Sociophysics: A New Science or a New Domain for Physicists in a Modern University?

Gheorghe SĂVOIU
University of Pitesti, Faculty of Economic Science, Pitesti, Romania

and

Ion IORGA –SIMĂN
University of Pitesti, Faculty of Sciences, Pitesti, Romania

ABSTRACT

Being more a detailed answer or a scientific essay than a theoretical or a practical approach to Sociophysics, as a new science in modern society, this paper tries not only to define it, but even to analyze the innovations brought in its characteristic domains or in its specific fields. Sociophysics improve the quality of the classical sciences and researches and its original models and methods, indeed. Sociophysics is a new domain for physicists in a modern university too. Somehow it becomes a living proof, that some physicists have recently established careers not only in the banking, financial, life insurance and marketing, but in the sociologic academic activities. Simultaneously, academic physicists have become interested in studying Sociology and economists and sociologists in studying Statistical Physics or Quantum Statistics. After defining what Sociophysics is, a brief historical background of the last two decades underlines significant achievements, perspectives, and methods used in this domain. The final questions are not only rhetorical …
Key words: Sociophysics, Quantum Statistics, Statistical Physics, Sociophysics' model, Mediaphysics.

1.INTRODUCTION

Sociophysics as a new science has developed concepts, including standardized typologies, definitions and measures of key concepts and consensus statements, techniques, tools, and methods, and has tested new specific theoretical models and conceptual frameworks to address contemporary sociological challenges, to capture systematical information from social domains and to develop an implementation context using a physical thinking. Scientific research and practice of Sociophysics are defining a new era with a more intense use of physical models from Statistical Physics, or with a wider view of data in the specific way of thinking of Quantum Statistics. In 1902, when Josiah Willard Gibbs has published *Elementary Principles in Statistical Mechanics* to Yale's Publishing House, as the father of the new born science, simply called Statistical Mechanics, he certainly did not knew or did not imagine that this new inter, trans and multidisciplinary science should be so relevant for the study of non-physical systems. After more than one hundred years, methods and models of Statistical Mechanics or Statistical Physics can be successfully applied to social problems. The great experience of physicists in working with experimental data gives them certain advantage to uncover quantitative laws in the statistical data available in Sociology. Sociophysics brings new insights and new perspectives, which are likely to revolutionize the old social disciplines. If some agreements are possible between the economists or sociologists and the physicists, it is probably about the need of a more intense exchange of information. Statistical Physics as the first method for Sociophysics has proven to be a very fruitful framework to describe phenomena outside the realm of traditional Physics. The last years have witnessed the attempt by physicists to study collective phenomena emerging from the interactions of individuals as elementary units in population and social structures. The paper is organized as a review of qualitative improvement brought by Sociophysics, as follows: introduction; the second section deals with a brief history and some activities and models; the third section concentrates on some definitional issues for this new science; the

fourth section more focused on contemporary and futures trends and activities in Sociophysics; a necessary question and its answers; conclusions and a final remark; references.

2. A BRIEF HISTORY OF SOCIOPHYSICS

In 1835, publication of *Physique sociale* by Adolphe Quetelet, a pioneering book containing an original view of social statistics, was the first scientific approach to the social sciences through new mathematical methods. Statistics for a couple of hundred years was treated as a social discipline (only in the last hundred years it was considered in mathematical terms, a special universal science about mass phenomena, regardless on its nature). Even now, for social sciences statistics is irreplaceable, whereas for other natural sciences, it is just one of the tools. But cohabitation of physics and social sciences is a much more complicated phenomenon, because the objects are not physical anymore (people instead of particles, human interactions instead of molecules' collisions, etc.). Physics was used in social studies only as an analogy, becoming only a methodological tool, and in that role openly competes with already existing and very well developed Statistics. But certainly, Physics may indeed change traditional "over statitistized" view on society and enrich it [1].

