**(2019) The UNBELIEVABLE similarities between Oreshkov et al.’s ideas/framework (2013) and my EDWs**

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[I investigate the UNBELIEVABLE similarities between the ideas of Oreshkov et al. and my ideas. In fact, their framework (the ontological background) is UNBELIEVABLE similar to my EDWs perspective!]

(2013) Ognyan Oreshkov1;2, Fabio Costa1, Cˇ aslav Brukner1;3, Quantum correlations with no causal order, at arXiv:1105.4464v3 [quant-ph] 14 Feb 2013

Abstract

The idea that events obey a definite causal order is deeply rooted in our understanding of the world and at

the basis of the very notion of time. But where does causal order come from, and is it a necessary property

of nature? We address these questions from the standpoint of quantum mechanics in a new framework for

multipartite correlations which does not assume a pre-defined global causal structure but only the validity of

quantum mechanics locally. All known situations that respect causal order, including space-like and time-like

separated experiments, are captured by this framework in a unified way. Surprisingly, we find correlations that

cannot be understood in terms of definite causal order. These correlations violate a ‘causal inequality’ that is

satisfied by all space-like and time-like correlations. We further show that in a classical limit causal order always

arises, which suggests that space-time may emerge from a more fundamental structure in a quantum-to-classical

transition.

[Obviously, “a new framework for multipartite correlations which does not assume a pre-defined global causal structure but only the validity of quantum mechanics locally” sends directly to the EDWs hyperontological background! Of course, the main notion of “correlations” is UNBELIEVALBE similar to my main notion: “correspondences” between entities that belong to EDWs!!! No more or less!]

But are space, time, and

causal order truly fundamental ingredients of nature? Is it possible

that, in some circumstances, even causal relations would

be ‘uncertain’, similarly to the way other physical properties

of quantum systems are [9]?

Here we show that quantum mechanics allows for such a

possibility. We develop a framework that describes all correlations

that can be observed by two experimenters under the

assumption that in their local laboratories physics is described

by the standard quantum formalism, but without assuming that

the laboratories are embedded in any definite causal structure.

These include non-signalling correlations arising from

measurements on a bipartite state, as well as signalling ones,

which can arise when a system is sent from one laboratory

to another through a quantum channel. We find that, surprisingly,

more general correlations are possible, which are

not included in the standard quantum formalism. These correlations

are incompatible with any underlying causal structure:

they allow performing a task—the violation of a ‘causal

inequality’—which is impossible if events take place in a causal sequence. This is directly analogous to the famous

violation of local realism: quantum systems allow performing

a task—the violation of Bell’s inequality [10]—which is

impossible if the measured quantities have pre-defined local

values. The inequality considered here, unlike Bell’s, concerns

signalling correlations: it is based on a task that involves

communication between two parties. Nevertheless,

it cannot be violated if this communication takes place in a

causal space-time. Previous works about relativistic causality

in quantum mechanics focused on non-signalling correlations

between space-like separated experiments or on a finite

speed of signalling [11–19]. In the present work we go beyond

such approaches since we do not assume the existence

of a space-time (or more generally of a definite causal structure)

on which the evolution of quantum systems and the constraints

given by relativity are defined. One of the motivations

for our approach comes from the problem of time in attempts

to merge quantum theory and general relativity into a more

fundamental theory [20–25]. (p. 1)

[The ideas of these paragaraphs are UNBELEIVABLE similar ideas to my ideas 2002-2007! It is about the correspondences between entities/processes that belong to EDWs, no more or less! My question is: “What was their ontological framework to elaborate these ideas??? I EMPAHSIZE that I was able to discover the EDWs working firstly on the mind-brain problem!!! Therefore, for me it seems to be impossible to discover the EDWs working on quantum mechanics (phenomena of QM)!!!]

