RMB Core Theory 2.1

The Unified Lagrangian Structure of the Space–Matter–Motion Theory

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1 Introduction

The RMB theory (Space–Matter–Motion) was systematically developed in the works RMB I–VII and tested against multiple empirical datasets. Across all of these publications, the same structural core appears: motion generates spatial deformation, and this deformation in turn feeds back into the dynamics of motion. The result is a field theory in which space is not a static background, but a dynamic continuum in which mass flows generate inertial potentials.

This document — *RMB Core Theory 2.1* — provides the consolidated, precisely formulated Lagrangian foundation of the entire RMB framework. Its goal is to unify in a single, consistent core model all central definitions, fields, and equations that have appeared throughout previous RMB publications in specialised or extended forms.

The motivation for presenting this unified formulation is threefold:

1. **Mathematical consistency:** RMB I–VII identify the motion tensor $M_{\mu\nu}$ as the central dynamical quantity. This document introduces the full Lagrangian formalism leading to the field equation
$$\nabla^\mu M_{\mu\nu} = 0,$$
embedding the RMB framework into the structure of modern field theories (GR, Yang–Mills, electrodynamics).

2. **Scale-independent formulation:** The RMB theory is applied to systems ranging from laboratory scales to galaxies and cosmology. Phenomena such as galactic rotation curves and cosmological expansion modulations (RMB VI [1]) require a unified core model. Speculative resonance structures (e.g. Schumann–LHC–Milky Way patterns) are treated exclusively in Appendix A as optional extensions.

3. **Experimental falsifiability:** The core RMB model yields concrete, measurable predictions— most notably flat rotation curves without dark matter. Additional speculative resonance phenomena (e.g. φ-scaling, 800 Hz signals, King-plot deviations) are reserved for Appendix A and separate specialised work (e.g. RMB VII [2]), and are not part of the core theory.

Thus, this paper is not a repetition of previous work but their logical foundation. All later applications (thermodynamics, hadrons, isotopic shifts, cosmological dynamics) derive from the structures formulated here.

2 Scope and Limitations of the RMB Core Theory

This chapter specifies the domain of validity and the limitations of the core model. RMB Core Theory 2.1 explicitly distinguishes between:

- **(A) Core model (Chapters 1–7):** field definitions, Lagrangian density, RMB master equation, linearisation, Newtonian limit, and rotation curves.
- **(B) Extensions (Appendix A):** φ-scaling, multi-scale resonance structures, and the proposed Schumann–LHC–Milky Way frequency pattern.

The following restrictions apply:

1. **Linearisation:** The derivation of the RMB wave equations is valid for $|\delta\rho| \ll \rho_0$ and small velocity gradients. Non-linear terms are not solved within the core model.
2. **Range of validity in the galactic context:** The Newtonian approximation is applied only to disc regions with weak gradients. Galactic centres and dense bulges do not lie within the linear RMB regime.
3. α_{RMB}**:** The coupling constant is *not* derived from first principles. In the present version it is treated as a **phenomenological parameter**, determined primarily from rotation-curve fits.
4. **Extensions:** φ-scaling, the 800 Hz resonance, and LHC–Schumann correlations are empirical hints and *not* part of the core theory. They are discussed exclusively in Appendix A.

This separation ensures scientific transparency and a clear distinction between well-founded structures and open research hypotheses.

Contents

3 Motivation and Connection to Previous RMB Work

The existing RMB publications have examined a broad range of physical systems, all grounded in the same mathematical framework:

- **RMB I–III:** Introduction of the RMB potential field Φ_μ, the field tensor $F_{\mu\nu}$, and the motion tensor $M_{\mu\nu}$, together with the first derivation of the dynamical field equations.
- **RMB IV:** Extension to fractal and non-smooth spatial structures in Fourier space; introduction of fractal correction modes and scale-dependent deformations of space.
- **RMB V** [3]: Formal definition of the frequency charge Q_f and of the universal RMB coupling factor α_{RMB}. This parameter later becomes central for φ-scaling and rotation-curve analysis.
- **RMB VI** [1]: Application to cosmological scales: a dynamical switching function $S(a)$, effective modulation of the Hubble expansion rate, a proposed resolution of the Hubble tension, and falsifiable bounds such as $|w(z) + 1| \leq 0.03$, a King-plot constraint $\leq 10^{-3}$, and a CMB angular-scale deviation $\leq 0.1\%$.
- **RMB VII** [2]: Introduction of the RMB resonance law, a reversible space–matter relation analogous to Ohm's law. It predicts a universal resonance feature around 800 Hz and accounts for King-plot nonlinearities at the kHz level.
- **RMB King-plot analysis** [2]: Application of RMB field coupling to isotopic shifts. The results indicate a characteristic deviation of approximately 2 kHz arising from RMB resonance coupling in the atomic regime.
- **RMB thermodynamics** [4]: Extension of classical thermodynamics: interpretation of phase transitions, anomalies, helium behaviour, and water structure as dynamical momentum densities of space.
- **RMB hadrons / exotic hadrons** [5]: Reinterpretation of tetra- and pentaquarks as transient knots of spatial deformation rather than classical point-like particles.

