The Energy Field of the Vacuum: a Contracting Universe as an Alternative to the Expanding Paradigm

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Abstract:

The standard cosmological model interprets the observed redshift of light from distant galaxies as a Doppler effect, implying an accelerating expansion of the Universe that requires the hypothetical constructs of dark matter and dark energy. In this paper, I challenge the mechanical analogy between electromagnetic and sound waves upon which this interpretation rests. Drawing upon Einstein's early analysis of the gravitational influence on light (1911), experimental evidence from atomic clocks at varying gravitational potentials, and Schrödinger's quantum-mechanical derivation of frequency shifts (1922) — which obtains the Doppler formula without the classical wave analogy — I propose an alternative framework. I argue that the vacuum is not empty but rather an active energy field that influences the frequency, wavelength, and local speed of propagating photons in synchrony with the gravitational field intensity. From this premise, I propose a model in which a contracting Universe causes photons to lose energy during propagation, producing a redshift proportional to distance traveled — reproducing Hubble's *redshift-distance* relation. This interpretation eliminates the need for dark energy and significantly reduces the inferred role of dark matter. The model is shown to be consistent with large-scale galactic flows (the Great Attractor) and Newton's law of universal gravitation.

I also propose an experimental test on board the International Space Station — using atomic clocks and a platinum-iridium reference rod — that could independently verify the fundamental premise of the vacuum as an active energy field. I conclude that presented the *"energy-spatial relationship"* may represent the "unrecognized principle of nature" that Edwin Hubble himself suspected, rather than evidence for cosmic expansion.

Keywords: Redshift, Vacuum energy field, Contracting Universe, Hubble's law, Dark matter and dark energy

INTRODUCTION

In 1911, Einstein published the second version of his article "On the Influence of Gravitation on the Propagation of Light" [1]. In this paper, Einstein derived a dependence of the propagation of light on the intensity of the gravitational field using the gravitational potential between two material systems. He derived his formulas, however, by assuming that quanta (photons) possess an effective gravitational mass, and as a consequence, photons lose energy when leaving a star's gravitational field.

The energy of each emitted or absorbed quantum from a particular atom is given by Planck's relation, which equals the difference between the energy levels of the participating pairs of quantum energy states of that atom ($E_{quantum} = Ei - Ej = hv$), where $E_{quantum}$ is the energy of the quantum, v is its frequency, and h is Planck's constant. According to Einstein's formula, the frequency of electromagnetic radiation will decrease as it leaves a star — a gravitational redshift. However, if a photon loses energy when overcoming a star's gravity (as Einstein's analysis suggests), then the photon would lose different amounts of energy depending on the mass of the source star. Consequently, the redshift would vary with stellar mass, and the spectral series of, for example, the hydrogen atom as observed on Earth would be shifted differently depending on the mass of the star from which the light originates. Such differences in shifts, however, are not confirmed by astronomical observations. Observations show that the spectral series of the hydrogen emission spectrum from nearby stars of different masses are not systematically shifted relative to each other in this manner.

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On the other hand, it has been experimentally established that atomic clocks tick faster at higher altitudes — that is, time runs faster in regions of weaker gravitational field intensity, where the "second" is defined by the frequency of electromagnetic radiation. In other words, experiments demonstrate that the energy (frequency) of a quantum emitted at a higher altitude (in a region of weaker gravitational field) is greater than that emitted at sea level (in a region of stronger gravitational field). This experimental fact invites a re-examination of certain aspects of Einstein's 1911 conclusion regarding the behavior of photons overcoming a star's gravity.

Astronomers observe a redshift (a decrease in frequency) in the spectrum of light coming from distant galaxies, interpreting the observed frequencies as if the light had been emitted locally on Earth. Furthermore, the observed redshift is consistent regardless of whether the telescope is located at sea level or in Earth orbit. This suggests:

- The frequency (i.e., energy) of emitted electromagnetic quanta is in synchrony with the gravitational field intensity at the surface of the source star.

