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Cooperative Dynamical Processes: the Emergence of Relativistic Quantum Theory

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Scenarios that strive to describe quantum theory as an emergent, non-primitive concept typically run into difficulties when trying to address a relativistic generalization. In this talk we discuss a possible way out of this situation by showing that the observed relativistic behavior in the quantum world might well be just a statistically emergent phenomenon out of deeper no-relativistic level of quantum dynamics. We start by discussing complex dynamical systems whose statistical behavior can be explained in terms of a superposition of simpler underlying dynamics —the so-called superstatistics paradigm. Then we go on by showing that the combination of two cornerstones of contemporary physics —namely Einstein's special relativity and quantum-mechanical dynamics is mathematically identical to a complex dynamical system described by two interlocked processes operating at different energy scales. The combined dynamic obeys Einstein's special relativity even though neither of the two underlying dynamics does. This implies that Einstein's special relativity might well be an emergent concept in the quantum realm.

To model the double process in question, we consider quantum mechanical dynamics in a background space consisting of a number of small crystal-like domains varying in size and composition, known as polycrystalline space. There, particles exhibit a Brownian motion. The observed relativistic dynamics then comes solely from a particular grain distribution in the polycrystalline space. In the cosmological context such distribution might form during the early universe's formation.
Ensuing implications for quantum field theory and cosmology (leptogenesis) will be also briefly discussed.

Related articles:
[1] P. Jizba and F. Scardigli, Special Relativity Induced by Granular Space, Eur. Phys. J. C (2013) 73: 2491
[2] P. Jizba and F. Scardigli, The emergence of Special and Doubly Special Relativity, Phys. Rev. D (2012) 86: 025029
[3] P.Jizba and H. Kleinert, Superstatistics approach to path integral for a relativistic particle, Phys. Rev. D (2010) 82: 085016

Summary

Primary author: JIZBA, Petr (Czech Technical University in Prague)

Presenter: JIZBA, Petr (Czech Technical University in Prague)

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