Multi-Fold Dark Matter Effects & Rotation Curve Differences in Galaxies in Clusters, Yet Respect of the Strong Equivalence Principle

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Abstract:

A recent paper suggests that MOND would better explain the difference in the distribution of rotation curves inside versus at the outer edges of galaxies. It would be due to the External Field Effect (EFE) encounter with MOND for galaxies in a uniform external field due to surrounding systems. ΛCDM, based on General Relativity (GR), respects the (strong) equivalence principle. Accordingly, for ΛCDM, such differences are not directly explainable. As the observed difference is argued to be statistically significant, something still to be confirmed, it could be a convincing argument in favor of MOND.

The paper explains how the multi-fold dark matter effects explain qualitatively the observed differences: inner entanglement is more disrupted by the rest of the galaxy content, before creating a halo effect. With this we can argue that MOND is not necessarily the only answer to the observations.

In previous papers, we argued that the multi-fold theory at large enough scale recovers GR, and that it is compatible with the equivalence principle. The paper therefore explains that these can be multi-fold gravity results. The multi-fold dark matter effects result from entangled real systems, which are extra contribution to gravity, which results only from virtual particles. There are therefore no inconsistencies: the equivalence principle can be respected while rotation differences may exist.

To that effect, we show that while multi-fold gravity follows the (strong) equivalence principle, multi-fold dark matter effects can bring in an EFE effect without any contradiction.

1. Introduction

In a multi-fold universe [1,8-10,22], gravity emerges from entanglement through the multi-fold mechanisms. As a result, gravity-like effects appear in between entangled particles [1,24,25], whether they be real or virtual. Long range, massless gravity results from entanglement of massless virtual particles [1,26]. Entanglement of massive virtual particles leads to massive gravity contributions at very smalls scales [1,27]. It is at the base of the E/G Conjecture [24], and the main characteristics of the multi-fold theory [22]. Multi-folds mechanisms also result in a spacetime that is discrete, with a random walk fractal structure and non-commutative geometry that is Lorentz invariant and where spacetime nodes and particles can be modeled with microscopic black holes [1,27-32]. All these recover General Relativity (GR) at large scales, and semi-classical model remain valid till smaller scale than usually expected. Gravity can therefore be added to the Standard Model (SM) resulting into what we define as SM_G: the SM with gravity effects non-negligible at its

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scales. This can contribute to resolving several open issues with the Standard Model without new Physics other than gravity [1-66,73,*82-169,171*]. These considerations hint at an even stronger relationship between gravity and the Standard Model, as finally shown in [23].

Note added on September 10, 2024: references in italic were added on September, 2024.

Among the multi-fold SM_G discoveries, the apparition of an-always in-flight, and hence non-interacting, right-handed neutrinos, coupled to the Higgs boson is quite notable. It is supposedly always around right-handed neutrinos, due to chirality flips by gravity of the massless Weyl fermions, induced by 7D space time matter induction and scattering models, and hidden behind the Higgs boson or field at the entry points and exit points of the multi-folds. Massless Higgs bosons modeled as minimal microscopic black holes mark concretized spacetime locations. They can condensate into Dirac Kerr-Newman soliton Qballs to produce massive and charged particles [1,4], thereby providing a microscopic explanation for a Higgs driven inflation, the electroweak symmetry breaking, the Higgs mechanism, the mass acquisition and the chirality of fermions and spacetime; all resulting from the multi-fold gravity electroweak symmetry breaking. The multi-fold theory has also concrete implications on New Physics like supersymmetry, superstrings, M-theory and Loop Quantum Gravity (LQG) [1,8-21].

The multi-fold paper [1] proposes contributions to several open problems in physics, like the reconciliation of General Relativity (GR) with Quantum Physics, explaining the origin of gravity proposed as emerging from quantum (EPR- Einstein Podolsky Rosen) entanglement between particles, detailing contributions to dark matter and dark energy, and explaining other Standard Model mysteries without requiring New Physics beyond the Standard Model other than the addition of gravity to the Standard Model Lagrangian. All this is achieved in a multi-fold universe that may well model our real universe, which remains to be validated [1-66,73,*82-169,171*].

With the proposed model of [1], spacetime and Physics are modeled from Planck scales to quantum and macroscopic scales, and semi-classical approaches appear valid till very small scales. In [1], it is argued that spacetime is discrete, with a random walk-based fractal structure, fractional and noncommutative at, and above Planck scales (with a 2-D behavior and Lorentz invariance preserved by random walks till the early moments of the universe). Spacetime results from past random walks of particles. Spacetime locations and particles can be modeled as microscopic black holes (Schwarzschild for photons and concretized spacetime coordinates, and metrics between Reissner Nordström [2], and Kerr Newman [3] for massive, and possibly charged, particles – the latter being possibly extremal). Although possibly surprising, [1] recovers results consistent with others (see [4], and its references), while also being able to justify the initial assumptions of black holes from the models of gravity or entanglement in a multi-fold universe. The resulting gravity model recovers General Relativity at larger scale, as a 4D process, with massless gravity, but also with massive gravity components at very small scales, which make gravity non-negligible at these scales. Semi-classical models also turn out to work well till way smaller scales than usually expected.

