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Research Article

The Asymmetry of the Cosmic Microwave Background Radiation as Signature of Local Lorentz Invariance Violation

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A difference in electric potential in a static conductor inside a static magnetic field and an anisotropic and asymmetric distribution of neutrons emitted in nuclear reactions induced by ultrasound are assumed as marks of local Lorentz invariance (LLI) violation. The asymmetry of the two experiments is related to the asymmetry of the Cosmic Microwave Background Radiation (CMBR). As common directions of asymmetry are found in these three cases, a fundamental asymmetry of the interactions is suggested which can also shed new light on the question of symmetry breaking in the history of the Universe.

1. Introduction

The Lorentz invariance together with the invariance for space and time translations establishes the Poincare symmetry, which is strictly valid only in flat space-time. The local Lorentz invariance (LLI), on the contrary, imposes an isotropic and flat space-time in any 4-dimension (4D) variety (Minkowski space-time) tangent to a possibly curved (Riemann) space-time, as assumed by the Einstein general relativity. The LLI holds in absence of local gravitational interaction. In this condition, the Einstein special relativity is valid.

It is an old debate whether the LLI holds at any distance and any energy [1]. At any rate, the validity of LLI at the Planck scale is queried, due to the quantum fluctuations.

In the case of speed of light, the deviations from a constant value of the light speed in vacuo, usually assumed as constant and equal to the value "c," are measured by a kinematical violation parameter δ defined as follows [2]:

$$\delta = \left(u^2/c^2\right), \tag{1}$$

where u is the actual measured speed.

This parameter can also measure different anisotropic contributions from the different interactions.

Theoretical studies on the LLI breaking, together with the consequent validity of special relativity, can be found in the literature. Some of them are reported in [3]. Starting from the theoretical ground, experimental tests were also proposed [4, 5], some of them to be performed in the space [6, 7].

Tests on the special relativity in cosmic rays and neutrino physics were proposed to investigate the LLI breakdown in the framework of the standard model [8–10].

Large contributions in this field came from Kostelecky. Together with his colleagues, he demonstrated the existence of anisotropy in string theory models [11] and considered the possible violations of space-time symmetry [12], specifically those underlying Einstein's theory of relativity. He discovered a general mechanism by which violations of Einstein's theory of relativity could occur without violating basic principles, leading to observable effects from the unification of gravity with quantum physics. His new version of the standard model of particle physics, called the standard model extension, characterized by parameters to be adjusted and operators that can break the Lorentz symmetry, is a classic reference for testing the relativity theory [13–16].

After considering possible asymmetries in the space-time at the Planck length, he challenged investigators of various fields, from particle physics to astrophysics, to experiments verify the consequences of these asymmetries.

Together with Stuart Samuel, he was the first to use the Bumblebee model in gravity to investigate the consequences of spontaneous Lorentz violation. In fact, a bumblebee field is characterized by a spontaneous Lorentz violation if it gets a nonzero vacuum value in the local Lorentz frame [16, 17].

A lot of tests based on the standard model extension have been proposed [18]. They concern, among others, the oscillations of neutral meson and of neutrino, muon properties, the baryon asymmetry, the clock rate on Earth and space, the motion of spin-polarized torsion pendulum, spectroscopic studies of hydrogen and antihydrogen, QED in a Penning trap, the cosmological birefringence, and microwave cavities.

Concerning the LLI breaking, it is useful to underline that the same general relativity implies it, although it only considers the curvature of space-time.

Furthermore, although in absence of gravitational fields, the general relativity keeps valid the LLI in any 4D space tangent to the curved space-time, and no similar assumption is possible in the case of parity nonconserving weak interactions.

The LLI allowed excluding the existence of an ether. Thus, a rupture of LLI can challenge to reconsider it, although with a new conception. The same space-time of the general relativity was considered by the late Einstein as a new type of ether, not rigid but able to deform [19, 20]. Thus, it is not surprising that new ether theories have still been proposed in modern times [20, 21].

We shall review two experiments: the authors described as violating the LLI at a short distance, in accordance with a theory, now called the deformed space-time (DST) theory [3]. According to this theory, the space-time is nonflat above or below some critical thresholds of energy that are different for the different fundamental interactions. Space-time is deformed in a quite general way, including asymmetry and anisotropy, and the well-known curvature of general relativity is only a particular case.

It is interesting to note that this theory, which gives a metric interpretation of the fundamental interactions, is not based on pure speculation but was introduced to take into account some detected processes, which could not be described in terms of the special relativity and the standard model: the decay time of ${K_s}^0$ meson by weak nuclear interaction [22, 23]; the Bose–Einstein correlation in pion production by strong nuclear interaction, in a wide energy range (one order of magnitude) [24]; the superluminal photon tunnelling by electromagnetic interaction [25–29]; and the slowing down of clocks by gravitational interaction [30].

The local asymmetry detected in the below-described experiments is put in correlation with a large-scale asymmetry, which is related to the direction of the Cosmic Microwave Background Radiation (CMBR), as it is observed from a terrestrial reference frame. This correlation between local scale and very-large-scale events is thus assumed as a hint of the asymmetry characterizing the same fundamental interactions and encouragement for more systematic measurements.

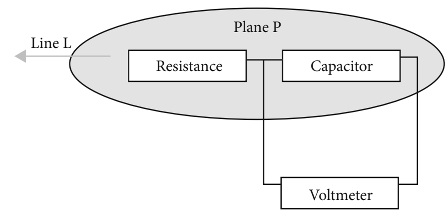


Figure 1: The P plane, perpendicular to the magnetic field, contains the conductor (resistance) and the capacity in series, aligned along the line L. The voltmeter detects the voltage at the ends of the capacitor.

2. The Coil Experiment

No difference in electric potential is expected in a static conductor inside a static magnetic field.

On the contrary, a circuit made of a conductor and a capacitor was kept fixed inside the static magnetic field of a Helmholtz coil generated by a steady-state current. In these conditions, a voltage above the instrumental zero of the voltmeter was measured in some cases [31].

