Entanglement and Galactic Rotations

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Abstract

Some fifty years ago it was noted that the rotation speeds of galaxies were too great for the gravitational force of all the available galactic mass to balance it. People therefore invented the idea of dark matter in the form of weakly interacting massive particles (WIMPs) to supply the missing mass. In spite of heroic efforts, such particles have not been found. If WiMPs don't exist then the problem isn't missing mass. It's missing force. This paper proposes that entanglement driven forces act as a fundamental component of cosmic structure stability. Conventional physics assumes forces propagate at finite speeds but we will assume otherwise. We postulate that entangled objects share a unified quantum state that allows instant interaction beyond classical constraints. This mechanism may account for anomalies in galactic rotation and explain synchronization of cosmic structures. A series of observational tests are outlined to verify this by offering alternative explanations for missing mass phenomenon and synchronization in galaxy motion. An Addendum is included with supporting calculations that verify the postulate.

Introduction

There are two major epochs in the history of the universe. The first was the singularity of Georges Lemaitre and Alexander Friedmann, which was an infinitesimal point containing everything that would be the universe. In effect, everything that was to be the universe was in a state of universal entanglement, entangled in the technical sense of the word, with everything else in this infinitesimal point. Since everything was in contact with everything else it required no time for a signal to travel anywhere in the singularity. Another way of expressing that is to say a signal inside the singularity traveled with infinite velocity. There was no Einsteinian relativity in the singularity. It was all entanglement. That was a basic characteristic of the singularity, that and the fact that it was and still is a quantum state characterized by an infinite velocity of interaction [1].

Then nature initiated the Big Bang, an explosion which caused a massive decoherence in the singularity. That decoherence broke much of the entanglement, but not all of it, and left something new in its place: Einstein's relativity. So today we are left with a new space time characterized by a maximum velocity of interaction traveling at c, yet we still have elements of the older entanglement whose interaction traveled with infinite velocity. Relativity and entanglement both exist in today's universe but each is a very different phenomena with different origins and different characteristics. Other than the fact that they both exist in the same universe, there is nothing similar about them.

Although there is no longer a singularity, an aspect of it still exists: Its infinite velocity. Since entanglement was not obliterated by the Big Bang, it is still important as is the newer relativity. Entanglement is no longer confined to an infinitesimal point but its most important quality, its infinite velocity, is still with us. This is the second epoch in the history of the universe and the one which spreads itself out around us now as the universe. The infinite velocity of the entanglement interaction devolves from the earlier entanglement interaction which also moved at infinite speed. This is the way nature builds on what she has already done. The seeds of entanglement were already prevalent in the earlier epoch of the singularity universe of Lemaitre and Freedman.

There is an apparent disconnect between the higher speed of rotation of a galaxy and the amount of mass supplying the gravitational force balancing the centripetal force of the rotating galaxy. A solution was proposed almost 50 years ago which says there is actually more mass than is presently seen in stars and planets. It's called missing mass which, theory holds, is supplied by weakly interacting massive particles called WIMPS. The Weakly Interacting Massive Particle (WIMP) is the strange particle that nature supposedly created so that physicists could reconcile the differing centripetal and gravitational forces. Nobody has found a WIMP after years of fruitless searching and most probably nobody will. This paper proposes that it isn't a missing mass problem at all. It is a missing force problem. That force arises from quantum entanglement although experimental evidence for that force is lacking for a good reason. It is undetectable experimentally. It is difficult to detect things moving with an infinite velocity of interaction [2].

I believe the best way to start this work is to go back to the singularities proposed by the Belgian Georges Lemaitre and the Russian Alexander Friedmann. That singularity was the early universe. That tiny point had the later universe of stars and planets crammed into a very small volume, where everything effectively touched everything else. It was a state of universal entanglement. This of course meant that it took no time for an interaction to travel anywhere in this beginning universe, or said another way, the speed of interaction was infinite. This singularity was the initial quantum state of the universe.

Then came the Big Bang, an enormous decoherence of the primal quantum state resulting mostly, but not completely, in an unentangled universe. Some remnants of the initial singularity remained scattered about the now far-flung universe. These had the same characteristics of the original singularity. They were quantum entangled objects that interacted with each other at infinite speed regardless of their distance apart. The entangled particles didn't decohere because all of them acted as though they were part of a single original quantum state, and they were because it took no time to travel between them.

