Local Lorentz Invariance violation and Quantum Mechanics

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John Stuart Bell, known for his inequalities by which he demonstrated once for all the intrinsic non-locality of quantum processes, pronounced the following sentence about quantum mechanics: "….*Those paradoxes* (Quantum Mechanics' paradoxes) *are simply disposed of by the 1952 theory of Bohm, leaving as The Question, the question of Lorentz Invariance. So one of my missions in life is to get people to see that if they want to talk about the problems of quantum mechanics - the real problems of quantum mechanics - they must be talking about Lorentz invariance.*" [1]
Indeed, also decades earlier, at the inception of quantum theory, Earnest Rutherford had made a subtle remark to Einstein about the quantum jump. He remarked that if a bound electron emits a photon of precise energy, it should know in advance to which state to jump to and that the apparent lack of this information seems to violate the principle of causality. This remark is one of the emblematic examples of the apparent lack of causality in quantum phenomena that, together with the other known examples showing non-locality, points directly at the heart of quantum mechanics that shall be conceived and formalised in the following years. However, despite the correctness of Bell's inequalities [2] and the experiments, like that of Alan Aspect [3], that corroborated them, I would like to try and put forward a *physical* picture for the clearly *non physical* concepts of non-locality and non-causality that are so fundamental in quantum phenomena and quantum mechanics.
I will show both theoretically and experimentally that in order to find the way to face these problems one has to deal with the principle of relativistic correlation and its violation that is, as John Bell said, to *talk about Lorentz Invariance* and its violation from a *physical* point of view. The principle of relativistic correlation implies that the time interval between the cause and the effect must be ever different from zero. In other words, the cause propagates in space at a velocity u that must be ever finite (locality) but in principle, I will show, is allowed to be unlimited (Lorentz violation) that is $u > c$. In this sense the *non physical* concept of *non-locality* is transformed into the more *physical* one of *non-Lorentzian-locality*. Besides, it will be shown that the violation of local Lorentz Invariance means also that local Space-Time has no longer a flat geometry (Minkowskian) and that, in this sense, it is deformed [4,5]. On this basis, I will show that it is the deformation of space-time that propagates at superluminal velocity, and that may be seen as playing the role of that cause that sometimes seems missing in quantum phenomena.
This is the framework in which we should be moving if we want to face *the real problems of quantum mechanics*.
I will present several phenomenological evidences of photon behaviour violating Lorentz Invariance and comment their results. I will briefly show two experiments carried out by the National Research Council by horn antennas in the microwave range of the electromagnetic spectrum. The first shows a superluminal propagation [6], the second an apparent lack of causality [7]. Then I will concentrate on an experiment performed at the university of L'Aquila and based on an idea of the late physicist Franco Selleri [8] who had proposed to modify an experimental suggestion of de Broglie and Andrade y Silva to measure the effect of the pilot wave. Three different runs of this experiment that complement and support each other were performed during three years. The experiment was designed on the indications of the theory of deformed Space-Time which studies the violation of Lorentz Invariance from the point of its effect on the metric of space-time. I will show that the results of this experiment have interesting interpretations that shed new light on the concept of pilot wave and the principle of complementarity [9,10,11,12]. Then I will present the results of an experiment carried out at the Institute of Optics of the National Research Council by orthogonally crossing to CO_2 laser beams [13] which showed an anomalous interference compatible with the violation of local Lorentz invariance and has the same energy parameter of

L'Aquila experiment. Besides, CCD images of the laser beam spot will also be presented with and without crossing of the two beams, and some comments will be given.
Eventually it will be shown that, although the results of the experiments with horn antennas maybe interpolated with Zenneck waves, a better fit may be obtained by the formalism of Deformed Space-Time theory [14].

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