All these works originate from the same fundamental fields:

$$\Phi_\mu, \qquad F_{\mu\nu}, \qquad M_{\mu\nu},$$

and from the master equation:

$$\nabla^\mu M_{\mu\nu} = 0.$$

The present document therefore constitutes the *core publication of the RMB theory*: a consistent foundation upon which all past and future RMB studies can be mapped in a logically and mathematically coherent manner.

4 Field Content of the RMB Theory

The RMB theory (Space–Matter–Motion) is based on the central premise that space, matter, and motion are not separate fundamental entities. Rather, motion itself generates a dynamic deformation of space. The field content of the theory follows directly from this assumption and consists of three mutually coupled objects:

1. the *RMB potential field* Φ_μ,
2. the *RMB field tensor* $F_{\mu\nu}$,
3. the *RMB motion tensor* $M_{\mu\nu}$.

This chapter defines these quantities, analyses their transformation properties, and establishes their connections to familiar structures from electrodynamics, fluid dynamics, and general relativity. The resulting framework forms the mathematical foundation for the subsequent field equations and for all experimentally testable predictions of the RMB theory.

4.1 The RMB Potential Field Φ_μ

The starting point of the RMB framework is a potential field of the form

$$\Phi_\mu = \rho\, c^2\, v_\mu, \tag{1}$$

where ρ denotes the local matter density and v_μ the four-velocity of the mass flow under consideration. This definition encodes one of the fundamental ideas of the theory:

> *Matter in motion carries a potential field directly proportional to its energy density ρc^2.*

In contrast to electromagnetic potentials, Φ_μ is not a charge-derived potential but an *inertial potential* representing the coupling between space and motion. It gives rise to a dynamical field structure determined by the spacetime variation of Φ_μ.

4.2 The RMB Field Tensor $F_{\mu\nu}$

Analogous in form to electrodynamics [6], though motivated by entirely different physics, an antisymmetric field tensor is defined via (1):

$$F_{\mu\nu} = \partial_\mu \Phi_\nu - \partial_\nu \Phi_\mu. \tag{2}$$

This tensor describes gradients and vortical structures of the inertial potential. Key properties include:

- $F_{\mu\nu}$ is **antisymmetric**, i.e. $F_{\mu\nu} = -F_{\nu\mu}$.
- It encodes *velocity gradients*, i.e. spatial variations of motion.
- It is manifestly *Lorentz covariant.*
- It satisfies the identity
  $$\partial_\lambda F_{\mu\nu} + \partial_\mu F_{\nu\lambda} + \partial_\nu F_{\lambda\mu} = 0,$$
  in full analogy with the Bianchi identities.

Whereas the electromagnetic field tensor arises from charge potentials, the RMB tensor $F_{\mu\nu}$ originates from the mass-density–velocity potential Φ_μ. Physically, it does not describe electric or magnetic fields but rather *inertial vorticity* and *spatial coupling of motion.*

4.3 The RMB Motion Tensor $M_{\mu\nu}$

The central dynamical quantity of the RMB theory is the motion tensor

$$M_{\mu\nu} = \rho\, v_\mu v_\nu + \alpha_{\mathrm{RMB}}\, F_{\mu\nu}, \tag{3}$$

a linear combination of:

- a *symmetric part* $\rho v_\mu v_\nu$, analogous to the energy–momentum flux of an ideal fluid,
- an *antisymmetric part* $\alpha_{\mathrm{RMB}} F_{\mu\nu}$, which weights the field-vorticity contribution by the RMB coupling constant α_{RMB}.

Hence, $M_{\mu\nu}$ naturally contains both inertial and field-like contributions. The symmetric component dominates in the weak-field regime, whereas the antisymmetric component introduces deviations from Newtonian and GR behaviour in strongly flowing or resonance-dominated systems.

4.4 Field Equation of the Motion Tensor

The fundamental dynamics of the RMB theory are obtained from the condition

$$\nabla^\mu M_{\mu\nu} = 0. \tag{4}$$

This is the **RMB master equation**:

- It replaces the geodesic equation of GR within the RMB formalism [7].
- It is formally analogous to the conservation equation of an energy–momentum tensor in fluid dynamics.
- It couples motion directly to spatial deformation.

Importantly, (4) leads to rotation-induced corrections to classical gravity, manifesting in flat galactic rotation curves (compare Milgrom [8] for historical context; Dellomonaco [9] for the RMB solution).

4.5 Comparison with Established Theories

The RMB field content can be clearly distinguished from existing models:

- **General Relativity (GR)** [7]: The GR energy–momentum tensor $T_{\mu\nu}$ is purely symmetric; RMB adds antisymmetric, vorticity-like contributions.
- **Maxwell Theory** [6]: Although both frameworks employ an antisymmetric tensor, RMB couples not to electric charge but to motion and mass density.
- **Fluid Dynamics**: The symmetric term $\rho v_\mu v_\nu$ resembles ideal-fluid dynamics, but the presence of $F_{\mu\nu}$ introduces an additional vorticity-driven spatial deformation.
- **MOND / Modified Gravity** [8]: RMB is not an empirical force law; it is a full dynamical field model with its own potential, field tensor, and Lagrangian structure.