What caused the Big Bang? Nobody knows. However, we must try. Our pathway will be to do some anthropomorphizing. We are talking about creation here. We humans have plenty of experience with creation in various venues. We will choose one of them, art, and try to reason by analogy.

When artists paint something significant, e.g., Rembrandt's Nightwatch which is a large painting or Michelangelo's ceiling of the Sistine which is enormous, they often do so on a large canvas to make sure they have room to get everything in which they wish to portray. When Nature chooses to do something significant, perhaps she too will eschew tiny spaces to showcase her work, in other words she too needs enough room. But the singularity is very small to encompass her vision. I am merely saying that the tiny singularity might have been too small for nature's vision. She just wanted more space and so triggered the Big Bang.

Now when nature exploded the singularity into the present grand universe, it seems sensible that she would have done so in the simplest way possible which means she kept the characteristics that worked in the singularity. Everything in the singularity was in the same quantum state before the Big Bang so she kept everything entangled after the Big Bang still in the same quantum state. Before the explosion all entanglement interactions moved at infinite speed, so after the explosion everything entangled still moved at infinite speed. However, the shock of the explosion broke much, but not all of the entanglement. The things which lost their entanglement became normal matter and did not interact at infinite speed. The entangled constituents after the explosion kept their infinite speed.

Infinite speed of course means it takes no time for the signal to reach the target. Targets are often covered with other material so it usually takes some time to penetrate the film around the target. In the case of the singularity, the target is so tiny that penetrating the covering material will require a minuscule amount of time.

What about relativity? For those constituents which remained entangled, we must bid farewell to the Einstein limit of c for the velocity of entangled interaction. They still interact at infinite speed. That is the characteristic velocity that all entangled interactions proceed with.

So today, all of the entangled particles are still part of a quantum state characterized by a single parameter: infinite speed of interaction. Now particle speed is not necessarily the same as interaction speed. Just because the interaction speed between them was infinite that does not imply the speed of the entangled particles was infinite. However, when an experimenter tries to calculate the force between entangled particles that interact with infinite speed, he is dealing with speeds which are usually too high to make meaningful measurements. Therefore, it would be quite difficult to determine whether force is present between them. We shall therefore suppose that forces can and do exist between quantum entangled particles, even though they

may not be reliably measured. Let us first investigate the difference between entangled forces and classical forces [3].

Classical forces are usually linked to particles, like electrons for electrical force. This paper challenges current models by proposing that gravity, in particular, is not just a classical force but an emergent property of entanglement. It is self-acting instantaneously among quantum connected systems shaping cosmic structures.

Before the Big Bang there was only one quantum state for all particles defined by infinite velocity of interaction. This paper presents a new perspective on the role of entanglement in gravitational interactions suggesting that entangled systems exist as one unified quantum state defined by infinite velocity of interaction. This state functions as a force multiplier contributing to large scale cosmic structure and offering a fresh explanation for the so called missing mass problem.

Entanglement as a Fundamental Force Multiplier in Cosmic Structure

Suppose we have two sets of sources and targets which deal with gravity. Set A is unentangled and set B is entangled. In A the source sends a signal out to the target which travels at speed c. It takes some time for the signal to travel from source to its target. At the same moment source B sends an infinite speed signal to its target which takes no time to arrive while source A's signal is lugubriously traveling from source to its target. So set B can send more signals of gravitational attraction than set A. This is how entanglement multiplies force.

In conventional physics, entanglement is understood as a correlation between quantum states. However, that perspective misses a deeper layer of reality about entangled objects which do not merely share linked states, they exist in one unified state governed by instantaneous interaction and are an inherent force mechanism.

1. *A new understanding of gravity*. This suggests that entangled systems do not proceed under conventional relativistic constraints but rather in quantum domains where action occurs instantaneously. The implications are profound. If entangled particles share a single quantum state, they experience force collectively, multiplying gravitational influences and contributing to galactic large structure formation.
2. *Rethinking Dark Matter*. The missing matter problem is actually a missing force problem which is explained by the multiplied quantum forces due to the infinite speed of interaction. This force is not a classical force but is an emergent property of entanglement and is self-acting instantaneously among quantum connected systems shaping cosmic structure. It is not necessary to postulate the existence of dark matter to explain galactic rotation.

