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# Pre-Big Bang, fundamental Physics and noncyclic cosmologies

## Possible alternatives to standard concepts and laws

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**Abstract.** Detailed analyses of WMAP and Planck data can have significant implications for noncyclic pre-Big Bang approaches incorporating a new fundamental scale beyond the Planck scale and, potentially, new ultimate constituents of matter with unconventional basic properties as compared to standard particles. Cosmic-ray experiments at the highest energies can also yield relevant information. Hopefully, future studies will be able to deal with alternatives: i) to standard physics for the structure of the physical vacuum, the nature of space-time, the validity of quantum field theory and conventional symmetries, the interpretation of string-like theories...; ii) to standard cosmology concerning the origin and evolution of our Universe, unconventional solutions to the cosmological constant problem, the validity of inflationary scenarios, the need for dark matter and dark energy... Lorentz-like symmetries for the properties of matter can then be naturally stable space-time configurations resulting from more general primordial scenarios that incorporate physics beyond the Planck scale and describe the formation and evolution of the physical vacuum. A possible answer to the question of the origin of half-integer spins can be provided by a primordial spinorial space-time with two complex coordinates instead of the conventional four real ones, leading to a really new cosmology. We discuss basic questions and phenomenological topics concerning noncyclic pre-Big Bang cosmologies and potentially related physics.

## 1 Introduction

WMAP [1] and Planck [2] data, together with ultra-high energy cosmic-ray (UHECR) experiments like AUGER [3] and JEM-EUSO [4], can open the way to new phenomenology concerning possible physics and cosmology beyond the Planck scale. They can test the standard Big Bang model and the standard picture of particle physics, but also less conventional approaches incorporating pre-Big Bang cosmologies, violations of relativity and quantum mechanics, breaking of energy and momentum conservation, new space-time configurations and possible ultimate constituents of the standard matter obeying a new dynamics. A theoretical hint on the practical feasi-

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bility of such a program has been provided, using WMAP data, by the claim [5] that the cosmological sky would be a weakly random one with mostly regular signal. This work has been followed by interesting and useful controversies and analyses [7].

Detailed studies of WMAP and Planck data can lead to tests of pre-Big Bang theories, not only in the case of cyclic cosmologies as considered by Gurzadyan and Penrose, but also for noncyclic ones. Noncylic pre-Big Bang cosmological patterns can incorporate a new fundamental scale beyond (or replacing) the Planck scale and/or an initial cosmic singularity, as well as new forms of matter (or pre-matter) with unconventional properties [8] and a new space-time structure.

More generally, alternatives to standard particle physics can be studied from a cosmological point of view for the structure of the physical vacuum, the nature and properties of space-time, the origin and evolution of our Universe, the validity of quantum physics and conventional symmetries including relativity... The notion of matter itself, such as described by quantum mechanics (QM) and quantum field theory (QFT) [9], is then to be challenged. UHECR can also be sensitive to new physics beyond Planck scale [10,11] and particle interactions can be modified. Standard gravitation [12] can similarly cease to be valid, possibly leading to observable effects [13]. The fate of the Planck scale in such scenarios would be far from obvious.

New solutions to the cosmological constant problem can then be explored beyond standard quantum field theory (SQFT) and standard space-time, together with alternatives to existing inflationary scenarios as well as to the usual cosmic dark matter and dark energy patterns, or to string-like theories. In such new Physics and Cosmology, space-time symmetries of the Lorentz type for the properties of matter (standard or superbradyonic [14,15]) can naturally emerge in the early evolution of our Universe as stable space-time configurations well adapted to the evolving structure and interaction properties of matter and vacuum while other metric configurations would generate vacuum instabilities [10,17]. Because of its lower cost in energy for a given momentum scale, standard Lorentz symmetry would be more stable [14] than a superbradyonic Lorentz-like symmetry with critical speed in vacuum $c_s \gg c$ (speed of light). But superbradyons may have governed an earlier phase of the Universe.

Even more primordial is the question of the origin of half-integer spins, that cannot be generated through internal orbital angular momentum in the usual real space-time. It has been pointed out [8] that the use of a spinorial space-time [16,17] with two complex coordinates instead of the conventional four real ones presents several potential advantages. Not only to naturally describe half-integer spins, but also to build a new basic cosmology. Taking the cosmic time to be the modulus of a SU(2) spinor incorporates a cosmic time origin and automatically leads by purely geometric means to a naturally expanding universe [17,18]. The ratio between cosmic relative velocities and distances is equal to the inverse of the age of the Universe. Such a result, equivalent to the well-known Lundmark - Lemaître - Hubble (LLH) law [19], is obtained without any reference to standard matter and radiation, hidden fields, gravitation, relativity, quantum mechanics... The value of the LLH constant thus obtained seems reasonable from a phenomenological point of view. The global pattern is really new but not in contradiction with present observational data and analyses.

