香港浸會大學
HONG KONG BAPTIST UNIVERSITY
FACULTY OF SCIENCE

Department of Physics & Institute of Computational and Theoretical Studies

JOINT COLLOQUIUM

Emergent Quantum Properties in Classical Dynamical Systems

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3:30pm – 4:30pm (Tea will be served)
T909, Science Tower, HSH Campus

Abstract

Quantum mechanics had emerged as the result of a successful resolution of empirical and conceptual conflicts within the development of atomic physics at the beginning of the 20th century. One refractory problem, among many others, had been the particle-wave dualism of light and matter; and the core of its resolution was a new interpretation of the concept of "pure physical state", replacing phase space points with Hilbert space rays. As a consequence, physical observables are called "complementary" when a pure state cannot be a common eigenstate of both observables, which is not possible in classical physics where pure states (i.e. phase space points) are always common eigenstates of every observable.

At a first glance, it therefore seems to be rather bizarre to apply concepts of quantum physics, such as complementarity or entanglement, to the description of classical dynamical systems as all classical observables are compatible with each other - which is the defining property of a classical system. However, a closer look shows that physical systems, either classical or quantal, can be described at different "epistemic levels". Pure states as referents of an "ontic" description may not be accessible with precise accuracy through physical measurement at an "epistemic" description. Therefore, statistical states are considered here which are probability distributions over phase space in classical physics.

If one takes such statistical states into account, the situation could change drastically. Then, the concept of a quantum mechanical eigenstate applies straightforwardly to an operationally restricted state space resulting from a phase space coarse-graining into equivalence classes. This "epistemic quantization" of classical dynamical systems introduced by [1-3] can be nicely illustrated for the complementarity of momentum and position of a classical harmonic oscillator. Moreover, coupling two oscillators together allows the introduction of "epistemically pure" states which might appear as mixtures through system separation, thereby exhibiting "emergent entanglement".

Finally, those findings might be relevant for the interpretation of coarse-grained neurodynamical systems in terms of cognitive computations [4] and the explanation of "quantum cognition" phenomena through bounded rationality [5].

References:

[1] beim Graben, P. & Atmanspacher, H. (2006). Complementarity in classical dynamical systems. Foundations of Physics, 36, 291 - 306.

[2] beim Graben, P. & Atmanspacher, H. (2009). Extending the philosophical significance of the idea of complementarity. In: Atmanspacher, H. & Primas, H. (Eds.) Recasting Reality. Wolfgang Pauli's Philosophical Ideas and Contemporay Science, Springer, 99 - 113.

[3] beim Graben, P.; Filk, T. & Atmanspacher, H. (2013). Epistemic entanglement due to non-generating partitions of classical dynamical systems. International Journal of Theoretical Physics, 52, 723 - 734.

[4] beim Graben, P. (2004). Incompatible implementations of physical symbol systems. Mind and Matter, 2, 29 - 51.

[5] Blutner, R. & beim Graben, P. (2016). Quantum cognition and bounded rationality. Synthese, 193, 3239 - 3291.

All Interested Are Welcome!