This is consistent with general relativity: time runs faster in regions of lower gravitational field intensity (the second is shorter). According to the definition of the second adopted by the 13th meeting of the CGPM (Resolution 1, 1967/68):

"The second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom, at rest at a thermodynamic temperature of 0 K."

According to general relativity, length contracts in regions of strong gravity and expands in regions of weak gravity. The unit of length in the SI system, defined by the 11th meeting of the CGPM (Resolution 6, 1960), was based on the wavelength of krypton-86 radiation. It follows that the wavelength of any electromagnetic radiation increases in regions of lower gravitational field intensity. If both the wavelength and the frequency of electromagnetic radiation increase in regions of weaker gravity, then the local speed of light in vacuum ($c = \lambda\nu$) would also vary with gravitational potential. This logical consequence of general relativity suggests that the proposition that the speed of light in vacuum constitutes a universal speed limit throughout the entire Universe may require careful re-examination in the context of varying gravitational fields. Existing experimental evidence relevant to this question is discussed in [2].

The author has previously proposed that this phenomenon — the variation of frequency and wavelength of electromagnetic radiation in regions of differing gravitational field intensity — could be experimentally tested on board the International Space Station (ISS) using atomic clocks and a platinum-iridium reference rod (sized and scaled) [2].

The above considerations imply that the characteristics of electromagnetic quanta (frequency, wavelength, and local vacuum speed) change in synchrony with the intensity of the gravitational field through which they propagate. This means that electromagnetic quanta transfer energy to the gravitational field when entering regions of stronger gravity and receive energy when entering regions of weaker gravity. *In this picture, light loses or gains energy because of interaction with the energy field of space itself — the vacuum understood as a compressed energy medium*.

An important conclusion is that space free of matter — the vacuum — can be interpreted as a form of compressed energy, compressed by gravity. Photons, as energy packets, interact with this energy field during their travel through this propagation medium.

The author has previously reported, at the 3rd conference in 2015, that the behaviour of electromagnetic radiation should be examined in two complementary aspects: in the "local physical reality" and in the "global physical reality" [3].

From the above considerations, it follows that the nature of the so-called "empty space" offers an alternative explanation for the observed redshift of spectral lines in the electromagnetic radiation emitted by distant galaxies. This explanation differs from the mainstream interpretation, which attributes the redshift to the Doppler effect due to the expansion of the Universe. In the alternative view presented here, the redshift arises from the interaction of electromagnetic quanta with the energy field of vacuum — a contracting medium of propagation — rather than from an expanding Universe. Modern cosmology attempts to explain the accelerating expansion of the Universe by postulating a high percentage of an unknown type of "dark matter" (whose particle nature has not yet been directly detected in laboratory experiments) and by invoking "dark energy" (whose physical nature remains poorly understood even within the standard cosmological model). The present work explores whether these hypothetical constructs might be unnecessary if the vacuum is understood as an active energy field.

ACCELERATING EXPANSION OF THE UNIVERSE AND THE DOPPLER EFFECT

Vesto Melvin Slipher was the American astronomer who carried out the first observations of the shifting of spectral lines of electromagnetic radiation coming from distant galaxies. Slipher used spectroscopy to investigate the rotation periods of planets and the composition of planetary atmospheres. In 1912, he was the first to observe and discover that the spectral lines of hydrogen absorption in the spectrum of distant galaxies were redshifted toward lower frequencies. He was also the first to suggest that this redshift might be related to velocity, assuming the Doppler effect applies to electromagnetic waves in the same manner as it does to mechanical waves. This assumption provided the first empirical basis for the hypothesis of an expanding Universe.

In September 1912, in "The Radial Velocity of the Andromeda Nebula" in the inaugural volume of the Lowell Observatory Bulletin, Slipher reported:

" The magnitude of this velocity, which is the greatest hitherto observed, raises the question whether the velocity like displacement might not be due to some other cause, but I believe we have at the present no other interpretation for it" [4].

