COURSE SYLLABUS

University	**Alexandru Ioan Cuza University of Iaşi**	**Course title**	
Faculty	**Physics**	**TOPICAL PROBLEMS IN PHYSICS OF SELF-ORGANIZED SYSTEMS**	
Department	**Physics**		
Domain	**Physics**	**Course category** (FC/SC/CC[1]): SC	**Term** (1-4): **3**
Level	**Postgraduate (MA)**	**Course type** (Co/El/F[2]):CO	

I. Course structure

Number of hours/week				Credits	Total class hours/ semester	Total hours of individual activity	Examination type (C/Ex/CE[3])	Teaching language
Course	Seminar	Lab.	Project	**6**	**56**	**124**	**Ex**	**English**
2	**2**	**-**	**-**					

II. Instructors

	Academic degree[4]	Scientific degree	Name and surname	Faculty position (tenure/ associate - organization)
Course	Assoc. prof.	Dr.	Sebastian POPESCU	tenure
Seminar	Assoc. prof.	Dr.	Sebastian POPESCU	tenure
Laboratory				

III. Prerequisites

Plasma Physics, Electrodynamics, Differential Equations, Complex Functions, Chaotic Phenomena and Control Methods

IV. Course objectives

1. Knowledge of the current methods used in the study of self-organized systems; **2.** Understanding of the self-assembling mechanisms of self-organized structures which appear in different complex systems; **3.** Ability to analyze different physical phenomena leading to similar behaviors of different complex systems; **4.** Awareness of the topical problems in the physics of self-organized systems, according to the mainstream scientific literature of the last decade

V. Course content

Course

CHAPTER 0: ***Complex systems. Self-organization***

(**§1.** Complex systems; **§2.** Order, organization and self-organization in complex systems; **§3.** Intermittent and cascade self-organization)

CHAPTER I: ***Negative differential resistance***

(**§1.** S-type negative differential resistance; **§2.** N-type negative differential resistance; **§3.** Equivalent electrical circuit of the ball of fire in plasma; **§4.** Electrical double layer and physical basis of negative differential resistances in plasma)

CHAPTER II: ***Turing structures***

(**§1.** What is a Turing structure? **§2.** Qualitative treatment of Turing structures; **§3.** Theory of Turing structures; **§4.** Applications. The Brusselator; **§5.** Turing structures in plasma systems. The ball of fire (quasi-spherical electric double layer)).

CHAPTER III: ***1/f noise***

(**§1.** Types of noise: thermal noise, shot noise, 1/f noise; **§2.** Self-organization at criticality. Critical phenomena close and far from thermal equilibrium; **§3.** Moving double layers and physical basis of anomalous transport in plasma; **§4.** 1/f noise and plasma edge fluctuations)

CHAPTER IV: ***Self-organization in fluids***

(**§1.** The turbulence phenomenon: **§1.1.** Energy cascade in turbulent flow. Kolmogorov K41 spectral law of energy; **§1.2.** Inverse cascade of energy. Vorticity,

[1] FC – fundamental course, SC – specialty course, CC – complementary course
[2] Co – compulsory, El – elective, F – facultative
[3] C – colloquium, Ex – exam, CE – colloquium AND exam
[4] Professor / Associate professor / Lecturer / Assistant professor / Teaching assistant

	enstrophy and helicity. Spectral laws; **§1.3** The appearance of self-organized structures in fluids. A variational principle; **§2.** Self-organization in hydrodynamics: **§2.1.** Equations of movement in hydrodynamics; **§2.2** Balance equations for energy, enstrophy and helicity; **§2.3** Self-organization in a bidimensional flow. Helmholtz equation; **§3.** Self-organization in MHD: **§3.1** Equations of evolution; **§3.2** Balance equations for energy and magnetic helicity; **§4.** Self-organization in MHD turbulence. Taylor equation for the reversed field pinch; **§5.** Kondoh – Sato generalized theory of self-organization; **§6.** Turbulence at the tokamak plasma boundary)
Seminar	Instabilities and bifurcations; Turing structures; 1/f noise; Negative differential resistance; Self-organization and turbulence in fluids and magetofluids; Elements of edge plasma physics; Topics for students' homework
Laboratory	

VI. Minimal required references

[1] ***S. Popescu***, Topical Problems in Physics of Self-organized Systems, Ed. TEHNOPRESS Iaşi, 2004 (in Romanian)

[2] ***H. Haken*** – Advanced Synergetics – instability hierarchies of self-organizing systems and devices, Springer Verlag (Berlin, Germany) 1983.

[3] ***H. J. Jensen*** - Self-Organized Criticality – emergent complex behavior in physical and biological systems, Cambridge Lecture Notes in Physics, vol. 10, Cambridge University Press (Cambridge, UK) 1998.

[4] ***P. M. Bellan*** – Spheromaks — a Practical Application of Magnetohydrodynamic Dynamos and Plasma Self- organization, Imperial College Press (London, UK) 2000.

VII. Didactic methods

Lectures, problems solving, discussions, didactic films

VIII. Assessment

Pre-conditions	Attendance (30% from the final grade), active participation to class activities	
Exam dates	**1st Assessment**	**November**
	2nd Assessment	**January – February**

	Assessment means and methods	**Percentage of the final grade**
Exam/Colloquium	Written paper	50%
Seminar	Problems solving, presentation of a research topic	20%
Laboratory		