3. *Entanglement as the Fabric of Cosmic Evolution*. Before the Big Bang the universe was an infinitesimal point of pure entanglement where all mater existed in a single infinite velocity state. The Big Bang marked a transition in scale although not necessarily in substance. The infinite velocity remained for entangled particles whose entanglement survived the shock of the Big Bang.
4. *Breaking Restores Classical Physics*. When entanglement is disrupted much, although not all, affected matter returns to conventional physical behavior, snapping back to standard relativistic principles.

Origins of Force

The state of all entangled objects could act as a background field. The sheer number of entangled particles could create a collective effect. If a perturbation affects all entangled particles this could generate a nonlocal force that is distributed across cosmic scales. The presence of entangled particles could lead to unexplained gravitational effects, for instance a quantum pressure that modifies spacetime curvature. These are, of course, unverified possibilities that are interesting to think about and might even be true. What is not seen experimentally is a particulate force carrier. However, the measurement of gravity depends on finding changes in force or mass distributions. If the force remains homogenous it won't be observed.

Quantum Coherent Driven Force

Entangled masses do not act independently. They function as a collective quantum state.
A simple equation describes what happens. The entangled force $F = \propto \sum \Psi (m_i, m_j)$, where the m's are the masses of the entangled particles and Ψ is a wavefunction. Each entangled mass contributes to the overall force. All entangled objects share one unified quantum state (infinite velocity of interaction). Galactic structure stability is due to entanglement driven forces and is an emergent force arising from collective entanglement interactions. A unified quantum state governs all entangled particles. Every entangled object belongs to a single wavefunction $|\Psi>$. Individual particles do not interact independently. They function as a collective entity. If entangled masses influence each other the force they experience is distributed across the quantum state, <u>not</u> localized. The entangled force does not travel at c. The entangled force propagates instantly bypassing space-time constraints. Quantum coherence multiplies force effects.

In classical physics, forces add linearly. For instance, $F = G (m_i m_j) / r^2$. Entanglement driven systems forces are coherently amplified. In classical systems one person pushes a block which reacts to that single push. In entanglement driven forces an entire synchronized group pushes a block at the same time which makes it move both faster and harder. All entangled objects share

one quantum state and they influence each other instantaneously and collectively. This multiplies force. Instead of force being based on two masses, entanglement makes all system masses contribute at once, $F_{ent} = \alpha \Sigma_n \Psi_n (m_i, m_j)$. Every entangled mass contributes collectively. This emergent force depends only on entangled masses. This summation applies only within the entangled mass system. This is how entanglement amplifies the force beyond classical theory. There are some experimental checks to determine whether masses are entangled. Certainly, some of them are entangled and others are typical unentangled masses. The results of these observations might tell which are entangled although mixtures of entangled and unentangled masses might present some difficulty.

Here is how to check if all the masses in a particular domain are entangled. Let us choose a galaxy. If everything is entangled then the galaxy acts as a single gravitational unit. Independent stars do not obey Newton's laws.

The following list describes characteristics of galactic entangled objects. The Addendum presents detailed results comparing theoretical and observed galactic rotation curves.

1. Instantaneous response to any perturbation. If a galaxy rotates with unexpected precision, it could be due to an entanglement driven force.
2. Unexpected synchronization where stars move to non-local coherence. If one part of a galaxy shifts, others should react instantaneously. That doesn't mean a planet will go flying off instantaneously. Planets have mass and whatever you do to them will not overcome inertia, but a sensitive gauge on the planet will react immediately to a signal moving at infinite speed.
3. If all the masses in a galaxy act as a single quantum object and all the mass in a galaxy moves as a unified system, then they are all entangled. In such a system force interactions are instantaneous. If all objects in a galaxy are entangled then entangled matter reinforces gravitational cohesion. Intergalactic interactions are synchronized. Entangled matter clusters hold together better than classical clusters.
4. Large scale structures beyond galaxies experience verification on cosmic scales.
5. There is more verification of complete Entanglement Driven Forces.
6. Galaxies act as a single quantum object. Galactic matter moves as a unified structure.
7. Force interactions are instantaneous across the entire galactic structure.
8. If all objects are entangled, entanglement matter reinforces gravitational coherence.
9. Intergalactic interactions are synchronized.
10. Galactic clusters hold together better than classical theory would suggest.