2.1. The Doppler Effect in Mechanical Waves

Mechanical waves are a propagation of vibrations of material particles belonging to a material propagation medium — vibrations of the material particles of the propagation medium around a stationary point in the frame of reference related to the propagation medium (which may be stationary with respect to space or may move, e.g., running water). The particles themselves are not transported from the source to the receiver: only the vibration itself is transported, transmitting energy in this way. The Doppler effect is the change in the measured frequency of a mechanical wave ascertained by an observer who moves relative to the source of the wave in the medium of propagation. The effect was named after the Austrian physicist Christian Doppler, who described the phenomenon in 1842 on the basis of his research with sound waves. Mechanical waves propagate through a material medium (solid, liquid, or gaseous) with a wave velocity that depends on the elastic and inertial properties of this medium.

2.2. The Nature of Electromagnetic Waves

Electromagnetic waves are fundamentally different. They consist of discrete energy packets (quanta) propagating radially from the source through space — a medium that, according to the present hypothesis, is itself a form of compressed energy. Because of this fundamental difference, the direct analogy with mechanical waves may not be uniquely applicable. In particular, an observed redshift in the electromagnetic spectrum does not necessarily imply a Doppler effect due to the motion of the source. Alternative interpretations, such as the one proposed in this paper, remain logically possible.

2.3. The Quantum-Mechanical Interpretation of Frequency Shifts

It is worth noting that the frequency shift of light reflected from a moving object — commonly attributed to the classical Doppler effect — can also be derived from quantum mechanics. In 1922, Schrödinger published a seminal paper [5] in which he derived the Doppler shift for light quanta using only the conservation laws of energy and linear momentum, without any reference to the classical wave analogy. Treating the reflecting atom and the photon as a closed system, he showed that the observed frequency shift follows from the energy exchange during reflection, including the recoil of the atom. This corpuscular derivation yields a formula that coincides with the classical Doppler formula to first order in v/c, but differs in that it naturally accounts for the atomic recoil — a feature absent from the wave theory. As Giuliani [6] notes, Schrödinger's treatment demonstrates that the classical wave analogy is not uniquely required to explain frequency shifts in light; a purely quantum-mechanical description based on energy-momentum conservation is equally valid and, in fact, more complete.

Thus, the observed frequency shift does not uniquely require the classical wave analogy; it is equally compatible with a quantum-mechanical description of photon-atom interactions. This observation opens the possibility that cosmological redshift — the shift observed in light from distant galaxies — might also admit an alternative explanation rooted in the interaction of photons with the energy field of the vacuum, rather than necessarily implying a Doppler shift due to the recession of galaxies.

2.4. Hubble's Reservations About the Doppler Interpretation

Throughout his life, Hubble did not unequivocally support Slipher's assumption that the redshift represents a "velocity-like displacement" resulting from the Doppler effect. According to Hubble's assistant and successor, Allan Sandage:

"Hubble believed that his count data gave a more reasonable result concerning spatial curvature if the redshift correction was made assuming no recession. To the very end of his writings, he maintained this position, favouring (or at the very least keeping open) the model where no true expansion exists, and therefore that the redshift 'represents a hitherto unrecognized principle of nature'" [b].

Hubble's law is properly understood as a *"redshift-distance"* relation, not necessarily a *"velocity-distance"* relation. In December 1941, Hubble reported to the American Association for the Advancement of Science that the results from a six-year survey with the Mount Wilson telescope did not support the expanding Universe theory. According to a Los Angeles Times article reporting on Hubble's remarks:

"The nebulae could not be uniformly distributed, as the telescope shows they are, and still fit the explosion idea. Explanations which try to get around what the great telescope sees, he said, fail to stand up. The explosion, for example, would have had to start long after the Earth was created, and possibly even after the first life appeared here". [c]

2.5. An Alternative Explanation

The real cause for the observed redshift of electromagnetic radiation coming from distant galaxies, according to the hypothesis developed in this paper, is the *"energy-spatial relationship"* based on the energetic nature of the vacuum. This relationship exists within the energy-space-time continuum of the Universe and corresponds to what Hubble suspected as an "unrecognized principle of nature." The following section develops this alternative explanation in detail.

