**Advancing Refined Relativistic Field Theory (RFT) to Version 5.0**

**Introduction:** *Refined Relativistic Field Theory* (RFT) is an entropy-based modification of gravity inspired by holographic principles, proposed as an alternative to the ΛCDM paradigm with no particle dark matter. While RFT has shown promise in explaining galactic rotation curves without dark matter​

[arxiv.org](https://arxiv.org/abs/2206.11685#:~:text=175%20nearby%20disk%20galaxies%20with,0.027%5Cpm0.003%24%20and)

, it must confront several empirical challenges. Notably, the standard ΛCDM model faces small-scale discrepancies – dwarf galaxies exhibit shallow central density cores instead of steep cusps, and far fewer satellites are observed around galaxies than pure dark matter simulations predict​

[arxiv.org](https://arxiv.org/abs/1707.04256#:~:text=10,including%20the%20observed%20planar%20and)

. Additionally, a persistent **Hubble tension** exists between early-universe and local measurements of the Hubble constant (a 5σ discrepancy between $H\_0 \approx 67.4$ from Planck CMB and $H\_0 \approx 73$ from local distance ladders​

[tritonstation.com](https://tritonstation.com/2023/02/13/early-galaxy-formation-and-the-hubble-constant-tension/#:~:text=Since%20that%20time%2C%20a%20tension,as%2067%20is%20right%20out)

). RFT v5.0 aims to bridge these gaps by refining baryonic physics in simulations, validating small-scale structure predictions, addressing the Hubble tension in an RFT cosmology, and solidifying the theory’s foundations with a covariant action principle.

**Task 1: Refining Baryonic Physics in RFT Simulations**

Realistic galaxy formation within RFT requires high-resolution hydrodynamical simulations that include detailed baryonic feedback processes. We will implement star formation, supernova-driven winds, and active galactic nucleus (AGN) feedback in an RFT-modified version of a modern simulation code (e.g. Gadget-4 or Arepo). These subgrid physics recipes will be calibrated so that *RFT-based simulations reproduce key galaxy observables*. This approach mirrors the strategy used in ΛCDM simulations like EAGLE, where feedback parameters were tuned to match the observed galaxy stellar mass function at $z\sim0$​

[arxiv.org](https://arxiv.org/abs/1501.01311#:~:text=relevant%20parameters%20were%20adjusted%20so,process%20of%20the%20reference%20model)

. By adjusting RFT’s feedback efficiencies, our simulations should yield galaxy populations with the correct stellar masses, sizes, and morphologies. In particular, we will verify that the **galaxy stellar mass function** in RFT (the number density of galaxies as a function of stellar mass) remains consistent with observations (as EAGLE demonstrated, both vigorous star-formation feedback in low-mass galaxies and AGN feedback in high-mass galaxies are required to reproduce the observed galaxy population​

[arxiv.org](https://arxiv.org/abs/1501.01311#:~:text=remaining%20nine%20simulations%2C%20a%20single,galaxy%20sizes%20be%20acceptable%20leads)

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We will ensure that **galaxy rotation curves** and structural properties in RFT simulations align with empirical data. Previous analyses have shown that alternative gravity theories can fit rotation curves of disk galaxies without dark matter​

[arxiv.org](https://arxiv.org/abs/2206.11685#:~:text=175%20nearby%20disk%20galaxies%20with,0.027%5Cpm0.003%24%20and)

. For example, using Verlinde’s emergent gravity (on which RFT is based), Yoon *et al.* (2022) found excellent agreement between predicted and observed gravitational accelerations in 175 rotation curves​

[arxiv.org](https://arxiv.org/abs/2206.11685#:~:text=175%20nearby%20disk%20galaxies%20with,0.027%5Cpm0.003%24%20and)

. RFT’s gravity law should similarly reproduce the Radial Acceleration Relation (RAR) – the tight correlation between baryonic and total acceleration in galaxies – as a natural outcome. *Figure 1* illustrates this for emergent gravity: the observed acceleration (black points) closely tracks the RFT/Verlinde prediction (red line) across many galaxies, improving upon a purely Newtonian (no-dark-matter) prediction【39†look】​

[ar5iv.org](https://ar5iv.org/pdf/2206.11685#:~:text=Image%3A%20Refer%20to%20caption%20,58%20Image)

. We will run RFT hydrodynamics for a range of galaxies (from dwarfs to spirals) and compare their rotation curve shapes and disk stability to observations, confirming that RFT yields realistic disk galaxy morphologies (fractions of spirals vs ellipticals) and Tully–Fisher relations.

