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Velocity limits of a nanomaterial in a fluid: relativistic effects and their influence on density and limiting velocity

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Abstract:*This article explores the fundamental limiting speed for a nanomaterial immersed in a fluid, considering the appearance of relativistic effects at high speeds and the imposition of the Planck density as a fundamental physical limit on density. Traditionally, the speed of light in a fluid medium is considered the upper bound on the speed of any object. However, when a nanomaterial is accelerated, length contraction and relativistic mass increase significantly alter its density. By imposing the condition that the relativistic density of the nanomaterial cannot exceed the Planck density, a new limiting speed is derived that depends on the nanomaterial's rest density and the Planck density. This limit is compared to the speed of light in the fluid, determined by its relative permittivity and relative electrical conductivity. The analysis reveals that for nanomaterials with intrinsically high densities, the limiting speed imposed by the Planck density can be significantly lower than the speed of light in the medium, suggesting a fundamental constraint on their dynamics at extreme scales. This finding has significant implications for the design and manipulation of nanomaterials in various nanotechnology applications.*

Keywords:*Nanomaterial, Fluid, Limiting Speed, Special Relativity, Length Contraction, Relativistic Mass, Density, Planck Density.*

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I. INTRODUCTION

This paper deals with the state of physical practice so far. The velocity limitations of nanomaterials in fluids are analysed. The study is limited to any nanomaterial with mass m and velocity v. As described below, the state of motion is related to the physical properties of the medium that carries the nanomaterial. That is, physical properties such as density and viscosity, among others, will be substituted by analysis at medium and extreme temperatures. It should be noted that at no point will these physical properties be analysed, so such densities and viscosities will be assumed as characteristics in themselves. Any separation of the medium temperature such as high and low will refer respectively to a working temperature and supply temperature under conditions with enquiries at respective pressures.

The velocity ratio of the nanomaterial will be assessed by measuring the application of the upper and lower limit concepts according to the motion. As discussed, there is an upper limit that depends on the state of motion, as any sub-relativistic state nanomaterial can express velocities at the change of considerable external energy input. In other words, interatomic transfers in the nanomaterial with respect to fluid velocities would allow the interatomic matter to reside by maintaining a minimised distance by mediating the kinetic or potential energy gain. In this way, by decreasing the tolerability of the fluid temperatures and increasing its velocity they could form and control densities much higher than those corresponding to the respective state of motion.

II. DETERMINATION OF THE LIMITING VELOCITY OF A NANOMATERIAL IMMERSED IN A FLUID

1.1 Fundamentals of relativistic mechanics

For the development of this article, we will focus on the fundamentals of relativity, with special emphasis on the differences that arise in systems with relativistic velocities, disregarding non-relativistic effects. We will learn about the principles that developed relativity and some of the most relevant results of the study of this physical model.

The antecedents of relativity could have been achieved centuries before with experiments that verified the inertia of bodies with respect to different reference systems, but they were only systematised at the end of the nineteenth century with the work of Maxwell. This chemist knew that his equations were independent of the reference system implemented, which is where the need to establish the phenomenon of light as a unique and universal verification appeared. By means of a series of experimental manoeuvres, Maxwell demonstrated that the results obtained would be the same for an observer at rest as for one in motion, which led him to establish that the speed of the electromagnetic wave should be unique for all observers. However, one physicist, Albert Michelson, failed to narrow down the relationship between two light rays in the transverse direction of motion with respect to an observer.

Even with the unconfirmed experiments, Huygens' model was strengthened and challenged by the discovery, among several researchers, of the Lorentz equations transforming time with high velocities concurrent to zero. The theory required a so-called ether. Postulated by Lambert and LaPlace, it served to explain the motion of light. It was said that all reference systems in motion with respect to the aether must be influenced by its principles, but when Einstein published his work on the special theory of relativity showing that there is no aether, he put the Lorentz equations on the suppressed line, limiting them to the motion of the body with respect to the system.

1.2 Basic principles of relativity

Since even before the formulation of the axioms corresponding to special relativity, a number of researchers were engaged in studying how Newton's classical mechanics, assumed to be valid for all phenomena, was affected when analysed from two inertial systems related by a particular transformation, resulting from the fundamental forces of nature, gravity and electromagnetism, were able to describe correctly the characteristic interactions of the investigated system in a simultaneous and equivalent way.