EXPLANATION OF THE OBSERVED REDSHIFT FROM DISTANT GALAXIES BASED ON THE ENERGY NATURE OF THE VACUUM

We now examine the propagation of light in the energy field of the vacuum (the "empty space") in three hypothetical cases: a static Universe, an expanding Universe, and a contracting Universe. The goal is to determine which scenario reproduces the observed redshift-distance relation (Hubble's law) without requiring additional hypothetical constructs such as dark matter and dark energy.

3.1. The Case of a Static Universe

- Emission: The frequency (energy) of emitted electromagnetic radiation is in full synchrony with the intensity of the gravitational field at the location of the source. This means that the quantum energy states of the emitting atom — and therefore the energy (frequency) of the emitted quanta — correspond to the gravitational field intensity at the atom's location.
- Propagation: The frequency of the propagating electromagnetic radiation changes in full synchrony with the intensity of the gravitational field in the regions through which it passes.
- Reception: The frequency of electromagnetic radiation arriving at the Earth's surface is such as if the radiation had been emitted locally at the Earth's surface.

This is the implicit logic underlying the standard interpretation of astronomical spectroscopy results. In a static Universe, no cosmological redshift would be observed beyond the local gravitational effects.

3.2. The Case of an Expanding Universe (Expanding Vacuum)

- Emission: The frequency (energy) of emitted electromagnetic radiation is in full synchrony with the intensity of the gravitational field at the location of the source.

[b] https://apod.nasa.gov/debate/1996/sandage_hubble.html
[c] https://en.wikipedia.org/wiki/Edwin_Hubble

• Propagation: The frequency of the propagating electromagnetic radiation changes in full synchrony with the intensity of the gravitational field in the regions through which it passes. However, during the travel time, if the vacuum is expanding, the quanta would receive additional energy from the expanding space during propagation — meaning their frequency will increase compared to the static case.

• Reception: Therefore, quanta arriving at Earth from distant galaxies would have "higher energy than expected (blueshifted)". This is because they would arrive with additional energy acquired from the expanding vacuum during their travel. Since astronomers actually observe a redshift (lower energy), this case does not correspond to observed reality.

3.3. The Case of a Contracting Universe (Contracting Vacuum) — the Proposed Model

• Emission: The frequency (energy) of emitted electromagnetic radiation is in full synchrony with the intensity of the gravitational field at the location of the source.

• Propagation: The frequency of the propagating electromagnetic radiation changes in full synchrony with the intensity of the gravitational field in the regions through which it passes. However, during the travel time, if the vacuum is contracting, the quanta would lose energy to the contracting space during propagation — meaning their frequency will decrease compared to the static case.

• Reception: Therefore, quanta arriving at Earth from distant galaxies will have "lower energy than expected (redshifted)". This is because part of their energy remains accumulated (stored) in the contracting vacuum during propagation. The longer they travel (i.e., the more distant the galaxy), the greater the portion of energy lost to the contracting space, and the greater the observed redshift will be.

This is the proposed alternative explanation for the redshift-distance law discovered by Edwin Hubble.

3.4. Formalizing the Redshift-Distance Relation

According to:

• Planck's relation, the changed energy of a photon is given by $\Delta Ephoton = h*\Delta v$), where h is Planck's constant, v is the frequency, and *Ephoton* is the energy of the quantum (photon).

• Hubble's law is properly understood as a "redshift-distance" relation: $z(D) = \Delta\lambda/\lambda = H*D$, where H is the Hubble's constant of proportionality, D is the "true distance" to the galaxy, and z is the redshift

• In any local spacetime region, the speed of light in vacuum is given by: $c = v\lambda$, where v is the frequency, λ is the wavelength, and c is the local speed of light in vacuum for the local time-spatial domain, which is different for the local time-spatial domains with different intensity of the gravitational field [2].

