Lorentz Contraction as a Field Preservation Phenomenon

Abstract

This work begins from a foundational physical assumption: Matter consists of a core (nucleus) surrounded by an electric field.

Based on this view, the well-known Lorentz contraction formula — which applies to matter in motion — must be consistent with the behavior of electric fields.

We examine the relativistic electric field of a moving charge, and specifically analyze how the field behaves in the direction of motion. By requiring that the field strength of the moving object remains constant — as it must, if it defines the physical structure of matter — we derive the classical Lorentz contraction law:
$R = R_0 \cdot \sqrt{(1 - v^2/c^2)}$

This result confirms the physical interpretation of Lorentz contraction: it is not a geometric artifact, but a necessary adjustment to preserve the intrinsic electric field that defines matter itself.

1. Introduction: Field-Based Approach to Contraction

This work explores whether the contraction behavior typically associated with Lorentz transformations can instead be derived from a more physical — and measurable — foundation: the preservation of electric field strength.

Rather than assuming a geometric contraction of length due to motion, we ask a simple question:

> If a moving charge maintains a constant electric field, how must its spatial distribution (radius) change with speed?

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2. Classical Electric Field and Motion

In classical electrodynamics, the electric field of a point charge at rest is given by Coulomb's law:

$E_0 = q / (4 \cdot \pi \cdot \varepsilon_0 \cdot R_0^2)$

Where: - q is the charge - R_0 is the distance from the charge to the point of measurement

When the charge begins to move, however, the field is no longer spherically symmetric. Relativistic corrections apply, and the field becomes dependent on both the velocity v and the angle θ relative to the direction of motion.

This leads us to the relativistic field formula, and ultimately to a derivation of contraction.

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3. Derivation of Lorentz-Like Radius Contraction from Field Preservation

In this section, we show that the classical requirement to preserve the electric field of a moving charge leads directly — and unavoidably — to a contraction law identical to the Lorentz contraction.

3.1 Starting Point: Electric Field of a Moving Charge

When a point charge moves with constant velocity, the field observed at a point along the direction of motion is given by a relativistic solution of Maxwell's equations.

The full expression for the electric field at angle θ from the velocity direction is:

$E(\theta) = [q / (4\cdot\pi\cdot\varepsilon_0)] \cdot [(1 - \beta^2) / (1 - \beta^2\cdot\sin^2\theta)^{3/2}] \cdot (1 / R^2)$

Where: - $\beta = v / c$ - R is the instantaneous distance between the charge and the observer - $\theta = 0$ corresponds to the forward (or backward) direction of motion

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3.2 Simplification for θ = 0

At $\theta = 0$, $\sin(\theta) = 0$, so the denominator becomes unity:

$E = q / (4\cdot\pi\cdot\varepsilon_0) \cdot (1 - \beta^2) / R^2$

This is the field component in the direction of motion. It is weaker than the field at rest, due to the multiplicative factor $(1 - \beta^2)$.

3.3 Requirement: Field Remains Constant During Motion

Suppose we demand that the electric field remains constant even when the charge is moving — perhaps because the structure surrounding the charge depends on it.

Let $E_0 = 1 / R_0^2$ be the rest field strength, and $E = (1 - \beta^2) / R^2$ be the field while moving. Then:

$(1 - v^2/c^2) / R^2 = 1 / R_0^2$

Multiply both sides by R^2:

$1 - v^2/c^2 = R^2 / R_0^2$

Take square roots:

$R = R_0 \cdot \sqrt{(1 - v^2/c^2)}$

3.4 Final Result

$R = R_0 \cdot \sqrt{(1 - v^2/c^2)}$

This is identical to the standard Lorentz contraction law.

However, in our case it was derived not from space-time geometry or coordinate transformations — but directly from the requirement to preserve field strength under motion.

This suggests a possible physical origin for Lorentz contraction — rooted in field stability.

We did not assume it.
We derived it.

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4. Summary and Implications

We began with the classical expression for the electric field of a moving charge and examined the special case where the field is observed along the direction of motion ($\theta = 0$).

By demanding that the field strength remains unchanged despite the charge's motion, we were led to the conclusion that the radial distance must contract by a factor of:

$\sqrt{(1 - v^2/c^2)}$

This is exactly the Lorentz contraction factor — derived not from coordinate systems or space-time transformations, but from the physical condition of preserving field strength.

This derivation: - Connects the geometry of contraction to the physics of fields - Suggests a possible physical explanation for Lorentz contraction - Avoids assumptions about observers, simultaneity, or relativistic postulates

In this view, contraction is not a measurement artifact — it is a real, physical adjustment required to keep the electric field configuration stable while in motion.
