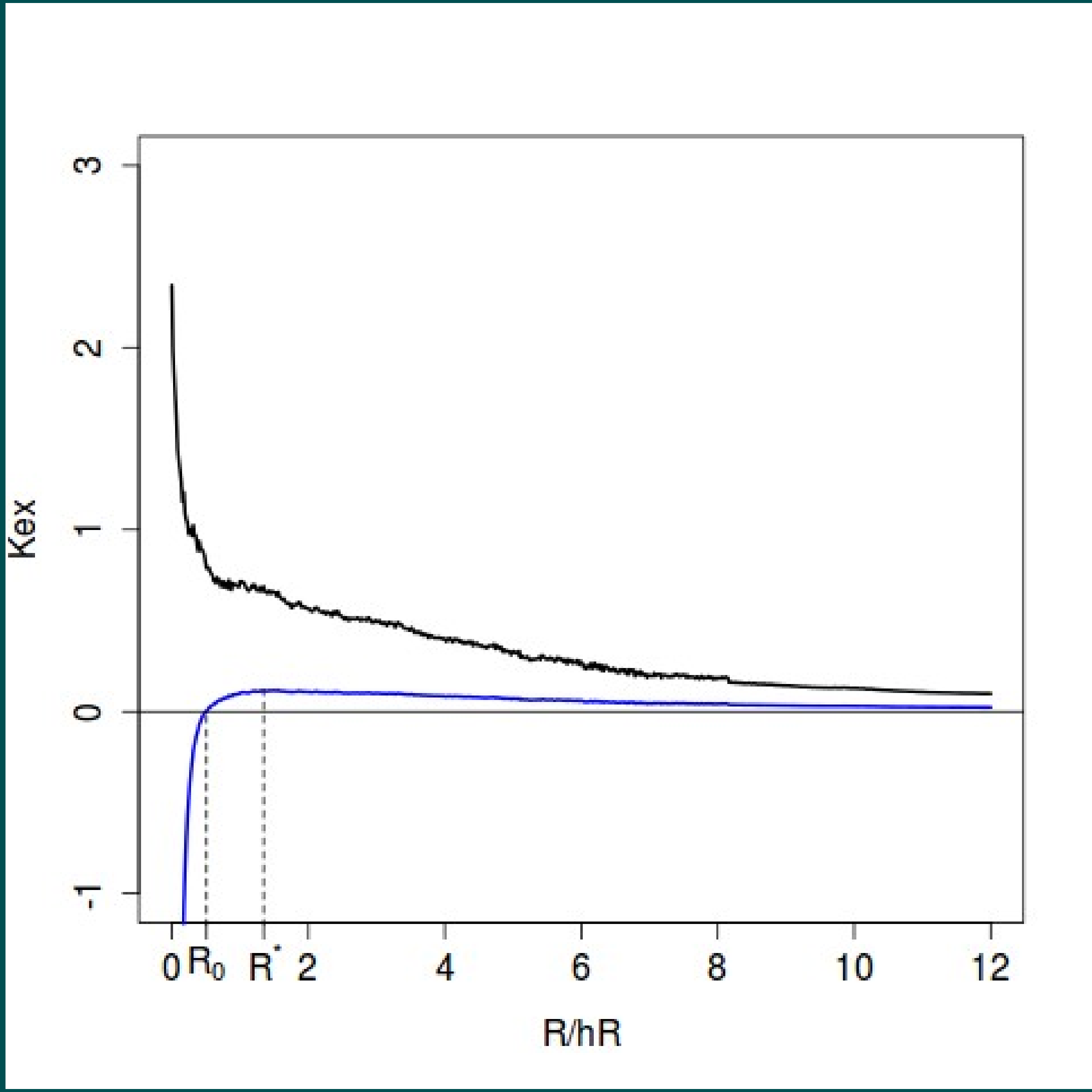
