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Classical dynamics from self-consistency equations in quantum mechanics

J. Math. Phys. **63**, 052101 (2022); <https://doi.org/10.1063/5.0039339> J.-B. Bru^{1,2,3,a)} and  W. de Siqueira Pedra^{3,4,b)}[View Affiliations](#)[View Contributors](#) PDF

ABSTRACT

During the last three decades, Pavel Bóna developed a non-linear generalization of quantum mechanics, which is based on symplectic structures for normal states. One important application of such a generalization is a general setting that is very convenient to study the emergence of macroscopic classical dynamics from microscopic quantum processes. We propose here a new mathematical approach to Bóna's non-linear quantum mechanics. It is based on C_0 -semigroup theory and has a domain of applicability that is much broader than Bóna's original one. It highlights the central role of self-consistency. This leads to a mathematical framework in which the classical and quantum worlds are naturally entangled. In this new mathematical approach, we build a Poisson bracket for the polynomial functions on the Hermitian weak*-continuous functionals on any C^* -algebra. This is reminiscent of a well-known construction for finite-dimensional Lie algebras. We then restrict this Poisson bracket to states of this C^* -algebra by taking quotients with respect to Poisson ideals. This leads to densely defined symmetric derivations on the commutative C^* -algebras of real-valued functions on the set of states. Up to a closure, these are proven to generate C_0 -groups of contractions. As a matter of fact, in generic commutative C^* -algebras, even the closableness of unbounded symmetric derivations is a non-trivial issue. Some new mathematical concepts are introduced, which are possibly interesting by themselves: the convex weak* Gâteaux derivative and the state-dependent C^* -dynamical systems. Our recent results on macroscopic dynamical properties of lattice-fermion and quantum-spin systems with long-range, or mean-field, interactions corroborate the relevance of the general approach we present here.

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