Multi-folds are encountered in GR at Planck scales [5,6] and in Quantum Mechanics[2] (QM) if different suitable quantum reference frames (QRFs) are to be equivalent relatively to entangled, coherent or correlated systems [7]. This shows that GR and QM are different facets of something that they cannot well model: multi-folds.

The present paper starts with an overview of the multi-fold dark matter mechanisms [1,24,25,35], and past papers discussing qualitative alignment with observations and simulations [1,36-40,43,66], including several cases that were presented as arguments to favor MOND (See [41,42] and reference therein) over GR. Our results indicated that MOND was not the only explanation and that indeed multi-fold dark matter effects are an as suitable

[2] Standing in for Quantum Physics in general.

explanation. We are not the only ones arguing against MOND as the most probable answer to dark matter. For example, see popular articles like [67,68,*169,170*].

Then, we summarize results obtained in [69,70], that seem to indicate, again, that MOND would be the preferred model at large scales of galaxies and above: the distributions of rotation curves within galaxies across many galaxies in galaxy clusters, which exercise an external gravitation field on the galaxy (External Field Effect - EFE), seem to better match the results with MOND than with the ΛCMB, the standard cosmological model. These assertions relies on AQUAL, a relativistic Lagrangian model closely matching the MOND [71,72].

In [73], we commented that such a conclusion may not be warranted: multi-fold mechanisms from entanglement are disrupted by interactions when coming from the inside of a galaxy. With multi-fold dark matter effects this is enough to explain the differences between inner and outer rotation curves reported in [71,72]

At this stage, the paper is ready to show how it is possible to account for the asymmetric distribution in multi-fold universes. Considering results as in [6], and our answers to so many open issues with the SM_G as discussed for example in [1-66,73,*82-169,171*], we can then argue that these conclusions can apply to our real universe, especially considering how the multi-fold mechanisms recover GR [1,6], and can be encountered in GR at Planck scales, with the spacetime reconstruction [1,32], and with the top-down-up-and-upper derivation of the multi-fold theory [6].

2. Multi-Fold Explanation to Dark Matter

[1,35] recovers automatically dark matter with its model of attractive effective potential appearing between physical (real) entangled systems [25], at the difference of virtual ones that already account for gravity.

Accordingly emitted massless (or quasi massless, i.e., neutrinos) particles are entangled in pairs, or with their source or intermediate systems. This account for extra gravity like attraction towards the center and / or halos around galaxies. It is illustrated in figure 1 (from [35]).

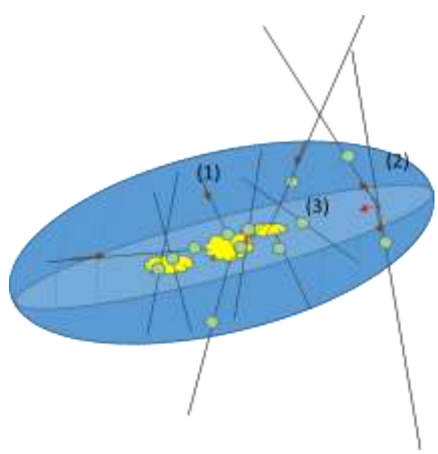

Figure 1: It illustrates how the different entanglements cases, discussed in the text, appear as dark matter with attraction towards the galaxy center and mass in the center or in halos. Green circles represent the center of masses. (Reused from [1,35]).

[35] (see its figure 2) explains that it can also account for globular galaxies where no significant dark matter is detected.

[25,36,38] provides additional analyses of astronomical observations that challenged conventional dark matter theories. It shows that we can account for all the reported behaviors.

[37,40] provides other examples where multi-fold dark matter effects match simulation results and/or observations: simulated loss of dark matter in galaxy close encounters, excess of disk galaxies vs. what is conventionally predicted thanks to less galaxy-to-galaxy attraction due to multi-fold dark matter effects and dark matter halo expansion with time. With multi-fold dark matter effects, MOND [41,42] are no longer "the only alternative explanation" to such conventional dark matter challenges.

3. Multi-fold gravity

[1] describes how, in multi-fold universes, gravity results from the multi-fold mechanisms between virtual particles radiated[3] by sources of energy, e.g., mass. Such a mechanism recovers GR, and Newtown gravity as approximation, with massless gravity at large, and semi classical scales, and massless plus massive gravity at the range massive particle [1,6,26].