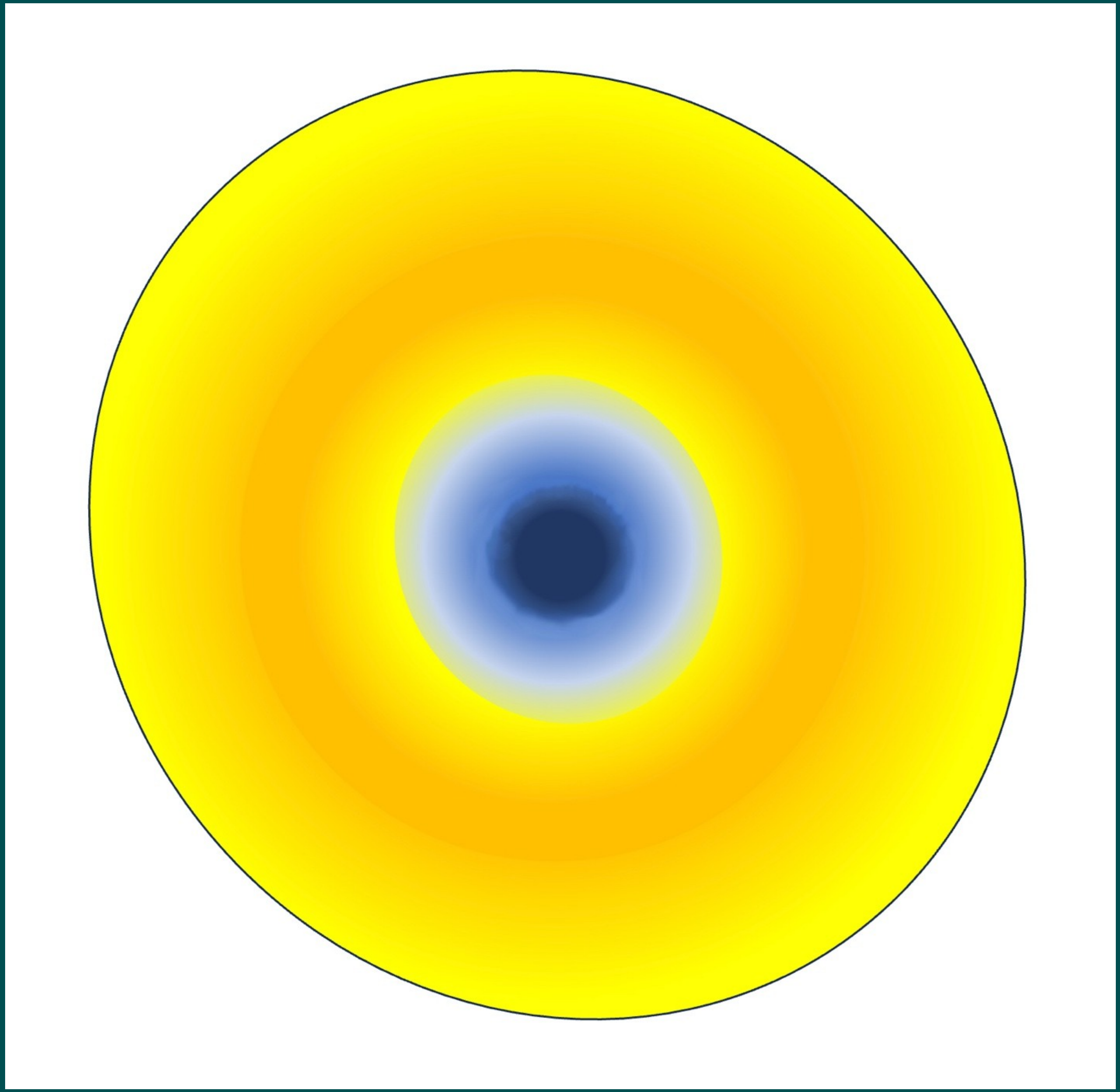


