Inertia as an Information-Latency Cost: A Fisher-Geometric Derivation in Open Rendered Systems

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We formulate an information-thermodynamic derivation of inertia in which sustained motion is interpreted as the continuous rewrite of rendered records in an open system. The starting point is a family of rendered boundary densities $p(x|X) = |\psi(x;X)|^2$ parameterized by a location variable $X(t)$. The minimal information needed to update the rendered record from X to $X + \mathrm{d}X$ is the Kullback-Leibler divergence between neighboring rendered states, whose local quadratic expansion is governed by the Fisher information metric $g_{ij}(X)$. Assigning a per-bit write cost set by a running latency scale $\Gamma_L(\mu)$ yields an effective computational power and, by identification with the kinetic term, an emergent inertial tensor

$$m_{ij}(\mu) = \frac{\hbar\Gamma_L(\mu)}{2\ln 2}\, g_{ij}.$$

In the isotropic limit, $m = (\hbar\Gamma_L/2\ln 2)g$. In this picture, mass is not primitive; it is the latency cost of maintaining localized rendered structure under translation. The framework provides a falsifiable bridge between information geometry, open-system latency, and effective mechanical response.

INTRODUCTION

The operational content of mechanics is ultimately inferential: a moving object is represented through successive distinguishable records. This observation suggests a minimal question. What is the information-theoretic cost of updating those records, and can that cost itself generate an effective inertial law? The present work answers that question in a compact open-systems setting inspired by MetaTime v42, while keeping the argument entirely within standard tools from information geometry, thermodynamics of information, and effective dynamics [1–5].

The starting postulate is deliberately modest. We distinguish between a latent state and its localized *rendered* record. A rendered object is not assumed to be ontologically fundamental; it is the local record that must be maintained if the system is to remain sharply resolved in a given observational channel. Translation of that record is therefore not free. It requires repeated updates of the boundary description. The minimal update budget is quantified by the Kullback-Leibler (KL) divergence between neighboring rendered states. Its local quadratic form is the Fisher metric. If, in addition, each logged bit carries an effective write cost set by a latency scale $\Gamma_L(\mu)$, then a kinetic term follows directly.

The result is a compact emergent-mass law,

$$m_{ij}(\mu) = \frac{\hbar\Gamma_L(\mu)}{2\ln 2}\, g_{ij}, \tag{1}$$

where g_{ij} is the Fisher information metric of the rendered family. The argument neither modifies quantum postulates nor assumes a specific microscopic substrate. It only requires: (i) a parameterized family of rendered records, (ii) a finite information cost for updating them, and (iii) a latency-to-energy conversion. The payoff is that inertia appears as the thermodynamic price of maintaining localization under change.

RENDERED FAMILIES AND REWRITE GEOMETRY

Let a rendered object be represented by a family of normalized boundary densities

$$p(x|X) = |\psi(x;X)|^2, \tag{2}$$

where $X(t)$ is the rendered location parameter and x labels the observational coordinate. A translation $X \mapsto X + \mathrm{d}X$ demands an update of the record. The minimal information required to discriminate the two consecutive rendered states is naturally measured by the KL divergence,

$$\mathrm{d}\mathcal{I} \equiv \frac{1}{\ln 2} D_{\mathrm{KL}}[p(x|X)\,\|\,p(x|X+\mathrm{d}X)]\,, \tag{3}$$

expressed in bits.

For small $\mathrm{d}X$, information geometry gives the local expansion

$$\mathrm{d}\mathcal{I} = \frac{1}{2\ln 2}\, g_{ij}(X)\,\mathrm{d}X^i\mathrm{d}X^j + \mathcal{O}(\|\mathrm{d}X\|^3), \tag{4}$$

where

$$g_{ij}(X) = \mathbb{E}[\partial_i \ln p\,\partial_j \ln p] \tag{5}$$

is the Fisher information metric of the rendered family. Equation (4) is the unique local quadratic distinguishability measure compatible with smooth statistical structure [4]. It therefore supplies the minimal rewrite geometry of consecutive rendered records.

The physical interpretation is immediate. Sharp localization makes neighboring rendered states more distinguishable, hence increases g_{ij}. Diffuse rendered states lower g_{ij}. The rewrite budget is therefore sensitive to resolution, coarse graining, and logging protocol. In this sense, inertia is already latent in the local information geometry before any mechanical identification is made.

LATENCY-TO-ENERGY CONVERSION AND EMERGENT MASS

To convert rewrite information into a physical cost, we introduce a per-bit write energy

$$\epsilon(\mu) = \frac{\hbar\Gamma_L(\mu)}{2}, \tag{6}$$

where $\Gamma_L(\mu)$ is an effective latency rate at resolution scale μ. This parameter is not assumed universal; it may run with scale or environment, and in an open-systems language it summarizes the dynamical overhead required to maintain rendered records at the chosen resolution.

