# Comparison of Lorentz Transformations and Electrodynamics

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## Abstract

Einstein explicitly stated that special relativity originates from Maxwell's electrodynamics; Feynman accorded the highest praise to Maxwell's electrodynamics. Given that both theories concern the electromagnetic fields of uniformly moving charges, it is reasonable and necessary to compare the Lorentz transformation—the core of special relativity—with electrodynamics. The comparison reveals that electrodynamics, without invoking any assumptions, derives the correct electromagnetic field for uniformly moving charges, with all reasoning processes conforming to established logical principles and empirical facts, yielding a rigorous and reliable conclusion. While Lorentz transformation can also derive the electromagnetic field of uniformly moving charges, it employs two assumptions—the "principle of the constancy of the speed of light" and the "principle of relativity"—which contain logical errors; the resulting length contraction and time dilation are virtual mathematical expressions rather than real physical spacetime.

## Full Text

## A Comparison Between Lorentz Transformation and Electrodynamics

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## Abstract

Einstein explicitly stated that special relativity originated from Maxwell's electrodynamics, and Feynman spoke extremely highly of Maxwell's theory. Since both theories address the electromagnetic fields of uniformly moving charges, a comparison between the Lorentz transformation—the core of special relativity—and electrodynamics is both reasonable and necessary. The comparison reveals that electrodynamics derives the correct electromagnetic field of a uniformly moving charge without invoking any hypotheses, with all reasoning processes conforming to established logical principles and empirical facts, yielding rigorous and reliable conclusions. While the Lorentz transformation can also be used to obtain the electromagnetic field of a uniformly moving charge, it relies on two assumptions—the principle of constancy of the speed of light and the principle of relativity. These two assumptions contain logical flaws, and the derived length contraction and time dilation are merely virtual mathematical expressions rather than descriptions of real physical spacetime.

**Keywords:** electrodynamics, Lorentz transformation, electromagnetic field, Coulomb potential, Liénard-Wiechert potential, moving scale contraction

## I. Debates on the Lorentz Transformation

To explain the Michelson interferometer experiment, Lorentz first proposed the electron contraction theory in 1895 and subsequently derived the Lorentz transformation formulas in 1904. However, Lorentz maintained that the time transformation was merely a mathematical device—that the transformed time was not real time—and that the Galilean transformation remained correct.

Einstein, starting from the principle of constancy of the speed of light and the Galilean principle of relativity, derived the coordinate transformation relations between two inertial frames. The mathematical form of this transformation was identical to the Lorentz transformation derived a decade earlier. Nevertheless, Einstein argued that the length contraction and time dilation derived from this Lorentz transformation represented the true spacetime of nature, and that the Galilean transformation was incorrect.

## II. The Relationship Between Special Relativity and Electrodynamics

In his book *Relativity: The Special and General Theory*, Einstein explicitly emphasized that special relativity was developed from electrodynamics and optics, and that while it did not significantly modify theoretical predictions, it greatly simplified the derivation of physical laws.

Feynman gave the highest praise to Maxwell's electrodynamics, stating: "From a long view of the history of mankind, there can be no doubt that the most significant event of the 19th century will be judged as Maxwell's discovery of the laws of electrodynamics." Upon careful examination of Maxwell's electrodynamics, we find that the theory employs no hypotheses whatsoever, and all its reasoning is rigorous, conforming to established logical principles and empirical facts.

After more than a century of development, the two fundamental principles of special relativity—the principle of constancy of the speed of light and the Galilean principle of relativity—remain mere assumptions, which is inconceivable. If these two fundamental principles were indeed correct, they should appear as axioms or postulates in special relativity. If they contain logical flaws, these flaws should first be eliminated.

This leads to the conclusion that electrodynamics is correct, while special relativity awaits verification. The assumptions of special relativity should be tested against the theory of electrodynamics.

## III. The Electric Field of a Uniformly Moving Point Charge

In a vacuum laboratory, the electric potential of a stationary point charge is given by the Coulomb potential:

$$\varphi = \frac{q}{4\pi\varepsilon_0 R} \tag{1}$$

where $q$ is the charge, $\varepsilon_0$ is the vacuum permittivity, and $R$ is the distance from the charge to the field point (observer).