Figure 4d

Kex, the blue curve, is the net rate of expansion of spacetime in the face of gravity at each radius from the galactic center. The value of Kex at each radius is obtained by subtracting the contraction of spacetime due to gravity, the purple curve, from the rate of creation of spacetime, the red curve, at each radius in the previous figure,

Kex is negative near the galactic center and increases to Kex = 0 at a critical radius, Ro. At and beyond Ro, Kex is positive so spacetime is expanding. The rate of expansion reaches a maximum at a radius R*, then decreases at increasing radius.

A RICCI SOLITON Figure 5



An isolated galaxy at the center of the figure. *Kex,* the net expansion of spacetime in the face of gravity is strongly negative near the center of the galaxy, *dark blue*, and become less negative at increasing radius from the galactic center.

At and beyond critical radius, **Ro,** spacetime begins to expand, *yellow region*, reaches a maximum rate of expansion at a radius **R*** orange, then

Testing the Construction by Matter of Spacetime

The QCST theory must predict that galaxies of a given stable baryonic mass that have *existed longer* have constructed more spacetime so should *rotate faster* than galaxies of the same stable baryonic mass that have lived less long.

This is extensively testable using the scatter in the BTFR data for all galactic masses, all rotation velocities, and all galactic lifetimes.

For a given mass, does rotation velocity increase monotonically with galactic lifetime at 5 sigma? Does it increase exponentially with galactic lifetime at 5 sigma?

