

Vacuum: Candidate for Ether

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Abstract

Physical space is the only medium for light propagation; air, water, glass, etc., are not. Atomic nuclei within these “medium” curve the surrounding physical space, causing photons to follow curved trajectories at the microscopic level during propagation. Meanwhile, the light speed (magnitude) remains unchanged, but the actual path length increases, resulting in the macroscopic manifestation of a “slowed” light speed within the “medium”. Meanwhile, light with longer wavelengths is more likely to bypass obstacles, so it travels fewer detours and exhibits “higher speed”. In a microscopic region at the boundary between two “media”, the physical space is anisotropic. As photons pass through this region, the spatial structure determines their deflection. When matter is in motion, its internal physical space is entirely dragged along. Therefore, the null result of the Michelson-Morley experiment on Earth’s surface is due to the entire dragging of the internal physical space by the air. Consequently, it is predicted that repeating this experiment on the lunar surface would yield observable shifts in the interference fringes. This would enable further measurement of the velocity of the Earth-Moon system’s motion relative to physical space in the cosmos. If the experiment is successful, then physical space is the long-sought ether.

Full Text

Preamble

Vacuum is a form of matter and the sole medium for light propagation. In regions far from galaxies, vacuum is flat; when an atomic nucleus is present, the surrounding vacuum becomes curved, analogous to a sponge. Photons passing near atomic nuclei therefore travel along curved paths. Though this microscopic effect cannot be detected directly, it manifests macroscopically as a reduction in the “speed” of light in “media” such as air, water, and glass—because the actual microscopic path length increases while the speed of light itself remains unchanged. Light with longer wavelengths more readily bypasses obstacles, taking fewer detours and thus exhibiting “higher speed.” Additionally, vacuum is

anisotropic in microscopic regions at the boundaries between two “media,” and the spatial structure in these regions determines photon deflection. Furthermore, when matter moves, its internal vacuum is completely dragged along.

This provides the actual explanation for the null result of the Michelson-Morley experiment conducted on Earth’s surface—not the principle of the constancy of the speed of light. Consequently, we predict that repeating this experiment on the lunar surface would yield observable shifts in the interference fringes. If successful, vacuum would be revealed as the long-sought ether.

Introduction

Why do photons appear so “smart” ? For instance, when entering water from air at a 45° angle, how can they instantly “know” the refractive index ($n = 1.333$) of the approaching medium and refract to 32° upon contacting the water surface? Another question concerns why light’s speed decreases in a medium. The conventional view attributes this to continuous interaction with electrons or molecules, which would imply that speed should decrease progressively with increasing medium length—yet no such phenomenon has been observed experimentally. An alternative suggestion that light interacts only with the first layer of electrons or molecules raises the equally puzzling question of how photons could distinguish which particles belong to that layer. Both explanations seem to endow photons with intelligence.

The principle that “matter tells space how to curve, space tells matter how to move” may offer a clue. In our model, the first “matter” refers to atomic nuclei in the so-called “medium,” while the second “matter” refers to photons.

2. Results

Photons possess no intelligence; they simply move along geodesics in vacuum, the sole medium for light propagation. In flat vacuum, light travels in straight paths; in curved vacuum, it follows curved paths; and when matter moves, the internal vacuum within it is completely dragged. When photons traverse a “medium,” their speed does not change, but their microscopic path length increases. Since the vacuum inside the “medium” is isotropic, photons still travel in macroscopically straight lines. The longer actual path length therefore reduces the macroscopic “speed” of light. Meanwhile, longer-wavelength light more easily bypasses obstacles, taking fewer detours and exhibiting higher “speed.” In microscopic regions at the boundary between two “media,” vacuum is anisotropic, and the spatial structure determines photon deflection. This structure also enables wavelength-dependent deflection angles, though further research is needed to characterize the precise spatial structure of vacuum in these regions.

Regarding the Michelson-Morley experiment, the principle of the constancy of the speed of light cannot explain the null result, as this principle only states that light’s speed (magnitude) remains constant across inertial frames while its

direction changes. A plausible explanation is that the vacuum within Earth's surface air is entirely dragged, making light isotropic in that single inertial frame. This work therefore predicts that conducting the Michelson-Morley experiment on the lunar surface would produce observable interference fringe shifts. If confirmed, vacuum would be the ether long sought after.

3. Analysis

A compact celestial body can curve the space around it, as demonstrated by starlight deflection near the Sun. However, one critical point was neglected: this curvature was detected using only two light paths—one from the ordinary night sky and one during a total solar eclipse. To determine whether a two-dimensional plane is curved requires three lines forming a triangle, measuring whether the interior angle sum equals 180° . By extension, detecting curvature in three-dimensional space requires even more lines. Therefore, the curvature around the Sun cannot be curvature of three-dimensional space; rather, it is curvature of vacuum.

This paper proposes that vacuum is a form of matter and the sole medium for light propagation. Like a sponge, vacuum can be curved by a compact celestial body composed of densely packed atomic nuclei. This curvature originates from the contribution of each individual atomic nucleus. Consequently, a single atomic nucleus can also curve its surrounding vacuum, albeit extremely weakly. Photons passing near atomic nuclei therefore follow slightly curved paths. Though this microscopic curvature is currently undetectable by direct observation, the physical mechanism manifests macroscopically.

