Newton &-Vs Lorentz

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Abstract

Is there a point of divergence between Classical Mechanics and Electromagnetism? This discrepancy is raised by many authors and arises between Newton's third law and the equation of Lorentz forces. Due to the transcendence of these expressions, their wide application in different situations is not a minor issue and should be given a consistent interpretation with both theories.

The discrepancy mentioned is based in that: according to the calculations of classical field theory, a particle with an electric charge moving immersed in a magnetic field suffers an action that diverts its trajectory, making it describe a circular path, which can not be compensated through a contrary force in the body that generated the magnetic field. The force on this second body is predicted, by this theory, at ninety degrees from the first, thus contradicting the principle of action and reaction.

This study shows why the Lorentz law does not contradict Newton's third law and gives a consistent explanation of how the equations of classical field theory should be applied so that the result is correct..

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Introduction

Authors who mention that Newton's laws, more precisely the third, are not fulfilled in all cases are:

[1] Feynman (pag. 26-5 Electromagnetism vol2, Chap: 26-2)

[2] Goldstein, (pag. 5 1.2 mechanics of system of particles).

[3] Taylor, Validity of Newton's Third Law (Cap 1 - pag. 21).

[4] Soldovieri.(pag. 12-13).

[5] Patrick C.

[6] A. P. French.

[7] Jing Zhu..

Materials and Methods

This work begins by confirming algebraically the compatibility of the expressions to reject that the discrepancy referred to has a mathematical origin; the problem is analyzed by differentiating the condition of the axial vectors of the polar ones and verifying the resulting units of measurements. Subsequently, it is physically studied from the dynamic point of view, setting initial and boundary conditions, defining the possible trajectories and the forces that generate one over another, thus reaching the desired solution.

Results and Discussion

Algebraic interpretation

There are two different kinds of vectors, the polar and the axial; between both there are subtle differences but that generate a different behavior, they vary of sign before a reflection. For which it is necessary to verify that we are comparing similar physical objects when wanting to apply the laws of mechanics to electromagnetic actions.

Knowing that the mechanical forces respond to the characteristics of the polar vectors, that the external product between two polar vectors is an axial vector and that the Lorentz equation contains an external product is the need to prove that the Lorentz force is a polar vector and not an axil.

While the Lorentz equation

$$qE + qv \otimes B = F \quad (1)$$

it contains an external product, it can be seen in the expression that the first term of the crus product is a polar vector, but the second is an axial vector. This is given that the vector Bis generated through another external product, this if between two polar vectors l and r

$$dB = \frac{\mu}{4\pi}\frac{idl \otimes \check{r}}{r^2} \quad (2)$$

Therefore in equation (1) there is an external product between a polar and an axial vector, this result in a polar vector.

Remember that the polar vectors (or ordinary) before a reflection change sign, on the other hand the axial vectors do not. Therefore the external product gives a pseudovector, dual of an antisymmetric tensor. Landau [8].That is to say C=A⊗B, it can be written as

$C_\alpha = \frac{1}{2} e_{\alpha\beta\gamma} C_{\beta\gamma}$, donde $C_{\beta\gamma} = A_\beta B_\gamma - A_\gamma B_\beta$

With this, it is ruled out mathematically that there is some discrepancy with respect to the characteristics presented by the forces generated by the action of the fields, with those considered by Newton's third law.

Physical interpretation

The movement of two bodies between which a force acts, of repulsion or attraction, is a classic problem of mechanics whose results are proven by experience. For two particles, with repulsive forces, of equal mass they will describe parabolic trajectories and symmetric with respect to the center of mass. Keep in mind that these calculations are made on the basis of classical mechanics, therefore we work with the premise of the action at a distance. As speeds are non-relativistic magnitudes, there should not be any discrepancy with the result obtained through field theory. But the analysis carried out by different authors based on the Lorentz equations, which is the approach by the field theory, is where the unbalanced forces appear, producing the aforementioned contradiction.

The problem in question deals with the movement of charged particles and for this it must be taken into account that the bodies that generate the fields are in movement, these displacements create the magnetic fields, but they are not uniform, they vary with the distance to the load and neither they are constant since the charges that produce them move in relation to the point where the field is being evaluated *.

** At this point it could have been proposed instead of two moving charges, two sections of conductors through which a current flows, which would turn the problem into a stationary regime. But the field maintains its variation with respect to distance and should incorporate the forces generated in the cable to maintain the form (or position) since the forces generated are not evenly distributed, this would make the reasoning more complex without changing the result.*

This modifies the trajectory, which for the case that the field and velocity of the particle are constant gives a circular orbit, to a path in which its radius of curvature varies as the distance to the load generated by the field varies. Therefore, the trajectory that he describes becomes a parabola, this is the path that an observer sees in a reference system that is solidary to the center of mass. That is, being in front of a field that is not constant or uniform modifies the trajectory of the body.

At this point to facilitate the analysis, the following assumptions are introduced:

a) The problem is posed from an inertial reference system solidary to the center of mass. This is justified given that being a problem raised between two particles, the presence of the other bodies of the universe have no interference in the process. In other words, the chosen reference system only takes into account the parameters of the actions between the bodies.

b) The two particles are of equal mass. This facilitates the interpretation of the behavior of the bodies and does not remove generality from the problem. Moreover, if the reader wishes to modify the masses of the bodies, he will find that although the trajectories are modified, there will be no variation in the direction of the components of the resulting forces. This statement is based on the fact that the change in the magnitude of some of the masses generates a variation in the magnitude of the velocity of the bodies and not in their direction. This is due to the conservation of the amount of movement.

From the aforesaid, it follows that from a system solidarity with the center of mass:

i) Without any reference to external bodies the only thing that can be appreciated is that the particles approach and move away from the center of mass on the same line. For this observer, repulsion is caused by electrical effects. Magnetic effects do not generate forces since the charges move on the axis of the magnetic field where their intensity is zero.

ii) With reference to external bodies sufficiently distant so that they do not intervene in the process, "stars of the sky". To interpret this case it is divided into two: The first due to the movement of translation in the direction that passes through the center of mass, which fit the same considerations of the previous point and therefore do not involve magnetic forces. The second with normal movement to the previous one and therefore parallel between both particles; in this case the generated magnetic forces, which are perpendicular to the movement, their directions are coincidental pass through the center of mass and their opposite senses. They comply with Newton's third law.

Conclusions

From the above it follows that there is no dichotomy between the laws of Newton and Lorentz, if not what is presented is an inadequate approach, where the law of Lorentz is incorrectly applied since the magnetic field is neither stationary nor homogeneous. The error arises from posing a field that is seen by an external observer and not the one that perceives the particle, which generates relative velocity forces that do not exist. If the trajectories that the two particles perform due to the mutual interaction forces are followed, the paths are two parabolas and the two laws are fulfilled.

Conflicts of Interest

There are no conflicts of interest.

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[8] Landau y Lifshitz,Física Teórica, V2, Teoría Clásica de los Campos. (pag. 26.