For a given rotation velocity, does galactic mass decrease

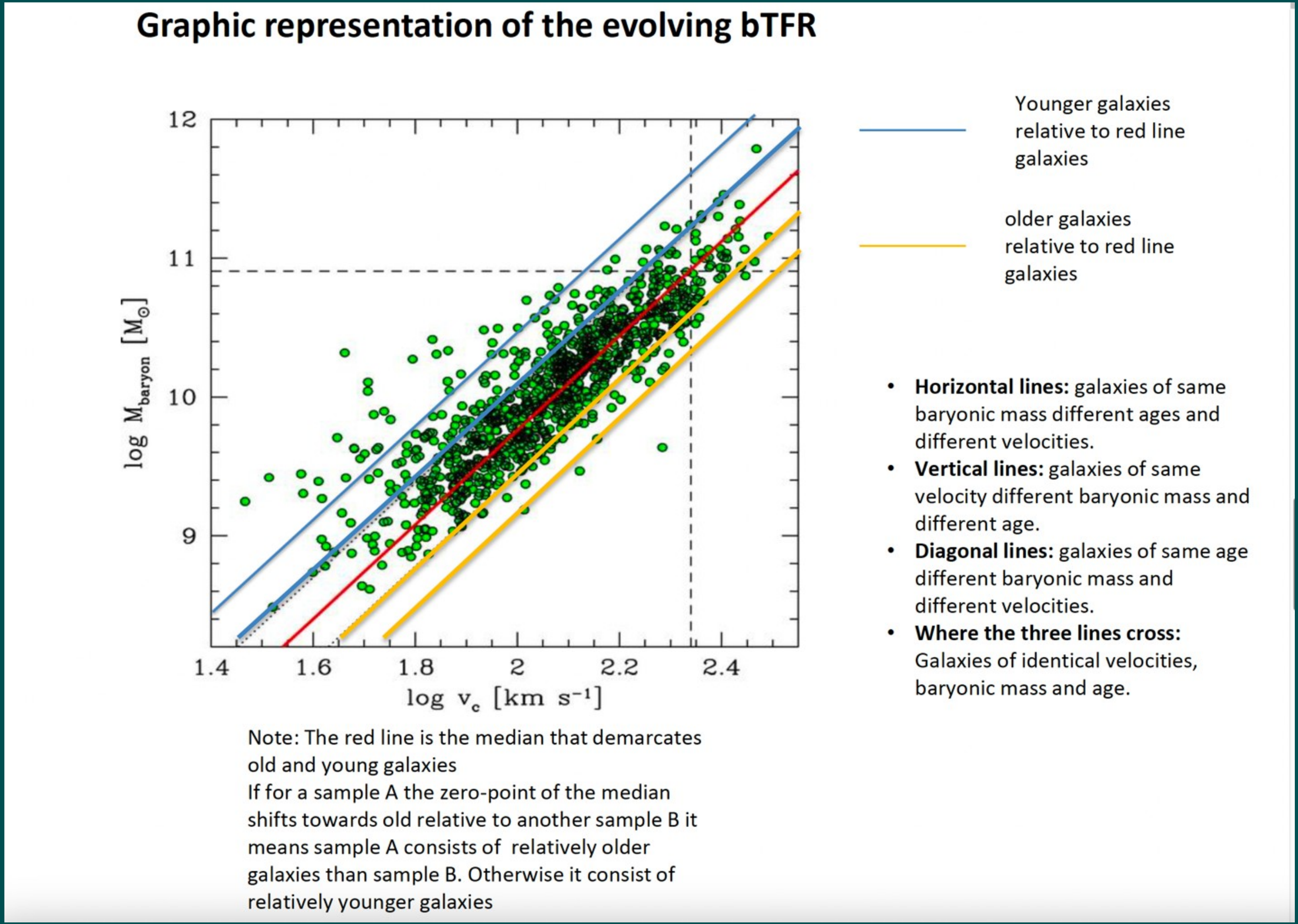


Figure 6a **Stuart Marongwe 2017**

Test for all horizontal lines.
Test for all vertical lines.

Retest using disjoint or overlapping sets of galaxies
to obtain the Baryonic Tully Fisher Relation.

Testing for 5 Sigma should be possible.

If the answer is YES, we would have strong evidence that matter does construct spacetime.

We would have to modify Einstein's Field Equations for General Relativity.

$$v = e^{Ht}(GM(r)H_0c)^{\frac{1}{4}}$$

Figure 6b. **The Marongwe equation**. This equation relates galactic rotation velocity, v, to an expression including mass, M, GM, to the ¼ power. This equation explains the rotation curves of galaxies and aldso galactic clusters Without invoking Dark Matter. Hence this exponential expansion of spacetime by Matter ^1/4 is a candidate to replace Dark Matter. See Stuart Marongwe Stuart Kauffman, **"Dark matter as a Ricci soliton with supporting data"**, OSF.