3.1 Stationary “medium”

The model suggests that conventional optical transmission media (e.g., air, water, glass) are not the actual medium; instead, the vacuum within these materials constitutes the true propagation medium. Inside materials, vacuum is isotropic, causing light to propagate along macroscopically straight paths. Microscopically, however, photons follow curved paths, increasing their actual path length while light speed (c) remains unchanged. The longer path length reduces the apparent “speed” of light in the “medium.” Qualitatively, longer-wavelength light more easily bypasses obstacles, taking fewer detours and traversing shorter microscopic paths, thus exhibiting “higher speed.”

The propagation time through such a “medium” can be expressed by Equation (1), where l is the microscopic path length, c is the speed of light in vacuum, l is the macroscopic distance through the “medium,” and v is the experimentally measured velocity. Letting $l = l + \Delta l$, Equation (2) becomes $\Delta l/l$, which is solely related to the physical properties of the “medium.”

For further investigation, Figure 1 [Figure 1: see original paper] shows the relationship between refractive indices n and $m \cdot R^{-1} \cdot V^{-1}$ for various common “media,” where m is the mass of atomic nuclei, R is the equivalent radius of

atomic nuclei, and V is the molar volume. For single-atom molecules, R is the atomic nucleus radius; for multi-atom molecules, R is derived using the surface area equivalent radius formula based on each atomic nucleus radius r and the number of atomic nuclei N in the molecule.

A brief explanation of the x-axis physical quantity is warranted. In General Relativity, the deflection angle of distant starlight passing near the Sun is proportional to $M \cdot R^{-1}$, making the inverse power of R more reasonable than other powers. For ideal gases, molar volumes are identical, making the V term negligible in the left panel. For liquids and solids, however, smaller molar volumes yield more atomic nuclei per unit volume, creating stronger spatial curvature and larger refractive indices. Thus, V is inversely proportional to n .

The figure shows that water vapor (left panel), liquid water (right panel), and ice (right panel) all fit well with the blue line. In the left panel, blue points representing single-atom molecular gases helium (He), neon (Ne), argon (Ar), krypton (Kr), and xenon (Xe) fit a straight line: $y = ax + b$, with $a = 354508(13)$ and $b = 0.99993706(2)$. Since b is very close to 1, this line is consistent with Equation (3).

An empirical equation relating material properties to refractive index n for single-atom molecular gases is therefore obtained: $n = a \cdot m \cdot R^{-1} \cdot V^{-1} + 1$, where $a = 354508(13) \text{ kg}^{-1} \cdot \text{m}^4 \cdot \text{mol}^{-1}$. However, the upper boundary of the light-blue region in Figure 1 corresponds to 1.5a, implying larger uncertainty for multi-atom molecules. Equation (4) is only an approximation, as demonstrated more clearly by CS_2 and CaF_2 in the right panel, warranting further investigation.

3.2 “Medium” in motion

The preceding analysis applies to stationary “media.” When the “medium” moves, is the vacuum within it stationary, partially dragged, or entirely dragged? The null result of the Michelson-Morley experiment demonstrates that vacuum in air is entirely dragged by moving air. It must be emphasized that the principle of the constancy of the speed of light cannot explain this null result. The Lorentz velocity transformation equations are:

$$u_{\parallel} = (u' - v) / (1 - u'v/c^2) \quad u_{\perp} = u' / (\gamma(1 - u'v/c^2))$$

In the parallel direction, when $u' = c$, then $u_{\parallel} = c$. In the perpendicular direction, when $u' = c$ (with $u_{\parallel} = 0$), then $u_{\perp} = -v$ according to the first equation and $u_{\perp} = c/\gamma$ according to the second. Consequently, $u = c$, but its direction is no longer perpendicular. The principle of constant light speed refers specifically to invariance of magnitude, while propagation direction changes in non-parallel cases.

In the Michelson-Morley experiment, the two light paths are orthogonal. A plausible explanation for the null result is that Earth’s surface air moves synchronously with Earth, and the vacuum within the air is entirely dragged. Consequently, the experiment involves only one inertial frame where light is isotropic,

yielding the null result.

In contrast, the Fizeau experiment involves two inertial frames: the vacuum in air and the entirely dragged vacuum in moving water. The observed “partial drag” effect is essentially a result of Lorentz transformation between these frames.

Based on this analysis, a feasible approach would be conducting the Michelson-Morley experiment on the lunar surface. In Figure 2 [Figure 2: see original paper], let v be the Moon’s velocity relative to vacuum. The lengths AC and AB both equal l . In the parallel direction, the light travel time is $T_{ACA} = l/(c - v) + l/(c + v)$. In the perpendicular direction, placing the mirror at B would prevent receiving the returning light, so the mirror must be positioned at B, slightly offset from B, with its angle adjusted to return light to point A. The time for light to travel segment AB at speed c equals the time to travel AB at speed u , giving $T_{ABA} = 2l/\sqrt{c^2 - v^2}$. Therefore, the time difference between the two paths is $\Delta T = T_{ACA} - T_{ABA} = (2l/c)(1/(1 - \beta^2) - 1/\sqrt{1 - \beta^2})$, where $\beta = v/c$.