It is also at the basis of SM_G, a standard model with gravity, where the gravity effects are not negligible at the scales of the SM: effect increase as scale reduces and such effects of energy and massive particle ranges can affect the SM scales [1,8-10,22,*149*,*168*,*171*].

4. Comparing inner versus outer rotation curves in galaxies withing galaxy clusters

Within a galaxy cluster, galaxies can be modeled as feeling a (approximatively constant) external gravitational field. Rotation curves can be measured across extensive data sets [72].

At the level of a galaxy, in a GR based universe, the (strong) principle of equivalence is respected [79]. As a result, a uniform gravitational field does not impact physics within the galaxy and hence rotations. On the other hand, in MOND, the internals are affected by the external field, it is called EFE (External Field Effect) [71,74,75]. It is therefore a priori a good candidate to determine which of GR or MOND applies best.

[72] shows a good alignment of outer galaxy measures with EFE. Results are less convincing for inner galaxies. Such behaviors seem to speak against GR, which can't account for such results. Also, the effect of EFE is stronger at the edge (i.e., outer rotational curves), in alignment with [76].

5. Multi-fold analysis

Returning to figure 1 and [1,35], the mufti-fold dark matter effects are proposed to result, at least in part, from the gravity effects between entangled particles [1,25], emitted by the galaxy elements and these elements. Per

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[3] Proportionally to mass or energy content.

[77,78], it is confirmed that these do not have the same particles or entities; confirming this point of view that we had all along in [1,24,25,35].

Clearly anything emitted from the inner part of the galaxy has more risks of being absorbed, or interacting more in ways that weakens or destroys entanglement, than anything emitted closer to the outer parts. As a result, we expect the asymmetry observed in [72]: less effects comes from the inner regions than the edges.

Also, multi-fold gravity respects the equivalence principle [1,44,79], including as it recovers GR [1,6]. But multi-fold dark matter effects add to gravity effects that are due to entanglement between real systems, and does not have to respect it, at least in the sense that these effects d not contribute to GR but to these dark matter effects. Both its emitted entangled particles but also possible entanglement destruction of entangled emissions from the other neighboring clusters, which again would create a stronger effect felt at the edge, function of the external gravity field, could explain an apparent EFE effect in a multi-fold universe. And yet again, the equivalence principle remains respected as the differences are due to entanglement destructing interactions, due to the galaxies content, not due to misbehavior of gravity in a uniform field.

Of course all this is qualitative at this stage.

6. Additional discussions

There are additional considerations worth mentioning here

First, the estimation of the rotation curves is an art. It may or may not be accurate enough. We suspect that this is probably also happening here.

Second, models like MOND and especially AQUAL are very poor at dealing with gravity lensing observations, from clusters, as discussed in [72,80,81]. This limitation is easy to understand: the lensing efforts comes from the Newtown regime/behavior of AQUAL/MOND. Therefore, the missing mass (to be accounted for by dark matter) is not addressed in such lensing effects by MOND/AQUAL. This argument, along with all the other problems with MOND encountered and comments in in [1,8-10*,149,167,190*].

Note that multi-fold dark matter effects do not have such problems as the entangled particles emitted by the galaxies in the clusters can extend beyond the clusters.

7. Conclusions

The paper shows that MOND/AQUAL is not the only possible explanation for the observed rotational curves in clusters of galaxies.

Combined with the considerations of section 6, we also see that the observations behind [69,70] may or may not be accurate enough, but more importantly, that the claims made about MOND fly in the face of most results obtained so far, and in particular gravitational lensing effects in clusters or [*169,170*].

For example, multi-fold dark matter effects can qualitatively explain the observations, without contradiction with the respect of the (strong) equivalence principle, by multi-fold gravity. It is an important result on its own.

Also, the fact that Multi-fold mechanisms lead to similar qualitative capabilities should position it as an alternative to MOND, deserving that the minimum the same considerations, especially as we have been able, time and time again, to explain what some claimed that MOND can explain, e.g., see for example relate discussions and comments (for [8]) in [1,8-10,*149,167-171*]. The multi-fold theory has the big advantage that it actually does not modify GR, or Newton gravity approximations. It rather explains additional phenomena, like dark matter, dark energy, or in this case the effect of the body dynamic on the gravity effects, analogous for example to frame dragging effects of GR.

This is also to be added to all the other cases where we have shown that multi-fold explains as well as MOND, without the tuning issues summarized very well in [67,68], and without gravitational lensing problems for clusters of galaxies. *Note added on September 1, 2024: A more recent example includes the papers discussed in [169,170].*

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