More in detail, the conductor was a copper straight wire ("resistance" in Figure 1). If any charge anisotropy occurred in it, a nonzero voltage was detected by the voltmeter at the ends of the capacitor. The magnetic field direction was perpendicular to the plane (P) containing the conductor and the capacitor, which were aligned along a line (L).

A left-handed reference system was assumed in the laboratory, the y-axis direction corresponding to the north of the local magnetic field of the Earth and the z-axis being upward vertical.

In the first step, the P plane was parallel to the xy plane and could rotate around the z-axis, which corresponded to the coil axis, the magnetic field B being oriented toward the z-direction (Figure 2(a)).

The rotation angle alpha (α) of the line L was measured starting from the negative direction of the y-axis. Steps of $\pi/4$ radians were performed from alpha = 0 to alpha = 2π, clockwise with respect to the z-axis.

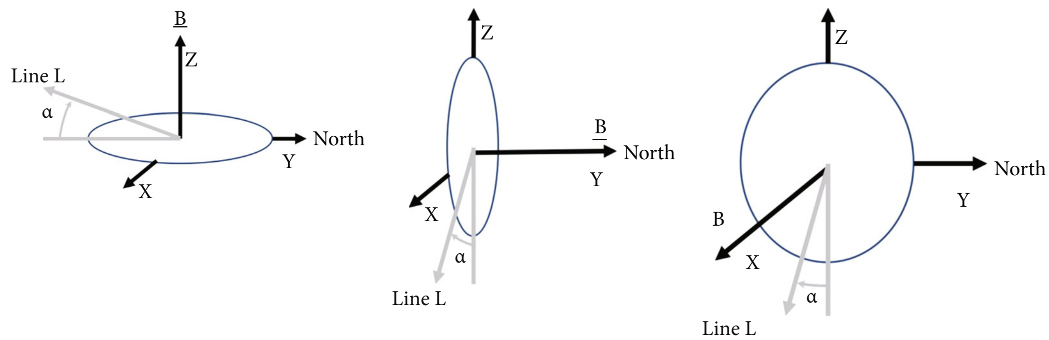
After each rotation step, the voltage measurement was performed when the coil and the circuit were at rest in the laboratory frame (and thus mutually at rest).

Each measurement was repeated five times, and the average value was considered.

The so-obtained voltage in the capacitor is reported in Figure 3(a) as a function of the rotation angle alpha. The corresponding incertitude was $\pm 10\,\mu$V.

Each result is represented as a rectangle, having a height corresponding to the incertitude interval, while the basis is the step of $\pi/4$ radians. This last value is very large with respect to incertitude on the alpha angle (less than 1/50 of radiant).

The whole measurements were repeated two times in different hours of the same day, 1998 June 8th: from 9h 00'



(a) (b) (c)

Figure 2: Orientation of the RC circuit (line L) in the P plane, perpendicular to the magnetic field (B) of the coil, with respect to the laboratory reference system (xyz). Plane P parallel to the xy plane. Plane P parallel to the xz plane. Plane P parallel to the yz plane.

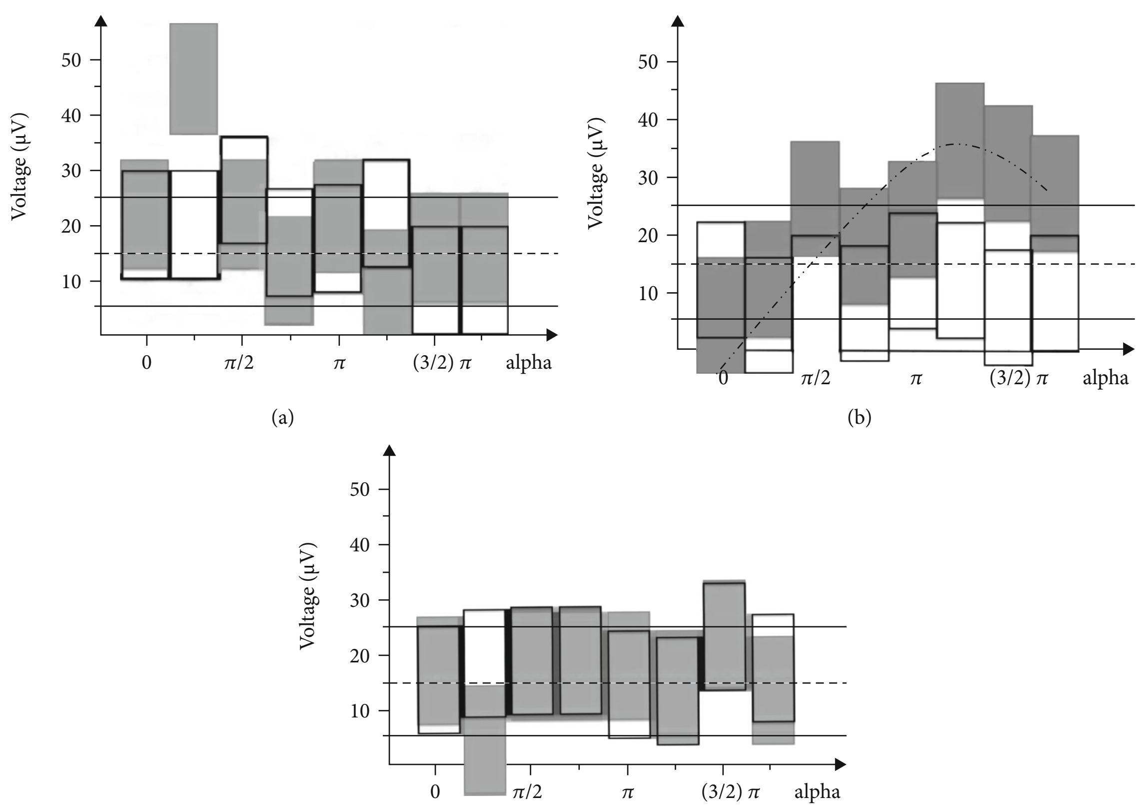


Figure 3: Capacitor voltage as a function of the rotation angle alpha. (a) Orientation on plane xy (Figure 2(a)). (b) Orientation on plane xz (Figure 2(b)). (c) Orientation on plane yz (Figure 2(c)). Two sets of measurements are reported in each figure. The range of instrumental zero ($15 \pm 10\,\mu$V) is indicated.

to 9h 59’ (reported as grey rectangles in Figure 3(a)) and from 12h to 12h 46’ (black border rectangles).