In this contribution, we discuss basic ideas, conceptual problems and phenomenological issues for noncyclic pre-Big Bang cosmologies within the context just described.

## 2 Beyond Big Bang and Planck scale

More than eighty years after the Big Bang hypothesis formulated by Georges Lemaître [25] in 1931, WMAP and Planck data may allow to explore the origin of the Universe, as well as the structure of matter and space-time, beyond the primeval quanta he postulated as *The Beginning of the World*. Studies of the cosmic microwave background radiation (CMB) are expected to play a crucial role in this unprecedented task. The existence of the CMB was predicted theoretically in 1948 [26] and discovered experimentally [27] more than thirty years after Lemaître's work. Systematic CMB explorations are more recent [28]. As considered in [29] and discussed in [11], UHECR studies can also contribute with relevant data and analyses. It is not yet clear if the observed fall of the UHECR flux can be related to the Greisen - Zatsepin - Kuzmin (GZK) cutoff or results from other phenomena [10,30].

In his 1931 paper, Georges Lemaître wrote: *"Now, in atomic processes, the notions of space and time are no more than statistical notions: they fade out when applied to individual phenomena involving but a small number of quanta. If the world has begun with a single quantum, the notions of space and time would altogether fail to have any meaning at the beginning; they would only begin to have a sensible meaning when the original quantum has been divided into a sufficient number of quanta"*. This argumentation, formulated just after the birth of quantum mechanics, assumes QM to hold at the ultimate space-time scale and standard particles to be the ultimate fundamental objects. Lemaître's hypothesis does not allow by itself to define initial space and time scales. In standard cosmology, only space and time above the Planck scale are considered except for possible formal extrapolations from conventional particle physics in models defined at larger space and time scales.

The patterns and ideas discussed here are attempts to consider the possible content and evolution of the Universe below the Planck distance scale and before Planck time. They incorporate alternatives to standard relativity and QM, as well as possible new fundamental particles or pre-particles (objects existing before QM applies).

Basic equations of conventional cosmology should then be reconsidered, such as the well-known Friedmann relation [31,32]:

$$H^2 \ = \ a_s^{-2}(da_s/dt)^2 = 8\pi G\rho/3 \ - \ kc^2 a_s^{-2} \ + \ \Lambda\, c^2/3 \qquad (1)$$

where $H$ is the usual LLH constant describing the ratio between relative speeds and distances at cosmological scale, $a_s$ the space-like scale factor, $G$ the gravitational constant, $\rho$ the energy density, $k$ the curvature parameter and $\Lambda$ the cosmological constant. In this formula, leaving aside the cosmological constant term that can be removed by a redefinition of $\rho$ [31], the explicit dependence on $c$ disappears using instead of $a_s$ the time-like scale factor $a_t \ = \ a_s\ c^{-1}$. The term $8\pi G\rho/3$ involving a standard coupling to gravitation is in all cases characteristic of the conventional properties of "ordinary" matter. The situation can be radically different with the spinorial space-time considered in Sect. 4.

As explained in Sect. 4, the second Friedmann equation :

$$a_s^{-1} d^2 a_s/dt^2 = -4/3\ \pi G\ (\rho + 3p_U c^-2) \ + \ \Lambda\, c^2/3 \qquad (2)$$

where $p_U$ is the pressure parameter, must equally be reconsidered if the spinorial space-time is used as the startpoint of a new cosmology.

WMAP data [33] are usually presented as confirming the validity of standard cosmology. But the phenomenological analyses supporting this claim concern only general features, use *a priori* parameterizations and lead to large amounts of unidentified cosmic dark matter and dark energy. Even following these schemes, there is no actual proof that such unknown matter and energy have conventional properties and do not originate from a pre-Big Bang evolution involving totally new physics.

Similarly, there is no reason why the observable effects usually attributed to standard inflation should have been generated after the Big Bang. A pre-Big Bang phase can produce a similar expansion more naturally [8], and even replace the Big Bang itself by a theory involving new matter and/or pre-matter [15,17].