Baryonic Tully Fisher Relation

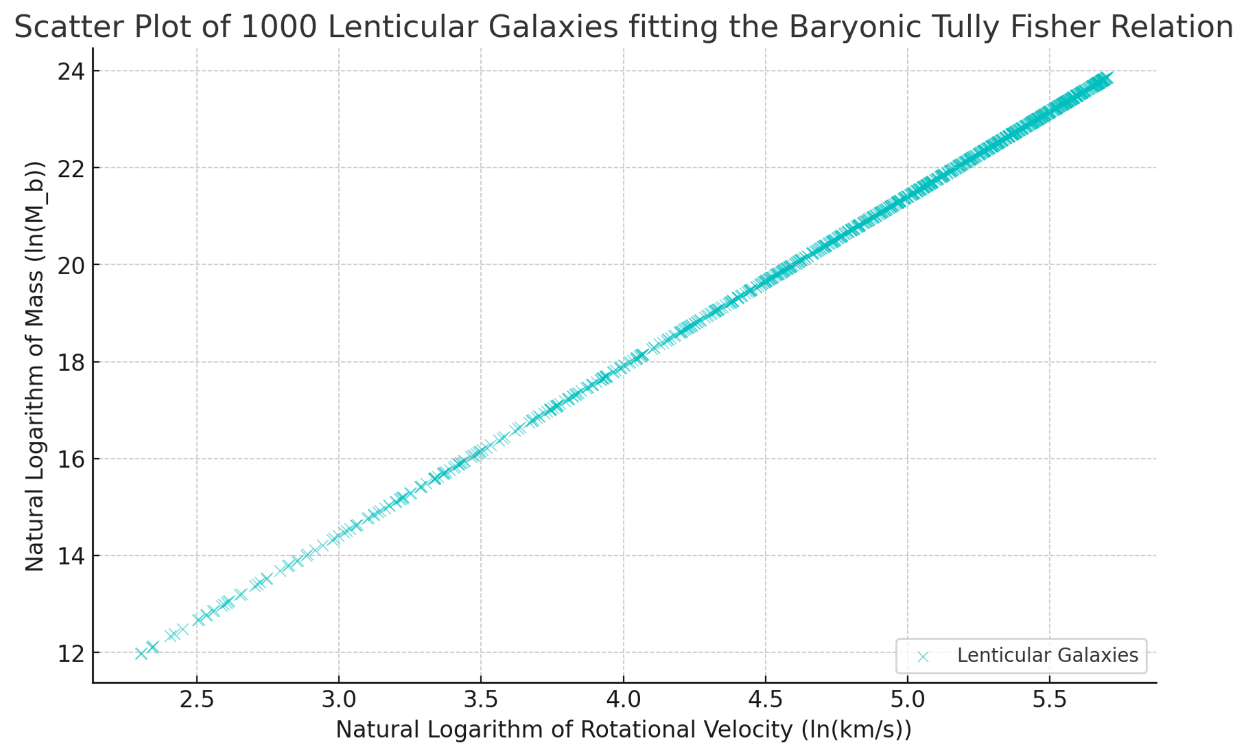
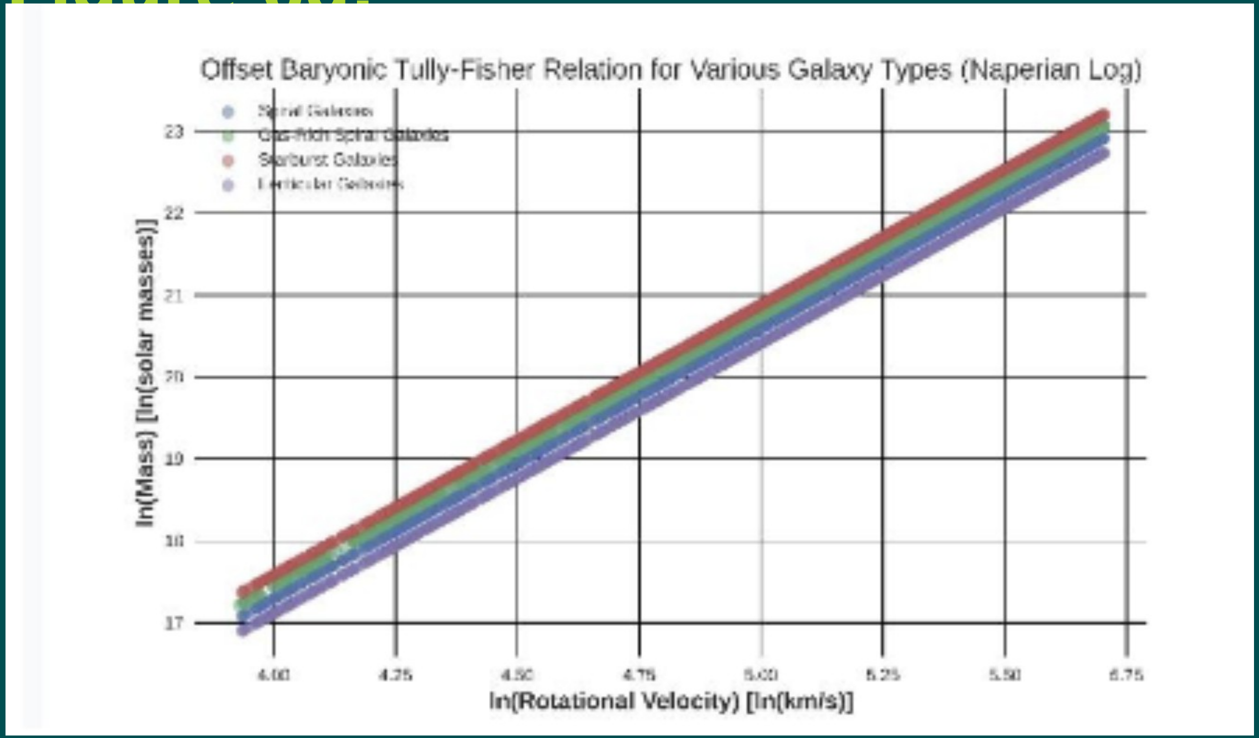


Figure 6c.
1000 Lenticular galaxies. Stuart Marongwe 2024

THE EMPERICAL TEST USING 4000 GALAXIES with Stuart Marongwe Figure 6d.



