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THE DYNAMICS OF HUMAN SOCIETY EVOLUTION

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ABSTRACT

Human society is an open system that evolves by coupling itself with various known and unknown (energy) fluxes. How do these dynamics precisely unfold? Energetics may provide some insights. We expand on Navier-Stokes' approach to studying non-equilibrium dynamics in a field that evolves with time. Based on the Social Field Theory, an induction of the classical field theories, we define social force, social energy and the Hamiltonian of an individual in a society. The equation for the evolution of an individual is proposed based on the time-dependent Hamiltonian that includes power dynamics (a forcing term). The power dynamics incorporates the surface (environmental-extrinsic) and body (intrinsic) forces. Our models of a human being possess capabilities to manipulate reaction forces as well as a natural aspiration to move up the energy ladder by processing various fluxes including information. These human capabilities are not often associated with an inanimate object and are non-Newtonian. An aggregated multi-body equation leads to a form of an implicit Fokker-Planck equation. The n-dimensional social field is contracted to R^3 for simplicity following Pierre Bourdieu. We present some implications this Hamiltonian based dynamics may bring forward for the economic dimension where we may abstract the Hamiltonian by money.

Keywords: evolution, human society, social field theory

NOMENCLATURE

S	social field strength
I	individual strength
r	social distance
Γ	trust vector, reciprocal of r

1. INTRODUCTION

Human life is a complex system. It is very difficult to interpret human life based on its physical properties alone. Let's postpone the genesis of life for later discussion; we will focus here on human life after it emerges. Whether one reads Longfellow [1] or Tesla [2], they each point out that human life is a movement. What is the nature of this movement? Instead of making an eponymous hypothesis, we conjecture that the human system and its underlying movement are not much different from many other systems around us. In order to make some sense of a conscious human being, we may need a higher level of comprehension along with some generalizations beyond the classical field theories.

The classical field theories define the potential energy of an object within the field of the other object that shares the same property such as mass or charge or (di)pole strength. A force is a gradient of the potential energy. Many phenomena in nature can be interpreted in terms of four fundamental forces: electromagnetic, gravity, strong and weak nuclear forces. Are the myriad phenomena in nature governed by just these four fundamental forces? Many of us assume such a notion to be true. These forces were uncovered in order to explain various phenomenon in natural science, and thus provide not enough clues to explain social dynamics of living beings. We think there exists a new type of force, especially among social beings. We have earlier made a case for the Social Field Theory [3] through a generalization of the classical field theories. Following the theory, we define the Hamiltonian of an individual in a society. The equation of evolution of an individual is sketched based on the time-dependent Hamiltonian that includes the power dynamics in the hierarchical social field.

2. LITERATURE

There is an inherent challenge to extend the classical mechanics into the social system. This challenge led curious minds like Alfred J. Lotka to rely on energetics to understand evolution [4]. In energetics, Lotka saw a physical principle competent enough to extend our systematic knowledge to natural selection. This is unfinished business; something that never took off the ground [5]– a history documented briefly by Richard Adams [6]. Recently, the Constructal Law by Adrian Bejan is gaining some momentum in order to interpret evolution both in animate and inanimate systems [7].

3. SOCIAL FIELD THEORY

There are many types of field theories in social science [8]. None of these theories are in the language of energy. The Social Field Theory (SFT) that we summarize here was born out of an effort to understand the link between energy access and poverty dynamics [3]. We have formalized it based on Bohr's theory of the H-atom, which connects the classical and quantum mechanics in a way many engineering students may find easy to understand.

The social field is characterized in terms of Social Strength (S), Individual Strength (I) and the social distance (r). The variables S and I have a bearing on the idea of the pole strength in a magnetic field. The social distance, according to Wright [9], is the relation of social entities to others measuring the degree of their contact or isolation. We define Trust Vector (Γ) as reciprocal of the social distance, i.e. $r \times \Gamma = 1$. The two hypotheses of the social field are [3].

HP01: Social Field is a quasi-conservative field, defined as a field for which total energy is a monotonic function of time.

HP02: Energy levels in the social field are quantized in similar notion as in established models of an atom, Bohr's theory [10] of the hydrogen atom and Schrödinger's equation.

What are the justifications for these hypotheses? The first hypothesis [HP01] was inspired by our hands-on experience of some developing societies around the world. This hypothesis is supported in part by a correlation that exists between the Energy Development Index and the Human Development Index. The second hypothesis [HP02] assumes continuity of living and non-living worlds. Human society at large must be governed by the same laws of nature we witness, for example, in the hydrogen atom. These two hypotheses provide a rationale to the social field in accordance with which many consequences can be deduced.

