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On a Quantum Algebraic Approach to a Generalized Phase Space

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We approach the relationship between classical and quantum theories in a new way, which allows both to be expressed in the same mathematical language, in terms of a matrix algebra in a phase space. This makes clear not only the similarities of the two theories, but also certain essential differences, and lays a foundation for understanding their relationship. We use the Wigner–Moyal transformation as a change of representation in phase space, and we avoid the problem of "negative probabilities" by regarding the solutions of our equations as constants of the motion, rather than as statistical weight factors. We show a close relationship of our work to that of Prigogine and his group. We bring in a new nonnegative probability function, and we propose extensions of the theory to cover thermodynamic processes involving entropy changes, as well as the usual reversible processes.

1. INTRODUCTION

Wigner[1] and Moyal[2] have proposed a very suggestive connection between quantum mechanics and some kind of phase space similar to that of classical physics. However, this proposal contains a number of difficulties, including especially the possibility of negative probabilities in phase space, and these difficulties prevent a completely satisfactory account of the subject from being made. In this paper, we shall approach the work of Wigner and Moyal from a different point of view, which avoids these problems, and which opens up the way to an extension of the basic concepts involved into new directions.

First we shall (along with Frohlich[3]) assume that the density matrix (or a certain generalization of this notion) be regarded as the fundamental description of the state of a system, while the wave function will be taken as an abstraction.

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