As the instrumental zero was evaluated to be $15 \pm 10\,\mu$V, only one value—at $\pi/4$ radians in the first measurements—is different from zero (Figure 3(a)).

A similar procedure was used on the following day: in this second step, the P plane was parallel to the xz plane and could rotate clockwise around the y-axis, which corresponded to the coil axis, the magnetic field B being oriented toward the y-direction (Figure 2(b)).

In the third step, the P plane was parallel to the yz plane and could rotate clockwise around the x-axis, which corresponded to the coil axis, the magnetic field B being oriented toward the x-direction (Figure 2(c)).

The former configuration was studied from 9h 45’ to 10h 47’ (grey rectangles in Figure 3(b)) and from 11h 10’ to 11h 58’ (black border rectangles).

The latter configuration is from 8h 30’ to 9h 20’ (grey rectangles in Figure 3(c)) and from 12h 18’ to 13h 05’ (black border rectangles).

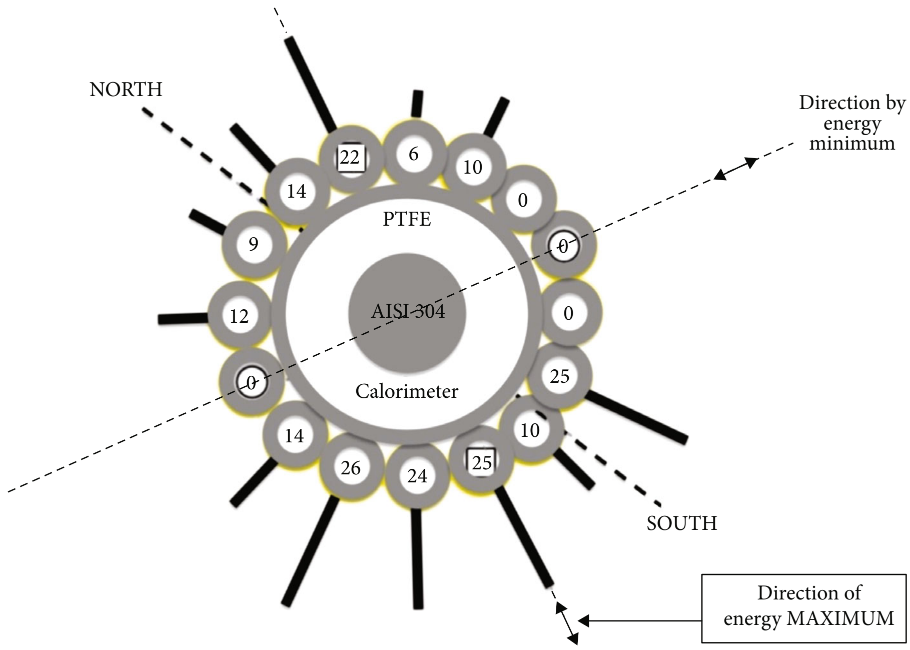


Figure 4: Sketch of the geometry and the neutron integrated intensity (microSievert) of each detector in the experiment of the steel bar subjected to 20 kHz ultrasound irradiation. The direction of the local magnetic field of Earth is indicated.

While the data of Figure 3(c) are compatible with a null voltage in all the cases, the earliest results of June 9th (grey rectangles in Figure 3(b)) at $5\pi/4$ radians are out of the band of instrumental error. Furthermore, if one assumes the instrumental zero strictly at 1.5 μV (in fact, the zero incertitude is a systematic error rather than an experimental one), four values are not compatible with zero, and these values are statistically correlated ($R^2 > 80\%$) thus being valid candidates for a positive signal.

Polynomial interpolation of this whole set of data is reported in Figure 3(b). The alpha value corresponding to the maximum is 3.757 radians, i.e., about 215°.

The variations of the Earth magnetic field (<5%), the coil magnetic field (<1%), and its direction (<0.5°) were measured, the voltmeter stability with temperature was considered, and they all were evaluated not to be sufficient to produce the measured deviation.

The main result is that an unexpected and asymmetric voltage is registered in the vertical xz plane at 3.8 radians (Figure 3(b)). A similar effect is also detected in the horizontal xy plane at $\pi/4$ radians (Figure 3(a), grey rectangle), although in this case, it appears as an effect occurring in a narrower angular range.

The starting point of this investigation was to test the deformed space-time (DST) theory [3]. It predicts that the four fundamental interactions can deform the space-time, the corresponding metric parameters both depending on the type of interaction and on the energy characterizing the process. A deformed space-time, i.e., a non-Minkowskian space-time, can also occur at low energy, and it implies a violation of the LLI in any case.

This experiment is aimed at checking the violation in the case of the electromagnetic interaction. However, it took place on the Earth; thus, a contribution from the gravitation interaction cannot be excluded.

3. Anisotropic Emission of Neutrons

Besides the asymmetry of the electromagnetic interaction, as it was investigated in the above-reported coil experiment, the asymmetry of the nuclear interactions was taken into consideration [32].

An AISI 304 steel cylinder, with 1.88 cm diameter and 9.05 cm height, was submitted to 20 kHz ultrasound (US) irradiation. The cylinder was kept vertical while the US wave-vector was parallel to the cylinder vertical axis. A Teflon (PTFE) circular crown, 2 cm thick, acted as a calorimeter all around the sample (Figure 4). Sixteen neutron detectors of PADC polycarbonate (CR39-AB, with boric acid) were set at a fixed regular distance all around the PTFE coat. They were calibrated at the ENEA Research Center in Casaccia (Rome, Italy) by using an americium-beryllium source of known intensity and also by the neutron beams from TRIGA Mark II and TAPIRO nuclear reactors.

