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back to namelist

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Quantum Features of Natural Cellular Automata

We review properties of discrete and integer-valued, hence natural, cellular automata (CA). A particular class of which comprises Hamiltonian CA with equations of motion that bear strong similarities to Hamilton's equations, despite presenting discrete updating rules. The resulting dynamics is linear in the same sense as unitary evolution described by the Schrödinger equation. Employing Shannon's Sampling Theorem, we construct an invertible map between such CA and continuous quantum mechanical models which incorporate a fundamental discreteness scale. This leads to a one-to-one correspondence of quantum mechanical and CA conservation laws. In order to illuminate the important issue of linearity, we presently extend this class of CA by incorporating nonlinearities. We argue that these imply nonlocal effects in the continuous quantum mechanical description of intrinsically local discrete CA; enforcing locality entails linearity. We recall the construction of admissible CA observables and the existence of solutions of the modified dispersion relation for stationary states, besides indicating next steps of the deconstruction of quantum mechanical models, including composite systems, in terms of deterministic CA.

H.-T. Elze, Are nonlinear discrete cellular automata compatible with quantum mechanics? J. Phys.: Conf. Ser. 631, 012069 (2015) [arXiv:1505.03764]; EPJ Web of Conferences 78, 02005 (2014) [arXiv:1407.2160]; J. Phys.: Conf. Ser. 504 (2014) 012004 [arXiv:1403.2646]

H.-T. Elze, Action principle for cellular automata and the linearity of quantum mechanics, Phys. Rev. A 89, 012111 (2014) [arXiv:1312.1615]

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