3.5. The Mechanism of Energy Loss in a Contracting Universe

We can now imagine the following sequence:

1. A photon is emitted from the surface of a distant star. Its initial frequency and energy are synchronized with the gravitational field intensity at the star's surface.

2. During its journey through space, the photon's frequency (energy) and local speed change in synchrony with the gravitational field intensity of the regions through which it passes.

3. Upon arrival at Earth, the photon's frequency and local speed are again in synch with the gravitational field intensity at the Earth's surface — *but* part of its energy remained absorbed by the contracting vacuum during the journey.

4. Consequently, the photon arrives with lower energy (lower frequency, longer wavelength) than would be expected if the vacuum were static. This is the observed redshift.

5. The longer the photon travels (i.e., the more distant the galaxy), the greater the portion of its energy that remains absorbed by the contracting space, and therefore the greater the redshift.

This mechanism reproduces Hubble's law *($z(D)$: $\Delta\lambda/\lambda = H*D$).* without requiring an expanding Universe, without requiring dark energy, and with a significantly reduced role for dark matter.

***Conclusion**: If, during the propagation of quanta through the vacuum of the Universe, the vacuum is contracting, then the quanta arriving at Earth from distant galaxies will have lower energy (redshifted). This is because part of their energy remains accumulated (stored) in the contracting vacuum during propagation. The*

longer they travel (from more distant galaxies), the greater the portion of the quanta's energy that remains absorbed by the contracting space, and the greater the redshift will be. This is the proposed explanation for the redshift-distance law discovered by Edwin Hubble.

EVIDENCE FOR THE CONTRACTION OF THE UNIVERSE: THE GREAT ATTRACTOR

The American astronomer Sandra Faber is known for her research on the formation and evolution of galaxies and the large-scale structure of the Universe. Faber and her collaborators have mapped the distribution of galaxies in three dimensions and analyzed the flow patterns of a vast number of galaxies. Their mapping techniques have changed the way we look at the Universe and contemplate its future.

While mapping a large region of the Universe that includes our own galaxy, Faber's team made a remarkable discovery: all the galaxies in this region are moving in a roughly parallel direction, like a great river of galaxies, at approximately 600 kilometers per second. They are heading toward an exceptionally massive concentration of matter — a super-supercluster of galaxies. This structure has been named the "Great Attractor."

4.1. Interpretation of This Discovery

This observed coherent motion of galaxies toward a common massive structure is consistent with Newton's law of universal gravitation: mass attracts mass. In the context of the present paper, this discovery can be interpreted as evidence for a contracting Universe — at least on the scale of our local supercluster.

Crucially, if the Universe as a whole were expanding uniformly, such large-scale coherent flows toward a single attractor would not necessarily be expected. The existence of the Great Attractor suggests that gravitational attraction is acting over immense distances, pulling galaxies — including our own — toward a common center of mass. This is precisely what one would expect in a contracting Universe, where matter is converging rather than diverging.

4.2. A Note on Scales

It is important to acknowledge that the Great Attractor represents a large-scale flow on the order of hundreds of megaparsecs. Whether this flow is indicative of a global contraction of the entire Universe, or only of a local overdensity within an otherwise expanding Universe, remains a subject of investigation. However, within the alternative framework proposed in this paper, the Great Attractor provides empirical support for the view that gravitational contraction dominates over expansion on the largest observable scales.

4.3. Conclusion of This Section

The discovery of the Great Attractor — a coherent flow of galaxies moving at approximately 600 km/s toward a massive supercluster — is consistent with Newton's law of universal gravitation and provides observational evidence supporting the hypothesis of a contracting Universe, at least on the scale of our local supercluster.

CONCLUSION

Considering the redshift of spectral lines in the spectrum of light coming from distant galaxies as a consequence of the interaction of photons with the energy field of the propagation medium — with the vacuum — together with the discovery of large-scale coherent galactic flows toward the Great Attractor, we are led to the following conclusion:

The Universe is in a state of contraction, and this is consistent with Newton's law of universal gravitation. There is no need for hypothetical constructs such as dark matter and dark energy to explain the observed cosmological phenomena.

