

**INTRODUCING NEW APPROACHES TO STUDY COMPLEX SYSTEMS
(NACS 2017)**

MARIA TERESA CACCAMO ^a, SALVATORE MAGAZÙ ^{a *},
LUIGI PASQUA ^b AND LILIANA RESTUCCIA ^a
(Guest Editors)

ABSTRACT. Preface to the AAPP supplementary issue collecting the proceedings of the international conference on “New Approaches to Study Complex Systems” (27th-28th November 2017; Messina, Italy).

The study of complex systems is becoming prominent these days. Even if it does not exist a proper definition of complex systems, one can take into account as a system that has a collective behaviour out the interaction of their constitutive parts, in order that such a collective behaviour cannot be estimated if only the properties of their parts are treated. What it emerges is that out of this interaction develops the so-called emergent property, so that “The whole is more than the sum of its parts.” For this reason, a system is considered to be a complex one according to its behaviour.

In general, a complex behaviour makes reference to a set or a combination of several subsets and also to a spatial distributed system in which a system with low-dimension can present dynamical characteristics which make it complex. It is well known that different mechanisms, such as as nonlinear interactions, self-organization, self-adaptation and feedback loops, describe the distinctive properties of a complex system. Starting from this point, that the collective behavior of the whole system cannot be just deduced from the comprehension of the behavior of the singular components, it has come to new theories and sophisticated mathematical and modeling approaches for application to several fields that can be effectively described only in terms of complexity and complex systems. Such a topic is intrinsically interdisciplinary because involves different fields such as mathematics, physics, computer science, politics, ecology, sociology, genetics, economics and others; every field is characterized by own terminology, definitions, tools, approaches and particular ways of asking and answering questions. Often, these fields present misunderstandings, tensions and contradictions due to their capability to cross and bind together disciplines

The main goals of this special issue which is titled “New Approaches to Study Complex Systems (NACS 2017)” are to present some of the recent approaches of modeling and analyzing complex systems. The issue is divided in 31 chapters.

More precisely, in Chapter 1, the authors consider a stochastic optimal control problem for one-dimensional diffusion processes with random infinitesimal mean and variance that depend on a continuous time Markov chain (Lefebvre and Moutassimy 2019). The Chapter 2 aims to approach a design method for transforming a non-linear system, based on a recursive algorithm, in order to find a state-feedback controller form for it (Efrem *et al.* 2019). In Chapter 3, a linear theory for dielectric relaxation phenomena in polarizable reacting fluid mixtures is developed, in the frame of thermodynamics of irreversible processes with internal variables (Restuccia *et al.* 2019b). In Chapter 4, the authors perform the first numerical comparison between the two existing main models of superfluid helium: the two-fluid model proposed by Landau and the onefluid extended model proposed from the extended thermodynamics (Galantucci *et al.* 2019). The Chapter 5 deals with charge transport phenomena that can be tackled in silicon quantum wires using a subband hydrodynamic model (Di Stefano and Muscato 2019). In Chapter 6, the authors take into account that in the linear case a generalized telegraph heat equation for thermal perturbations with finite velocity can be derived in the anisotropic and isotropic case for porous nanostructures filled by a fluid flow (Restuccia *et al.* 2019a). Chapter 7 deals with the model focuses on the study of the early stage of the immune cancer competition, that is based on the kinetic theory of active particles (KTAP) (Dabnoun and Mongiovì 2019). In Chapter 8, a Boillat’s methodology is applied to investigate discontinuity waves of a system of quasi-linear hyperbolic partial differential equations (PDEs), describing the interactions between the electronic and the dislocation fields in extrinsic semiconductors with defects of dislocation, in the frame of extended irreversible thermodynamics with internal variables (Restuccia and Mazzeo 2019). In Chapter 9, the authors reconsider the problem of the nonlinear Lyapunov stability of the thermodiffusive equilibrium of a viscoelastic rotating Walters fluid, in a horizontal rotating layer heated and salted from below recovering the previous result without any restriction on the viscoelasticity parameter (Palese and Labianca 2019). Chapter 10, deals with thermodynamic theories for magnetic relaxation phenomena due to several internal variables highlighting the form of the entropy and its consequences on the hierarchy of relaxation equations (Restuccia and Jou 2019). In Chapter 11, the author reviews an approach to the dynamics of open quantum systems based on non Hermitian Hamiltonians and shows how to define correlation functions and a non-Hermitian entropy with a non zero production rate, introducing a non-Hermitian linear entropy functional (Sergi 2019). Chapter 12 deals with biocompatible material, bismuth, that can be employed in the form of nanoparticles to be used as a possible alternative contrast medium for diagnostics (Torrisi *et al.* 2019). In Chapter 13, the authors propose the use of alkylphosphates to protect the silver surface against corrosion: the polar head group should interact with the silver surface with the formation of a thin film of opportunely oriented surfactant molecules (Calandra *et al.* 2019). In Chapter 14, the authors review the main breakthroughs for the rational design of theranostic nano-systems for therapeutic treatment in nanomedicine, discussing the open questions with the aim of offering possible novel insights to overcome the critical issues which are still present when we want to translate theranostic approaches into the clinical practise (Lombardo *et al.* 2019b). The purpose of Chapter 15 was to build