A reference frame is called inertial when its velocity is constant, i.e. without acceleration or rotation. In any inertial reference frame, Newton's first immediate or mechanical law of momentum and quantity of motion applies to any body or system of bodies and states that any body that does not undergo a net pair of forces is rectilinearly uniform or at rest with respect to its immediate neighbours. Newton's second law states that the vector product between the mass of a body or system of bodies and its acceleration is equal to the net value of the pair of forces applied to it. The corresponding scalar value is valid in inertial reference frames. In all reference frames, regardless of whether they are inertial or not, mechanics exerts the same effects on all their state vectors and, finally, on their energy quantities and other quantities. As a consequence of this property, energy is another of the quantities whose value is the same in both systems, i.e. it is invariant.

1.3 2.2. Relativistic equations

The Theory of Special Relativity, proposed by Albert Einstein in 1905, revolutionised our understanding of space, time, mass and energy. It is based on two fundamental postulates:

- The laws of physics are the same for all observers in inertial reference frames. This means that the laws of physics have the same mathematical form regardless of whether an observer is at rest or moving at a constant speed.
- The speed of light in a vacuum (c) is the same for all inertial observers, regardless of the motion of the light source. This fundamental constant has a value of approximately 3×108 metres per second.

From these postulates, a number of formulae are derived that describe relativistic effects:

Lorentz factor (γ):

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

γ (gamma): This is the Lorentz factor, a dimensionless factor that appears in many of the equations of special relativity.

v: The relative velocity between the object or observer and the frame of reference in question.

c: is the speed of light in a vacuum.

The Lorentz factor is always greater than or equal to 1. It approaches 1 when the velocity v is much less than the speed of light c, and tends to infinity as v approaches c.

Length Contraction:

$$L = \frac{L_o}{\gamma} = L_o\sqrt{1 - \frac{v^2}{c^2}}$$

L: The contracted length measured by an observer in a frame of reference in which the object is moving. The contraction occurs only in the direction of motion.

L_o: The proper length, measured by an observer at rest with respect to the object.

This equation shows that the length of a moving object is shortened in the direction of its motion compared to its length when at rest.

Relativistic Mass:

$$m = \gamma m_o = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}}$$

m: is the relativistic mass of the moving object, measured by an observer at rest.

m_o: is the rest mass of the object (the mass when the object is at rest with respect to the observer).

This equation reveals that the mass of an object increases as its velocity approaches the speed of light.

1.4 Nanomaterials and their properties

Nanomaterials are generically defined as materials that possess at least one physical, chemical or biological characteristic on a nanometric scale, i.e. whose dimensions are in the range of 1 - 100 nm. By reaching this scale in all its axes, improvements in their physical properties such as electrical conductivity, increased wear resistance, difference in melting or boiling points compared to larger forms, or new properties are achieved by being produced at smaller scales. These differences in properties have atomic or molecular as well as spatial foundations. This work suffers from a sense of rupture in that it considers properties at scales smaller than the prevailing one. This earlier scale is considered threshold as a function of the change in interatomic parameters between the nanomaterial and the surrounding fluid, ideally occurring at the instant prior to braking and detachment of the nanomaterial from the incipient fluid and is expressed as: vfluid≥cfluid/ries, where the ratio cfluid/ries is obtained by applying a parallelogram fluid Controlled deformation up to the threshold of opposite direction melting.

Nanomaterials can be classified according to different forms. Based on the atomic arrangement of their molecules, it is possible to distinguish between crystalline and amorphous nanomaterials. Crystalline nanomaterials are those in which the constituent molecules are arranged in such a way that they form discrete lattices or large oriented packages, in contrast to materials with an amorphous structure. This variety allows the analysis of dissipation variations as a function of typical mowing shifts towards impaired and chronic shape positions.

1.5 Interaction of nanomaterials with fluids

Nanomaterials form an essential part of a multitude of applications due to their remarkable physical properties, which are decisive in the behaviour they exhibit as components. No general consensus has yet been reached on the existence of specific boundaries or dimensions at which certain properties of matter change. However, it is accepted that beyond a certain size or scale there are quantum effects and macroscopic properties that vary with respect to the atomic-scale material. One of the most promising applications is in the engineering of nanofluids, which are suspensions of nanoparticles in a base fluid, which can be in a liquid or gaseous state. The incorporation of these particles into the fluid allows significant alterations to its thermophysical properties, resulting in improvements in the performance and efficiency of the systems.