*Figure 1: Observed vs predicted accelerations in disk galaxies under different gravity models. Panel (a) shows the relation between observed rotation curve acceleration $g\_{\rm obs}$ and that predicted by baryons alone ($g\_{\rm bar}$) in Newtonian gravity (no dark matter), revealing a systematic discrepancy at low accelerations. Panels (b) and (c) show the improved agreement when using an entropy-based emergent gravity (RFT) model with parameters set by a de Sitter or quasi-de Sitter universe, respectively. The data (black points and binned red boxes) closely align with the one-to-one line (green dashed) under RFT, indicating that RFT’s extra “dark” gravity can explain the missing mass without particle dark matter​*

[*ar5iv.org*](https://ar5iv.org/pdf/2206.11685#:~:text=Image%3A%20Refer%20to%20caption%20,58%20Image)

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A critical test in **low-mass dwarf galaxies** is whether RFT can resolve the longstanding cusp–core problem *without invoking dark matter*. In ΛCDM, dark matter halos naturally form steep density cusps, but real dwarfs like Fornax and IC 2574 have ∼kpc-sized constant-density cores​

[arxiv.org](https://arxiv.org/abs/0810.2119#:~:text=mass,density%20core)

. Baryonic feedback in standard simulations can transform cusps to cores by expelling central gas through bursty star formation​

[en.wikipedia.org](https://en.wikipedia.org/wiki/Cuspy_halo_problem#:~:text=,203G)

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[aanda.org](https://www.aanda.org/articles/aa/full_html/2021/11/aa39420-20/aa39420-20.html#:~:text=The%20baryon%20cycle%20of%20Seven,model%20for%20clustered%20SN)

, but RFT provides an alternate explanation: if gravity is modified, perhaps no cusp ever forms. We will simulate well-studied dwarfs (Fornax, Carina, IC 2574) in an RFT framework *without dark matter particles*. The stellar and gas dynamics in the simulation will show whether RFT’s altered gravity law produces flat central density profiles consistent with observations of these dwarfs. For instance, the Fornax dSph’s kinematics imply a shallow inner mass profile with a core radius of order 1 kpc​

[mdpi.com](https://www.mdpi.com/2075-4434/10/1/5#:~:text=particularly%20in%20the%20case%20of,%E2%88%BC10%20Gyr%20ago%29%20could)

. Similarly, high-resolution H I rotation data indicate IC 2574’s dark matter distribution is inconsistent with a cuspy NFW profile and is best fit by a ∼1 kpc core​

[arxiv.org](https://arxiv.org/abs/0810.2119#:~:text=mass,density%20core)

. Our RFT simulations will measure the rotation curves and mass distribution in the inner ∼1–2 kpc of these dwarfs. Success for RFT v5.0 will be achieved if the simulated dwarfs naturally develop cored mass profiles and slowly rising rotation curves (or velocity dispersion profiles) that match the observed data **without any dark matter**. Such a result would demonstrate that RFT’s modified gravity, coupled with realistic baryonic physics (star formation, feedback, etc.), can solve the core–cusp issue on dwarf galaxy scales.

Additionally, we will compare **morphology and kinematics** of RFT galaxies to observational benchmarks. Disk galaxies in RFT should exhibit realistic spiral structure and rotation support, while massive halos with strong AGN feedback may produce quenched spheroid-dominated galaxies, paralleling morphology–density trends seen in the real universe. By adjusting feedback, we expect to recover the observed distribution of galaxy types (e.g. the fraction of disk vs. elliptical galaxies as a function of stellar mass and environment). These checks ensure that RFT’s galaxy formation is not only theoretically sound but also *empirically accurate* across multiple galactic observables (stellar masses, rotation curves, morphology, and internal structure).