A pre-Big Bang scenario based on string models has also been suggested [34]. But, as stressed in [18,35], it is well known that strings can be the expression of an underlying composite structure [36]. Therefore, they may no longer make sense below some critical distance and time scales or even be deformed by compositeness and new physics well above these scales. Deformations of relativity and QM can be detectable at the highest cosmic-ray energies if a privileged local rest frame exists [29,35].

### 2.1 Superbradyons

Contrary to early models of matter beyond standard particles that used preons as mere building blocks with similar properties to those of quarks, leptons and gauge bosons [37], the superbradyon hypothesis proposed in 1995 [14,15] suggests a basically new description of vacuum and particles. It is in particular assumed that the critical speed $c_s$ of the new preonic constituents is much larger than the speed of light $c$, just as $c$ is about a million times the speed of sound.

The physical vacuum is then a material medium ultimately made of the new fundamental constituents of matter (the superbradyons), where conventional particles can exist as excitations similar to phonons, solitons... In a limit where the usual kinematical concepts would still make sense, a simple choice for the relation between energy ($E_s$), momentum ($p_s$) and velocity ($v_s$) of a superbradyon would be:

$$E_s \ = \ c_s \ (p_s^2 \ + \ m_s^2 \ c_s^2)^{1/2} \tag{3}$$

$$p_s \ = \ m_s \ v_s \ (1 \ - \ v_s^2 \ c_s^{-2})^{-1/2} \tag{4}$$

where $m_s$ is the superbradyon mass. Standard special relativity can then be compared to the low-momentum limit of the phonon kinematics obtained from a simple monoatomic one-dimensional Bravais lattice in a solid where superbradyons would be the basic constituents [29]. In a solid, the kinematics of low-momentum phonons exhibits a relativistic symmetry with the speed of sound as the critical speed.

As emphasized in [17], the actual superbradyonic properties can be substantially different from standard particle physics concepts including QM, and superbradyons are just an illustrative example of the possible unconventional properties of new physics beyond the standard Planck scale. Such a scale may then just disappear.

The choice of a Lorentz metric for superbradyons with $c_s$ as the critical speed in vacuum is a simple one, and appears natural if the notion of free particle still applies. Other space-time metrics can produce vacuum instabilities [8,38], for instance if zero-energy states can have nonzero momentum as it would be the case with a Euclidean space-time metric. A preferred local reference frame (the "vacuum rest frame", VRF) is necessary in order to simultaneously describe superbradyons and "ordinary" particles (those with a critical speed in vacuum equal to $c$).

The VRF will then be a basic and permanent ingredient of such new physics and cosmology. Gravitation would be a composite phenomenon and we expect its properties to be seriously modified above some critical energy scale. Superbradyons can be very weakly coupled to standard gravitation, especially at low energy where strong bounds on standard Lorentz symmetry violation (LSV) exist. Even in this case, if the graviton and conventional particles are not elementary objects, we expect conventional black hole dynamics to be substantially modified.

A superbradyonic phase in the genesis of the Universe would remove the need for inflation, not only because of the superluminal speeds involved but also because the monopole problem disappears if SQFT does no longer hold. Instead of the conventional Big Bang, an initial cosmic superbradyonic phase can thus lead the expansion of the early universe before standard matter is formed and becomes dominant. Other kinds of pre-Big Bang (and pre-matter?) phases can produce similar effects.

If superbradyons can exist in our Universe as free particles with speeds larger than $c$, they are expected to spontaneously emit "Cherenkow" radiation in the form of standard particles [14,39]. Remnant superbradyons with a speed close to $c$ can then form a cosmological sea and a new dark matter and/or dark energy component [10,17]. Superbradyon decays can also contribute to the UHECR flux [39,40].

### 2.2 A possible new approach to quantum field theory

In SQFT, the vacuum is an effective medium where the fields associated to standard particles can condense. But the origin and the deep content of this *ad hoc* vacuum remain unclear, and standard fields associated to conventional particles govern its apparent dynamics. In particular, it is impossible to obtain any experimental information on the internal structure of such a vacuum in the absence of free (not confined in vacuum) conventional matter. Similarly, SQFT is based on postulated local gauge symmetries where the existence of gauge bosons is required by invariance under local symmetry transformations. Such gauge bosons, as well as the scalar bosons, are assumed to have harmonic-oscillator zero modes. But the actual presence in vacuum of the zero modes of QFT bosons at all frequencies, as required by SQFT, cannot be tested experimentally in the absence of free standard particles.