A nanofluid is a fluid that has been made by adding two types of particles to a fluid to form a mixture. The composition can be varied, to obtain the desired properties, through changing the composition, for example. The end result becomes more versatile with the use of nanofluids as particularities are added. Thermal conduction properties are greatly altered to achieve an increase in the conductive capacity of the fluid. It is used as a medium for heat transport and heat exchange, and its increase is determined as a function of the amount and type of addition material. As the amount of CNT particles was increased from 1 to 5 % by volume, and varying the particle size between 5-11.91 nm. A descriptive outline of possible properties, mechanisms and areas of application is given in this work.

1.6 4.1. Fluid dynamics

One of the main properties studied in a fluid, whether macroscopic or microscopic, is its viscosity, which represents the fluid's resistance to the sliding of one surface over another in contact with it. Below a given velocity threshold, a fluid behaves like a solid and the resistance to sliding is due to the interatomic bonds in the matter. Introducing an element that exceeds this velocity into the fluid, the resistance to displacement is given by viscosity-dependent frictional forces that increase with velocity. When the velocity increases, we move from a laminar flow regime to a turbulent flow regime. This happens because a boundary is formed that divides the flow experiencing pressure thrust, which comes from the volume displaced to the front, from the flow going backwards, which experiences viscous drag. In this study, we will calculate what we call frictional pressure, the resistance experienced by the nanomaterials as they move through the fluid, so that this resistance will depend on the flow of the fluid atoms that have to be dispersed in order for the nanomaterial to move and the celestial space they have to travel to do so. Moreover, as the nanomaterial moves, it will not stop experiencing this resistance, so we will have to calculate the thrust versus the flow of the fluid as a function of time. Once we have verified that there is no violent acceleration or braking on the part of the nanomaterial, the process is repeated in the opposite direction, we swap roles between the colloidal mixture and ourselves and observe the flow experienced by the colloidal mixture against the nanomaterial that is at a standstill.

1.7 Velocity of a nanomaterial in a fluid

In this work we consider the limiting velocity of a nanomaterial in a fluid as the maximum velocity that a nanomaterial can reach at rest in a liquid, i.e. in the absence of an electromotive force that causes the liquid to move. For this purpose, we focus on the particular case of a fluid without viscosity, using Archimedes' principle.

Being subject to Newton's laws of motion, a fluid without viscosity presents a minimum resistance when maintaining a solid body of axial symmetry with the capacity to be introduced into a submerged container flowing from bottom to top.

Through this analysis we will conclude the search for the minimum horizontal velocity necessary for the device to reach the major line. As we move forward in a value called because the force of gravity acts. The advantage of this consideration is that we calculate that once we have covered the distance the device has covered more of the major line.

If we wish to speak of a specific minimum velocity of a material. The impossibility of a particle of split length to fall could verify a link with its connection, i.e. the length of the relationship.

In this way we analyse whether by means of any impulse the line would fall. And therefore, we conclude the progress according to whether we reach the time that takes away the recommended time or shape, leaving finally to conclude the list of the rectangular image.

1.8 Definition of limiting velocity

The limiting velocity of a particle is the maximum velocity of the particle that it can attain under some factor that retains or reduces its velocity. At any moment in its trajectory and under any external influence.

1.9 Relativistic effects on the speed of a nanomaterial

For more than a century, since the special theory of relativity was formulated, the behaviour of particles that reach speeds significant to the speed of light, i.e. that approach the speed limit c, has been studied. This formalism has as its scientific basis the invariance of spacetime, a property that underlies Galileo and Newton's neoclassical formulation of relativity. Therefore, when reaching a significant nanomaterial velocity in limit c this theory has to be demonstrated and validated. Often, the mathematical calculations in this formalism are very complex and require a complete and thorough comprehensive analysis. The results are striking as they are outside what is expected or recorded in the actual formalism of the universe or, in the worst case, leave room for gaps in physics not yet explainable.

1.10Relativistic acceleration and velocity.

We study how a particle reaching a possible constant acceleration will observe an increase in velocity, reaching an upper limit to it, although relativistically we take into account the property of the vacuum which does not allow us to see a transmission of order by a material field in a state of tranquillity. This property will not change if we observe in the system or in the laboratory a multiplicity of external pressures trying to influence this form of neuromaterial.

1.11Relativistic acceleration and velocity

Considering the inertial system at rest, the latter is simply Newton's relation in each of its coordinates.

To properly describe the motion with respect to the reference frame travelling with velocity, it is necessary to use the relativistic velocity composition. The relativistic model corresponds to the domain of the behaviour of a constrained system, i.e. corresponding to an object with a different density from the fluid through which it travels. It is also used to simulate the appearance of images in the system. This image, which corresponds to the object itself, is not at rest with respect to this local referential system of which it only remains to project its design, as a form of superlucent construction.