**Task 2: Validating Small-Scale Structure Predictions**

With baryonic processes in place, we next test RFT’s predictions for **satellite galaxies and substructure** in halos. This addresses the “missing satellites” and “too-big-to-fail” problems that challenge ΛCDM on small scales​

[arxiv.org](https://arxiv.org/abs/1707.04256#:~:text=10,including%20the%20observed%20planar%20and)

. We will run high-resolution $N$-body simulations of galaxy cluster and Milky Way-mass halos under RFT-modified gravity (and hydrodynamics for baryons). In RFT, the absence of collisionless dark matter particles could drastically alter the formation of satellite systems – structure grows more slowly from baryons alone, but RFT’s extra gravity might effectively mimic the clustering of dark matter. We will quantify the **abundance of satellite galaxies** formed around a Milky Way–like host in RFT. This entails identifying bound substructures (satellites) in the simulations and constructing their luminosity function (satellite number vs. stellar mass or magnitude) and radial distribution.

These predictions will be directly compared to the latest deep observational surveys, particularly results enabled by *JWST* and *LSST*. The James Webb Space Telescope is providing ultra-deep, high-resolution views that can detect faint dwarf galaxies in the local universe and beyond, while the Vera C. Rubin Observatory (LSST) is expected to deliver a near-complete census of Milky Way satellites down to extremely low luminosities​

[lsst.org](https://www.lsst.org/sites/default/files/enews/milky-way-0910.html#:~:text=The%20LSST%E2%80%99s%20deep%20and%20wide,the%20limits%20of%20galaxy%20formation)

. Historically, dark matter–only simulations of ΛCDM predicted hundreds of satellites in Milky Way-sized halos, vastly exceeding the ∼ dozens observed (the **missing satellites problem**). Recent wide-field surveys have indeed begun to find more ultra-faint dwarfs – for example, the Subaru HSC survey uncovered several new Milky Way companions, bringing the total known to 9 and estimating that the full sky could contain on the order of $\sim220$ satellites down to very faint levels​

[sciencedaily.com](https://www.sciencedaily.com/releases/2024/06/240628124950.htm#:~:text=Now%2C%20the%20team%20has%20discovered,standard%20theory%20of%20dark%20matter)

. If that extrapolation holds, we might even face a “too many satellites” problem, as one analysis suggests the Milky Way could host up to $\sim500$ satellites when correcting for survey coverage​

[sciencedaily.com](https://www.sciencedaily.com/releases/2024/06/240628124950.htm#:~:text=However%2C%20the%20footprint%20of%20the,missing%20satellites%20problem)

. Rubin Observatory’s upcoming deep survey will clarify this by finding ultra-faint dwarfs out to the Milky Way’s virial radius​

[lsst.org](https://www.lsst.org/sites/default/files/enews/milky-way-0910.html#:~:text=The%20LSST%E2%80%99s%20deep%20and%20wide,the%20limits%20of%20galaxy%20formation)

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Against this backdrop, RFT’s predictions will be illuminating. Because RFT does not rely on invisible subhalos, the **formation of satellites in RFT** likely requires the presence of baryonic matter clumps. We anticipate that RFT might naturally predict fewer satellite galaxies, as only baryon-rich substructures experience the enhanced gravity needed to form bound galaxies. This could alleviate the missing satellites problem – RFT may yield satellite counts closer to observed values without invoking suppression mechanisms like reionization or warm dark matter. We will compare the cumulative satellite luminosity function from RFT simulations to observations (including recent discoveries). The radial distribution of satellites (how they orbit their host) will also be checked: in ΛCDM, many subhalos crowd the inner halo, but feedback and tidal disruption are needed to reduce their central counts. In RFT, the gravitational environment differs; we will see if satellites in RFT are more naturally confined to certain orbits or distances.

Crucially, we will test the **Too-Big-To-Fail (TBTF)** problem: in ΛCDM, the most massive subhalos in simulations are too dense to host any of the observed dwarf satellites of the Milky Way – they would have been “too big to fail” to form luminous galaxies, yet no such overly dense satellites are seen. RFT might circumvent this because it lacks heavy dark subhalos with no baryons. Our RFT simulation should be checked for the presence (or absence) of overly massive satellite potentials. We will compare the **inner density profiles and velocity dispersions** of the largest RFT satellites to those of known dwarfs like the bright Milky Way companions (e.g. the Magellanic Clouds, Fornax, Draco). If RFT yields satellite galaxies with internal dynamics consistent with observations (e.g. maximum circular velocities ~ 20–50 km/s for the brightest dwarfs, and no large population of unseen high-$V\_{\max}$ subhalos), it would demonstrate that RFT naturally avoids the TBTF issue. This comparison will leverage new precision data on dwarf satellites’ dynamics coming from instruments and surveys (Gaia for orbital motions, JWST for star formation histories, etc.), ensuring our tests are state-of-the-art.