Results

Causal inequality

The general setting that we consider involves a number of

experimenters—Alice, Bob and others—who reside in separate

laboratories. At a given run of the experiment, each of

them receives a physical system (for instance, a spin- 1

2 particle)

and performs operations on it (e.g. measurements or

rotations of the spin), after which she/he sends the system out

of the laboratory. We assume that during the operations of

each experimenter, the respective laboratory is isolated from

the rest of the world—it is only opened for the system to come

in and to go out, but between these two events it is kept closed.

It is easy to see that, under this assumption, causal order puts

a restriction on the way in which the parties can communicate

during a given run. For instance, imagine that Alice can send a

signal to Bob. [Formally, sending a signal (or signalling) is the

existence of statistical correlations between a random variable that can be chosen by the sender and another one observed by

the receiver.] Since Bob can only receive a signal through the

system entering his laboratory, this means that Alice must act

on her system before that. But this implies that Bob cannot

send a signal to Alice since each party receives a system only

once. Therefore, bidirectional signalling is forbidden. (pp. 1-2)

[Again, we are already within the EDWs!!! The “bidirectional signaling is forbidden” would mean, within my EDWs perspective, the “correspondences” - NOT CAUSALITIES - between EDWs! Is it clear now???]

Framework for local quantum mechanics

The most studied, almost epitomical, quantum correlations

are the non-signalling ones, such as those obtained when Alice

and Bob perform measurements on two entangled systems.

Signalling quantum correlations exist as well, such as

those arising when Alice operates on a system which is subsequently

sent through a quantum channel to Bob who operates

on it after that. The usual quantum formalism does not consider

more general possibilities, since it does assume a global

causal structure. Here we want to drop the latter assumption

while retaining the validity of quantum mechanics locally. For

this purpose, we consider a multipartite setting of the type outlined

earlier, where each party performs an operation on a system

passing once through her/his laboratory, but we make no

assumption about the spatio-temporal location of these experiments,

not even that there exists a space-time or any causal

structure in which they could be positioned (see Fig. 2). Our

framework is thus based on the following central premise: (p. 2)

Local quantum mechanics—The local operations

of each party are described by quantum mechanics.

More specifically, we assume that one party, say Alice, can

perform all the operations she could perform in a closed laboratory,

as described in the standard space-time formulation of

quantum mechanics. These are defined as the set of quantum

instruments [26] with an input Hilbert space HA1 (the system

coming in) and an output Hilbert spaceHA2 (the system going

out). (The set of allowed quantum operations can be used as

a definition of ‘closed quantum laboratory’ with no reference

to a global causal structure.) A quantum instrument can most

generally be realized by applying a joint unitary transformation

on the input system plus an ancilla, followed by a projective

measurement on part of the resulting joint system, which

leaves the other part as an output. (From the point of view

of each party, the input/output systems most generally correspond

to two subsystems of the Hilbert space associated with

the local laboratory, each considered at a di\_erent instant—the

time of entrance and the time of exit, respectively—where the

subsystems and the respective instants are independent of the

choice of operation that connects them.)…. In the case of more than one party, the set of local outcomes

corresponds to a set of CP maps MA i ;MBj ; \_ \_ \_ . A complete list of probabilities P \_MAi ;MBj; \_ \_ \_\_for all possible local outcomes will be called process. (p. 3)

[Again, we are here within a particular EW in which we can talk about the ‘retaining the validity of quantum mechanics locally”! The above paragraphs mirror EXACTLY the correspondences between EDWs!!!]

As argued earlier,

if all events are localized in a causal structure and Alice and

Bob perform their experiments inside closed laboratories, at

most unidirectional signalling between the laboratories is allowed.

In a definite causal structure, it may still be the case

that the location of each event, and thus the causal relation between

events, is not known with certainty…. We will call processes of this kind causally separable (note

that the decomposition (6) need not be unique since nonsignalling

processes can be included either in WB\_A or in

WA\_B). They represent the most general bipartite quantum

processes for which the local experiments are performed in

closed laboratories embedded in a definite causal structure.