After three minutes of US irradiation, the steel bar temperature raised from 20°C to 92°C while the PTFE calorimeter melted and was locally carbonised.

From the energetic point of view, the energy transferred to the bar was evaluated to be about 6 kJ, due to its mass of 181 g and specific heat of about 0.5 J K/g. The amount of energy deposited in the calorimeter, on its side, was evaluated to be about ten times larger.

The PADC detectors registered neutron emissions with a highly anisotropic and asymmetric distribution, the null intensity corresponding to directions where the calorimeter was not carbonised. A pictorial representation of this

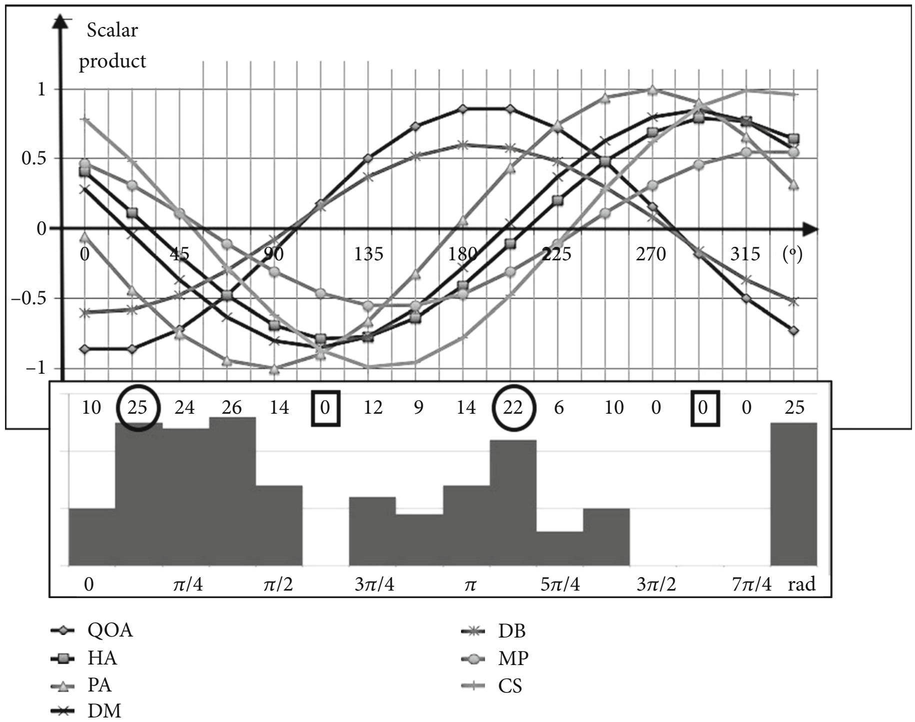


FIGURE 5: Scalar products between the seven directions of CMBR asymmetry and the 16 directions of the neutron detectors in a plane tangent to the Earth's surface. In Rome, 19th of December 2012; time: 11:30 a.m. The lines are a guide for the eye. Bottom: the corresponding intensities of Figure 5 are reported.

distribution is reported in Figure 4, where the length of the lines corresponding to each detector is proportional to the measured neutron intensity.

Thus, the distribution of carbonised zones and the intensity measured by the detector are mutually coherent and support the assumption that the emitted neutrons are responsible for the high energy deposited in the calorimeter.

One can note that the direction of the highest intensity ($25 + 22$ microSievert) and that of the lowest intensity ($0 + 0$ microSievert) are mutually perpendicular.

The next step was to consider whether the detected asymmetry and anisotropy could be put in relation to others occurring at a larger scale.

To this end, the seven directions corresponding to the anisotropy of the Cosmic Microwave Background Radiation (CMBR) were taken into consideration:

(i) QOA (galactic coordinates: longitude 234°, latitude 67°): alignment between the orientation of the quadrupole and the octupole components

(ii) HA (237°, -20°): hemispherical asymmetry (angular power spectrum asymmetry on the sky)

(iii) PA (193°, -3°): power asymmetry (dipolar power spectrum asymmetry on the sky)

(iv) DM (227°, -15°): dipole modulation (by power spectrum asymmetry expressed in terms of a multiplicative dipole modulation model)

(v) DB (264°, 48°): Doppler boost (dipole modulation inducted by the Earth motion with respect to the CMBR rest frame)

(vi) MP (264°, -17°): mirror parity (mirror symmetry with respect to a plane)

(vii) CS (209°, -57°): the cold spot (anomalous cold area in the CMBR)

These directions were put in relation to the 16 directions of the neutron detectors in the plane tangent to the Earth's surface.

Figure 5 reports the scalar products between the seven directions of CMBR asymmetry and the 16 directions of the neutron detectors. They are compared with the corresponding intensities.

4. Discussion

Results of the neutron emissions, resumed in Figure 4, show a correlation between the direction of intensity maximum ($25 + 22$ microSievert) corresponding to $\pi/8$ and $9\pi/8$ radians and the maximum projection of QOA and DB. This direction is in a plane almost perpendicular to DM, PA, HA, MP, and CS.

Coherently, the direction of zero intensity ($5\pi/8$ and $13\pi/8$ radians) is in a plane perpendicular to QOA and DB and almost in the direction of the other five anomalies.