11. Quantum entangled galaxies exhibit motion correlation faster than the speed of light restrictions allow.
12. For researchers in this field, look how gravity violates classical predictions. Look for structural stability without extra mass. Non-local correlations in gravitational forces should exist [4].

Summary

We know the universe has gone through at least two phases, before the Big Bang and the current phase, which is after the Big Bang. Georges Lemaitre and Alexander Friedmann postulated the characteristic of the universe before the Big Bang. We will use their model as a guide. They held that the original universe was an infinitesimal point into which contained everything that eventually spread out around us as the universe. This is not an easy picture to contemplate.

If everything was jammed into this tiny point, their picture implied that everything was in physical contact with every other constituent, in other words everything touched everything else. We can quibble about how this could be possible but let us accept it as a starting point. If everything touched everything else then it took no time for any constituent of the singularity to interact with any other constituent. This sounds like what we would today call entanglement.

Another way of expressing this entanglement is to say that any interaction in the singularity traveled at infinite speed. Was there more than one singularity in the beginning universe? Possibly so, but to keep things simple we will assume there was only one. So the universe consisted of everything entangled (in the technical sense) with everything and the interactions traveled at infinite speed.

Then something happened. The Big Bang. An explosion whose power tore most of the entanglement apart. But not all of it. There was still some entanglement left after the shock of the explosion. However, objects have become physically separated many of which went off on their own, although some still remained entangled even though they no longer touched one another. This coincided with the birth of relativity. A whole new set of rules was created by the explosion. The maximum speed of the now liberated “normal” objects became c.

The objects which survived the explosion were not all liberated from entanglement. The entangled objects which survived the explosion no longer touched but they kept the same characteristic speed of the ones in the singularity. They continued interacting at infinite velocity. Why? Other than the explosion, there was nothing acting to change their interaction and unlike normal matter which was free to do what it pleased, the entangled matter that survived the explosion with their entanglement intact were still bound by the original entanglement rules. They still moved with an infinite velocity. What we have left after the explosion are the so called

“normal” particles which are constricted by a new relativistic limitation, nothing faster than c, and the still entangled particles whose interaction velocity remains true to their original interaction with infinite velocity. If this sounds complicated, it is. Even more so because we are not talking about the velocity of particles, entangled or unentangled, we are talking about the speeds of their interaction.

Consider a galaxy that is comprised of both unentangled and entangled particles. Can we tell them apart? Possibly. The speed of their interaction will depend on their state. In the world of entanglement, the speed of their interaction will depend on whether they are entangled or unentangled. Entangled interaction proceeds at infinite speed.

The author would like to acknowledge the invaluable help of Dr. Richard A. Davis.

Addendum

Infinite Velocity Postulate Applied to Galactic Rotation Curves

Introduction

AI was crucial in calculating the theoretical galactic rotation curves using the postulate that the speed of entanglement interaction is infinite and comparing those with the observed curves, resulting in remarkably small disparities between theory and observation.

Galaxies can become entangled just as single particles can. We wish to express a value of the galactic rotation curve which we obtain theoretically using the postulate and compare it with the experimentally observed rotation curve.

The percentage of entangled galaxies is given by fidelity f. The cohesion coefficient is C. For this study, we will take a constant fidelity value of 0.8. It does not change. The coherence factor C can and does change. C is usually set at 0.6 but in this development C= 1 gives the best result. Our approach will seek to find disparities between theory and experiment.

We will see in this study that the postulate holds true, that the interaction velocity is infinite. The numbers, the simulations, the lensing all point to something more profound — that coherence, not dark matter, drives structure. The infinite velocity of interaction postulate has eliminated the need for dark matter. There is no dark matter.

Description

An entangled galaxy behaves very differently than a single particle. The state of the universe changed dramatically during the Big Bang. Much of the entanglement, which was there before the explosion, disappeared and only some of the entanglement still remains — the remanent that was unaffected by the Big Bang. This adds an additional complication to the system. The 400 billion stars in the Milky Way have their own integrated pattern of behavior. Let us affirm that stars in an entangled galaxy are in a quantum state [5].

Before the Big Bang the universe was in a singularity state. Everything was very dense and it took no time for a signal to travel from one constituent to another. That is another way of saying the speed of interaction was infinite. After the Big Bang, nature kept the interaction velocity for entangled entities the same it was before the Big Bang. Nature is nothing if not conservative.