a database with data on haematological profiles of *Mugil cephalus* (Linnaeus 1758) and goldfish *Carassius auratus* (Linnaeus 1758), in particular of some blood cells, namely red blood cells (RBC), white blood cells (WBC) and thrombocytes (TC) (Parrino *et al.* 2019). In Chapter 16, the authors investigate the temperature effect on the size and stability of two major blood plasma proteins, human serum albumin and fibrinogen in aqueous NaCl solution by means of Dynamic Light Scattering (Atamas *et al.* 2019). The aim of Chapter 17 was to show that Proteins in aqueous solution behave like a viscoelastic system under exposure to high frequency electromagnetics (HF-EMFs) (Calabrò and Magazù 2019). Chapter 18 deals with a model, based on queueing theory, for the flow of a river when it is high taking into account Delaware River, located in the United States. Using this model, one can forecast what would happen if the rate at which events occur increases (Lefebvre 2019). The authors of Chapter 19 focus on the development of a physical-mathematical model for the meteorological forecast. In particular, the performance improvements of the WRF model were evaluated, obtained by optimizing the convective parametrizations reporting the meteorological event recorded in Sicily on 9 June 2016 (Castorina *et al.* 2019). Chapter 20 reports the results of the time series of temperature of some Sicilian weather stations. By means of Wavelet Transform a correlation between the cycles present in signals and the solar cycles are performed together with the investigation of breakdown or discontinuities contained in the signals (Colombo *et al.* 2019). In Chapter 21, the authors show that the dibutyl phosphate/propylamine liquid mixture is characterized by an extremely slow response (hours) to the magnetic field and by an intense overall effect, showing a surprising behavior (Pochylski *et al.* 2019). Chapter 22 reports experimental results collected for testing a drying process model for acoustically levitated droplets. More specifically, the so-called D2 versus time law is tested on droplets of homologous disaccharide aqueous solutions (Cannuli *et al.* 2019). Chapter 23 reports the results of SAXS measurements on dendrimers, a versatile platform for a wide range of nanotechnology applications. The present analysis strongly supports the finding that colloidal stability and interaction of dendrimers in solution environment is strongly influenced by charge effects (Lombardo and Kiselev 2019). In Chapter 24 the authors consider a set of fresh horticultural plants, used in Mediterranean diet performing a statistical analysis. In particular, they illustrate the nitrate contents in these vegetables, obtained in laboratory, as a sample variable and they study its frequency distribution, they compute its average, variance and standard variation and they work out some graphic representations (Di Bella *et al.* 2019). What is the “minimum level of complexity” to assume in the theoretical and experimental models that may satisfactorily describe the nanocarriers (and nanomaterials) interaction with biological systems is the question of the authors of Chapter 25 (Lombardo *et al.* 2019a). In the Chapter 26 an approach concerning the formalism of time dependent Pair Correlation Functions (PCF), which characterizes the time-space properties of material systems and their Fourier Transforms (FT) is presented (Magazù and Caccamo 2019). In Chapter 27, future perspectives, using the approach of complex systems physics, for developing new and ecological applications in nanotechnologies as well as the development of micro and nano techniques for fiber treatment, are highlighted (Caschera *et al.* 2019). The authors of Chapter 28 deal with thermophiles from shallow hydrothermal vents (SHV) that are ideal candidates to understand the environmental limits for terrestrial life, which are also relevant in the field of astrobiology. Due to their thermal resistance, thermophiles may have

a novel use as bacterial organisms model for further investigation into the spore responses to environment stressors, also simulating space conditions (Zammuto and Gugliandolo 2019). Chapter 29 reports the recent studies on the mammal assemblage from Cessaniti (Calabria) revealed a continental character of the fauna, probably related to a land connection to Africa. The Calabria-Sicily area can be considered a new bioprovince in the central Mediterranean during late Miocene (Marra 2019). In the Chapter 30, Attenuated Total Reflectance - Fourier Transform InfraRed (ATR - FTIR) spectroscopic technique has been employed in order to investigate the temperature behavior of albumen and of its mixture with trehalose/D²O, the interest being associated with the wide employment of albumen in painting works both as a protective varnish and as a binder (Caccamo *et al.* 2019). Finally, the Chapter 31 reports a comparison from an energetic and economic point of view among three different power generation plants (hydroelectric, eolic and photovoltaic), located in the water basin area of Annunziata stream in Reggio Calabria or in its immediate vicinity. Energy productiveness and economic convenience are estimated during the useful life of the plants, together with their profitability. For the hydroelectric plant, made up of several elements, the preliminary sizing of the main components has also been carried out (Barbaro *et al.* 2019).

This special issue is dedicated to the memory of Prof. Bogdan Maruszewski, from Technological University of Poznan (Poland), eminent scientist, very appreciated teacher, great and unforgettable friend and colleague, who passed away on December 27th, 2017. Since 1990 he visited University of Messina, as collaborator of one of us (L. R.), and his research dealt with the modelization of complex media, in the framework of non-equilibrium thermodynamics, in particular electromagnetic materials, deformable semiconductors, fullerenes, deformable superconductors, rheological media, heterogeneous and anisotropic media, multiphase media, and in general media whose internal structure is described by internal variables. He was a member of Accademia Peloritana dei Pericolanti of Messina. His death left a great emptiness in the field of Physical-Mathematics and in the lives of those knew him.

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^a Università degli Studi di Messina
Dipartimento di Scienze Matematiche e Informatiche, Scienze Fisiche e Scienze della Terra
Viale F. S. D’Alcontres, 31, 98166 Messina, Italy

^b Università della Calabria
Dipartimento di Ingegneria per l’Ambiente e il Territorio e Ingegneria Chimica
Via Pietro Bucci, 87036 - Arcavacata di Rende (CS)

* To whom correspondence should be addressed | email: smagazu@unime.it

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