A similar treatment can be performed in the case of the coil experiment. Figure 6 reports the scalar products

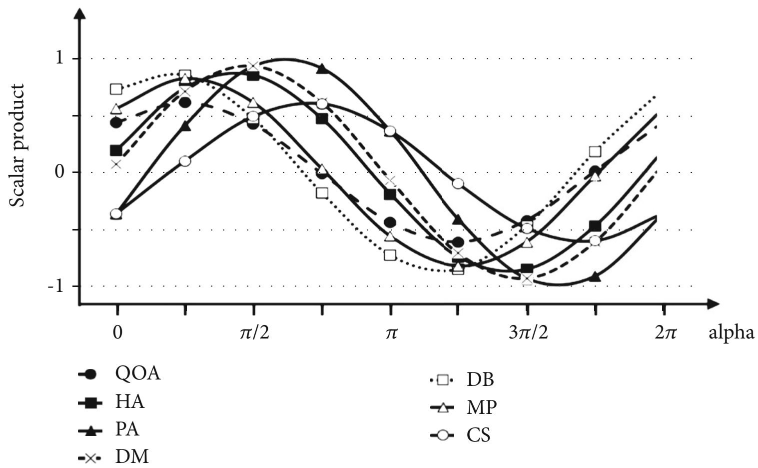


Figure 6: Scalar products between the seven directions of CMBR asymmetry and the eight directions of alpha angles in the *xz* plane. Rome (Italy), 9th of June 1998, time 8:30–9:20 a.m. Lines are a guide for the eye.

between the eight directions of alpha angles of the measurements reported in Figure 3(b) (corresponding to the largest angular range of anomalous behaviour, with a maximum at $5\pi/4$ radians) and the seven directions of CMBR asymmetry at that time.

By comparison with the curves of Figure 6, we deduce that this anomalous behaviour occurs along the direction of MP, DB, QOA, and DM anomalies of CMBR (in particular, it is antiparallel, as the scalar product is close to -1).

In conclusion, the anomalies observed in the two experiments appear to be strongly correlated with three directions of the CMBR anisotropy. In fact, their direction is that of QOA and DB in a plane perpendicular to CS.

In these correlations, two points are of huge importance: firstly, a similar result is obtained in two different interactions, electromagnetic and strong nuclear. Secondly, but not less important, the local anisotropies are put in relation with anisotropies at a very large (cosmic) scale.

Concerning the other directions, having different relevance in the two experiments, we do not exclude that they are related to the gravitational interaction, as the directions lie in different planes, vertical in the first case and horizontal in the second.

The above-reported results, i.e., the anisotropic voltage detected in a fixed conductor in a stationary magnetic field and the anisotropic and asymmetric emission of neutrons induced by ultrasound irradiation, share main features which make them of relevant importance. In fact, they both cannot occur according to the local Lorentz invariance (LLI), which assumes a flat, isotropic, and symmetric local space-time and symmetric isotropic interactions at any value of energy. In the case of electromagnetic and strong interactions, which act in the above experiments, the LLI is commonly assumed to hold, and the reported results are not predicted.

On the contrary, the deformed space-time (DST) theory [3] predicts a deformed space-time, therefore the LLI breakdown, in ranges of energy which are different for the different interactions. An energy threshold exists, different for the different interactions, above which (greater than $20\,\mu$eV for gravitational interaction; greater than 370 GeV for strong interaction) or below which (less than $4.5\,\mu$eV for electromagnetic; less than 81 GeV for weak interaction) the space-time is deformed with respect to that commonly considered. This last is the space-time of our instruments and our perceptions, i.e., the electromagnetic space-time above the $4.5\,\mu$eV threshold [3].

A further step of the DST theory was to derive the thresholds of energy density from the energy thresholds [33]. In fact, the volume where the DST reactions take place was evaluated to have characteristic sizes (some microns).

This theory predicts spatial anisotropy and asymmetry (with respect to "our" space-time) in the region where the processes occur, if the energetic conditions for deformation are fulfilled. These microscopic deformations give rise to macroscopic anisotropy and asymmetry in the electromagnetic space-time where we and our instruments are usually embedded.

The anisotropic distribution of neutrons can be attributed to this kind of phenomenon. Production of nuclear reactions by using ultrasound can be explained in terms of energy density and thresholds, as predicted by the DST theory, while it is impossible in terms of energy, the Coulomb barrier, and flat space-time.

The coil experiment too can be explained in terms of DST theory. Starting from the Friedman equation [34], a critical density of energy for a spatially flat universe is obtained: 1.88×10^{-29} g/cm^3, which corresponds to 1.05×10^4 eV/cm^3.

This value is comparable to the thresholds of energy density predicted by the DST theory in the case of electromagnetic and gravitational interactions: by considering the size of the interaction volume, having a radius evaluated [33, 35] between 4 and 10 microns, the threshold of electromagnetic interaction varies between 1.7×10^4 and 0.1×10^4 eV/cm^3, while it varies between 7.5×10^4 and 0.5×10^4 eV/cm^3 for gravitational interaction.

The above-reported considerations are aimed at putting in relation the anisotropy of the microscopic processes not only to our macroscopic detection but also to very-large-scale asymmetry. Given that these correspondences between local asymmetry and large-scale asymmetry hold, not only the local breakdown of symmetry is studied in these experiments, but the same general asymmetry [36] of the interactions is put in evidence.

Among the consequences of this asymmetry of the interactions, the fundamental question of the symmetry breaking [37] along the history of the Universe can find a new solution. In fact, no breaking of symmetry is necessary if the interactions are fundamentally not symmetric: no symmetry has to be broken as no symmetry holds in every condition but only in limited conditions. Therefore, spontaneous symmetry breaking is no longer necessary.

Finally, some theoretical considerations must be emphasized. The nuclear reactions were assumed to occur in a deformed space-time but were analysed in a flat space-time: this last is the flat space-time of the detectors and does not imply a general flat space-time. In fact, the detectors are always based on the electromagnetic interaction: thus, they always operate in a flat Minkowski space-time as the energy characterizing their electromagnetic process is usually higher than 4.5 μeV.

The real novelty of the DST theory is the asymmetry, which must be implemented as a fundamental part both of the LLI violation and of the space-time deformation.

In other words, a fundamental asymmetry exists in nature. It must be implemented as a fundamental characteristic and not only as an additional theoretical hypothesis.

As a general comment, we can learn the fundamental characteristics of nature—in this case, the asymmetry of the interactions—from nature itself; then, we must adapt our opinions and find a theoretical/mathematical formalism able to describe them.