If the vacuum is made of superbradyonic matter and standard particles are just vacuum excitations, standard gauge theories and conventional symmetries (including Lorentz symmetry) will provide only a sectorial low-energy limit of particle physics. At very small distances, the vacuum is expected to appear as a superbradyonic medium. Taking for simplicity a lattice description of the superbradyonic structure, our conventional gauge interactions can at the origin be associated to nearest-neighbour couplings (local potentials) describing the interaction between different superbradyonic local excitation modes. Quantum mechanics would not necessarily apply at these scales, and the virtual standard particles of SQFT would not yet be needed.

It is therefore perfectly conceivable [38,41] that a new kind of dynamics be at work, at a more fundamental level than the standard vector and scalar boson fields associated to the conventional gauge forces. In this case, it may happen that SQFT vector bosons be generated from the superbradyonic matter and degrees of freedom only in specific situations. Basicallly, when the superbradyonic nearest-neighbour couplings turn out to depend on position, time and direction due to the material presence of propagating vacuum excitations (the standard particles) involving the same family of local excitation modes of the superbradyonic matter. In the absence of surrounding conventional particles, the vacuum structure and interaction properties can thus be different from that suggested by SQFT concerning standard field condensates.

Then, the Higgs boson and the zero modes of bosonic harmonic oscillators would not need to be permanently materialized in vacuum at all frequencies or in the absence of standard particles. The cosmological constant problem may be naturally solved in this way, as usual QFT calculations would no longer apply.

It then also follows that the present situation leaves room for theories beyond SQFT with possible implications at energies nowadays available for direct measurements, including at accelerator experiments. As the computation of Feynman diagrams at high energy is a difficult task [42] and experimental error bars cannot be neglected, existing deformations of SQFT whose strength would increase with energy may have escaped data analyses. The standard particle theory can then fail at ultra-high energy. Alternative interpretations of SQFT also exist [43] and can potentially lead to new approaches to QFT. Possible connections with the ideas dealt with here deserve further attention if a new alternative theory is to be considered.

## 3 Symmetries, Planck scale, pre-Big Bang

As just discussed, in the scenarios considered here: i) QFT, including renormalization and the calculation of Feynman diagrams, is expected to undergo modifications at high energy [8,10]; ii) quantum mechanics, relativity and other currently admitted principles of Physics will not necessarily hold at the Planck scale or even before reaching it [17,38]. But the concept of symmetry itself is also questioned: the apparent symmetries of standard particle physics can reflect basically our lack of knowledge of the deepest structure of particles and vacuum. It is often assumed that the standard symmetries of particle physics should look more and more exact as the energy scale considered increases and masses can be neglected as compared to the energies involved. But it may actually happen that, above some transition energy well below Planck scale, the situation changes and observable tracks from new physics generated at the Planck scale and beyond become increasingly important [17,44]. Standard physics dealt with at accelerators would then become less and less relevant.

Thus, the standard concept of symmetry can be just a mathematical construction to account for the intrinsic limitations of our low-energy view of matter. Particles whose internal differences at a very small distance scales cannot be observed through existing experiments are described as "identical" in the sense of symmetry. Similarly, as the Planck scale is no longer an absolute reference, it may happen that grand unification of standard symmetries and interactions never occurs. A new critical scale different from Planck can then exist, playing the role of an effective fundamental scale for physics and cosmology in our present Universe. Such a scale can be numerically not too different Planck scale, or look more like the expression of an initial singularity.

In this context, two kinds of pre-Big Bang scenarios can in particular be considered: i) a pre-Universe made of the actual ultimate constituents of matter and ruled by their own dynamical laws; ii) an initial singularity followed by a process generating a new version of the "primeval quanta" [25] of the Big Bang. The initial singularity in ii) can actually correspond to a nucleation inside the pre-Universe of i). As already stressed, the Big Bang itself can then be replaced by a superbradyon era [15,18] with a transition to standard matter at a lower temperature, thus providing a direct alternative to inflation [15,35]. Similarly, if superbradyons are weakly coupled to gravitation as usually assumed, the new vacuum structure can naturally avoid standard drawbacks like the cosmological constant problem. The space-time geometry is crucial for the study of pre-Big Bang patterns and can lead to unexpected modifications of conventional views concerning the origin and evolution of our Universe.

## 4 A spinorial space-time

It is well known that spin-1/2 particles do not belong, strictly speaking, to representations of the standard Lorentz group such as it can be defined using four real space-time coordinates. The situation is similar if only the three real space dimensions are considered with the standard rotation group. In particular, a 360 degrees rotation acting on a half-integer spin wave function is well known to change the sign of the spinor. As spin-1/2 particles exist in our Universe, it may seem compelling to build a picture of space and time directly compatible with such an evidence.

