Quantum Mechanics, space-time, preons and entanglement

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In two previous papers, we discussed the possible origin of Quantum Mechanics from a contradiction between the space-time geometry as seen locally at the preonic level inside vacuum, and the macroscopic space-time used in standard physics. The implications of the spinorial space-time (SST) at cosmic and local levels were given particular attention and were used as a mathematical illustration, but other possibilities were also considered. This crucial role of preon dynamics naturally includes a possible superbradyonic structure of vacuum, with a preonic critical speed much larger than the speed of light c . We discuss here the expected role of superluminal preons inside the physical vacuum in connection with entanglement and the violation of Bell inequalities.

1. Introduction

In [1, 2], we completed the reflexion developed in [3, 4] on the possible origin of Quantum Mechanics from a preonic vacuum with a specific space-time geometry. It turns out that Quantum Mechanics can then be the dynamical expression of a contradiction between the space-time structures at the local preonic level and in the macroscopic world. The spinorial space-time (SST) was used to provide an explicit example of such a space-time contradiction [1, 4].

It was simultaneously emphasized, as already in [5, 6] and in subsequent papers, that if the standard "elementary" particles are actually excitations of a more fundamental preonic vacuum structure, we do not expect the preon critical speed to be equal to the speed of light c . Just as the speed of light is much larger than that of sound in condensed matter, the critical speed of preons is expected to be much larger than c (the superbradyon hypothesis [5]).

In this note, we explicitly discuss the question of entanglement in such an unconventional preonic scenario. Even if the conclusion seems obvious for superbradyons, a clear statement on the subject appears appropriate in the present situation in view of the recent announcement by B. Hensen et al. [7] confirming entanglement and the violation of Bell inequalities [8].

2. Superluminal preons and Bell inequalities

In [4], the following question was explicitly raised about the origin of Quantum Mechanics:

"The subject of the origin of Quantum Mechanics is a very fundamental one and, by now, looks particularly mysterious. It therefore seems necessary to elucidate if it can be naturally understood in terms of a preonic (superbradyonic?) underlying vacuum structure and in the framework of a specific space-time geometry (the SST?)."

(end of quote)

Recent material [1, 2] seems to have provided a possible answer to these questions [9].

The space-time contradiction between preonic (inside vacuum) and conventional macroscopic worlds can lead vacuum dynamics to forbid continuous motion of the standard particles at the space-time scale where they are generated. Only discrete motion with various possible paths would thus be allowed.

A situation close to that described by the

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Feynman path integral at larger space-time scales would then arise, leading to the set up of Quantum Mechanics.

What can be, in this context, the situation concerning quantum entanglement?

2.1. Superbradyons and entanglement

In the approach considered here, preons are not "quark-like" constituents of the standard "elementary" particles. They are instead the basic constituents of the vacuum of which the standard particles are excitations. It is precisely this specific "condensed matter" scenario, that suggests a superluminal nature of preons as already considered in [5, 6].

A superbradyonic vacuum would then obviously violate a basic principle leading to the Bell inequalities: the requirement that any theory of Physics be "local" in the sense that no influence or information should propagate faster than light. But the authors of [7] report a clear violation of the CHSH-Bell inequality [10].

If preons are superluminal, faster-than-light propagation of signals and correlations in vacuum will necessarily be allowed. The speed of light will just not be a fundamental parameter of space, time and ultimate superbradyonic constituents inside the vacuum. As previously explained, the superbradyon critical speed c_s is expected to be much larger than c.

Therefore, a superbradyonic vacuum would be naturally consistent with the data announced by B. Hensen et al. If $c_s \simeq 10^6\ c$ (10^6 is the ratio between c and the speed of sound), the time scale associated to a distance of 1.3 Km would be $\simeq 4.10^{-12}$ seconds.

Thus, a superbradyonic vacuum can not only generate Quantum Mechanics but naturally produce entanglement.

3. Deformed quantum mechanics

If Quantum Mechanics is generated from a space-time contradiction between the preonic vacuum and the macroscopic world, a deformed version of Quantum Mechanics will hold at very high energy, close to the scale where it is initially created by vacuum dynamics. The usual quantum-mechanical equations of standard Physics will then be a low-energy limit.

Possible deformations of Quantum Mechanics have been considered, in particular, in [4, 11].

3.1. From the first preon models to a preonic vacuum

In [11], we remind and analyse this statement by Abdus Salam in his December 1979 Nobel lecture [12]:

"Einstein knew that nature was not economical of structures: only of principles of fundamental applicability. The question we must ask ourselves is this: have we yet discovered such principles in our quest for elementarity, to justify having fields with such large numbers of components as elementary.

Recall that quarks carry at least three charges (colour, flavour and a family number). Should one not, by now, entertain the notions of quarks (and possibly of leptons) as being composites of some more basic entities (PRE-QUARKS or PREENS), which each carry but one basic charge." (Salam cites here several articles)

These initial preon models were "quark-like", and attempted to better describe the variety of quantum numbers of the "elementary" particles by assuming quarks and leptons to be made of "more elementary" constituents. But the question whether the ultimate constituents of matter should really obey the same laws of Physics (standard relativity, quantum mechanics...) as quarks and leptons was only raised in [5, 6] and in our subsequent papers.

Similarly, the preons initially considered by Salam and other authors were direct constituents of the standard particles. The possibility that they actually be constituents of the physical vacuum, and the standard particles excitations of this vacuum, was an original suggestion of [5, 6] followed by [13, 14], [15] and subsequent work on the subject.

The approach presented here is therefore radically different from the initial preon models, and the deformation of Quantum Mechanics at high energy a logical consequence of the way this

law of standard paricles is generated. Similarly, we expect Quantum Gravity to be deformed at high energy and no longer make sense beyond the space and time scales where Quantum Mechanics begins to exist. The effects of the preonic vacuum on renormalization at high energy should also be taken into account.

4. Conclusion

The recently reported evidence for quantum entanglement car also be an evidence for a fundamental superbradyonic vacuum structure of which the standard "elementary" particles would be "condensed matter" excitations.

Further theoretical, experimental and observational work is obviously required, including the direct search for free superbradyons.

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