The coil experiment was suggested to one of the authors (F.C.) by Umberto Bartocci in 1996/97 [38]. Umberto Bartocci and his coworkers performed a similar experiment with a fixed direction of the apparatus at the Perugia University. They obtained limits for the LLI violation similar to those already known. Therefore, they did not publish the results. The reason why they did not reach lower limits is that the anisotropy was not considered. In fact, they were inspired by the method proposed by Stefan Marinov [39] who, in his turn, was inspired by the two electromagnetic experiments by Albert Einstein performed at the Zurich Polytechnic University [20, 40]. In the Bartocci experiments, the isotropy was assumed as a natural condition. Thus, although some anomalies were observed in some cases, they were not reproducible due to the assumption of isotropy and were averaged among different directions.

The novelty of the coil experiment above-reported is the measurements and analysis in different directions which allowed us to find narrow angular regions where an LLI violation could occur.

A further important point concerns the limits of the LLI breakdown. In fact, usually, the main problem is to find the upper limit for the violation parameter δ. In fact, the greater the deviation, the more astonishing the result. These limits are so low (δ less than 10-8 in the isotropic case of electromagnetic tests and δ less than 10-21 in the anisotropic case of nuclear tests [2]) that in most of the cases, people assumed δ as zero, and the LLI is postulated as perfect symmetry. In this framework, finding the lower limits is considered a completely pointless problem. However, the lower the value of δ, the more intriguing the result as a small deviation too makes the LLI not valid. The DST theory predicts the existence of lower limits too, above which the LLI is valid and below which LLI is violated, depending on the interaction (we recall that the best definition of the theory of relativity is given by the axiomatic relativity). It achieved the great result of demonstrating, as a consequence and not as a postulate, the existence of a relativistic invariant, having a dimension of a squared speed. This is the ground for the success of the second postulate of the Einstein relativity, imposing the constancy of the numeric value of the light speed in a vacuum. This last value is used to define the value of δ (references on axiomatic relativity can be found in [3]).

Concerning this point, one of the authors (F.C.) was told by three famous theoretical physicists [41] that "under the upper limits of the LLI <hunting is free> for any violation"; i.e., the search and finding of any lower limit are quite legitimate.

About the problem of the LLI limits, usually, they are reported as a function of energy. On the contrary, the DST theory predicts that different energy limits exist for the different interactions. Moreover, these limits can be either upper or lower. Thus, if one puts all the experimental data together, as it is commonly performed, the panorama becomes quite confusing.

As the last comment, the violation parameter δ is defined as a numeric value related to the speed. After the above discussion, a new definition is to be sought (supposedly a multidimensional tensor), which also considers anisotropy and asymmetry.

5. Perspectives

According to the DST theory, the transition from a flat to a deformed space-time and vice versa corresponds to the crossing of the energy thresholds, which are found not only at high energy but also at low energy.

The above-reported experiments are aimed at putting in evidence this effect by studying the anisotropy of DST reactions and the corresponding energy.

The next step could consist in artificially creating a geometrical deformation inside a flat space-time to induce those reactions that occur in a deformed space-time or, inversely, in creating a geometrical deformation that counteracts the anisotropy of interaction thus restoring the lost symmetry.

The former case is the spatial correspondence of the predicted "Mignani condition" [42], namely, even in the absence of an external electromagnetic field, the metric relative to the atomic electromagnetic field "mimes" (for an in-depth view of the mathematics for the Mignani condition, see chapters 2 and 5 of [3]), a temporal property of the hadronic metric, thus leading to nuclear emissions. This condition was suggested to occur for nuclear emission detected in the region between the thresholds of weak and strong interaction in stressed steel bars [33].

The latter case, if applied to the electromagnetic interaction, could correspond to an antenna producing an anisotropic and asymmetric field because measured in a non-DST condition (e.g., flat Minkowskian space-time). A proper deformation of the antenna could restore the lost symmetry of the irradiated energy.

This last statement seems to be recently verified in a torsional antenna [43]. In fact, despite its asymmetric geometry, the lost symmetry of the irradiated energy was recovered at a proper torsional angle, and symmetric distribution of the irradiated energy was detected.

We aim to verify this last result by using an ellipsoidal geometry. In fact, although the used antenna was in a geometry for which a highly asymmetric distribution of energy was expected by following the Maxwell equations, the whole apparatus could be inscribed inside a sphere.

A further forecast improvement is to operate in an anechoic chamber replacing the used anechoic corner in order to increase the signal-to-noise ratio.

6. Conclusions

The asymmetry of two experiments where the LLI appears to be violated is put in relation to the asymmetry of the CMBR, both from a geometric and an energetic point of view. As common directions of asymmetry are found in the three cases, a fundamental asymmetry of the interactions rather than a local violation of the Lorentz symmetry is so suggested.

If this finding is confirmed, some of the main problems of symmetry could find a new solution. Among them, no symmetry breaking needs to be introduced in the history of the Universe: the same interactions which are at the basis of the known world are intrinsically asymmetric, while symmetry, including a flat space-time, is only a special case occurring in different ranges of energy for the different interactions, as predicted by the DST theory.

We remark that the found correlations among the directions of the three cases do not imply that these directions may get relevance in general or that any fixed point may get this relevance. We evaluated these directions from the point of view of an observer on the Earth. Different directions could correspond to different points of view in the Universe. We just put in evidence that some local directions of asymmetry could be related to some asymmetry directions at a larger scale, as these directions are seen from our terrestrial point of view.

This fact changes the so-called Copernican principle "the Earth is not a privileged point of view of the Universe" into the fact that "the Earth is a conditioned point of view of the Universe," conditioned by the here-existing asymmetry.

In conclusion, here we presented hints that asymmetry is a fundamental property, characterizing any fundamental interaction existing in the Universe.

7. Final Remarks

LLI violation from astrophysical information is an open question for the scientific community as long as measurements of cosmic rays were considered [44, 45]. In this paper, we tackle the subject from the point of view of CMBR.