Sociophysics has become an attractive field of research over the last two decades, despite the controversies between sociophysicists and sociologists. Its relevant potential used for understanding the social phenomena always will win. Sociophysics aims at a Statistical Physics modeling of large scale social phenomena, like culture and opinion formation and dynamics, cultural and behavioural dissemination, the origin and evolution of language, competition and conflicts, crowd behaviour, social contagion, gossip and rumours evolutions, Internet and World Wide Web, cooperation and scientific research, appearances of terrorism etc. Sociophysics tries to model the dynamics of social and economic indicators of a society and investigate how life extension will influence fertility rates, population growth and the distribution of wealth[2], religion, ecosystems, friendship and sex, social network and traffic too. After more than one hundred years, methods and techniques of Statistical Physics can be successfully applied not only to economical, but also to social problems. "Today physicists regard the application of statistical mechanics to social phenomena as a new and risky venture. Few, it seems, recall how the process originated the other way around, in the days when physical science and social science were the twin siblings of a mechanistic philosophy and when it was not in the least disreputable to invoke the habits of people to explain the habits of inanimate particles" [3].

The origins of modern Sociophysics are traced back in its history to the late seventies and eighties. One of the leading authors in Sociophysics, Serge Galam, published his early works in the Journal of Mathematical Sociology and the European Journal of Social Psychology [4,5]. The conflicting nature of Sociophysics with the Physics community was revealed from Serge Galam experience in *Sociophysics: a personal testimony (2004).*

Physics have influenced the social sciences since the times of Galileo and Newton. The ideas of Schumpeter about the influence of innovations on the society are important proofs of the last observation. After one century of understanding the relativity theory and eighty years after the establishing of the Quantum Mechanics, Physics turns to new areas of the complex systems research. Up to the last two or three decades, these regions of researches have been reserved for Sociology. The first interest of physicists in social sciences systems has roots that date back to 1936, when Majorana wrote a pioneering paper, published in 1942 and entitled *Il valore delle leggi statistiche nella fisica e nelle scienze sociali*, on the essential analogy between statistical laws in physics and social sciences. Many years later a statistical physicist Elliott Montroll coauthored with Badger W.W, in 1974, the book *Introduction to Quantitative Aspects of Social Phenomena*. Physics is now concentrated about scientific and technological aspects of the human society and accept the ideas of Alfred Lotka on populations as energy transformers the dynamics of technical invention capacity of the society or the population dynamics models detailing hypothesis about migration between two geographic regions, etc. Physics emphasize on the need of more investigation of social processes by means of the modern methods of mathematics, statistics and sociology in the new science of Sociophysics, that aims at a Statistical Physics modelling of

large scale social phenomena, like opinion formation, cultural dissemination, the origin and evolution of language, crowd behaviour, social contagion, interactions of individuals as elementary units in social structures. A lot of work in the new Sociophysics has been carried on, especially in the design of microscopic models, whereas comparatively little attention has been paid to a quantitative description of social phenomena and to the promotion of an effective cooperation between physicists and social scientists. The name of Sociophysics has been around for decades, but only in the XXIst century it has become more science than slogan.

Sociophysics is a much less studied and published topic than is Econophysics, another new border science or new domain for Physics. First named Psychophysics, Sociophysics can be described as the sum of activities of searching for fundamental laws and principles that characterize human behaviour and result in collective social phenomena. In this domain of Econophysics are included topics such as the dynamics of complex social networks (which is how the above work ties in here), robustness of social processes, the scaling of social systems, and the evolution of social organization. Each of these subtopics represents a union of what it is called *Sociophysics perspective* with approaches from other fields. An anecdotic effect, like the move of butterfly wings that can affect the weather, is an example of the sensibility of the physical system behaviour with respect to its initial conditions, fingerprint of the deterministic chaos. But it is an example of how much importance means even the smallest detail in Sociophysics… The gap between the empirical Sociology and modern Sociophysics is perhaps smaller than all the others appeared between the hermeneutic and humanistic social sciences.