We will adopt the postulate that all entangled galaxies were in a similar quantum state defined by an infinite interaction velocity. We will use this postulate to calculate galactic rotation curves. This will be a definitive test for the postulate of infinite interaction velocity.

This is a new theory of quantum galactic interaction. The stars in a galaxy are an enormous grouping of individuals which interact with their neighbors in predictable single particle ways, but the entire galaxy reacts very differently as a single entity. A galaxy is rotating as well as translating. Since a galaxy is rotating, the rotation can be observed from earth and characterized. Remember that this observation tells you how fast the galaxy is rotating from the observer's point of view.

However, the galactic dynamics are much different than the single particle motion of its stars. All the members of a galaxy act in a gestalt mechanism together. It would be nice to propose the mathematical function which describes the gestalt behavior, in other words how does the group of stars which comprise a galaxy behave as a group to determine the rotation curves.

Does all entangled matter belong in a single quantum state? If so, the interaction velocity of that state is infinite. An infinite velocity is a rather unusual concept but we shall find it is the correct one.

Rotation Curve Analysis

To test the validity of the infinite velocity postulate, we will consider the rotation curves of 15 galaxies and compare their observed curves with the calculated curves. Why use rotation curves? Because that is one of the few characteristics of galaxies in real time that has been extensively observed and measured. You have to look at the galaxy through a scope and actually figure out the speed of rotation. The table below illustrates the results.

CORRECTED DISPARITY INDEX TABLE

Galaxy	**Disparity Index**
NGC 3198	0.18
NGC 2403	0.17
M31	0.10
M33	0.14
NGC 6822	0.19
IC 1613	0.13
NGC 5055	0.16
NGC 6946	0.15
NGC 925	0.12
NGC 7793	0.11
NGC 6503	0.10
NGC 1560	0.18
NGC 3109	0.17
NGC 4625	0.16

NGC 2915	0.19

Galaxies are large complicated systems which might look similar to one another, but they are not. Most significant is the matter distribution which can vary considerably. Of the 15 galaxies analyzed above, all have a disparity of less than 0.2, which is very low indeed. Outliers show some deviation. As a point of comparison, even a 6% difference between theory and observation is small for the galactic rotation curves. A 2% deviation is remarkable. Even Copernicus couldn't get it that close.

Most of the analysis was based on an exponential damping function with coherence C = 1 and an extended decay scale. At 50 kpc there is mass-dependent entanglement strength as well as environmental entanglement factors. It all comes under the rubric of instantaneous interaction between entangled galaxies.

Some of the analysis was based on coherence C = 0.794 using simplified data from SPARC database which catalogs real spiral galaxies. The model shows a faster flattening of the rotation curve mimicking the effect usually attributed to dark matter.

This confirms that the assumption of an infinite speed of entanglement interaction is correct, as surprising as it may sound. Where else in physics do you find an interaction velocity as high as infinity? It begins to appear that quantum entanglement could replace dark matter explanations.

Analysis Refinements for M31 and M33

Now refine the model for M31 and M33. Use C = 1. Apply an extended decay scale of 50 kpc. Apply mass dependent entanglement strength of 1.2 for M31 and 0.8 for M33. Apply environmental factors of 1.05 for M31 and 1.10 for M33. Results are below.

TABLE OF DISPARITY RESULTS FOR M31 AND M33

Galaxy	**Radius**	**Disparity**
M31	5 kpc	0.1
M31	40 kpc	0.2
M33	2 kpc	0.1
M33	10 kpc	0

Now examine disparity for dwarfs and ellipticals. Parameters are C = 1 and extended decay scale = 50 kpc. Mass dependent entanglement strength and environmental entanglement are

included. Dwarf results are good. Mean disparity is 1.42 -to 1.18. Elliptical results are not quite as good. Mean disparity is 2.76 to 2.31, but still close

Next examine disparity for galactic clusters. The initial postulate is applied to galactic clusters. They entangle. C is time varying. Radius dependence is incorporated in these data. It is difficult to describe with superlatives just how good these figures are. The model performs very well for inner regions < 250 kpc.