A recent paper [46] reports a lower density of visible matter detected in the direction of the CMBR cold spot. This fact was considered the cause of the cold spot.

On the contrary, we propose that the same asymmetry of the interactions which is at the basis of the cold spot could be at the basis of the lower density of the matter in that direction, as it is seen from our terrestrial point of view.

Thus, anisotropy in the distribution of the matter and energy is to be expected in that direction. However, the occurrence of this direction is not a suggestion about a rotation axis of the Universe, as suggested by the metrics of Gödel [47] or other exact solutions [48] of the Einstein field equations. In fact, the absence of spiral-shaped trajectories of light from far objects excludes this hypothesis [49].

A further question on the asymmetry of the Universe is found in a still more recent paper [50]: with the help of artificial intelligence methods, the emitted light from quasars at 13 billion light-years was investigated in order to find time variations of the fine constant α. To this end, the relative shifts between atomic—not molecular—species were compared. Although no variation was detected in time, small variations in different directions were obtained after comparison and in accordance with previous measurements.

Last, but not least, we point out that a recent work [51] showed that the properties of the DST lead to a plurality of potential physical phenomena that should occur, provided that the resulting formalisms can be considered useful models for the description of some aspects of physical reality. A list is given of available experimental evidence not easy to be interpreted, at present, by means of the more established models, such as the standard model, with its variants aimed at overcoming its descriptive limits. The list includes anomalies in the double-slit-like experiments, nuclear metamorphosis, torsional antennas, and the physical effect of the "geometric vacuum"(as defined in analogy with quantum vacuum), in the absence of an external electromagnetic field, when crossing critical thresholds of energy parameter values, energy density in space, and energy density in time. Concrete opportunities are suggested for experimental exploration of phenomena, either already performed but still lacking a widely accepted explanation or conceivable in the application of the approach here presented, but not tackled until now. The list of such experimental opportunities turns out to be quite rich, although it does not necessarily require new facilities, since reference is made purely to experimental infrastructures already in operation; the performances just need expanding. What can be done with the need for only limited additional resources?

Data Availability

They are in the paper.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgments

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References

[1] J. D. Bjorken and S. D. Drell, *Relativistic Quantum Fields*, vol. 11, McGraw-Hill, NY, USA, 1965.

[2] C. M. See Will, *Theory and Experiment in Gravitational Physics*, Cambridge University Press, 1993.

[3] F. Cardone and R. Mignani, *Deformed Spacetime, Ed*, Springer, Dordrecht, The Netherlands, 2007.

[4] H. P. Robertson, "Postulate versus observation in the special theory of relativity," *Reviews of Modern Physics*, vol. 21, no. 3, pp. 378–382, 1949.

[5] R. M. Mansouri and R. U. Sexl, "A test theory of special relativity: I. Simultaneity and clock synchronization," *General relativity and Gravitation*, vol. 8, no. 7, pp. 497–513, 1977.

[6] S. Buchmanetal, "A superconducting microwave oscillator clock for use on the space station," in *In Proceedings of 52nd Frequency Control Symposium*, p. 534, Washington, DC, 1998.

[7] C. Lämmerzahl, H. Dittus, A. Peters, and S. Schiller, "OPTIS: a satellite-based test of special and general relativity," *Classical and Quantum Gravity*, vol. 18, no. 13, pp. 2499–2508, 2001.

[8] S. Coleman and S. L. Glashow, "Cosmic ray and neutrino tests of special relativity," *Physics Letters B*, vol. 405, no. 3-4, pp. 249–252, 1997.

[9] S. Coleman and S. L. Glashow, "High-energy tests of Lorentz invariance," *Physical Review D*, vol. 59, no. 11, article 116008, 1999.

[10] R. Jackiw, "Chern-Simons Violation of Lorentz and PTC Symmetries in Electrodynamics," in *Confluence of Cosmology, Massive Neutrinos, Elementary Particles, and Gravitation*, pp. 95–100, Springer, Boston, MA, 2002.

[11] V. A. Kostelecký and S. Samuel, "Spontaneous breaking of Lorentz symmetry in string theory," *Physical Review D*, vol. 39, no. 2, pp. 683–685, 1989.

[12] V. A. Kostelecký and N. Russell, "Data tables for Lorentz and *CPT* violation," *Reviews of Modern Physics*, vol. 83, no. 1, pp. 11–31, 2011.

[13] D. Colladay and V. A. Kostelecký, "CPT violation and the standard model," *Physical Review D*, vol. 55, no. 11, pp. 6760–6774, 1997.

[14] D. Colladay and V. A. Kostelecký, "Lorentz-violating extension of the standard model," *Physical Review D*, vol. 58, no. 11, article 116002, 1998.

[15] V. A. Kostelecký, "Gravity, Lorentz violation, and the standard model," *Physical Review D*, vol. 69, no. 10, article 105009, 2004.

[16] R. Bluhm, "Overview of the Standard Model Extension: Implications and Phenomenology of Lorentz Violation," in *Lecture Notes in Physics*, J. Ehlers and C. Lämmerzahl, Eds., vol. 702, pp. 191–226, Springer, Berlin/Heidelberg, 2006.

[17] R. Bluhm, N. L. Gagne, R. Potting, and A. Vrublevskis, "Constraints and stability in vector theories with spontaneous Lorentz violation," *Physical Review D*, vol. 77, no. 12, 2008.

[18] V. A. Kostelecky, *Cpt And Lorentz Symmetry*, World Scientific, Singapore, 2002.

[19] A. Einstein, *Aether Und Reloativitatstheorie*, Spillger, Berlin, 1920.

[20] L. Kostro, *Einstein and the Ether Apeiron*, Apeiron, Montreal, 2000.

[21] F. Winterberg, "The Planck Aether model for a unified theory of elementary particles," *International journal of theoretical physics*, vol. 33, no. 6, pp. 1275–1314, 1994.

