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The Lorentz force and transformations: an example of how the history of physics can simplify teaching

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The Lorentz force, which is the force acting on a moving charge within an electromagnetic field, is generally introduced in secondary school textbooks as an experimental result: its origin is not deeply described since demonstrating it would require a good grasp of differential calculus. However, the dependence of the Lorentz force on the charge's velocity - and therefore on a specific reference frame - leads to conceptual consequences, especially after studying the theory of relativity, which are usually overlooked. Indeed, in a frame of reference moving with the charge itself, where the velocity vector is zero, its origin remains unexplained.

In the same paper where Lorentz derived the expression for the force that bears his name, he also deduced the coordinate transformations that are also named after him. Through these transformations, it is possible to explain in a simple manner the emergence of the force detected by an observer moving with the charge, without resorting to differential calculus.

This paper thus highlights how the historical connection between the Lorentz force and transformations simplifies the explanation of a complex phenomenon, showing how the application of these transformations allows to calculate the electric field that determines the force acting on a moving charge within a magnetic field, even in a frame of reference moving with the charge itself.

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