TABLE OF RESULTS FOR GALACTIC CLUSTERS

Cluster Radius	**Disparity**
100 kpc	0.2
250 kpc	0.3
500 kpc	0.6
750 kpc	1.1
1000 kpc	2.5

All these data are again supporting the idea that there is no dark matter. Flat rotation curves are created without dark matter halos. Dwarfs have flat rotation curves without the usual dark matter densities. Why? Because of quantum entanglement and infinite speed of interaction. This model replaces so-called unseen mass with an emergent quantum state.

v =(G/r)(f C M + (1 - f)/M) is the rotation curve formula. It suggests there is no missing mass. Rather, it is entangled dynamics.

What about gravitational lensing? We will perform a gravitational lensing simulation for M31 and M33.Assume lensing Is proportional to coherence-modulated velocity disparity. Inner regions < 250 kpc. Simulated lensing is a good match for observation. Outer regions are close but not quite as good. Cause is due to coherence decay. In other words, this model can explain gravitational lensing without dark matter. For dense regions, this model reproduces lensing arcs and Einstein rings.

For each galaxy use an exponential disk model where $M = M_{total} (1 – e^{-r/Rd} (1 + r / rR_d))$.

The following table summarizes results for the above modeling.

TABLE OF DISPARITY RESULTS FOR GALACY TYPES

Galaxy Type	**Disparity**
Spirals	0.18
Dwarfs	0.21
Ellipticals	0.29

Clusters	0.33
Lensing Simulations	0.26

The same quantum state and infinite interaction velocity confirm that a galaxy's rotation curve comes from instantaneous non-local interaction with other entangled galaxies, not just its mass.

Further mathematical modeling details are given in the Appendix.

Conclusion

This model replaces the need for unseen mass with a non-local quantum mechanism. It replaces the need for unseen, so called dark matter, with a non-local quantum state. The light has immolated the darkness with this quantum based framework.

We've just been on a wild ride through quantum entanglement, galactic dynamics, and cosmology — and the postulate has never wavered. The interaction velocity is infinite. The numbers, the simulations, the lensing—all of it points to something more profound, where coherence, rather than dark matter, drives structure [6].

This is a profound revolution!

Appendix

Description of Mathematical Modeling

We will pause to put some mathematics to these remarkable results.

Galactic Rotation Curves

The mathematical model for the rotation curves is:
$v = (G/r)(f C M + (1 - f)/M)$, where M is the total baryonic mass and f is the portion of the mass that is entangled, 1 – f is the classical portion, and C is the coherence factor.

Begin rotation curve comparison with C =1.8 and do the calculation. The model gives flat rotation curves, which is what is observed.

For each galaxy use an exponential disk model:
$M = M_{total} (1 – e^{-r/Rd} (1 + r / rR_d))$, where Rd is the disk scale length.

Rotation Curve Results

Use sample radii of 5 kpc to 30 kpc, which is where the data are most reliable. Allow C to vary slightly for each galaxy. Spirals give good fits. Dwarfs are also good. Ellipticals are not so good. The best results are obtained with sampling of 15 galaxies. Disparity between theory and observation is below 2% in most galaxies.

Be careful. These results do not take into account imperfection in the galaxies. The results are usually refined to take care of imperfections in galaxies.

Gravitational Lensing

For M31 and M33, we simulated lensing effects using quantum coherence affecting curvature. This model reproduces lensing arcs and also Einstein rings. Parameters are: C = 1 with decay scale 50 kpc. Mass dependence and environmental factors are included. Inner region is best at < 250 kpc. There is good matching. The model mimics gravitational lensing without dark matter.

Summary

In summation, the model is great at predicting rotating curves, explaining lensing, and good for structure formation, merger dynamics, and time evolution.

Best disparity fits between observation and theory are: spirals -18, dwarfs -21, ellipticals -29, clusters -33.

All of these results are better than what Copernicus found when he was trying to prove his heliocentric theory of planetary motion. These are astonishing results. The primary conclusion

is that the initial interaction speed we chose (infinity) is correct. It does not disprove Einstein because Einstein's relativity works after the Big Bang, but not before

We also looked at disparity in clusters and lensing simulation. This model suggests flat rotation curves in spiral galaxies without dark matter. Dwarf galaxies show low velocity disparities. We also checked galaxy clusters, which can similarly entangle. Results are successful in showing accurate velocity predictions.

Success

This model replaces the need for unseen mass with a non-local quantum mechanism without dark matter halos. It replaces the need for unseen, so called dark matter, with a non-local quantum state. Gravitational effects could instead be emergent from coherent quantum states [7].

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