The presented explanation of the observed redshift of electromagnetic radiation coming from distant galaxies — based on the energy nature of the vacuum (what we may call the *"energy-spatial relationship"*) — is in full accordance with Newton's law of universal gravitation. In this model:

1. The vacuum is understood as a compressed energy field, compressed by gravity.

2. Photons interact with this energy field during propagation, losing energy to the field when the vacuum is contracting.

3. The energy loss is proportional to the distance traveled, reproducing Hubble's redshift-distance relation.

4. The observed coherent motion of galaxies toward the Great Attractor provides empirical evidence consistent with gravitational contraction on large scales.

On the Interpretation of Redshift

The misunderstanding that the Doppler effect — interpreted through the classical wave analogy — is the only possible explanation for cosmological redshift has led to what some authors have described as a widely discussed and critically examined interpretation of the 20th century: the accelerating expansion of the Universe. Because the hypothesis of an expanding Universe is difficult to reconcile with Newton's law of universal gravitation (which predicts attraction, not repulsion), modern cosmology has introduced the hypothetical constructs of dark energy (whose physical nature remains poorly understood) and dark matter (whose particle nature has not yet been directly detected in laboratory experiments) to preserve the expanding Universe paradigm.

As noted throughout this paper, Edwin Hubble himself did not support the assumption that the redshift represents a “velocity-like displacement” resulting from the Doppler effect. To the very end of his writings, he favoured — or at the very least kept open — the possibility that no true expansion exists, and that the redshift “represents a hitherto unrecognized principle of nature.”

A Proposed Experimental Test on the International Space Station

The hypothesis presented in this paper rests on a fundamental claim: that the vacuum is an energy field which influences the frequency, wavelength, and vacuum speed of the electromagnetic field — of photons. This claim can be experimentally tested independently of the cosmological redshift interpretation.

A proposed experiment on board the International Space Station (ISS) would consist of the following:

1. **Atomic clocks:** High-precision atomic clocks operating at the orbital altitude of the ISS (where the gravitational field intensity is weaker than on Earth's surface) would be compared with identical clocks on the ground. While gravitational time dilation is already confirmed by general relativity, the present hypothesis additionally requires that the measured frequency of electromagnetic radiation varies in synchrony with the gravitational potential.

2. **Platinum-iridium reference rod:** A physical length standard — a rod made of platinum-iridium, whose length is defined by atomic spacings — is expected to remain **unchanged** in length, serving as an invariant reference. Its purpose is not to expand or contract, but to provide a fixed standard against which any change in the wavelength of a suitable electromagnetic radiation can be measured. By comparing the interference pattern of that radiation on the ISS with the pattern on Earth's surface, any variation in wavelength induced by the difference in gravitational potential would be detected.

3. **Direct measurement of the local speed of light:** By combining measurements of time (from atomic clocks) and wavelength (from the interference pattern relative to the platinum-iridium rod) at the same orbital location, the local speed of light $\(c = \lambda \upsilon)$ could be determined in situ.

What would this experiment prove?

If the measured value of c on the ISS differs from that measured on Earth's surface (with the difference corresponding to the difference in gravitational potential), this would ***“directly demonstrate that the vacuum is an active energy field which influences the frequency, wavelength, and vacuum speed of photons”***. It would therefore confirm the fundamental premise of the present paper.

What would this experiment not prove?

This experiment would not directly prove that the cosmological redshift is caused by a contracting Universe rather than by the Doppler effect. The explanation of the redshift remains a theoretical interpretation that builds upon this fundamental premise. However, if the premise is experimentally confirmed, then the alternative explanation proposed in this paper — that photons lose energy to the contracting vacuum during propagation — becomes a logically consistent and empirically grounded framework that deserves serious consideration alongside the standard expanding Universe paradigm.

The author has previously proposed this experimental test in his previous publications and invites the scientific community to consider its implementation.

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