Galaxy Type	Mean of ln mass	Standard Deviation	offset	Age/Gyrs
Starburst	21.0264	1.6090	0.2877	2
Gas-Rich Spiral	20.9792	1.6036	0.2405	8
Spirals	20.7387	1.6090	0.0000	10
Lenticular	20.5564	1.6090	-0.1823	12

Test for all horizontal lines.
Test for all vertical lines.

Retest using disjoint or overlapping sets of galaxies **to obtain the Baryonic Tully Fisher Relation.**

Testing for 5 Sigma should be possible.

THE PREDICTIONS ARE CONFIRMED AT 7.5 SIGMA, P = 6 X 10 ^-12

The answer is YES, we now have strong evidence that matter does construct spacetime.

We may indeed have to modify Einstein’s Field Equations for

Impossible Galaxies:

Stuart Marongwe permits me to say that we are finding an explanation for Impossible Galaxies in our framework

An article should be on-line within a month and the data will be publicaly available.

UNITING DARK MATTER AND DARK ENERGY
The theory automatically has a Dark Energy

Dark Matter and Dark Energy have long been considered as distinct. Dark Matter may be particles, Dark Energy may be the Cosmological Constant.

If Matter constructs spacetime might Dark Matter and Dark Energy be united as this single process?

A construction of spacetime by Matter ^ ¼ is an automatic Dark Energy.

The Proposal: Dark Energy is the slow construction of spacetime by relatively non-dense matter at the time of the CMB and in Voids. Dark Matter is the more rapid construction of spacetime by clumped matter in galaxies and galactic clusters

The Hubble Tension:

Ho of the early universe via CMB is 67.8 km/sec/Mpc

Ho of the late universe is 73.4 km/sec/Mpc

Tension now 5 sigma. Lambda CDM does not explain this.

There were no galaxies or galactic clusters at the time of the CMB, so the Ho of the early universe really may be less than the Ho of late universe. Ho in voids is low, like that at the CMB. Voids are 15% the average density and about 80% of the volume of the universe.

The theory that matter constructs spacetime predicts the very existence of a Hubble Tension.

Testing the Predicted Hubble Tension:

From our joint papers, (46, 53) the rate, r, of the expansion of spacetime due to an expanding Ricci soliton near a galaxy is r = v/Ho, where v is the rotation velocity of a galaxy. Considering Figure 8d, and equal numbers of galaxies rotating at $e^{4.0}$ Km/sec/Mpc, $e^{4.25}$, … $e^{5.75}$ Km/sec/Mpc , and taking Ho as 67.8 Km/sec/Mpc, *yields an average excess expansion of spacetime by clumped matter of 2.264 Km/sec/Mpc.*

This excess is over and above the slower background 67.8 Km/sec/Mpc driven by the diffuse low-density matter, Dark Energy, at the time of the CMB and in voids. Then 2.264 Km/sec/Mpc is the deduced estimate of the Hubble Tension yielded by the data in (52, 53).

The Standard Deviation of the deduced Hubble Tension is 1.3414 Km/sec/Kpc. Based on this, our deduced mean Hubble Tension, 2.262 Km/sec/Mpc differs from the observed Hubble Tension, 5.6 Km/sec/Mpc, by less than 3.0 sigma.