Then, rather than using *ad hoc* solitons, the most natural description of space-time would be a primordial spinorial one [16,17] incorporating, at least, a space-like SU(2) symmetry group [38]. With these minimal hypotheses, taking a preferred reference frame (the VRF) as suggested by cosmological data (and furthermore required if superbradyons exist as ultimate constituents of matter), a cosmic time can be defined.

### 4.1 Space, time and transformations

Given a space-time SU(2) spinor $\xi$, and considering the positive SU(2) scalar $\mid \xi \mid^2 = \xi^\dagger \xi$ where the dagger stands for hermitic conjugate, a definition of the cosmic time can be $t \ = \ \mid \xi \mid$ with an associated space given by the $S^3$ hypersphere $\mid \xi \mid \ = \ t$.

Then, if $\xi_0$ is the observer position on the $\mid \xi \mid = t_0$ hypersphere, space translations inside this hypersphere correspond to SU(2) transformations acting on the spinor space, i.e. $\xi \ = \ U \ \xi_0$ where:

$$U \ = \ exp \ (i/2 \ \ t_0^{-1} \ \sigma.\mathbf{x}) \ \equiv U(\mathbf{x}) \tag{5}$$

$\sigma$ is the vector formed by the usual Pauli matrices, and the vector $\mathbf{x}$ thus defined is the spatial position of $\xi$ with respect to $\xi_0$ at constant time $t_0$. $\mathbf{x}$ is clearly different from the spinorial position that can be defined as $\xi \ - \ \xi_0$.

Space rotations with respect to a fixed point $\xi_0$ are obtained as SU(2) transformations acting on the spatial position vector $\mathbf{x}$. A standard spatial rotation around $\xi_0$ is now a SU(2) element $U(\mathbf{y})$ turning any $U(\mathbf{x})$ into $U(\mathbf{y}) \ U(\mathbf{x}) \ U(\mathbf{y})^\dagger$. The vector $\mathbf{y}$ provides the rotation axis and angle.

The origin of our time can be associated to the point $\xi \ = \ 0$. This leads in particular to a naturally expanding Universe where cosmological comoving frames would be described by straight lines crossing the origin $\xi \ = \ 0$.

Contrary to the mathematical structure of the standard Poincaré group, the spinorial space-time transformations just described incorporate space translations and rotations in a single compact group. Thus, the assumptions that led to the Coleman-Madula theorem [45] concerning possible unifications of space-time transformations with internal symmetries do not apply in the present case [17].

Such a description of space-time can be compared to a SO(4) approach where, instead of being imaginary, the cosmic time would be given by the modulus of a four-vector [17] obtained from the four real components of $\xi$. The spinor space considered is also in a sense similar to the subset of null (zero-norm) vectors in a SO(4,1) pattern where the fifth dimension would be the cosmic time $t$, and the metric:

$$X^2 \ = \ \xi^\dagger \xi \ - \ t^2 \tag{6}$$

$X$ being the 5-vector formed by the four real components of the space-time and $t$.

### 4.2 Cosmological implications

The above geometry, when applied to relative velocities and distances at cosmic scale for comoving frames, automatically yields the LLH law with a LLH constant (the velocity/distance ratio) equal to the inverse of the age of the universe. If $\theta$ is a constant angular distance between two cosmological comoving frames, the $S^3$ spatial distance $d$ between the two corresponding points on the $\mid \xi \mid \ = \ t$ hypersphere will be $d \ = \ \theta \ t$, and the relative velocity $v \ = \ \theta$. The ratio between relative velocities and distances is then given by $t^{-1}$. $t$ is actually the only time scale available.

This value is in reasonable agreement with present observations while matter, radiation, standard relativity, gravitation and specific space units have not yet been introduced in our description of space-time. It would correspond to a situation essentially different from equation (1), with no matter density and a positive term $t^{-2}$ instead of $- \ kc^2 a_s^{-2} \ + \ \Lambda \ c^2/3$. There is no track of the standard general-relativistic explicit curvature term using such a spinorial space-time, where the space is positively curved and spin-1/2 orbital wave functions are allowed. The cosmological constant term also disappears. The same result would be obtained with other power-like definitions of cosmic time if simultaneously the associated space scale is suitably defined. Similarly, it can be readily checked that the equivalent of equation (2) becomes:

$$dH/dt \ + \ H^2 \ = \ 0 \tag{7}$$

implying $\Lambda = 0$ in a naive comparison between both equations.