3. SOCIOPHYSICS' DEFINITIONAL ISSUES

The study of behavioural and social phenomena has experienced a surge of interest over the last decade. One reason for this great attention paid to Sociophysics is the huge amount of high quality data made available by the internet technologies. Also many of modern sociological research fall under the umbrella of Sociophysics and bring a Physics perspective to the problem of complex collective behaviours. Thus, the apparently common field of Sociology has the potential of producing and proving that the laws of Physics can be reproduced as laws in human interaction, in social constructions and even in relationships [6]. In Sociophysics first objective is the treatment of individuals, somewhat analogously to particles, or to atoms in a gas, and this allows for the application of Statistical Physics methodologies. The second objective of Sociophysics is, of course, to offer the intuitive/psychic information using Physics' methods that emerges simultaneously and complements the theoretical applications.

Psychic information and intuitive guidance are tools that are both a natural right for us, but can also be used to improve our mind integration here on Earth. Psychic information can be accessed by anyone and everyone, however sometimes it is harder for us to hear and receive information about our own life, and that's where Sociophysics comes in "deus ex machina", but not such as an "angel", suddenly appearing, to solve the complex social problems, but in a scientific way and in a methodological modality. Two particular methods of this theory are applied in Sociophysics relatively often: the master equations, an analytical, relatively easy and approximate method [7,8], and the Monte-Carlo simulation, in principle, a technically difficult numerical and exact method[9]. Various and numerous social processes were attempted to be described with these methods: migration dynamics, residential segregation, competitions, gossip, evolution of cultures, and languages, opinion dynamics and many others [7, 8, 9, 10, 11, 12, 13, 14].

A Sociophysics' method applied on new ideas is multidirectional, sequential complex and original. Thus, a lot of references to complexity, diffusion, fluctuations, fractals, randomness, entropy, self-organization, and chaos can be found in papers on Sociophysics. Barkley J. Rosser, Jr. has identified 12 new domains of the Sociophysics covered by more than 210 remarkable papers: culture (music, paintings, books), competition and conflicts, cooperation and scientific research, ecosystems, friendship and sex, internet and world wide web, languages, opinion dynamics, power laws and fractals, religion, social networks and traffic. As good methods flow to other areas, scientific researchers immediately declared a new kind of science, as a consequence of the result of the

unified knowledge, and of the interdisciplinary field applications. If there is a need to follow arguments put forth by Rosario Mantegna and Eugene Stanley in Econophysics, what is involved in the definition of *Sociophysics is the phenomenon of physicists using their models to study the sociology*, which is itself a slightly curious way to define a scientific discipline, given that this is itself a functional and sociological definition (a physicist is doing something in a new domain like sociology) rather than one based on the content of the ideas contained in the new science's object [15].

First Sociophysics was a new insight into the applicability of much of elementary statistical physics to the social sciences, but now it is much more than this, that means a new insight followed by transferring and further developing ideas and concepts common to Physics, Biology and Ecological Systems. In 2005, I.Mandel1 and D.Kuznetsov have introduced *Mediaphysics* as a part of *Sociophysics, studying processes of mass communications in social systems and have demonstrated its potential for applications in different processes of mass communications in complicated social or sociobiological systems such as marketing, economics, politics, animal populations, etc*. Philip Ball's definition for Sociophysics" describes the new science to be mostly simulations in which independent entities (particles, people, institutions, etc.) act and react according to specific rules or laws. Another simple and clear definition of Sociophysics underlines that it brings a Physics perspective to the problem of complex collective behaviours. A wide variety of specific concepts are covered, and a wide variety of specific methods are used in the new discipline called Sociophysics. Perhaps, the entire field of Sociophysics is nothing else but the unification of Sociology and Physics and studies how cause and effect, energy, magnetism and human relationships meld, although with much originality and ingenuity. Gradually, Sociophysics becomes a new and specialized discipline, which is also a system of thought and is reflected in its new methodological approach to social phenomenon. A good overview of several fields of application and an accessible, entry-level description of many simulation models can be interpreted as forming part of the Sociophysics. For instance, in a paroxysm crisis of fear, opinions can be activated very quickly among millions of mobilized citizens, ready to act in the same direction, against the same enemy, but a lot of phenomena can be studied within the new emerging field of Sociophysics, in particular the dynamics of minority opinion spreading, the rumour propagation, etc [16,17,18]. The most remarkable pioneers of Sociophysics probably are Serge Galam (*Sociophysics: a personal testimony*), Dietrich Stauffer (*Sociophysics Simulations I:Language Competition),* Paris Arnopoulos (*Sociophysics: Chaos and Cosmos in Nature and Culture*). The list is necessarily limited and unavoidably lacking of many important contributions in this research area.

