# Accepted Manuscript


Multi-channels coupling-induced pattern transition in a tri-layer neuronal network

Fuqiang Wu, Ya Wang, Jun Ma, Wuyin Jin, Aatef Hobiny

PII: S0378-4371(17)31051-8
DOI: https://doi.org/10.1016/j.physa.2017.10.041
Reference: PHYSA 18755

To appear in: *Physica A*

Received date : 2 July 2017
Revised date : 24 September 2017

Please cite this article as: F. Wu, Y. Wang, J. Ma, W. Jin, A. Hobiny, Multi-channels coupling-induced pattern transition in a tri-layer neuronal network, *Physica A* (2017), https://doi.org/10.1016/j.physa.2017.10.041

# Multi-channels coupling-induced pattern transition in a tri-layer neuronal network

Fuqiang Wu[1] Ya Wang[1] Jun Ma[1,4*] Wuyin Jin[2] Aatef Hobiny [3]

[1]Department of Physics, Lanzhou University of Technology, Lanzhou 730050, China

[2]College of Mechano-Electronic Engineering, Lanzhou University of Technology, Lanzhou 730050, China

[3]NAAM-Research Group, Department of Mathematics, Faculty of Science, King Abdulaziz University, Saudi Arabia

[4]College of Electrical and Information Engineering, Lanzhou University of Technology, Lanzhou 730050, China

**Abstract**: Neurons in nerve system show complex electrical behaviors due to complex connection types and diversity in excitability. A tri-layer network is constructed to investigate the signal propagation and pattern formation by selecting different coupling channels between layers. Each layer is set as different states, and the local kinetics is described by Hindmarsh-Rose neuron model. By changing the number of coupling channels between layers and the state of the first layer, the collective behaviors of each layer and synchronization pattern of network are investigated. A statistical factor of synchronization on each layer is calculated. It is found that quiescent state in the second layer can be excited and disordered state in the third layer is suppressed when the first layer is controlled by a pacemaker, and the developed state is dependent on the number of coupling channels. Furthermore, the collapse in the first layer can cause breakdown of other layers in the network, and the mechanism is that disordered state in the third layer is enhanced when sampled signals from the collapsed layer can impose continuous disturbance on the next layer.

**Key words**: neuronal network; collapse; target wave; pattern formation

## 1 Introduction

The mammalian brain is composed of a large number of neurons and these neurons can present various firing patterns and dynamical properties in electrical activities by applying appropriate external stimulus. Since the breakthrough in electrophysiology achieved by Hodgkin and Huxely, the biological neuronal model [1] based on neuraxon of squid and its improved versions [2-6] have been used to investigate the dynamical properties of isolate neuron, collective behaviors of neurons, pattern selection and synchronization of networks. For example, *Volman et al.* [7] proposed a neuron-astrocyte model to detect the effect of astrocyte on neuronal activities. *Gu et al*., [8] discussed the bifurcation behavior based on

* Corresponding author: hyperchaos@163.com, ORCID: 0000-0002-6127-000X