4. Discussion

Equation (5) is incomplete as it does not account for wavelength dependence, while Equation (4) appears somewhat rough and unsatisfactory. The geometric structure of vacuum within material media requires deeper investigation. Inside such “media,” vacuum is isotropic; light’s path curves microscopically but appears straight macroscopically. Light speed (magnitude) remains unchanged, but the increased path length leads to macroscopic measurements of “slowed” light speed. In microscopic boundary regions between two “media,” vacuum becomes anisotropic, and its geometric configuration determines light deflection. This configuration also enables wavelength-dependent deflection angles. Additionally, anisotropic media such as calcite (CaCO_3) and quartz (SiO_2) likely have asymmetrical spatial arrangements of atomic nuclei.

The existence of an absolute inertial frame does not contradict Special Relativity; it can be treated as an ordinary inertial frame without privileged status. If clocks were distributed throughout the observable universe, at least one would tick fastest, and the corresponding inertial frame would constitute the absolute inertial frame.

It can be inferred that curved vacuum generates a repulsive force that may serve as the origin of gravity and potentially act as its propagation medium. If lunar surface experiments yield positive results, vacuum may indeed be the ether—but not absolutely at rest, as previously assumed. Whether cosmic ether is absolutely stationary or exhibits relative motion requires further experimentation.

5. Conclusion

The conclusions of this work are summarized as follows:

1. Vacuum is a type of matter and the only medium through which light propagates. Air, water, glass, etc., are not actual media.
2. The curvature around a compact celestial body is not curvature of three-dimensional space but rather curvature of vacuum.
3. Atomic nuclei curve the surrounding vacuum, causing light to follow curved paths at the microscopic level during propagation in “media.” This mechanism results in macroscopic measurement of “slowed” light speed. Equation (5) provides an empirical relationship between material properties and refractive index n for single-atom molecular gases.
4. In microscopic regions at the boundary between two “media,” vacuum is anisotropic, and the spatial structure determines photon deflection.
5. The null result of the Michelson-Morley experiment is due to complete dragging of the internal vacuum by Earth’s surface air, not the principle of the constancy of the speed of light.
6. Repeating the Michelson-Morley experiment on the lunar surface is predicted to yield observable interference fringe shifts. If successful, vacuum is the long-sought ether—but not absolutely at rest.
7. Curved vacuum generates a repulsive force that may serve as the origin of gravity and potentially act as its propagation medium.
8. Since vacuum can be curved and entirely dragged, it may not be continuous.
9. The existence of an absolute inertial frame does not contradict Special Relativity; it can be treated as an ordinary inertial frame without privileged status.

Acknowledgments

In the 19th century, Fizeau, Michelson, and Morley designed ingenious experiments to search for the ether and obtained crucial results. In 1905, Einstein discovered Special Relativity. In 1911, Rutherford revealed that matter contains vast vacuum within. In 1915, General Relativity demonstrated that space (indeed the vacuum) could be curved. In 1930, Dirac proposed that the vacuum is not truly empty. These groundbreaking achievements served as vital sources of inspiration for the present discovery. These brilliant scientists deserve the highest tribute.

This paper does not require any reference.

Appendix A: Physical parameters of the “media”

TABLE I. Refractive indices and molar volumes of the “media” .

molecular formula	molar volume ($\text{m}^3 \cdot \text{mol}^{-1}$)	molecular formula	molar volume ($\text{m}^3 \cdot \text{mol}^{-1}$)
$\text{H}_2\text{O}(\text{liquid})$	1.807e-5	$\text{H}_2\text{O}(\text{gas})$	2.241e-2
CH_3OH	4.047e-5	$\text{C}_2\text{H}_5\text{OH}$	5.836e-5
$\text{C}_3\text{H}_8\text{O}_3$	7.300e-5	$\text{C}_3\text{H}_6\text{O}$	7.360e-5
$\text{H}_2\text{O}(\text{solid})$	9.651e-5	$\text{C}_{10}\text{H}_7\text{Br}$	1.388e-4
CaCO_3	1.965e-05		
	2.269e-05		
	2.455e-05		
	2.700e-05		

These values were obtained from: <https://refractiveindex.info> and the CRC Handbook of Chemistry and Physics, under standard temperature and pressure (STP) conditions and a wavelength of 589.3 nm.

TABLE II. The masses and radii of atomic nuclei.

element	atomic mass (u)	radius (fm)	element	atomic mass (u)	radius (fm)
H	1.007	0.8783	Na	20.1797	3.0055
He	14.006	2.5582	Cl	32.059	3.2611
O	20.1797	3.0055	Ar	35.446	3.3654
			Kr	79.901	4.1629
			Br	40.078	3.4595

u: 1.6605×10^{-27} kg. The masses were obtained from: https://physics.nist.gov/cgi-bin/Compositions/stand_alone.pl. *fm*: 1×10^{-15} m. The radii were obtained from: <https://www-nds.iaea.org/radii>.

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

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