We will also incorporate **JWST observations** of high-redshift dwarf galaxies to check RFT’s consistency across time. JWST’s early deep field results have revealed surprisingly abundant *bright* dwarf-mass galaxies at very high redshift (a potential challenge to standard structure formation). We can use RFT simulations to examine if structure grows faster (or slower) in the early universe under modified gravity, and whether the abundance of dwarfs at $z>6-10$ is in line with JWST counts. Although JWST is not primarily surveying the Local Group satellites, its detection of distant low-mass galaxies provides complementary constraints on small-scale power. We will ensure RFT’s parameters (e.g. any critical acceleration scale tied to $H\_0$) produce a consistent picture: enough early structure to form galaxies seen by JWST, yet not an overabundance of bound subhalos at $z=0$ that would contradict local satellite counts.

Finally, our RFT satellite results will be synthesized in light of upcoming LSST findings. By predicting the satellite mass function down to very low masses, we can create a forecast for what LSST should see if RFT is correct, versus what ΛCDM with feedback predicts. LSST will either discover **any “missing” satellites** or confirm a cutoff in the satellite luminosity function. Because LSST will provide a **complete census of Milky Way satellites to extremely faint limits​**

[**lsst.org**](https://www.lsst.org/sites/default/files/enews/milky-way-0910.html#:~:text=The%20LSST%E2%80%99s%20deep%20and%20wide,the%20limits%20of%20galaxy%20formation)

, it will be an acid test for RFT. If RFT’s gravity (with no dark matter) matches the eventual LSST-observed satellite populations in number and distribution, it will strongly support RFT as a viable alternative theory on small scales. Conversely, any significant mismatch would highlight areas to refine RFT’s treatment of small-scale structure (for instance, maybe RFT would require an additional ingredient or modification at sub-galactic scales).

**Task 3: Re-testing the Hubble Tension in an RFT Cosmology**

A major goal for RFT v5.0 is to address the **Hubble tension** within the framework of modified gravity. RFT modifies the Friedmann equations of expansion via its altered gravity law (potentially affecting the effective energy density or the relation between matter and expansion). We will incorporate RFT’s cosmological field equations into a Boltzmann solver such as CLASS or CAMB – software that computes detailed predictions for the Cosmic Microwave Background (CMB) anisotropies and large-scale structure, given a set of cosmological parameters. This requires deriving the background expansion $H(a)$ and linear perturbation growth under RFT gravity. For example, if RFT emerges from an entropic interpretation of gravity (à la Verlinde), it might predict a specific extra component or modification in the Friedmann equation proportional to the horizon entropy or $H\_0$. We will encode these modifications in the Boltzmann code, ensuring features like the CMB acoustic peak positions, peak heights, and matter power spectrum can be computed for a given set of RFT parameters.

With the Boltzmann solver in hand, we will perform a full Markov Chain Monte Carlo (MCMC) exploration of RFT cosmological parameters. This involves varying parameters such as the baryon density ($\Omega\_b$), curvature, any RFT-specific parameters (e.g. an “entropy gravity” parameter that could play the role of dark matter or dark energy), and of course the Hubble constant $H\_0$. The aim is to see if there exists an RFT cosmology that fits all precise cosmological observations *while yielding a value of $H\_0$ consistent with local measurements*. We will fit RFT against: **Planck CMB data** (temperature and polarization power spectra), **baryon acoustic oscillation** (BAO) measurements from galaxy surveys, and the latest **Type Ia supernovae** distance measurements (e.g. the Pantheon+ sample). We will also include the **local distance ladder Hubble constant** (e.g. the SH0ES Cepheid-SN result) as a separate constraint to explicitly check tension. In practice, we might run two sets of MCMCs: one without the local $H\_0$ prior (to see what RFT predicts from early-universe data alone) and one with it.