The speed of light plays no special role in this geometric construction where no specific velocity or distance scale is defined at the present stage and space dimensions are described in time units. The overall spatial domain considered can naturally be much larger than our conventional Universe where standard matter has been formed. In such a situation, the effective global density of standard matter can be very weak at the actual cosmological scale defined by the spinorial space-time. For similar reasons, the effective space curvature of the Universe as measured in our observations would be much smaller than naively expected for $k \ = \ 1$ in equations like (1).

The spinorial space-time would therefore be particularly well suited for a pre-Big Bang (superbradyonic?) scenario. If the vacuum is made of superbradyonic matter (or pre-matter), the actual size of the Universe can indeed be much larger than the estimated size of the conventional observable Universe, and the nucleated standard matter may occupy only a very small part of the space just defined.

In the spinorial space-time presented here, standard Lorentz symmetry can exist as an approximate (low momentum) local space-time structure for conventional matter, similar to the situation for phonons in a solid (see Sect. 2). Then, general relativity can also remain valid as a low-energy limit in our standard Universe.

We are simultaneously assuming that the cosmic time considered in this chapter is not fundamentally different from the age of the standard matter Universe where we live. There is by now little observational difference between the measured Hubble constant and the inverse of the estimated age of the Universe.

If the LLH expansion of the Universe is not generated by gravitation and geometry through (1), and if instead a spinorial space-time is leading it at a much larger cosmological distance scale, it is tempting to conjecture that the usually postulated dark energy is not necessarily required to explain the observed acceleration of the expansion of our Universe. Gravitational and other standard effects can possibly account for past fluctuations of the velocity/distance ratio [17,18], and there is no obvious reason for the expansion of our Universe to keep accelerating in the future.

A specific cosmological property of such a spinorial space-time is [17] that to each point $\xi$, a privileged space direction can be associated at cosmic scale through the subspace where for any point $\xi'$ one has:

$$\xi^\dagger \ \xi' \ = \ \mid \xi' \mid \ \ \mid \xi \mid \ \ exp \ (i\phi) \tag{8}$$

and $exp \ (i\phi)$, with $\phi$ real, stands for a complex phase. This subspace is generated using a $\sigma$ matrix of which $\xi$ is an eigenstate. Then, the privileged space direction is obtained by multiplying $\xi$ by an arbitrary complex phase.

### 4.3 Half-integer spins

Although the spinorial relative position $\xi \ - \ \xi_0$ corresponds to a path through past times violating standard causality, and the experimental production of half-integer orbital angular momenta has never been reported, such a position spinor can make sense at very small distance and time interval scales (see the *arXiv.org* Post Scriptum to [17]). Using the spinor $\xi - \xi_0$ in the wave function, it would be possible to generate the spin 1/2 as an actual internal orbital momentum in a composite picture of quarks and leptons. A pre-Big Bang cosmology would also incorporate this kind of structure. Then, the ultimate constituents of matter would not need to carry spin.

In such a context, half-integer spin can be interpreted as an evidence for causality violating physics or some equivalent change in space-time structure at the ultimate length and space scales. The spinorial space-time would then be crucial for the understanding of the structure of matter or pre-matter beyond SQFT.

This SU(2) approach to space-time and its natural SL(2,C) extension can potentially open the way to a new unification between space-time and internal symmetries [17] as far as particle symmetries will make sense. Such a new unified symmetry may in turn provide indirect checks of the spinorial space-time pattern suggested.

## 5 Conclusion

If the standard elementary particles are not really elementary, and if a pre-Big Bang era has preceded and modified the evolution of the Universe described by standard cosmology, our knowledge of particle physics and cosmology remains by now preliminary and possibly far from the actual fundamental laws.

As the really primordial objects and phenomena would then remain to be discovered and studied, an adapted strategy seems necessary. In particular:

- New missions following WMAP and Planck are required in order to extract as much as possible information on our early universe, allowing in particular to systematically search for signatures of possible pre-Big Bang phenomena.

- Similarly, a new generation of UHECR experiments should explore the highest cosmic-ray energies where possible violations of standard principles and new physics generated beyond Planck scale can produce detectable effects.

- Special phenomenological and experimental work should also be devoted to a systematic check of the numerical validity of SQFT at high energy, including at accelerators. Searches for superbradyon-like objects and LSV signatures in high-energy accelerator experiments must also be performed.

Thus, the three main experimental tools of particle physics and cosmology can contribute to this crucial and unique exploration.

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