[22] S. H. Aronson, G. J. Bock, H.-Y. Chang, and E. Fishbach, "Energy dependence of the fundamental parameters of theK0 −K¯0system. II. Theoretical formalism," *Physical Review D*, vol. 28, no. 3, pp. 495–523, 1983.

[23] N. Grossman, K. Heller, C. James et al., "Measurement of the lifetime of KS0 mesons in the momentum range 100 to 350 GeV/c," *Physical Review Letters*, vol. 59, no. 1, pp. 18–21, 1987.

[24] "Bose-Einstein correlations in pp interactions at $\sqrt{s}=0.2$ to 0.9 TeV," *Physics Letters B*, vol. 226, no. 3-4, pp. 410–416, 1989.

[25] A. Enders and G. Nimtz, "On superluminal barrier traversal," *Journal de Physique*, vol. 2, no. 9, pp. 1693–1698, 1992.

[26] A. Enders and G. Nimtz, "Zero-time tunneling of evanescent mode packets," *Journal de Physique*, vol. 3, no. 5, pp. 1089–1092, 1993.

[27] A. Enders and G. Nimtz, "Evanescent-mode propagation and quantum tunneling," *Physical Review E*, vol. 48, no. 1, pp. 632–634, 1993.

[28] A. Ranfagni, D. Mugnai, P. Fabeni, and G. P. Pazzi, "Delay-time measurements in narrowed waveguides as a test of tunneling," *Applied physics letters*, vol. 58, p. 774, 1991.

[29] A. Ranfagni, P. Fabeni, G. P. Pazzi, and D. Mugnai, "Anomalous pulse delay in microwave propagation: a plausible connection to the tunneling time," *Physical Review E*, vol. 48, no. 2, pp. 1453–1460, 1993.

[30] C. Alley, "Quantum Optics, Experimental Gravitation, and Measurement Theory, Proceedings of the NATO Advanced Study Institute on Quantum Optics and Experimental General Relativity. August 1981, Bad Windsheim, Germany," in *Proper time experiments in gravitational fields with atomic clocks, aircraft, and laser light pulses*, P. Meystre and M. O. Scully, Eds., vol. 94 of NATO Science Series: B, pp. 363–427, Plenum Press, New York, 1983.

[31] F. Cardone, R. Mignani, and R. Scrimaglio, "New experimental results on the lower limits of local Lorentz invariance," *Foundations of Physics*, vol. 36, no. 2, pp. 263–290, 2006.

[32] A. Petrucci, A. Rosada, and E. Santoro, "Asymmetric neutron emissions from sonicated steel," *Modern Physics Letters B*, vol. 29, no. 14, p. 1550067, 2015.

[33] F. Cardone, V. Calbucci, and G. Albertini, "Deformed SPACE-TIME of the piezonuclear emissions," *Modern Physics Letters B*, vol. 28, no. 2, article 1450012, 2014.

[34] J. Beringer, "Review of particle physics," *Chinese Physics C*, vol. 38, no. 9, article 090001, 2014.

[35] F. Cardone, W. Perconti, and A. Petrucci, "Lorentz violation, cosmic microwave background radiation anisotropy and critical energy density of the Universe," *ournal of Advanced Physics*, vol. 7, no. 1, pp. 81–87, 2018.

[36] G. Albertini, D. Bassani, and F. Cardone, "Two questions about a non-flat nuclear space-time," *The European Physical Journal Plus*, vol. 133, no. 2, p. 39, 2018.

[37] R. Brout and F. Englert, "Spontaneous symmetry breaking in gauge theories: a historical survey," 1998, https://arxiv.org/abs/hep-th/9802142.

[38] "Umberto Bartocci (Perugia University) personal communications (1996-97)".

[39] S. Marinov, "The velocity of light is direction dependent," *Czechoslovak Journal of Physics B*, vol. 24, no. 9, pp. 965–970, 1974.

[40] A. Pais, *Subtle Is the Lord: the Science and the Life of Albert Einstein*, Oxford University Press, 2005.

[41] R. Jakiw, "Sheldon Glashow (Harvard) and the late Sydney Coleman," in *Personal communications*, Harvard, 2000.

[42] R. Mignani, F. Cardone, and A. Petrucci, "Metric gauge fields in deformed special relativity," *Electronic Journal of Theoretical Physics*, vol. 10, no. 29, pp. 1–20, 2013.

[43] F. Cardone, G. Albertini, and D. Bassani, "Lorentz violation in torsional antenna," *Foundations of Science*, vol. 27, pp. 43–55, 2022.

[44] B. Altschul, "Improved bounds on Lorentz symmetry violation from high-energy astrophysical sources," *Symmetry*, vol. 13, no. 4, p. 688, 2021.

[45] W. Bietenholz, "Cosmic rays and the search for a Lorentz invariance violation," *Physics Reports*, vol. 505, no. 5, pp. 145–185, 2011.

[46] I. Szapudi, A. Kovács, B. R. Granett et al., "Detection of a supervoid aligned with the cold spot of the cosmic microwave background," *Monthly Notices of the Royal Astronomical Society*, vol. 450, no. 1, pp. 288–294, 2015.

[47] K. Gödel, "An example of a new type of cosmological solution of Einstein's field equations of gravitation," *Reviews of Modern Physics*, vol. 21, no. 3, pp. 447–450, 1949.

[48] M. P. Ryan and L. Shepley, *C "Homogeneous Relativistic Cosmologies"*, Princeton University Press, Princeton, 1975.

[49] D. Saadeh, S. M. Feeney, A. Pontzen, H. V. Peiris, and J. D. McEwen, "How isotropic is the Universe?," *Physical review letters*, vol. 117, no. 13, article 131302, 2016.

[50] M. R. Wilczynska, J. K. Webb, M. Bainbridge et al., "Four direct measurements of the fine-structure constant 13 billion years ago," *Science Advances*, vol. 6, no. 17, 2020.

[51] S. Bellucci, F. Cardone, and F. Pistella, "A new insight on physical phenomenology: a review," *Symmetry*, vol. 13, no. 4, p. 607, 2021.