The Seventh Conference on Information Theory and Complex Systems
TINKOS 2019

BOOK OF ABSTRACTS

Belgrade, Serbia, October 15-16, 2019

Mathematical Institute of the Serbian Academy of Sciences and Arts
Institute of Physics Belgrade

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МИНИСТАРСТВО ПРОСВЕТЕ, НАУКЕ И ТЕХНОЛОШКОГ РАЗВОЈА

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Does 'the Old Man' play dice?

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Summary

In 1926, Einstein wrote to Born [1]: '*Quantum mechanics commands much respect. But an inner voice tells me that it is not Mr. Right. The theory delivers a lot, but it hardly brings us closer to the mystery of the Old Man. Anyway, I'm sure* he *does not play dice.*'

This quote carries the very essence of the 'quantum puzzle(s)' and provides an intimate link with the mathematical problem of interpretation of probability [2, 3, 4, 5]. In the narrower physical context, this is a never-ending debate about determinism versus randomness, which Einstein (like most of the working physicists) could not easily adopt for the 'simple' reason that 'pure randomness' seems to be elusive [5]–the concept of probability appears to be vague in the context of the *single* physical system. For this reason, it is widely believed that dynamics of a quantum ensemble can be 'unraveled', i.e. that carries at least one dynamically well-defined ensemble decomposition. More precisely, a ('mixed') quantum ensemble is imagined to consist of subensembles, each of which is in a uniquely-defined ('pure') quantum state that dynamically evolves in time independently of the others.

Much of the interpretations of quantum theory adopt the unraveling as assumed, if not explicitly introduced. Furthermore, the ensemble unraveling as briefly described above is essential also for some important quantum information processing [6]. However, quite recently, the absence of the ensemble unraveling has been put forward for an important class of the quantum linear dynamical processes (dynamical maps) [7].

For some typical quantum Markovian processes, it proves that the ensemble unraveling is *not* possible. Formally, the mixed ensembles appear basically equal with the 'pure' ensembles–every single element of the mixed ensemble is in the same mixed state for those quantum dynamical processes. This, technically simple, observation [7] unexpectedly revives and directs the old debate on whether or not 'the Old Man' plays dice.

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