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BREAKDOWN OF TIME-REVERSAL SYMMETRY: INTRINSIC RANDOMNESS, TIME OPERATOR, SCATTERING

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Abstract. Misra-Prigogine-Courbage theory of irreversibility is revisited on the basis of Nagy-Foiaş dilation theory and Halmos-Helson theory of invariant subspaces. Universal models for intrinsically random dynamics are given as well as equivalent conditions to the existence of internal time operators, where innovation processes and Lax-Phillips scattering appear in a natural way.

1. Introduction

The problem of reconciling the apparent irreversible behavior of (macroscopic) systems with the reversible nature of fundamental microscopic laws of physics, including both classical and quantum mechanics, is far from being completely solved. Even experimental evidences of the irreversible behavior at microscopic level associated to chaotic behavior and with no requirement that the dynamical equations violate time-reversal symmetry or the system be coupled to a source of external noise have been recently found [9]. In the late 1970's Misra, Prigogine and Courbage (MPC) [7,8] already discussed the question of the dynamical meaning of the second law of thermodynamics at microscopic level expressing intrinsic irreversibility in terms of the existence of Lyapounov operators – i.e., observables varying monotonically in time – and their close links with the inherent randomness of the system, its dynamical instability – for instance, mixing property is necessary – and the existence of internal time operators.

This work is a mathematical approach to MPC theory of irreversibility in the context of statistical mechanics. Universal models for intrinsically random dynamics are given in Section 2 on the basis of Nagy-Foiaş dilation theory [10]. Equivalent conditions to the existence of internal time operators are derived in Section 3 in terms of Halmos-Helson theory of invariant subspaces [4, 5], where innovation processes [11] and Lax-Phillips scattering [6] appear as alternative descriptions.