Differentiating Eq. (4) with respect to time yields the instantaneous rewrite rate. Multiplying by $\epsilon(\mu)$ gives the computational power required to sustain motion,

$$P_{\text{comp}} = \epsilon(\mu)\,\dot{\mathcal{I}} = \frac{\hbar\Gamma_L(\mu)}{4\ln 2}\, g_{ij}\,\dot{X}^i\dot{X}^j. \tag{7}$$

This has exactly the structure of a kinetic term. We therefore identify the inertial Lagrangian as

$$L_{\text{in}} = \frac{\hbar\Gamma_L(\mu)}{4\ln 2}\, g_{ij}\,\dot{X}^i\dot{X}^j \equiv \frac{1}{2}m_{ij}(\mu)\,\dot{X}^i\dot{X}^j, \tag{8}$$

which immediately yields the emergent mass tensor

$$m_{ij}(\mu) = \frac{\hbar\Gamma_L(\mu)}{2\ln 2}\, g_{ij}. \tag{9}$$

For isotropic rendering,

$$g_{ij} = g\,\delta_{ij}, \tag{10}$$

so that

$$m = \frac{\hbar\Gamma_L}{2\ln 2}\, g. \tag{11}$$

Mass is thus reinterpreted as the latency cost of continuously updating the rendered state under translation. More sharply localized families, or environments with larger latency overhead, produce greater inertial weight.

The connection with ordinary mechanics follows by adding an external cost landscape $V(X)$ and defining

$$L = \frac{1}{2}m_{ij}(\mu)\,\dot{X}^i\dot{X}^j - V(X). \tag{12}$$

For constant m_{ij} the Euler-Lagrange equation gives

$$\frac{\mathrm{d}}{\mathrm{d}t}\left(m_{ij}\dot{X}^j\right) = -\partial_i V, \tag{13}$$

which reduces to Newton's law in the isotropic constant-mass limit,

$$m\,\ddot{X}^i = F^i. \tag{14}$$

In this formulation, the Newtonian inertial law is not taken as primitive. It is the low-order equation governing minimal-cost record transport.

INTERPRETATION AND SCOPE

The derivation above is intentionally effective. It does not require a detailed ontology for the rendered record. The family $p(x|X)$ may arise from a quantum wavepacket, a mesoscopic coarse-grained object, or any localized distribution whose observational update can be meaningfully tracked. Likewise, $\Gamma_L(\mu)$ is not specified microscopically here; it is the effective latency channel converting rewrite information into energetic overhead.

This separation is an advantage. It allows the mass law in Eq. (9) to be read as a general statement about open rendered systems rather than as a claim tied to one speculative substrate. The physical content is that maintaining a localized distinguishable history through time is a resource-consuming operation. Inertia is the bookkeeping shadow of that operation.

The interpretation also clarifies why the Fisher metric is the correct geometric object. The same metric that controls local distinguishability in inference now controls local inertial response. In this sense, mechanics inherits its quadratic form from statistical geometry. The kinetic term is not imposed; it is selected by the minimal local rewrite geometry compatible with neighboring rendered states.

The framework naturally extends beyond elementary particles. Any persistent low-entropy localized pattern carries a rewrite burden under transport. In principle, structured mesoscopic objects, engineered devices, or stabilized boundary configurations should all inherit an analogous information-latency cost, though the effective g_{ij} and $\Gamma_L(\mu)$ may differ strongly across scales.

QUANTITATIVE PREDICTIONS AND FALSIFICATION

The proposal is useful only if it can be discriminated from a purely formal relabeling of mechanics. Its experimental content resides in the dependence of inertial response on resolution-sensitive rewrite geometry and on an effective latency scale.

P1. Resolution dependence. If the same physical system is described under different controlled rendering resolutions, the inferred effective inertia should correlate with a Fisher-metric proxy built from the corresponding rendered family. The null model is strict resolution independence of the rewrite sector.

P2. Mesoscopic sensitivity. In systems where localization can be tuned continuously, Eq. (9) predicts that tighter rendered localization should increase the effective rewrite burden. The key comparison is not absolute mass renormalization, but systematic correlation between response coefficients and Fisher distinguishability.

P3. Open-system latency. If $\Gamma_L(\mu)$ is altered by controlled coupling to an environment, the theory predicts a measurable shift in the effective inertial coefficient extracted from the rendered channel. The null model is that environmental latency affects decoherence or damping without any correlated change in the information-geometric inertial proxy.

These statements are deliberately modest. They do not claim that ordinary inertial mass can be arbitrarily dialed in tabletop settings. They claim that, in regimes where rendered localization, observational resolution, and environmental latency are experimentally controllable, the effective kinetic bookkeeping should reveal the structure of Eqs. (9) and (11). The framework fails if no such correlation can be extracted even in principle from controlled mesoscopic platforms.

CONCLUSION

We have derived an effective inertial law from three ingredients: neighboring rendered states, their minimal rewrite information, and a finite latency-to-energy conversion. The result,

$$m_{ij}(\mu) = \frac{\hbar \Gamma_L(\mu)}{2 \ln 2}\, g_{ij},$$

shows that mass can be interpreted as the information-latency cost of sustaining localized rendered structure under translation. In the isotropic limit this becomes $m = (\hbar \Gamma_L / 2 \ln 2) g$.

The conceptual gain is straightforward. Instead of treating inertia as an unexplained primitive, one may view it as the energetic consequence of maintaining distinguishable histories in an open system. The quadratic kinetic form then emerges from Fisher geometry, and Newtonian motion appears as the low-order transport law of minimal rewrite cost. Whether this perspective remains purely formal or becomes empirically discriminating depends on the fate of the prediction program. That, rather than metaphysical ambition, is the relevant next test.

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