Thus, the field content defined here constitutes the mathematical core of the RMB theory and provides the foundation for all subsequent derivations, including the Lagrangian density in Chapter 5.

5 Lagrangian Density and Variational Principle of the RMB Theory

The RMB theory is based on the premise that motion itself induces a local deformation of space, and that this deformation is described by the motion tensor $M_{\mu\nu}$. This chapter demonstrates how the RMB field equations follow from a consistent variational principle, thereby placing the theory on a Lagrangian foundation compatible with modern field frameworks (GR [7], Maxwell theory [6], Yang–Mills structures), while preserving the characteristic features of the RMB approach.

5.1 Conceptual Basis of the Variational Ansatz

A general Lagrangian density $\mathcal{L}_{\text{RMB}}$ is required to satisfy the following criteria:

1. It must reproduce the RMB master equation
$$\nabla^\mu M_{\mu\nu} = 0.$$
2. It must couple motion and space dynamically through the RMB potential Φ_μ and the field tensor $F_{\mu\nu}$, as first formulated systematically in RMB II [10].
3. It should possess a well-defined energy–momentum structure, comparable to that in GR [7] and in classical field theories.
4. It must reduce, in the weak-field limit, to Newtonian scaling supplemented by RMB corrections that contribute to the explanation of rotation curves [9].

From Chapter 4, the RMB motion tensor is defined as

$$M_{\mu\nu} = \rho\, v_\mu v_\nu + \alpha_{\text{RMB}} F_{\mu\nu}, \tag{5}$$

a structure first analysed comprehensively in RMB V [3].

We adopt a fully dynamical variational principle in which Φ_μ is treated as the fundamental field-theoretic variable, while v_μ and ρ are regarded as fluid variables with the constraint $v_\mu v^\mu = -1$ implemented as usual.

5.2 Lagrangian Density of the RMB Theory

A minimal yet complete Lagrangian density is given by

$$\boxed{\mathcal{L}_{\text{RMB}} = -\frac{1}{2}\,\rho\, v_\mu v^\mu - \frac{1}{4}\,\alpha_{\text{RMB}}\, F_{\mu\nu}F^{\mu\nu} + J^\mu \Phi_\mu.} \tag{6}$$

The three terms have the following physical significance:

- **(i) Inertial term:**
$$-\frac{1}{2}\,\rho\, v_\mu v^\mu$$
describes the classical mass–motion energy of a fluid element.
- **(ii) Field term:**
$$-\frac{1}{4}\,\alpha_{\text{RMB}} F_{\mu\nu}F^{\mu\nu}$$
is formally analogous to the Maxwell Lagrangian [6], although motivated by entirely different physics: here $F_{\mu\nu}$ arises from density gradients and vortical motion, not from electric charge.
- **(iii) Coupling term:**
$$J^\mu \Phi_\mu,$$
where $J^\mu = \rho\, v^\mu$ is the natural RMB mass-current density.

5.3 Variation with Respect to Φ_μ

Variation with respect to Φ_μ yields the field equation

$$\partial_\mu F^{\mu\nu} = \frac{1}{\alpha_{\mathrm{RMB}}} J^\nu, \tag{7}$$

which plays a role analogous to a Yang–Mills equation, but couples to mass current rather than electric charge.

5.4 Variation with Respect to v^μ

Variation with respect to the four-velocity gives

$$v^\nu \nabla_\nu v_\mu = \frac{1}{\rho} F_{\mu\nu} v^\nu. \tag{8}$$

This equation is formally reminiscent of the Lorentz force, but physically represents a pure inertial-vorticity field. It forms the mechanical core of galactic dynamics [9] and of φ-scaling [11].

5.5 Derivation of the RMB Master Equation

Combining the field and motion equations and using the identity $J^\mu = \rho v^\mu$ yields

$$\nabla^\mu \left(\rho v_\mu v_\nu + \alpha_{\mathrm{RMB}} F_{\mu\nu} \right) = 0,$$

i.e.

$$\nabla^\mu M_{\mu\nu} = 0.$$

Thus we obtain:

Central Result of Chapter 5

The RMB master equation

$$\nabla^\mu M_{\mu\nu} = 0$$

follows directly from the variational principle applied to the Lagrangian density $\mathcal{L}_{\mathrm{RMB}}$.

5.6 Interpretation

The variational formulation shows:

1. RMB is a *genuine field theory*, analogous to GR [7], Maxwell theory [6], and Yang–Mills frameworks.
2. The mass current J^μ acts as the source term for spatial deformation fields.
3. The field tensor $F_{\mu\nu}$ constitutes an inertial vorticity field with its own dynamics.
4. The motion equation replaces the geodesic equation of GR with a rotation-sensitive, scale-dependent coupling.
5. The master equation $\nabla^\mu M_{\mu\nu} = 0$ forms the foundation of all subsequent applications, from rotation curves [9] to cosmological effects [1].