Cosmic Inflation and *Dilutional Homogenization*

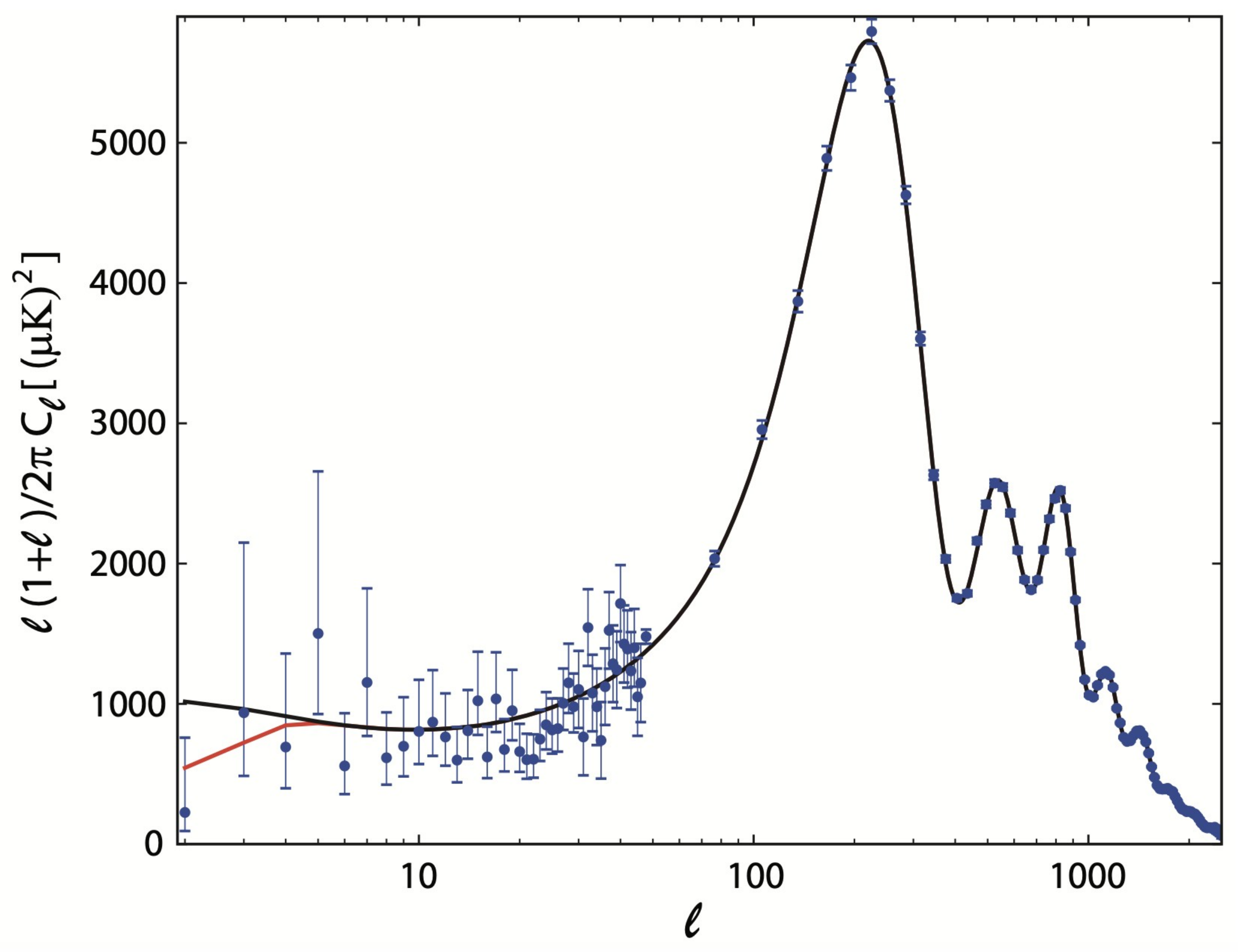
The physics of inflation is unknown. If Matter exponentially constructs spacetime at a rate scaling as the fourth root of Matter, this may be the missing physics of Inflation.

On the standard Big Bang theory there was a very high initial isotropic and homogeneous density of matter. This would drive a very rapid initial expansion of the universe slowing as 1/r^3. Here Inflation slows to become Dark Energy. There is no Infinite Inflation.