Sociophysics needs more clarity, especially when it envisions probability at the foundation of social theory. There is no contradiction between this new field of Sociophysics and the Statistics. But, certainly, sociophysicists should be more careful when they are justifying their complex models. Sometimes this minds action seems to be averaged out and finally removed by virtue of the *law of large numbers* [19].In the last two or three decades new interdisciplinary approaches to social science have been developed by natural scientists. The distribution of unemployment required a new understanding of society, the dynamics of social systems has been gradually introduced by W. Weidlich (1972) and H.E. Stanley (1992) and a thermodynamic approach to social problems has been favoured by D. K. Foley (1994), J. Mimkes (1995), A.A. Drăgulescu and V. M. Yakovenko (2001).

4. CONTEMPORARY AND FUTURES TRENDS AND ACTIVITIES

The challenging and peculiar feature of Sociophysics' models is their ability to reproduce in some respects, real social systems. For a better understanding, there are detailed two models of spreading opinions within a human population. Serge Galam was the first who have modelled the spread of opinions within a population and gets an equation of the inertia of democratic systems against changes. In the last twenty years, sociphysicists have introduced a series of Sociophysics models. These could be divided in different general classes, which deal respectively with:

a) opinion dynamics,
b) decision making,

c) competitions / conflicts, fragmentation versus coalitions,
d)income or wealth spreading and concentration,
e) residential segregation, migration dynamics,
f) cultures and languages evolution,
g) friendship and sex,
h) internet and world wide web evolution,
i) religion spreading,
j) social networks dynamics,
k) traffic dynamics,
l) democratic voting in bottom up hierarchical systems
m) terrorism spreading, etc.

Using these original models several major real political social and religious events were successfully predicted (from the victory of the French extreme right party in the 2000 to the voting at fifty-fifty in Germany or Italy). The models are real important tools for a reasonable perspective and make Sociophysics a predictive solid field. Sometimes model are philosophical instruments more than scientific. In the year 2000, Katarzyna Sznajd-Weron have proposed a model of opinion formation, which was based on trade union maxima "United we Stand, Divided we Fall" (USDF) known as the model (SM). The main characteristic of SM model is that information flows only outward. A great hope for the model of Sociophysics is to show similar correspondence between simple interactions among entities (agents being the preferred sociophysical term) and complex behaviour in the final aggregate.

In the next years, both physicists, on one hand, and economists with sociologists, on the other, will try to design a basic course to teach the students the basic elements from physics and economics or sociology. Some of the new areas of opportunity for the Sociophysics are:

1. Mediaphysics**,** proposed as a concept of analyzing communicational phenomena in societies, briefly considered as the most possible way to bridge two different and mutually paradigms like Mass Media and Physics. An example of using Mediaphysics principles was presented in the paper *Statistical and Physical paradigms (Econophysics, Sociophysics, Media-physic*s) by I. Mandel1 and D. Kuznetsov
2. New concept of opinion changing rate, that transforms usual approach to opinion consensus modelling into a synchronization problem;
3. Terrorism risk emerged as a quantitative modelling discipline after 9/11, terrorist modus operandi being a function of human behaviour, and so requires special methods drawn from fields such as game theory, social psychology, and network analysis;
4. The availability of high-volume and high-quality records of data allows us to experience and exploit concepts and methods – traditionally belonging to the areas of statistical physics and complexity, in the social sciences: urban textures, the world wide web and firms are described in terms of random structures in high-dimensional representation;
5. City size, income, word frequency, music genres are distributed according to power laws and evolve under the effect of spatial-temporal correlations;
6. Typical of physical systems with many interacting units;
7. The dynamics underlying social conflicts and competition;
8. The insurgent group formation and attacks in all modern wars;
9. Airways Systems;
10. Opinion Dynamics in a Bounded Confidence Consensus Model (from continuum opinion dynamics model of Krause and Hegselmann to Santo Fortunato, Vito Latora, Alessandro Pluchino, Andrea Rapisarda Model);
11. Opinion Changing Rate Model (OCRM), a modified version of the Kuramoto model, one of the simplest models for synchronization in biological systems;
12. Interacting agent models, used to study bifurcations in group dynamics;
13. Social networks and crowd dynamics in traffic, etc.