We have demonstrated that if the point charge moves with constant velocity $\mathbf{u}$ relative to the laboratory, its potential is no longer the Coulomb potential but transforms into the Liénard-Wiechert potential:

$$\varphi = \frac{q}{4\pi\varepsilon_0 R(1 - \beta \cdot \mathbf{e}_r)} \tag{2}$$

where $q$ is the charge, $\varepsilon_0$ is the vacuum permittivity, $R$ is the distance from the charge to the field point, $\beta \equiv \mathbf{u}/c$ is the normalized velocity of the charge relative to the laboratory, $c$ is the speed of electromagnetic waves in vacuum under source-observer stationary conditions, and $\mathbf{e}_r$ is the unit vector pointing from the charge to the field point.

Comparing equations (1) and (2) clearly reveals that for the same source charge, the Coulomb potential is observed by an observer at rest relative to the charge, while the Liénard-Wiechert potential is observed by an observer moving relative to the charge. These two potentials are significantly different!

There is no justification for assuming that two observers in relative uniform motion will obtain identical observations of the same source charge. The misunderstanding in Lorentz transformation arises from a fundamental misinterpretation of Galileo's ship experiment. The physics underlying Galileo's ship experiment with uniform motion is essentially identical to that of the electric field of a uniformly moving point charge.

In Galileo's ship experiment, the mechanical laws within the ship remain the same whether the ship is stationary at the dock or moving uniformly relative to the dock. This is not because two observers in relative motion observe the same mechanical process and obtain identical physical laws, but rather because whether the ship is stationary or moving uniformly ensures that the relative motion state between source and observer remains unchanged within each ship, thereby preserving the mechanical laws!

We must emphasize: the essence of Galileo's ship experiment is not observing the same physical experiment from two reference frames, but rather implementing and observing the same physical process separately in two laboratories—one observer per source. Each source-observer pair has the same relative motion state, so the physical laws appear identical. If two observers in relative uniform motion were to observe the same physical experiment—that is, two observers but one source—the results would certainly differ, as proven at the beginning of this section.

The conclusion is clear: Galileo's description of the ship experiment was correct, but the interpretation of the Galilean principle of relativity is erroneous. When two observers in relative uniform motion observe the same point charge, the electromagnetic fields they measure are definitely different, and electrodynamics provides the correct description. The principle of special relativity cannot hold.

## IV. Distortion of Real Spacetime by Lorentz Transformation

The derivation of Lorentz transformation employs both the principle of constancy of the speed of light and the principle of relativity.

First, we have proven that the principle of constancy of the speed of light is a special principle applicable only when the source and observer are relatively stationary; it does not hold when the source and observer are in relative motion. Since Lorentz transformation specifically addresses relative motion between two inertial frames, the principle of constancy of the speed of light is clearly inapplicable.

Second, we have proven in Section III that the principle of relativity fails for the case of two observers and one source. Lorentz transformation deals precisely with the motion of two observers relative to the same source charge, which is exactly the two-observers-one-source scenario. Therefore, the principle of relativity is also inapplicable.

Now reconsider equation (2), which is the correct electrodynamical description of the potential of a uniformly moving point charge. The Lorentz transformation interpretation asserts that this Liénard-Wiechert potential is identical to the Coulomb potential, with only the distance measurement differing:

$$\frac{q}{4\pi\varepsilon_0 R} = \frac{q}{4\pi\varepsilon_0 R(1-\beta\cdot\mathbf{e}_r)} \tag{4}$$

This implies that the relationship between distances measured by moving and stationary rulers is:

$$R = R(1 - \beta \cdot \mathbf{e}_r)$$

This indicates that due to relative motion, the moving ruler is contracted—this is precisely the length contraction of Lorentz transformation.

However, electrodynamics, praised by Einstein and Feynman and unanimously endorsed by all physicists, has clearly demonstrated that the Liénard-Wiechert potential and the Coulomb potential are not identical. Therefore, equation (4) cannot be physically valid.

Evidently, relation (4) is merely a virtual mathematical expression, not a real physical relationship. The conclusion is inescapable: the two fundamental principles employed in deriving Lorentz transformation—the principle of constancy of the speed of light and the principle of relativity—lack a sound logical foundation, and the resulting length contraction and time dilation are virtual constructs devoid of genuine physical meaning.

## V. Discussion

Lorentz transformation derives the relationship between coordinates of observers in two inertial frames, attempting to establish connections between physical laws in these frames. However, because the two fundamental principles underlying its derivation are invalid, the spacetime derived from Lorentz transformation is virtual rather than representing real physical spacetime.

A new approach is needed—one that considers the relationship between physical laws and source-observer relative motion from first principles. We propose to replace the "Lorentz principle of relativity" with a "source-observer principle of relativity."

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*Note: Figure translations are in progress. See original paper for figures.*