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Sensitivity and chaos on product and on hyperspatial semiflows

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ABSTRACT

We study stronger forms of sensitivity on the arbitrary product of semiflows on Hausdorff uniform spaces. Moreover, Devaney chaos, Poincaré chaos, and their related properties are studied on product semiflows. Furthermore, we study relations between the chaos-related properties of a semiflow and that of its induced hyperspatial semiflow. Some results regarding stronger forms of sensitivity are also obtained on hyperspatial semiflows.

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1. Introduction

In recent years, there has been a significant study of semiflows under general monoid actions. Chaos is one of the core phenomena studied extensively in the theory of semiflows. In 1975, Li and Yorke have introduced the mathematical concept of chaos [9]. Since then, the theory of chaos has seen major developments. An essential feature of chaos is the impossibility of prediction of its long-term dynamics due to the eventual separation of the orbits of most nearby points. Devaney's definition of chaos is widely accepted in which a semiflow must exhibit topological transitivity, dense set of periodic points and sensitive dependence on initial conditions (sensitivity) [5]. Sensitivity is one of the key features of chaotic semiflows as it is the unpredictability characteristic of the chaos. The notion of sensitivity was introduced by Auslander and Yorke [4] and popularized later by Devaney [5]. In order to measure the strength of sensitivity, Moothathu [16] proposed three stronger forms of sensitivity: cofinite sensitivity, multi-sensitivity and syndetic sensitivity. Later on, several other stronger forms of sensitivity like thick sensitivity, thickly syndetical sensitivity and ergodic sensitivity have been introduced and studied for general semiflows [10,21]. In 2016, Akhmet and Fen [3] have introduced the concept of an unpredictable point and of Poincaré chaos. It was the first time in the literature that description of chaos was initiated from a single motion. Recently, these notions have been generalized for general semiflows by Miller [13]. It is important to note that a convincing theory of semiflows is developed under the assumption that the underlying phase space is a metric space. Sometimes one prefers to extend these notions to nonmetrizable topological spaces. On the other hand

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