6 Linearisation of the RMB Field Equations

The RMB field equations

$$\nabla^\mu M_{\mu\nu} = 0, \qquad M_{\mu\nu} = \rho\, v_\mu v_\nu + \alpha_{\mathrm{RMB}} F_{\mu\nu},$$

were first derived in full form in RMB II [10]. They represent a nonlinear coupling between mass current, inertial potential, and field-like vorticity structures. For astrophysical, geophysical, and laboratory applications, however, the weak-field regime is typically relevant:

$$v \ll c, \qquad |\delta\rho| \ll \rho_0,$$

as also shown in RMB VI for cosmological scales [1]. In this chapter we perform the full linearisation, which later forms the basis for the RMB wave equations (see Appendix A) and for subsequent, more speculative resonance analyses.

6.1 Background and Perturbation Ansatz

All quantities are expanded around a stationary background:

$$\rho = \rho_0 + \delta\rho, \qquad v_\mu = (c,\, \mathbf{v}), \qquad |\mathbf{v}| \ll c.$$

From $\Phi_\mu = \rho c^2 v_\mu$ one obtains for the background values:

$$\Phi_0^{(0)} = \rho_0 c^3, \qquad \Phi_i^{(0)} = 0,$$

and for the linear perturbations:

$$\delta\Phi_0 = c^3\, \delta\rho, \qquad \delta\Phi_i = \rho_0 c^2\, v_i.$$

6.2 Linearised RMB Field

The RMB field tensor

$$F_{\mu\nu} = \partial_\mu \Phi_\nu - \partial_\nu \Phi_\mu$$

yields in the linear regime:

$$F_{0i} = \partial_0 \delta\Phi_i - \partial_i \delta\Phi_0 = \rho_0 c^2\, \partial_0 v_i - c^3\, \partial_i \delta\rho,$$

$$F_{ij} = \rho_0 c^2 (\partial_i v_j - \partial_j v_i).$$

6.3 Linearisation of the RMB Motion Tensor

The motion tensor decomposes into two contributions:

$$M_{\mu\nu} = M_{\mu\nu}^{(S)} + M_{\mu\nu}^{(A)},$$

$$M_{\mu\nu}^{(S)} = \rho\, v_\mu v_\nu, \qquad M_{\mu\nu}^{(A)} = \alpha_{\mathrm{RMB}} F_{\mu\nu}.$$

For the symmetric part one finds:

$$M_{00}^{(S)} \approx \rho_0 c^2, \qquad M_{0i}^{(S)} \approx \rho_0 c\, v_i, \qquad M_{ij}^{(S)} \approx 0.$$

For the antisymmetric part:

$$M_{0i}^{(A)} = \alpha_{\mathrm{RMB}} F_{0i}, \qquad M_{ij}^{(A)} = \alpha_{\mathrm{RMB}} F_{ij}.$$

6.4 Divergence of the Linear Motion Tensor

The RMB master equation is

$$\nabla^\mu M_{\mu\nu} = 0.$$

In locally flat coordinates this becomes

$$\nabla^\mu M_{\mu\nu} \approx \partial^\mu M_{\mu\nu}.$$

(i) Time-component equation $\nu = 0$

$$\partial^\mu M_{\mu 0} = \partial^0 M_{00} + \partial^i M_{i0} = 0.$$

Inserting the explicit expressions yields the modified continuity equation:

$$\rho_0 c\, \nabla \cdot \mathbf{v} + \alpha_{\mathrm{RMB}}\, \partial^i F_{i0} = 0.$$

(ii) Spatial components $\nu = i$

$$\partial^\mu M_{\mu i} = \partial_t(\rho_0 c\, v_i + \alpha_{\mathrm{RMB}} F_{0i}) + \partial_j(\alpha_{\mathrm{RMB}} F_{ji}) = 0.$$

Using the linearised tensors, one obtains:

$$\rho_0 c\, \partial_t v_i + \alpha_{\mathrm{RMB}} \rho_0 c^2 \left(\partial_t^2 v_i - \nabla^2 v_i\right) + \text{density-gradient terms} = 0.$$

The density-gradient terms vanish once the continuity equation is used to eliminate $\delta\rho$. This leads to

$$\partial_t^2 v_i - \frac{1}{c_{\mathrm{RMB}}^2}\, \partial_t v_i - \nabla^2 v_i = 0, \tag{9}$$

with the effective RMB wave speed

$$c_{\mathrm{RMB}} = c\sqrt{\frac{\alpha_{\mathrm{RMB}}}{\rho_0}}. \tag{10}$$

In typical situations, where $\partial_t v_i \ll c_{\mathrm{RMB}}\, \partial_t^2 v_i$ holds, equation (9) simplifies to

Since α_{RMB} carries the dimension $\mathrm{m^3\,kg^{-1}}$ and ρ_0 has the dimension $\mathrm{kg\,m^{-3}}$, the ratio $\alpha_{\mathrm{RMB}}/\rho_0$ is dimensionless. Consequently, c_{RMB} consistently has the dimension of a velocity.

$$\partial_t^2 v_i - c_{\mathrm{RMB}}^2\, \nabla^2 v_i = 0. \tag{11}$$

7 The RMB Newtonian Limit

The RMB master equation

$$\nabla^\mu M_{\mu\nu} = 0, \qquad M_{\mu\nu} = \rho v_\mu v_\nu + \alpha_{\mathrm{RMB}} F_{\mu\nu},$$

yields, in the nonrelativistic limit, an effective additional acceleration that leads to flat galactic rotation curves. This connection has been demonstrated quantitatively using SPARC data in the RMB rotation-curve analysis [9, 12]. In this chapter the Newtonian limit is derived in full and linked to realistic density profiles.

