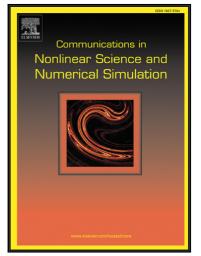# Accepted Manuscript

Effects of noise correlation on the coherence of a forced van der Pol type birhythmic system

R. Yamapi, R. Mbakob Yonkeu, G. Filatrella, C. Tchawoua

Please cite this article as: R. Yamapi, R. Mbakob Yonkeu, G. Filatrella, C. Tchawoua, Effects of noise correlation on the coherence of a forced van der Pol type birhythmic system, *Communications in Nonlinear Science and Numerical Simulation* (2018), doi: 10.1016/j.cnsns.2018.02.018

Effects of noise correlation on the coherence of a forced van der Pol type birhythmic system

R. Yamapi

Fundamental Physics Laboratory, Department of Physics, Faculty of Science, University of Douala, Box 24 157 Douala, Cameroon. and Max Planck Institute for Mathematics in the Sciences, Inselstrasse 22, D-04103 Leipzig, Germany

R. Mbakob Yonkeu

Laboratory of Mechanics and Materials, Department of Physics, Faculty of Science, University of Yaoundé I, Box 812, Yaoundé, Cameroon.

G. Filatrella

Department of Sciences and Technologies and Salerno unit of CNSIM, University of Sannio, Via Port'Arsa 11, I-82100 Benevento, Italy.

C. Tchawoua

Laboratory of Mechanics and Materials, Department of Physics, Faculty of Science, University of Yaoundé I, Box 812, Yaoundé, Cameroon.

Abstract

We investigate the effects of noise correlation on the coherence of a forced van der Pol type birhythmic system. The coherence of the dynamics on the time scale of intrawell oscillations, as measured by the Signal-to-Noise- Ratio, is shown to be maximized for an appropriate choice of the noise intensity and of the noise correlation time . Other measures, related to the autocorrelation function and applicable on the longer time scale of interwell oscillations do not exhibit such nonlinear behavior. When occurs, the coherence appears similar to noise induced stochastic resonance in ordinary bistable potential systems, while the investigated birhythmic system only posses a nonequilibrium or quasi-potential associated to the orbits. Thus, it is demonstrated that correlated noise, even if the attractors are not fix points but orbits, can give rise to stochastic resonance.

Keywords: *Correlation time, birhythmic system, auto-correlation function, Signal-to-noise ratio, Stochastic resonance.*

Highlights

- We investigate correlated noise in a forced birhythmic van der Pol type oscillator.
- Two measures of coherence are introduced: the auto-correlation function and the signal-to-noise ratio.
- The analysis on different time scales shows different types of coherence.
- It is proved that noise, even correlated, can improve coherence on the short time scale, but it cannot on the long time scale.

1. Introduction

The peculiar effect of noise in nonlinear systems [1, 2, 3, 4, 5, 6] is of special interest, for random fluctuations can induce counterintuitive dynamics in a broad class of systems ranging from physics and chemistry to biological sciences. The addition of a deterministic drive further enriches the dynamics [2, 7, 8, 9, 10]. If a system is perturbed by a harmonic deterministic excitation and a random noise, the response has several interesting features arising from the interaction between the unperturbed limit cycles, the harmonic excitation and the stochastic noise [11], especially for bistable systems. Numerous investigations have also shown that the average escape time from

metastable states in fluctuating or static potentials exhibits nonmonotonic behavior as a function of the noise intensity [4, 5]. This implies that the stability of metastable states can be enhanced by noise; i.e., the lifetime of a metastable state can be prolonged by the presence of noise . A related phenomenon, often referred to as Stochastic Resonance (SR), hints to another type of nonmonotonic behavior: when the coherence between the system oscillations and the external drive is enhanced by the noise [2, 7, 8, 9]. Thus, SR entails that an increase in the noise intensity improves the synchrony with the deterministic drive. Instead, in the case of noise enhanced stability, one observes that noise increases the stability, as measured, e.g., by the mean first passage time through a threshold (the separation