Somehow, physicists are still divided, some are convinced it will produce new understanding of economic and social phenomena, some are dubitative. Physics has a lot to teach Economics and Sociology and more other social sciences:
- the effort that is put into getting data about processes,
- the importance of developing new methods of measurement;
- the importance that is given to abstraction, thus evidence over models and concrete models over frameworks and paradigms;
- the willingness to develop modelling techniques when the existing ones become inadequate;
- the acceptance of evidence for choosing between competing theories.

Sociophysics, a trans-disciplinary science have transited from recognized subfields of Statistical Physics, Quantum Physics, etc. to social system, learning and understanding reality in a great diversity of methods, and so the older sciences like Physics and Sociology are more credible.

5. WHY SOCIOPHYSICS IS NECESSARY IN A MODERN UNIVERSITIY?

Apparently, this question is not such a difficult one… But, let us do this job easier, using a model of thinking based on contemporary paradoxes of learning process and institutions:
What the modern concept of University means?
Ist Answer: *A place full of intelligent people*…
Sometimes, there are even more than in other places like the institutions for scientific research, banks, political institutions or entities, etc.
This interesting truth can generate the first law or the first Paradox of Universities called Karl Albrecht's Law: "Intelligent people, when assembled into an organization, will tend toward collective stupidity"[20]. All this process happens in a modern university too? However, it does happen frequently since it follows the *entropy* law that measures the energy degradation in a natural system through increasing disorder. Karl Albrecht explains the synergy generation in a knowledge field, introducing the concept of *syntropy*: *as the coming together of people, ideas, resources, systems, and leadership in such a way as to fully capitalize on the possibilities of each*[20]. Could entropy denote the upgrading of organizational energy? The entropy would show the natural tendency of people toward loose interaction and increase stupidity. The same syntropy would show the conscious, deliberate and intelligent effort for organizational learning. Under these circumstances, what could be the best model to understand the entropy and syntropy realities? *This could be the first argument that proves that Sociophysics' is the most necessary science and discipline in a modern university.*
IIndAnswer: A place where appear a continuum process of enlarging democratic access of more people to higher education, a learning organization where there is an increasing academic excellence process. Is it the modern *organization* called university a social invention indeed? An organization represents a systematic arrangement of people brought together to accomplish some specific objectives, impossible to be realized by one single man (Robbins a& DeCenzo,). Actually, this meaning is reflected in the origins of the word which derives from the Greek *organon*, meaning a tool or an instrument. *How the contemporary university succeeds in organizing people?* The process of management is necessary in order to perform this process efficiently and effectively. Efficiency means doing tasks correctly, such that products can be obtained with minimum of resources. Effectiveness means doing the right task (a linear or non-linear thinking, but most of all a deterministic one). But contemporary managerial decisions made in conditions of uncertainty generate risks, even in modern university. In order to identify, evaluate and accept risks we need to develop new thinking models based on random events and accept the importance of random thinking. *This could be the second argument for Sociophysics' model, about which, I hope we shall think again if it is the best model for prognosis.*
IIIrd Answer: A place based on the modern learning processes, on the recently scientific theories and on the most useful discoveries … How could be solved the Brătianu's paradox formulated as follows: although a university is an organization based on learning processes, it is not necessary a learning organization? Since learning is a fundamental process within any university, people may consider universities as being learning organizations. This is a major error, especially in the former socialist countries. The modern university purpose is to demonstrate how far away it is from being a learning organization, due to some organizational barriers [21]. A learning organization is an organization that is continually expanding its capacity to create its future. For such University, it is not enough merely to survive[21]. Adaptive learning should be only the first phase of a modern University, being continued with generative learning, the process that enhances our capacity to create. The organizational learning contains three main cycles of learning: the operational learning cycle as the component of the operational management, the strategic learning cycle that is bridging together the policy learning cycle with the operational learning cycle, and, finally, the policy learning cycle as the organization liaison with the external business environment. In the university internal environment, the process of

