

Yingcui Zhao, Lidong Wang*, and Nan Wang

Li-Yorke chaos for maps on G -Spaces

Abstract: We introduce the definition of Li-Yorke chaos for the map f on G -spaces, and show G -Li-Yorke chaos is iterable for f . Li-Yorke chaos implies G -Li-Yorke chaos, while the converse is not true. Then we give a sufficient condition for f to be chaotic in the sense of G -Li-Yorke. Also, we prove if f is G -transitive and there exists a common fixed point for f and all the maps in G , then f is chaotic in the sense of G -Li-Yorke.

Keywords: G -spaces, G -Li-Yorke chaos, G -transitivity, fixed point, periodic point

1 Introduction

Chaos comes from practical problems such as physics, biology, economics, medicine and chemistry. The theory of chaotic dynamical system is one of the challenging issue of dynamical systems. By convention, "chaos" means "a state of confusion without order". While in the theory of chaotic dynamical systems, "chaos" is a technical term. The term "chaos" in discrete dynamical systems was introduced firstly by Li and Yorke in 1975 [1].

Let X be a metric G -space and $f : X \rightarrow X$ be a continuous map. $Y \subset X$ is said to be a Li-Yorke chaotic set of f , if it contains at least two points and any pair of distinct points $x, y \in Y$ is a Li-Yorke pair, i. e.,

$$\liminf_{n \rightarrow \infty} d(f^n(x), f^n(y)) = 0, \quad \limsup_{n \rightarrow \infty} d(f^n(x), f^n(y)) > 0.$$

Moreover, if there exists an uncountable Li-Yorke chaotic set $S \subset X$ of f , f is said to be chaotic in the sense of Li-Yorke.

In the last fifty years, a large number of papers have been devoted to the study of chaos in the sense of Li and Yorke. Xiong[2] showed if f is transitive and there exists a fixed point for f , then f is chaotic in the sense of Li-Yorke. Wang[6] gave a sufficient condition for f to be chaotic in the strong sense of Li-Yorke. Seeing [7, 8, 9, 10] for more results about Li-Yorke chaos.

In addition to the topology domain, chaos theory is also being researched in other settings. Recently, chaos is being defined and studied for group actions, set-valued maps, iterated function system and so on. The present paper focuses on G -space.

Ekta studied Devaney's chaos for maps on G -space in [11]. Ali and Ekta defined and studied the notion of chain transitivity for maps on G -spaces in [12]. Phiniao and Khundrakpam investigated the G -mixing, G -sensitive and G -shadowing property of f in [13]. Ji Zhanjiang introduced the concepts of G -chain mixing, G -mixing, and G -chain transitivity in metric G -space, and then researched them in [14]. Raad and Ishikar studied the sequence G -asymptotic average shadowing property with G -chain transitive in [15].

The aim of present paper is to define and study Li-Yorke chaos for maps on G -spaces. The specific layout of the present paper is as follows. Some preliminaries and definitions are introduced in the next section. Then we will give some propositions in Sec. 3. In the last section, the main conclusions are given.

2 Preliminaries and Basic Concepts

Throughout this paper, $\mathbf{N} = \{0, 1, 2, \dots\}$, $\mathbf{Z}^+ = \{1, 2, 3, \dots\}$ and $\mathbf{Z} = \{\dots, -2, -1, 0, 1, 2, \dots\}$. Let (X, d) be a metric G -space, G be a topological group and φ be a continuous map from $G \times X$ to X [4]. The (X, G, φ) or X is called to be a metric G -space if the following conditions are satisfied:

- (1) $\varphi(e, x) = x$ for all $x \in X$ where e is the identity of G ;
- (2) $\varphi(g_1, \varphi(g_2, x)) = \varphi(g_1 g_2, x)$ for all $x \in X$ and all $g_1, g_2 \in G$.

Yorke Chaos Solution Manual

Stephen K. Scott



Yorke Chaos Solution Manual:

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Attractors, Bifurcations, and Chaos Tönu Puu, 2000-03-06 Attractors Bifurcations Chaos now in its second edition begins with an

introduction to mathematical methods in modern nonlinear dynamics and deals with differential equations Phenomena such as bifurcations and deterministic chaos are given considerable emphasis both in the methodological part and in the second part containing various applications in economics and in regional science Coexistence of attractors and the multiplicity of development paths in nonlinear systems are central topics The applications focus on issues such as business cycles oligopoly interregional trade dynamics and economic development theory **Chemical Chaos** Stephen K. Scott,1991 Table of contents 1 Introduction 2 Mappings 3 Flows 1 Two variable systems 4 Flows II Three variable systems 5 Forced systems 6 Coupled systems 7 Experimental methods 8 The Belousov Zhabotinskii reaction and other solution phase reactions 9 Gas phase reactions 10 Heterogeneous catalysis 11 Electrodeposition reactions 12 Biochemical systems Index **Applied Mechanics Reviews** ,1996 Register and Manual Connecticut. Secretary of the State,1982 *Mathematics Today* ,1998

The Impact of Chaos on Science and Society Celso Grebogi,James A. Yorke,1997 Prompted by the growing body of knowledge about chaotic behavior in an increasing number of scientific disciplines this volume brings together a distinguished group of experts to evaluate the impact that chaos has had on the conduct of science and on our understanding of society Government Reports Announcements & Index ,1983 Books in Print Supplement ,1979 **Business Books and Serials in Print** ,1977 *International Aerospace Abstracts* ,1983 **Books Out Loud** ,2007 **Books in Print** ,1953 **American Book Publishing Record** ,1995 Words on Cassette, 2002 R R Bowker Publishing,2002 The Publishers' Circular and the Publisher & Bookseller ,1935 *Publishers' Circular and Booksellers' Record of British and Foreign Literature* ,1935 Index to Sixteen (i.e., 16) mm Educational Films National Information Center for Educational Media,1975

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