7.1 Nonrelativistic Approximation

For

$$v_0 \approx c, \qquad v_i \ll c$$

the symmetric part of the motion tensor reduces to

$$M_{00} \approx \rho_0 c^2, \qquad M_{0i} \approx \rho_0 c\, v_i, \qquad M_{ij} \approx 0.$$

The antisymmetric contribution remains:

$$M^{(A)}_{\mu\nu} = \alpha_{\mathrm{RMB}} F_{\mu\nu}.$$

7.2 Continuity Equation

The component $\nu = 0$ of the RMB equation gives

$$\nabla_\mu M^{\mu 0} = 0 \quad \Rightarrow \quad \partial_t \rho_0 + \rho_0 \nabla \cdot \mathbf{v} = 0,$$

which is the classical continuity equation in the Newtonian limit, consistent with standard fluid dynamics [13].

7.3 Spatial Components and the Additional RMB Force

The equation for $\nu = i$ reads

$$\nabla_\mu M^{\mu i} = 0.$$

Inserting the linearised terms from Chapter 6 yields

$$\rho_0 \frac{dv_i}{dt} = -\alpha_{\mathrm{RMB}}\, \partial_j F^{ji}.$$

Using

$$F_{ji} = \rho_0 c^2 (\partial_j v_i - \partial_i v_j)$$

one finds

$$\partial_j F^{ji} = \rho_0 c^2 \left[\nabla^2 v_i - \partial_i (\nabla \cdot \mathbf{v}) \right].$$

In the stationary, divergence-free case ($\nabla \cdot \mathbf{v} = 0$), this simplifies to

$$\rho_0 \frac{dv_i}{dt} = -\alpha_{\mathrm{RMB}}\, \rho_0 c^2\, \nabla^2 v_i.$$

This defines an effective RMB acceleration:

$$\mathbf{a}_{\mathrm{RMB}} = -\frac{\alpha_{\mathrm{RMB}}}{\rho_0} \nabla \times (\nabla \times \mathbf{v}), \tag{12}$$

an inertial-space-induced additional force arising from vortical and gradient structures of the motion field, which, in the galactic context, can generate flat rotation curves [9].

7.4 Axisymmetric Case

For axisymmetric rotation with velocity $v(r)$:

$$\mathbf{v} = v(r)\,\mathbf{e}_\varphi,$$

equation (12) yields

$$a_{\mathrm{RMB}}(r) = -\frac{\alpha_{\mathrm{RMB}}}{\rho_0}\left[\frac{d}{dr}\left(\frac{1}{r}\frac{d}{dr}(rv(r))\right)\right].$$

The total radial acceleration is then

$$a_r(r) = a_{\mathrm{Newton}}(r) + a_{\mathrm{RMB}}(r).$$

This expression forms the basis of the rotation-curve analysis in Chapter 8.

7.5 Incorporating Realistic Density Profiles

The Newtonian contribution

$$a_{\mathrm{Newton}}(r) = \frac{GM(<r)}{r^2}$$

depends on the enclosed mass $M(<r)$. For spiral galaxies, the following profiles are typically employed [13, 12].

7.5.1 (i) Exponential Disk

For a Freeman disk [14]

$$\rho_{\mathrm{disk}}(R,z) = \rho_0\,\exp(-R/R_d)\,\exp(-|z|/z_0)$$

one obtains the well-known Newtonian acceleration:

$$a^{\mathrm{disk}}_{\mathrm{Newton}}(r) = \pi G\Sigma_0\left[I_0(y)K_0(y) - I_1(y)K_1(y)\right], \qquad y = \frac{r}{2R_d},$$

where I_n, K_n are modified Bessel functions.

7.5.2 (ii) Isothermal Halo

The isothermal profile [13]

$$\rho_{\mathrm{iso}}(r) = \frac{\rho_0}{1 + (r/r_c)^2}$$

gives

$$a^{\mathrm{iso}}_{\mathrm{Newton}}(r) = \frac{4\pi G\rho_0 r_c^2}{r}\left[1 - \frac{r_c}{r}\arctan\left(\frac{r}{r_c}\right)\right].$$

7.5.3 (iii) Burkert Profile

For the empirical Burkert halo [15]

$$\rho_{\mathrm{Burkert}}(r) = \frac{\rho_b}{(1 + r/r_b)(1 + (r/r_b)^2)}$$

one has

$$a^{\mathrm{Burkert}}_{\mathrm{Newton}}(r) = \frac{GM_{\mathrm{Burkert}}(<r)}{r^2},$$

where $M_{\mathrm{Burkert}}(<r)$ is an analytically known mass function.

7.5.4 (iv) NFW Profile

For an NFW profile [16]

$$\rho_{\mathrm{NFW}}(r) = \frac{\rho_s}{(r/r_s)(1 + r/r_s)^2}$$

one obtains

$$a_{\mathrm{Newton}}^{\mathrm{NFW}}(r) = \frac{4\pi G \rho_s r_s^3}{r^2} \left[\ln\left(1 + \frac{r}{r_s}\right) - \frac{r/r_s}{1 + r/r_s} \right].$$

These four profiles cover the SPARC galaxy population [12] and form the basis of the numerical fits in [9].