The key question: *Can RFT self-consistently reduce the Hubble tension?* If RFT is to succeed, the fit to CMB+BAO data will prefer a higher Hubble constant than ΛCDM does, without spoiling the CMB fit. Standard ΛCDM with Planck data gives $H\_0 = 67.4\pm0.5$ km/s/Mpc, in 4–6σ tension with the local $73\pm1$ km/s/Mpc​

[tritonstation.com](https://tritonstation.com/2023/02/13/early-galaxy-formation-and-the-hubble-constant-tension/#:~:text=Since%20that%20time%2C%20a%20tension,as%2067%20is%20right%20out)

. Many new-physics proposals (e.g. Early Dark Energy) have been explored to resolve this. For instance, adding a transient early dark energy component can raise the CMB-inferred $H\_0$ to about 69–70 km/s/Mpc, bringing the discrepancy down to $\sim2.5σ$​

[arxiv.org](https://arxiv.org/abs/2011.04682#:~:text=SPTPol%20CMB%20data%20with%20the,Overall%2C%20the%20EDE%20scenario%20is)

. We will investigate whether RFT’s modified gravity produces a similar effect. RFT might effectively act like an extra energy component or alter the sound horizon at recombination. We will look for an **RFT best-fit model** where the CMB and BAO data are well-fit (with residuals comparable to ΛCDM’s excellent fit) but the derived Hubble constant is higher, ideally $H\_0 \approx 70$–72. Such a model, when also confronted with the local distance ladder measurement, should show consistency within <2σ. Our MCMC analysis will quantify this: we expect to report the posterior for $H\_0$ under RFT and the tension metric (e.g. difference in $H\_0$ between early and late-universe estimates).

Beyond just $H\_0$, the MCMC will tell us if RFT demands different parameter values (e.g. adjusted $\Omega\_m$ or effective neutrino species) to fit the data. We will also check structure formation implications – e.g. does RFT predict a different amplitude of matter fluctuations ($\sigma\_8$) that could be tested with lensing or cluster counts? It’s important that RFT not only addresses $H\_0$ but remains compatible with **other cosmological observables**. In the end, we will be able to say whether RFT provides a robust solution to the Hubble tension. A successful outcome would be that **RFT fits all cosmological data with a higher $H\_0$ that overlaps with the local measurements within <2σ**, thus eliminating the strong tension. If instead RFT cannot raise $H\_0$ without ruining the CMB fit, that will guide modifications (for example, perhaps RFT needs an additional degree of freedom in the early universe, analogous to early dark energy or extra relativistic species).

Moreover, RFT’s holographic approach to gravity might offer an *explanation* for why the Hubble tension existed: if RFT ties the strength of gravity to horizon-scale entropy or a running of the gravitational “constant” with scale, it could naturally lead to a calibration difference between early and late epochs. We will attempt to interpret our results in this light. For instance, Verlinde’s formula introduces an acceleration scale $a\_0 = cH\_0$ in the gravity law​

[arxiv.org](https://arxiv.org/abs/1611.02269#:~:text=displacement%20caused%20by%20matter,currently%20attributed%20to%20dark%20matter)

. If $H\_0$ differs (early vs late), the effective strength of the emergent gravity might shift, impacting distance measures. Our analysis will clarify if such a mechanism is at play and whether it indeed alleviates the tension once all data are accounted for.

**Task 4 (Optional): Variational Action-Based Derivation of RFT**

To strengthen RFT’s theoretical foundations, we will develop a rigorous **variational formulation** of the theory. Earlier versions of RFT were motivated by thermodynamic and information-theoretic arguments, but to fully integrate with mainstream physics, RFT v5.0 should be derivable from an action principle – ensuring *general covariance* and *energy-momentum conservation*. In this task, we seek a Lagrangian (or an effective action) whose field equations reproduce RFT’s modified Einstein equations. This typically involves adding new fields or non-standard terms to the Einstein-Hilbert action of general relativity.

