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Classical Hilbert space, statistical mechanics and gauge freedom

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The Koopman-von Neumann (KvN) formulation brings Hilbert space to classical mechanics, and has applications from dynamical systems to quantum-classical interaction. The formulation, however, has not been exploited to its full extent. We show that the existence of a family of extensions to the KvN equation allows for the derivation of the canonical ensemble distribution through simple separation of variables. This indicates that certain assumptions of statistical mechanics translate into simple statements in the KvN formulation. Further, we show a procedure for constructing an orthonormal set of vectors in that Hilbert space for arbitrary phase-space regions, and a procedure for forming non-trivial superpositions across solutions to the family of extended KvN equations. Finally, we show that the spectrum of the Liouvillian operator comprises relevant physical quantities, and the connection is found through the canonical conjugate of the Hamiltonian. This helps interpret and give meaning to variables often dubbed "extra" or "auxiliary" in the KvN formulation.

Keyword-1

Koopman-von Neumann

Keyword-2

Statistical Mechanics

Keyword-3

Classical Hilbert Space

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