7.6 RMB Correction for Real Density Profiles

Inserting the rotation velocity $v(r)$ obtained from a given density profile into the RMB acceleration yields

$$a_{\mathrm{RMB}}(r) = -\frac{\alpha_{\mathrm{RMB}}}{\rho_0} \frac{d}{dr} \left(\frac{v(r)}{r} \right).$$

For an exponential disk whose rotation curve would decline in the absence of additional components, RMB automatically generates a positive contribution in the outer disk region. For a generic profile one finds:

$$v^2(r) = r \left[a_{\mathrm{Newton}}(r) + a_{\mathrm{RMB}}(r) \right]. \tag{13}$$

In the Newtonian limit this leads to:

RMB Result for the Newtonian Limit

The RMB framework introduces an additional, vorticity-driven acceleration

$$a_{\mathrm{RMB}}(r) = -\frac{\alpha_{\mathrm{RMB}}}{\rho_0} \frac{d}{dr} \left(\frac{v(r)}{r} \right),$$

which, in combination with realistic density profiles, reproduces flat rotation curves without the need to invoke dark matter [9].

8 RMB Correction of Galactic Rotation Curves

Galactic rotation curves are among the central empirical indications for additional dynamics beyond Newtonian gravity. The SPARC catalogue provides one of the most precise current data sets for this purpose [12]. The RMB framework supplies the necessary correction not via additional matter components, but through a dynamical vorticity term in space, which follows from the master equation

$$\nabla^\mu M_{\mu\nu} = 0$$

and has already been tested systematically in RMB rotation-curve studies [9]. This chapter derives the full formulation for rotation velocities and connects it to the observed SPARC data.

8.1 Fundamental Relation for Rotation Velocities

For stationary rotation, the circular velocity $v(r)$ satisfies

$$\frac{v^2(r)}{r} = a_{\text{Newton}}(r) + a_{\text{RMB}}(r). \tag{14}$$

The RMB contribution from Chapter 7 reads

$$a_{\text{RMB}}(r) = -\frac{\alpha_{\text{RMB}}}{\rho_0} \frac{d}{dr}\left(\frac{v(r)}{r}\right). \tag{15}$$

Hence the total velocity becomes explicitly

$$v^2(r) = r\, a_{\text{Newton}}(r) - \frac{\alpha_{\text{RMB}}}{\rho_0}\, r\, \frac{d}{dr}\left(\frac{v(r)}{r}\right).$$

This equation couples the velocity profile $v(r)$ directly to its own radial gradient — an intrinsically self-consistent mechanism.

8.2 Including Real Baryonic Components

The Newtonian contribution decomposes into

$$a_{\text{Newton}}(r) = a_{\text{disk}}(r) + a_{\text{gas}}(r) + a_{\text{bulge}}(r),$$

where the components are parametrised according to standard galaxy models [13, 12]:

- The *exponential disk* (Freeman disk) employs the standard Bessel-function combination [14]:

$$a_{\text{disk}}(r) = \pi G \Sigma_0 \left[I_0(y)\, K_0(y) - I_1(y)\, K_1(y)\right], \qquad y = \frac{r}{2R_d}.$$

- The *gas* contribution is tabulated directly in SPARC; the acceleration follows from

$$a_{\text{gas}}(r) = \frac{G M_{\text{gas}}(< r)}{r^2}.$$

- A *bulge* (if present) is modelled as a spherical profile:

$$a_{\text{bulge}}(r) = \frac{G M_{\text{bulge}}(< r)}{r^2}.$$

In this way the baryonic dynamics are fully captured without explicitly introducing dark components.

8.3 RMB Acceleration: Closed Radial Form

Inserting $v(r)\,\mathbf{e}_\varphi$ into the general expression (15) gives

$$a_{\mathrm{RMB}}(r) = -\frac{\alpha_{\mathrm{RMB}}}{\rho_0}\left[-\frac{v(r)}{r^2} + \frac{1}{r}\frac{\mathrm{d}v(r)}{\mathrm{d}r}\right]. \tag{16}$$

Thus RMB directly modifies the local slope of the rotation curve and generates an asymptotically flat velocity regime for slowly declining profiles.

8.4 Asymptotic Solution: Flat Rotation Curves

For large radii $r \gg R_d$, baryonic density $\rho_b(r) \to 0$, and small derivatives $\frac{\mathrm{d}v}{\mathrm{d}r} \approx 0$, equation (14) simplifies to

$$\frac{v_\infty^2}{r} \approx -\frac{\alpha_{\mathrm{RMB}}}{\rho_0}\left(-\frac{v_\infty}{r^2}\right),$$

from which one obtains

$$v_\infty^2 = \alpha_{\mathrm{RMB}}\,\Omega_0,$$

with

$$\Omega_0 = \frac{1}{\rho_0}$$

as an effective normalisation factor of the local mass density.

This yields a *constant asymptotic velocity* without the introduction of dark matter, in agreement with the observed flat rotation curves of large spiral galaxies [12, 9].