One promising approach is inspired by efforts to covarially formulate Verlinde’s emergent gravity. Hossenfelder (2017) proposed a covariant Lagrangian for emergent gravity that introduces a vector field filling de Sitter space, which couples to baryonic matter​

[arxiv.org](https://arxiv.org/abs/1703.01415#:~:text=model%20is%20proposed,can%20also%20mimic%20dark%20energy)

. The physical interpretation is that this vector field encodes the “entropy displacement” effect – when matter is present, it perturbs the entropy in the space, and the vector field’s response produces an additional gravity-like force. Remarkably, such a field can mimic the effects of dark matter on galactic scales and even behave like dark energy on cosmological scales​

[arxiv.org](https://arxiv.org/abs/1703.01415#:~:text=filled%20with%20a%20vector,can%20also%20mimic%20dark%20energy)

. We will take inspiration from this to construct RFT’s action. For example, we may introduce a vector field $U^\mu$ or a tensor field that couples to the metric and matter in a way that reproduces the RFT modification (perhaps through a term that yields an extra acceleration $a\_0$ at large scales). Alternatively, a scalar–tensor formulation or a non-local term (motivated by entropy-area vs entropy-volume competition) could be explored, since some studies have noted connections between emergent gravity and non-local gravity theories​

[arxiv.org](https://arxiv.org/abs/2303.14127#:~:text=gravity%20arxiv,local%20gravity%20theories)

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The variational derivation will proceed by positing an action $S = \int d^4x \sqrt{-g} [,\frac{1}{16\pi G}R + \mathcal{L}*{\rm RFT}(g*{\mu\nu}, \phi, ...)+ \mathcal{L}*{\rm m}(g*{\mu\nu}, ...),]$, where $\mathcal{L}*{\rm m}$ is the matter Lagrangian and $\mathcal{L}*{\rm RFT}$ contains new terms or fields encoding RFT’s deviations. We will enforce that the resulting field equations are *generally covariant* (no preferred frames or violations of coordinate invariance) and that the covariant conservation law $\nabla\_\mu T^{\mu\nu}=0$ holds when matter obeys its Euler-Lagrange equations. This typically comes for free if the action is generally covariant (by Noether’s theorem and the Bianchi identity), but it is a crucial consistency check – earlier heuristic forms of RFT might not have manifestly obeyed energy conservation, which we must now guarantee.

We will explore different formulations for $\mathcal{L}*{\rm RFT}$: one might involve the invariant $U^\mu U^\nu g*{\mu\nu}$ of a timelike vector field that “knows” about the horizon entropy (e.g. its field equation could produce terms proportional to $H\_0$ or the de Sitter horizon). Another idea is to utilize a scalar field $\phi$ that emerges from the variation of horizon entropy, yielding an extra source term in the Einstein equations. The end goal is to derive **modified Einstein equations** of RFT in a clear way. These equations should reduce to $G\_{\mu\nu} + H\_{\mu\nu} = 8\pi G,T\_{\mu\nu}$, where $H\_{\mu\nu}$ is an extra tensor (derived from $\mathcal{L}*{\rm RFT}$) representing the “entropy-induced” stress-energy that mimics dark matter. We will ensure that $H*{\mu\nu}$ is divergenceless on-shell, so that it can be interpreted as an effective dark matter or dark energy component that respects the usual conservation laws.

By deriving RFT from an action, we can more easily connect it to known theories. For instance, we can check the limits in which RFT’s action might reduce to MOND’s TeVeS theory (a tensor-vector-scalar theory by Bekenstein) or to Moffat’s MOG, or whether it has similarities with certain $f(R)$ or non-local gravity models. We will particularly examine connections to **Verlinde’s holographic model**: since Verlinde’s approach was rooted in de Sitter space thermodynamics​

[arxiv.org](https://arxiv.org/abs/1611.02269#:~:text=emerge%20together%20from%20the%20entanglement,states%20do%20not%20thermalise%20at)

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[arxiv.org](https://arxiv.org/abs/1611.02269#:~:text=displacement%20caused%20by%20matter,currently%20attributed%20to%20dark%20matter)

, our action-based RFT will illuminate how those thermodynamic concepts translate into fields and interactions in a Lagrangian. This could provide a more solid bridge between the intuitive “emergent gravity” picture and a concrete relativistic field theory.