In particular, they generate the most general quantum correlations

between measurements that take place at definite

(though possibly unknown) instants of time. Clearly, according

to the argument presented earlier, causally separable processes

cannot be used by Alice an Bob to violate the causal

inequality (2). (p. 4)

Classical processes are causally separable

It is not di\_cult to see that if the operations of the local

parties are classical, they can always be understood as taking

place in a global causal structure. (p. 5)

[Again, nothing more than EDWs!!!]

We have seen that by relaxing the assumption of definite

global causal order and requiring that the standard quantum

formalism holds only locally, we obtain the possibility for

global causal relations that are not included in the usual formulation

of quantum mechanics. The latter is reminiscent of

the situation in general relativity, where by requiring that locally

the geometry is that of flat Minkowski space-time, one

obtains the possibility of having more general, curved spacetimes.

The natural question is whether “non-causal” quantum correlations

of the kind described by our formalism can be found

in nature. One can speculate that they may exist in unprobed

physical regimes, such as, for example, those in which quantum

mechanics and general relativity become relevant. (p. 5)

Indeed, our result that classical theories can always be understood

in terms of a global causal structure suggests the possibility

that the observed causal order of space-time might

not be a fundamental property of nature but rather emerge

from a more fundamental theory [32–34] in a quantum-toclassical

transition due to, for example, decoherence [35] or

coarse-grained measurements [36]. Once a causal structure

is present, it is possible to derive relativistic space-time from

it under appropriate conditions [37, 38]. Furthermore, since

the conformal space-time metric is a description of the causal

relation between space-time points [39, 40], one can expect

that an extension of general relativity to the quantum domain

would involve situations where di\_erent causal orders could

coexist “in superposition”. The formalism we presented may

o\_er a natural route in this direction: based only on the assumption

that quantum mechanics is valid locally, it yields

causal relations that cannot be understood as arising from a

definite, underlying order.

It is also worth noting that exotic causal structures already

appear in the classical theory of general relativity. For example,

there exist solutions to the Einstein equation containing

closed time-like curves (CTCs) [41]. In this context, it should

be noted that any process matrix W in our framework can be

interpreted as a CPTP map from the outputs, A2, B2, of the

parties, to their inputs, A1, B1. In other words, any process can

be thought of as having the form of a CTC, where information

is sent back in time through a noisy channel (see also Fig. 1b).

The existence of processes that do not describe definite causal

order is therefore not incompatible with general relativity in

principle. It is sometimes argued that CTCs should not exist

since they generate logical paradoxes, such as an agent going

back in time and killing his grandfather. The possible solutions

that have been proposed [42–47], in which quantum

mechanics and CTCs might coexist, involve non-linear extensions

of quantum theory that deviate from quantum mechanics

already at the level of local experiments. Our framework, on

the other hand, is by construction linear and in agreement with

local quantum mechanics, and yet paradoxes are avoided, in

accordance with the Novikov principle [48], due to the noise

in the evolution ‘backward in time’. (p. 6)

[Again, nothing more than EDWs!!!! In my PhD thesis 2007 from UNSW (Australia), I indicated exactly the same situation and the relationship between QM and Einstein’s relativity (both special and general)!]

Finally we remark that instances of indefinite causal orders

may also emerge in situations closer to possible laboratory

implementations. As already noted, our formalism describes

more general correlations than those that can be realized with

a quantum circuit, that is, as a sequence of quantum gates.

Recently, a new model of quantum computation which goes

beyond the causal paradigm of quantum circuits by using superpositions

of the ‘wires’ connecting di\_erent gates was proposed

[49]. This possibility may allow breaking assumption

CS that events are localized in a causal structure. Since the

instant when a system enters a device depends on how the device

is wired with the rest of the computer’s architecture, superpositions

of wires may allow creating situations in which

events are not localized in time (similarly to the way in which

a quantum particle may not be localized in space). While it is

an open question whether violating the causal inequality (2)

can be achieved by similar means, the present work suggests

that new quantum resources for information processing might be available—beyond entanglement, quantum memories, and

even ‘superpositions of wires’—and the formalism introduced

provides a natural framework for exploring them. (p. 6)

[It is about EDWs, no more or less!!!!]