8.5 Comparison with SPARC Data (176 Galaxies)

For each SPARC galaxy, the data series

$$\{r_k,\ v_{\mathrm{obs}}(r_k),\ a_{\mathrm{disk}}(r_k),\ a_{\mathrm{gas}}(r_k),\ a_{\mathrm{bulge}}(r_k)\}$$

were taken from the official tables [12]. The model velocity is then

$$v_{\mathrm{RMB}}(r) = \sqrt{r\left[a_{\mathrm{disk}}(r) + a_{\mathrm{gas}}(r) + a_{\mathrm{bulge}}(r) + a_{\mathrm{RMB}}(r)\right]}.$$

The fit was performed via χ^2 minimisation [9]:

$$\chi^2(\alpha_{\mathrm{RMB}}) = \sum_k \frac{\left(v_{\mathrm{obs}}(r_k) - v_{\mathrm{RMB}}(r_k)\right)^2}{\sigma_k^2}.$$

The global minimum yields

$$\alpha_{\mathrm{RMB}}^{\mathrm{fit}} = -3.20025 \times 10^{-21}\,\mathrm{m}^2\,\mathrm{kg}^{-1}, \qquad \sigma_\alpha = 2.48 \times 10^{-24}.$$

In the present work, α_{RMB} is explicitly interpreted as a phenomenological coupling parameter whose value is inferred from SPARC rotation curves. The fitted value lies numerically close to previously discussed φ-based expressions (see Appendix A), without any theoretical connection being asserted at this stage.

8.6 Falsifiability

Within the RMB Core Theory 2.1, α_{RMB} is treated as a phenomenological parameter constrained by observed rotation curves. Thus galactic rotation becomes an immediate testing ground for the core model:

- For a given choice of density profiles (disk, gas, bulge), the radial form of $a_{\mathrm{RMB}}(r)$ is uniquely fixed. Deviations between $v_{\mathrm{RMB}}(r)$ and $v_{\mathrm{obs}}(r)$ can be quantified directly.
- A globally consistent best-fit value of α_{RMB} across many galaxies is a necessary condition for the validity of the RMB rotation-curve model.
- Earlier work on φ-scaling and on multiscale resonance structures (Schumann–LHC–Milky Way, 800 Hz signal) provides additional, but speculative, consistency checks and is therefore discussed exclusively in Appendix A.

Hence the RMB formulation of rotation curves is experimentally well testable without requiring a prior fundamental derivation of α_{RMB}.

8.7 Central Result

RMB Result for Rotation Curves

Without introducing dark matter, the RMB framework yields

$$v^2(r) = r\,\left[a_{\mathrm{disk}}(r) + a_{\mathrm{gas}}(r) + a_{\mathrm{bulge}}(r) + a_{\mathrm{RMB}}(r)\right],$$

with

$$a_{\mathrm{RMB}}(r) = -\frac{\alpha_{\mathrm{RMB}}}{\rho_0}\left[-\frac{v(r)}{r^2} + \frac{1}{r}\frac{\mathrm{d}v(r)}{\mathrm{d}r}\right].$$

This structure generically produces flat rotation curves in the outer regions of galaxies, in agreement with all SPARC systems analysed so far [12, 9], without requiring additional dark mass components.

Appendix A: Speculative Extensions of the RMB Theory

This appendix contains hypotheses and empirical indications that are not part of the core RMB field-theoretic model (Chapters 1–7), but which may be of interest as potential extensions. They concern, in particular:

- the empirical φ-scaling pattern,
- multi-scale resonance structures,
- proposed LHC–Schumann–galactic correlations,
- the suggested 800 Hz laboratory signal,
- the φ-power structure appearing in numerical forms of α_{RMB}.

The material presented in this appendix has the character of empirical hints and working hypotheses. It is *not* part of the mathematical foundation of the RMB core model and plays no role in the derivation of the central field equations.

The following subsections summarise these speculative ideas, outline the current evidence, and describe how they might guide future research without implying any confirmed physical relationship at this stage.

A RMB Wave Equations

The full linearisation of the RMB field equations derived in Chapter 6 leads to a wave dynamics for velocity perturbations $\delta\mathbf{v}$, arising directly from the motion tensor

$$M_{\mu\nu} = \rho\, v_\mu v_\nu + \alpha_{\mathrm{RMB}} F_{\mu\nu}.$$

These waves do not describe curvature of the metric—as in gravitational waves—but represent dynamical deformations of space generated by mass flows. Comparable vectorial vortex waves are well known in classical fluid and plasma dynamics [17, 18, 19].

A.1 Starting point: linear RMB field equations

From Chapter 6 we have, in the perturbative regime,

$$F_{ij} = \rho_0 c^2 \,(\partial_i v_j - \partial_j v_i),$$

and inserting this into

$$\nabla_\mu M^{\mu\nu} = 0,$$

with $M^{\mu\nu} = \rho_0 v^\mu v^\nu + \alpha_{\mathrm{RMB}} F^{\mu\nu}$, yields the linear equation of motion:

$$\partial_t^2\, \delta\mathbf{v} - c_{\mathrm{RMB}}^2\, \nabla^2 \delta\mathbf{v} = 0, \tag{17}$$

where the RMB wave speed is defined by

$$c_{\mathrm{RMB}} = c\sqrt{\frac{\alpha_{\mathrm{RMB}}}{\rho_0}}. \tag{18}$$

This structure is analogous to non-dispersive vector waves in flowing media [17].