Throughout this derivation, we will verify that the theory does not violate well-tested principles. For example, does it predict gravitomagnetic effects or gravitational lensing differently from GR + dark matter? (We can compare to observed lensing by galaxies to ensure consistency.) We will also ensure that in the limit of weak fields and slow motion, the theory reproduces the known successes of MOND/emergent gravity on galactic scales (the deep-MOND limit, the Tully-Fisher relation scaling, etc.), while in the strong-field regime it still passes solar system tests (perhaps the new fields decouple in high-acceleration environments). Achieving a robust action-based formulation will position RFT as a more rigorously defined competitor to ΛCDM, one that can be studied and simulated by the broader community with clarity on its assumptions and equations.

**Expected Outcomes**

By completing these tasks, we expect to deliver **RFT version 5.0** with significantly bolstered empirical and theoretical credentials:

* **Improved Galactic-Scale Validity:** Hydrodynamical simulations with RFT will show that galaxies form and evolve realistically without dark matter. We anticipate producing rotation curves, stellar distributions, and feedback-driven outflows in RFT that match observations of galaxy scaling relations and morphologies. A key result will be demonstrating RFT’s solution to the cusp–core problem in dwarf galaxies (Fornax, Carina, IC 2574, etc.), purely through its modified gravity and baryonic physics, rather than through exotic dark matter solutions.
* **Small-Scale Structure Success:** We will provide predictions for the number and properties of satellite galaxies in an RFT universe that can be directly compared to current and upcoming observations. If RFT is correct, it will naturally resolve the missing satellites problem (no huge overabundance of subhalos) and avoid the too-big-to-fail issue (no overly dense invisible subhalos). Our results should show **consistency between RFT’s satellite galaxy population and the latest deep surveys** – for example, matching the satellite luminosity function observed by surveys and the radial distribution of dwarfs around the Milky Way. Such agreement would underscore RFT’s predictive power on small scales where ΛCDM faces challenges​

[arxiv.org](https://arxiv.org/abs/1707.04256#:~:text=10,including%20the%20observed%20planar%20and)

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* **Alleviation of the Hubble Tension:** Through rigorous cosmological tests, we aim to demonstrate that RFT can bring the early- and late-universe measurements of $H\_0$ into much closer agreement. A successful outcome (e.g. RFT predicting $H\_0 \approx 70$–71 km/s/Mpc from CMB data, consistent with local measurements within <2σ) would be a major achievement, indicating RFT offers a solution to the Hubble tension that has plagued standard cosmology. We will back this claim with detailed MCMC analyses comparing RFT to CMB, BAO, and supernova data, showing that RFT fits as well as ΛCDM on those probes while reconciling the Hubble discrepancy​

[arxiv.org](https://arxiv.org/abs/2011.04682#:~:text=SPTPol%20CMB%20data%20with%20the,Overall%2C%20the%20EDE%20scenario%20is)

. Moreover, any unique RFT signatures (like a modified matter power spectrum or specific CMB residuals) will be documented as potential observational tests.

* **Theoretical Foundation and Links to New Physics:** The optional variational principle task will yield a covariant set of field equations for RFT, derived from an action. This solidifies RFT as a true field theory rather than an ad-hoc modification. We expect to report the form of the RFT Lagrangian and how it leads to modified Einstein equations that respect conservation and covariance. In doing so, we will clarify the connection between RFT and holographic gravity ideas, possibly showing that RFT emerges as a low-energy limit of a more fundamental theory with entropic gravity underpinnings. By relating RFT to frameworks like vector-tensor theories​

[arxiv.org](https://arxiv.org/abs/1703.01415#:~:text=model%20is%20proposed,can%20also%20mimic%20dark%20energy)

, we make it easier for others to understand, reproduce, and further develop the theory. RFT v5.0 will thus be positioned as a **rigorously defined alternative to ΛCDM**, with clear equations and predictions that can be independently tested.

In summary, this research will produce a refined RFT that addresses key empirical tests from galactic cores to cosmic expansion. If successful, RFT v5.0 will stand as a compelling alternative cosmological model: one that *eliminates dark matter* by explaining galactic dynamics via modified gravity, *solves small-scale structure puzzles* by altering halo formation, and *reduces cosmological tensions* through new gravitational physics – all under the unifying principle of gravity emerging from horizon entropy. Such a model, supported by both simulations and observational comparisons, would mark a significant step forward in our understanding of the universe’s true workings.

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