As elongation in space and, respective to its essence, difference of locations. The shape of a situation will vary the ratio. However, as space is given, the relaxation that can occur in thermodynamics is restricted. This is the famous twin paradox. You would like to be the one who is better at each multiplicity and you are not.

Knowing this, numerically one can observe that a system in this case relativistic not necessarily registered, that is to say, a fluid that becomes superlucent, also involves different fissures in the superfluidity of the fluid itself or gains in landscapes that behave as non-Euclidean. Then, the dilation of the space that would have the restrictive movement following the previous one would be greater, but it would depend almost reciprocally on what closes its places or shares a certain function. The latter can be useful when a light beam continues with translation while it will capture more or less material availability to the joint law to foul as an object, it will thus obtain images corresponding to its closing capacities.

1.12Relationship between density and speed

By the very definition of density as the ratio of mass to volume, density will depend on the mass and size of a nanomaterial. It is obvious that as the mass increases or the volume decreases, the density increases. However, it is also important to keep in mind that the density of a set of particles represented by a nanomaterial, as well as its time evolution, is a function of velocity. Of course, Laplace's model itself allows the density to be expressed in terms of the velocity and density of the particles flowing alongside it. According to Bernoulli's Theorem, the effect on fluids of very large velocities on the compression they induce is usually neglected.

In spite of Bernoulli's theorem, several authors agree that the compression that a fluid can induce in the surrounding medium for velocities lower than the speed of sound is always negligible. In fact, the vf3n is not due to the discontinuity in density that differs when the medium is at rest and when it is moving kinetically, but to an alteration in the density of the cooling liquid through which it is immersed, with a velocity lower than the vf3n. In other words, for subcritical velocities, its behaviour should be analogous to that of a turbulent one, depending on the perimeter. For its part, it has been shown that a nanomaterial moving with a vf3n penetrates any liquid, affecting the surrounding fluid and the cooling property in a way that is not detailed here.

1.13Effects of relativistic compression

The increase in velocity of a nanomaterial in a fluid is, as we have seen, directly proportional to the increase in density of that material in the fluid, but the physics of the different interaction forces between the molecules of the fluid and those of the nanomaterial causes an increase in density in a very special way: in relativity, the increase in density caused by an increase in velocity is ‘compressed’ within a certain characteristic interval that depends on that velocity. This effect has been experimentally verified. For example, maximum velocities above 99.95%, which is the speed of light, have been measured.

Such effects on the pressure intensity of a fluid, combined with the increase in density of the moving material, cause, among other consequences, nanomaterials to become denser and denser, and this affects the ultimate decrease in the limiting velocity, given by the equation. This does not just happen, as the nanomaterial continues to increase in density until it stabilises. In this sense, we are now tackling the explanation of our second particular objective, which focuses on the study of the behaviour of tiny particles (nanomaterials) such as those computed and their relationship with velocities greater than and relativistic effects at these extremes. However, in case future experiments do not experimentally verify our results, we have opened here a new and exciting possibility of study.

1.14Theoretical models

When the size of the object immersed in the fluid becomes comparable in magnitude to the size of the lattice, hydrodynamic theory can accurately describe the phenomena involved in both the continuous phase and the discrete lattice. However, as the continuous phase becomes incomprehensible on a scale of the order of atomic uniqueness of the interactions between the discrete particles in the lattice within the fluid, the discrete nature of the non-parametric particle must be taken into account. For flows in intermediate regions of connection between the continuous phase and the discrete lattice there is the theory of Spatial Collapse. For central or angle-dependent collision forces, that this type of binding between the immersed translucent object and the fluid interface can be found in the standard continuum mechanics text. This theory is based on the explicit and explicit way of solving the equation of one-dimensional, two-dimensional, and even three-dimensional flows. From the point of view of quantum theory, the matter of all solids consists of particles, which are bound together by different types of interatomic bonds.

With some limitations, until a few years ago it was common for any solid to be accepted as consisting of a perpetually discontinuous lattice solely by the thermal effect. A molecule or a particle suspended in the lattice is an immobile object from which goods are obtained inside the fluid, describing a permanent state with equal determination in the intensity of the mixture as the responsible contributor at the origin of this force, and taking into consideration that interactions available at greater distances are excluded from it. As a result, the intensity of the binding would be constant. Reviewing the nature of the inertial quantities that allows the infinitesimal scaling of the thickness of the flow, it can be seen that the characteristic angle is determined by the confluent ratio and in an immersed translucent object.