A.2 Transverse and longitudinal RMB waves

The decomposition

$$\delta\mathbf{v} = \delta\mathbf{v}_{\parallel} + \delta\mathbf{v}_{\perp},$$

with

$$\nabla \times \delta\mathbf{v}_{\parallel} = 0, \qquad \nabla \cdot \delta\mathbf{v}_{\perp} = 0,$$

is the classical Helmholtz decomposition [20].

Transverse: vortex-type RMB waves Because the antisymmetric tensor $F_{\mu\nu}$ responds directly to vorticity, the transverse part satisfies

$$\partial_t^2 \delta\mathbf{v}_{\perp} - c_{\mathrm{RMB}}^2 \nabla^2 \delta\mathbf{v}_{\perp} = 0.$$

Longitudinal: compressive RMB waves The continuity equation,

$$\partial_t \delta\rho + \rho_0 \, \nabla \cdot \delta\mathbf{v} = 0,$$

implies

$$\partial_t^2 \delta\mathbf{v}_{\parallel} - c_{\mathrm{RMB}}^2 \nabla^2 \delta\mathbf{v}_{\parallel} = 0.$$

Thus, both modes exist—in contrast to electromagnetism or general relativity, where only transverse waves propagate [21].

A.3 Dispersion relation

For plane-wave solutions,

$$\delta\mathbf{v}(t, \mathbf{x}) = \delta\mathbf{v}_0 \, e^{i(\mathbf{k}\cdot\mathbf{x} - \omega t)},$$

the dispersion relation becomes

$$\omega^2 = c_{\mathrm{RMB}}^2 k^2. \tag{19}$$

This is the classical non-dispersive wave relation [17].

A.4 Sources of RMB waves

The full RMB theory includes sources through

$$\partial_\mu F^{\mu\nu} = \frac{1}{\alpha_{\mathrm{RMB}}} J^\nu, \qquad J^\nu = \rho v^\nu.$$

Mass flows—not electric charges—act as sources of RMB waves. Representative examples include:

- **Astrophysical:** large-scale plasma vortices in supernovae [18], and rotating galactic discs (SPARC [12]).
- **Terrestrial:** atmospheric mass flows and conductive plasma structures, such as lightning channels [22].
- **High-energy physics:** coherent proton mass flows in the LHC beam, characterised by the revolution frequency 11245.51 Hz [23, 24].

A.5 Scale range of RMB waves

Due to their field-theoretic structure, linear RMB waves span a wide range of physical scales. Relevant examples include:

- atmospheric modes in the Hz regime [25, 26],
- terrestrial and technical excitations in the 10^2–10^3 Hz band,
- structured mass flows in accelerator physics, such as the LHC (1–10^4 Hz) [23],
- galactic-scale vortex modes at extremely low frequencies ($\sim 10^{-15}$ Hz) inferred from rotation curve data [12].

Earlier work discussed possible multi-scale structural patterns and resonances. These ideas remain purely speculative and are treated only in Appendix A as potential extensions, not as part of the core theory.

A.6 Experimental testability

The RMB wave equations offer several experimentally accessible regimes:

- **Laboratory-scale experiments:** controlled excitation and detection in the frequency range 100–2000 Hz.
- **Atmospheric observations:** precise analysis of global EM and plasma modes of the Earth, particularly the Schumann resonances [26].
- **High-energy physics:** near-field measurements along the LHC beam pipe and analysis of mass-flow modulations [23].

A.7 Central result

RMB Wave Equations – Central Result

In the linear regime, the RMB theory yields the non-dispersive vector wave equation

$$\partial_t^2\, \delta\mathbf{v} - c_{\mathrm{RMB}}^2\, \nabla^2 \delta\mathbf{v} = 0,$$

with wave speed

$$c_{\mathrm{RMB}} = c\sqrt{\frac{\alpha_{\mathrm{RMB}}}{\rho_0}}.$$

These waves are generated by mass flows and represent dynamical vorticity modes of space. They constitute the foundation for all subsequent—and only in Appendix A discussed—speculative multi-scale resonance phenomena.

Glossary

ρ_0 Stationary background density of the local space–matter field. It defines the unperturbed reference state of RMB dynamics.

Φ_μ RMB potential field:

$$\Phi_\mu = \rho\, c^2\, v_\mu.$$

It couples matter density and motion into an inertia-induced potential field.

$F_{\mu\nu}$ RMB field tensor:

$$F_{\mu\nu} = \partial_\mu \Phi_\nu - \partial_\nu \Phi_\mu.$$

$M_{\mu\nu}$ RMB motion tensor:

$$M_{\mu\nu} = \rho\, v_\mu v_\nu + \alpha_{\mathrm{RMB}} F_{\mu\nu}.$$

v_μ Four-velocity.

$\delta\mathbf{v}$ Linear velocity perturbation satisfying the RMB wave equation.

$a_{\mathrm{RMB}}(r)$ RMB correction term in rotation curves.

c_{eff} Effective propagation speed in the linear RMB regime.

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