EUROPHYSICS LETTERS 1 August 1999

Europhys. Lett., **47** (3), pp. 298-303 (1999)

Noise-induced spiral dynamics in excitable media

J. García-Ojalvo[1,2] and L. Schimansky-Geier[1]

[1] *Institut für Physik, Humboldt-Universität zu Berlin*
Invalidenstr. 110, D-10115 Berlin, Germany
[2] *Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya*
Colom 11, E-08222 Terrassa, Spain

(received 11 February 1999; accepted in final form 2 June 1999)

PACS. 05.40−a – Fluctuation phenomena, random processes, noise, and Brownian motion.
PACS. 47.54+r – Pattern selection; pattern formation.
PACS. 87.18Hf – Spatiotemporal pattern formation in cellular populations.

Abstract. – We report the existence of complex spiral dynamics induced by external noise in a simple two-dimensional model of excitable media, with local dynamics of the FitzHugh-Nagumo type. Different dynamical regimes can be observed, depending on the value of the activator diffusion, including complex states resembling deterministic spiral turbulence, and spiral meandering. The complex dynamical behavior is seen to be driven by spiral breakup. The complexity of these noise-induced states can be characterized by the number and size distribution of coherent space-time clusters. In particular, the turbulent-like regime is characterized by a cluster-size distribution that displays power law scaling.

Many recent studies reveal the relevant influence of external noise on the spatiotemporal behaviour of excitable media [1-6]. Most of these investigations concentrate on the subexcitable regime, where by definition no structures can propagate under purely deterministic conditions. In that situation, an optimal amount of noise has been seen to support the propagation of structures such as spirals [1], irregular waves [2], travelling pulses [4] and pulsating spots [6]. The present work, on the other hand, directs its attention towards noise effects within the excitable region. We will show that, in this regime, parametric noise is able to induce complex spiral dynamics in a simple model of excitable media in which only stable (static or meandering) spirals exist in the absence of fluctuations [7]. Specifically, noise will be seen to induce turbulent-like states driven by spiral breakup.

Spiral breakup is a type of spatial instability leading to defect-mediated turbulence that has been recently observed in experiments with chemical excitable media [8]. Besides interest on the turbulent state by itself as a simple representation of spatiotemporal chaos [9, 10], the phenomenon of spiral breakup has attracted much attention due to its possible relation to the occurrence of ventricular fibrillation in human hearts [11]. Many questions remain open concerning the nature of the instability, such as for instance what is the minimal model in which it appears. Spiral breakup in homogeneous media has been reported so far in coupled-map lattices [12, 13], sophisticated models of cardiac tissue [11, 14], and generalizations of