Inflation has been proposed to account for the homogeneity of the universe. Because regions that cannot have been in causal contact at large angles across the sky are nearly the same, Inflation proposes that very early at least one small region, homogeneous by causal contact, rapidy inflated to constitute the entire visible universe.

If matter constructs spacetime there is a remarkable new effect: Consider two regions, A and B, that are not in causal contact. If matter density is higher in A than in B, region A will create spacetime faster than will region B, hence A will more rapidly dilute its initial matter density than will B. Thus, without causal contact, A and B can become more homogeneous by this

Melia, Ma, Wei & Yu: The CMB large-scale anomalies



Low L < 30 CMB Are Underpowered

Figure 7

It is well known, Figure 7, that the low L, long wavelength modes of the CMB are underpowered. We have no agreed-upon explanation for this anomaly. More broadly, at least **five anomalies in the "statistics of the CMB** at large angular scales are in conflict with the nearly scale invariance predicted by inflation, or with the isotropy and homogeneity assumed by the Lambda CDM". **The anomalies include:** i. **Power suppression**, a lack of two point correlations for low multipoles, or for angles larger than 60 degrees. ii. **Parity Anomaly**, a preference for odd parity multipoles in the range of L [2 50]. iii. **Dipolar Modulation anomalies**. This is a correlation between L and L+1 multipoles in the range of L [2 64]. iv. **The correlation between the Quadrupole and Octupole alignment.** **v. These anomalies are all at low L, hence are not scale invariant.** A failure of scale invariance itself is also an anomaly with respect to the lambda CDM theory. The statistical deviation of any one of these with respect to the Lambda CDM model does not rise to 5 sigma. However, were a single theory capable of explaining all of these, the joint statistical significance of their departure from the predictions of Lambda CDM might rise high enough to warrant "new physics".

CMB Anomalies and Dilutional Homgenization

The implications of such dilutional homogenization with respect to CMB anomalies may be important, even explanatory. Such local dilutional homogenization had longer to act on the initial long wavelength low L modes as the universe expanded, than on the shorter, later modes. **Therefore, if such "dilutional homogenization" played a role during Inflation, the effects would not be scale invariant**. This feature fits that observed for the CMB anomalies, seen only in multipoles below about 60.

Power suppression of the two-point correlation function for low L large angles above 60 degrees might be explained by dilutional homogenization. Because such smoothing had longest to act on the lowest L

The Parity anomaly might also be explained. The even L multipoles are symmetric. The odd multipoles are asymmetric. Many pairs of even symmetric multipoles can simultaneously align multiple peaks. In contrast pairs of odd L asymmetric multipoles that both are prime numbers can only align a single peak. Dilutional homogenization may be unable able to "smooth" hence reduce the power, in these odd L multipoles. The same dilutional smoothing might better reduce the amplitudes in even L multipoles.

The CMB Anomalies and Dilutional Homogenization

The Quadrupole Octupole alignment correlation might also be explained. These are an adjacent low L pair of symmetric multipoles. Dilutional homogenization might be able to align their axes.

modes, a lack of power above 60 degrees might be explained.

The Dipole anomaly, a correlation between L and L + 1 multipoles may also be explained. Adjacent L and L+1 multipoles are of opposite symmetries, symmetric and asymmetric. Dilutional homogenization of adjacent multipoles may introduce correlations not captured by the Lambda CDM theory based on isotropy and homogeneity, where the analysis treats successive modes as independent.

Conclusions

Nonlocality is firmly established. Starting with nonlocality demands that matter constructs spacetime.

One approach uses 4 mutually entangled particles to construct a growing four –dimensional Minkowski spacetime via sequential actualization events.

Collective autocatalysis among SU(3) x SU(2) x U(1) can drive Cosmogenesis, Baryogenesis and Inflation.

This construction directly yields a Hubble Scale Dark Energy that can increase if Matter density increases. Matter denisity does increase as galaxies and galactic clusters form. Matter exponentially constructs spacetime at M^1/4

Dark Energy is the *slow* creation of spacetime by dilute matter, Dark Matter is the more *rapid* creation of spacetime by clumped

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THANK YOU

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