1.15Velocity of electromagnetic waves in a non-empty medium

One of the basic physical quantities, which relates to the concept of an electromagnetic medium, is the maximum velocity of propagation of a vibration, i.e. the velocity of electromagnetic waves in such a medium. For a non-empty medium, this speed, denoted by the letter c, is determined by the famous ratio

$$c = \frac{1}{\sqrt{\mu\varepsilon}}$$

This formula shows us that this given velocity depends, fundamentally, on two main characteristics of the medium, which are the ratios of their respective magnetic permeabilities, μ, and electrical capacitances, ε.

Determination of the limiting velocity of a nanomaterial immersed in a fluid.

is a particle moving at velocity v the particle has a radius L_o and a mass m_o so the density is

$$\rho_o = \frac{3m_o}{4\pi {L_o}^3}$$

$$\rho = \frac{3\gamma^4 m_o}{4\pi {L_o}^3}$$

$$\rho = \frac{3m_o}{4\pi {L_o}^3\left(1-\frac{v^2}{c^2}\right)^2}$$

$$\rho = \frac{3m_o}{4\pi {L_o}^3(1-\mu\varepsilon v^2)^2}$$

Considering ρ as the limiting density (Planck density) and solving for the velocity, the limiting velocity of the nanomaterial is obtained.

$$v^2 = \frac{1}{\mu\varepsilon}\left(1-\sqrt{\frac{3m_o}{4\pi\rho {L_o}^3}}\right)$$

$$v = \sqrt{\frac{1}{\mu\varepsilon}\left(1-\sqrt{\frac{3m_o}{4\pi\rho {L_o}^3}}\right)}$$

Where the Planck density is

$$\rho = \frac{2\pi c^5}{hG^2}$$

$$\rho = \frac{2\pi}{hG^2\sqrt{\mu^5\varepsilon^5}}$$

Then the limiting velocity of a nanomaterial is

$$v = \sqrt{\frac{1}{\mu\varepsilon}\left(1 - \sqrt{\frac{3m_o hG^2\sqrt{\mu^5\varepsilon^5}}{8\pi^2 {L_o}^3}}\right)}$$

1.16Future Perspectives

Throughout this work, we have seen the influence of different parameters that affect the limiting velocity of a nanomaterial dispersed in a fluid such as a liquid or a gas. The dynamics occurring for these systems are different from those of a rigid body, where interactions between parts of different nature and dimensions lead to a homogeneous, equilibrated state in the fluid, and the phenomenology is treated within the framework of a theory. In the dispersion of nanomaterials in fluids, the integration of the main interactions between the nanometer-scale nanomaterial and the fluid, taking into consideration their plane-layer perspective, is fundamental for the theoretical analysis. Furthermore, the variation in velocities between different nanomaterials, or between different fluids, depends on the main properties of the solid and the fluid involved, such as density and viscosity (the effect of density on the limiting velocity must be investigated).

III. CONCLUSION

Physics uses various theories to frame the understanding of the "entities" it studies, as well as their interactions when these "entities" change position in space. One of these theories is the Theory of Special Relativity, which, among other postulates, proposes that the speed of light in a vacuum is a constant. However, the proposed calculation would be valid if the object being studied does not move at high speeds. All those who have explored it have come to realize that this calculation becomes invalid as it approaches the speed of light. That is, as the flow of the "entity" we are studying (in this case, a nanomaterial in a fluid) approaches c, it seems increasingly difficult to exceed it, eventually causing the speed to become absolutely stagnant in terms of total displacement. By analyzing the various components that have direct influences on the speed that this "entity" can adopt, we can replace the relativity of the effects with the results that the Theory of Special Relativity produces when observing its components, final speed. Thus, obtaining that in the limit c we have an approximate speed that we can also replace in the density as a variable that affects the tendency to determine the constant speed and its addition in D'Alembert's theory. An example of these numerical results is our progressive progress of simply increasing the size of the nanomaterial under study, or some more fluid in which it operates, thus keeping all other parameters constant, the large-scale averages less impulsive, but also that by having a slight suspension effect, it is likely that having various elements in suspension that act by weight effect or gravimetry, will rise or greatly increase the "impulsive effect" that the nanomaterial is taking on in changes of density to several different fluids.

Conflict of interest

There is no conflict to disclose.

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