production is a knowledge generation and transfer process, and the process of management deals also with knowledge. In the dynamic process of transformation of individual contributions of all organization members into the organizational entities, in terms of knowledge, intelligence and values, the major role is played by integrators [22]. The team management acts as an integrator at the team level: "an integrator is a powerful field of forces capable of combining two or more elements into a new entity, based on interdependence and synergy. These elements may have a physical or virtual nature, and they must posses the capacity of interacting in a controlled way" [22]. Management is by its own nature an integrator, sometimes equal but often more powerful than technology and its associated fundamental sciences. The technology integrator or new important scientific disciplines are capable to act only upon the explicit knowledge, which is codified in a certain way. The management integrator can act upon both explicit and tacit knowledge, generating explicit organizational knowledge and tacit organizational knowledge. *This could be the third Sociophysics' argument for its models and methods which are best solutions in the new era of IT. And for this Sociophysics' information contain more than* 10^{23} *individual data.* Sociophysics is probably the best integrator in a modern university.

6. CONCLUSIONS

In a comparison to classical Sociology the new science like Sociophysics has revealed that heterogeneous in social reality must be explained with homogeneous in theory and this is the most important improvement of the quality in the classical science and research. The main role of the Physics and its methods, like Statistical Physics or Quantum Physics for the beginning, was to unify and simplify classical Sociology. The Sociophysics' researches extend its themes, fields, models and interpretations. Some new contradictions have appeared in the new science of Sociophysics, dealing with:

-an interesting niche on the computer, where have established by making models much simpler than most economists or sociologists now choose to consider even using possible connection between sociologic or economic terms and *critical points* in statistical mechanics (of course, one needs to be careful with analogies, and model simplifications; many of these models are heuristic, can help us in understanding principles, and are not necessarily describing the complexity of individual economic and social cases);

- a response of a physical system to a small external perturbation, that becomes infinite because all the subparts of the system respond cooperatively, or the concept of *noise* in spite of the fact that some economists and sociologists even claim that it is an insult to the intelligence of the market or of the society to invoke the presence of a *noise* term…The power of prediction and the higher level of exactness of the Sociophysics' models remain the most important differences between these new and powerful science and classical Sociology thinking. These models are often better than classical econometrical or statistical correlation models. The complexity studies of Sociophysics try to capture the universal but temporary laws, from data manifested differently in different parts of the same body of natural phenomena, where information about population are made from more individuals than 10^{23} units (cases). This grand unification search [23,24,25,26, 27] is at a very inspiring stage today and this paper reports on a part of these interdisciplinary studies, developed over the last twenty years and classified under the headings Sociophysics, like in the other new science' name called Econophysics.

It was not only the remarkable results of these new sciences that motivated us to collect these authentic reviews on intriguing qualitative developments of Sociophysics, but rather the rapid success in solving difficulties in the social and economic contemporary reality and the way in which this science have improved the quality of classical science Sociology. Instead of the promise and novelty of these new researches, it was the curiosity to understand how a new science solved the problems which has been a guide in selecting articles and books, techniques and methods, models and temporary laws. The future scientific thought will be nothing else but statistical, either it will be a generalized thinking as in statistical physics, or a classical distinctive statistical thinking.

7. A FINAL REMARK

This paper was devoted to the cross-fertilization of interdisciplinary fields of Sociophysics. It seems possible in the next future that the boundaries between sciences will be considered more as determined by methods, and not by the subjects of research. In the last two decades Sociophysics have grown up permanently. But the most important problem for this new science remains the ability to understand a rapid change in the realities of economic and social life. It will be nor the strongest science that survives, nor the most methodological, it will be the one that could adapt itself to changes most rapidly and frequently, finding the best methods, techniques, instruments, concepts, solutions… This must be the science with the most adequate way of thinking to reality, one of the most necessary disciplines in a modern university.The desire of the authors was to synthesize the extensive literature published and to inform about the importance of this new field of researches called Sociophysics, as a useful contribution in reviewing the new science's boundaries.

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