3.1 Rationale for the field concept and Social field

Let us consider the energy of an apple A at the surface of the earth E. An apple may be characterized by a multidimensional variable A = A(size, mass, color, sweetness, etc.), the terms in the bracket are some dimensions relevant to the apple, obviously not an exhaustive list. In the same way, the earth may also be characterized by E(size, mass, magnetic moment, density/charge distribution, etc.). Let us simplify this energetics interactions focusing on one of the dimensions common both to an apple and the earth. If the dimension under study is "mass" m, we are dealing with an interaction between the apple and the earth in the gravitational field.

The potential energy of an apple in the gravitational field of the earth (PE_1) = $\frac{G\, m_E\, m_A}{r_E}$; r being the radius. Consider the same apple A is now in the field of the moon M at its surface. The potential energy of the same apple now becomes, (PE_2) = $\frac{G\, m_M\, m_A}{r_M}$. One may show that $PE_1 \approx 22.15 \times PE_2$. The apple is the same here-- nothing changed for the apple. Just because the apple was moved to the moon's field, it has a different absolute potential energy. We argue in the paper that this relationship is true also for a human being and human society.

Here is our argument to support the social field. Consider two individuals identical in all respects, in each of the dimensions that may define the individual strength I of an individual. Please note that I is a multidimensional variable just as A was above for an apple. Assume, the first individual is in Nepal and the other is in the USA. These two human beings can have different potential energy because they are in two different societies, or two different social fields to be more specific. Obviously, the strength S_A of American society is much higher than that of the strength S_N of Nepalese society. This difference in strength of societies may be attributed to the migration tendency of an individual.

Let us consider one of the individuals above that got a Diversity Visa and migrated to a developed country in the West, say America. The life trajectories of these two identical individuals could be entirely different in the economic dimension. This may not be explained without taking into account the differences of social strengths ΔS between American and Nepal. In the future, some of these insights may be compared to the facts that may come out of some empirical method. We don't yet have a clear sight of any empirical method to be utilized.

3.2 Hamiltonian in the Social field

How would one characterize system dynamics from the perspective of natural science? A few different types of methods are out there. At the end of the day, essentially all methods are based one way or the other on the Hamiltonian of the system. If we follow the suggestions of Anthony J. Leggett, a 2003 Noble Laureate in Physics, it becomes important first to distinguish various levels of the problems we encounter in any disciplines. As is the case with condensed matter physics [11], the open problems in social science may also be classified into the following three categories [12]:

i. Hamiltonian known and tractable
ii. Hamiltonian partially known but intractable
iii. Hamiltonian not even known.

The total energy of an individual in the social field is Hamiltonian $\mathcal{H}$ of an individual which is composed of two forms of energy, Potential Energy (PE) $= -$SIΓ, and Kinetic Energy (KE) = ½ SIΓ. In the social field, we equate the potential energy to the capabilities C_2, and kinetic energy to capital C_1, of an individual. Hence, the Hamiltonian of an individual, $\mathcal{H} = \mathcal{H}(C_1, C_2, t)$. The entropy in the social field turns out to be $\bar{I}\log(SI)$. The social field is a non-inertial field that autonomously evolves with time. HP02 provides a structure to the hierarchical social field.

A measurement space for the social field is an n-dimensional phase space of class C2. For each dimension, we have two sub-dimensions: potential energy and kinetic energy. We call these sub-dimensions the class C2: capabilities and capital in the social field respectively.

A target of this paper is to develop provisional "equations of motion for social systems" in the way Wolfgang Weidlich [18] has long sought for. We quantify Hamiltonian in the social field in natural units, and make use of the Hamiltonian in order to propose equations of motion for social systems. The equations we have developed for the social system are based on kinetics. The equations are energetic descriptions of the social system that takes the source term – the social power– into account. In the following section, we review briefly the science of energetics as it is relevant to this study.

4. EQUATIONS OF MOTION

The equations of motion (EOMs) describe time evolution of the state of a system. In fact, the equation we propose for the social field is a power equation, power P = F × v, where power is defined as the rate of change of energy. The change of energy is expressed in terms of the total derivative of the Hamiltonian $\mathcal{H} = \mathcal{H}(C_1, C_2, t)$ in the framework of Navier-Stokes equations. The EOM for an individual in the social field turns out to be,

$$\frac{\partial \mathcal{H}}{\partial t} + \frac{\partial \mathcal{H}}{\partial C_1}\frac{dC_1}{dt} + \frac{\partial \mathcal{H}}{\partial C_2}\frac{dC_2}{dt} = (F_{en} + F_{ex})\frac{1}{\Gamma^2}\frac{d\Gamma}{dt} \pm \dot{\mathbb{Q}}. \quad (1)$$

The Hamiltonian of a society can be aggregated in terms of probability distribution function H_s. Hence for society, EOM will be

$$\frac{\partial}{\partial t}\mathcal{H}_s(n, t) = -\sum_{i=1,2}^{n}\frac{\partial \mathcal{H}_s(n,t)}{\partial C_i}\dot{C}_i + \Big(F_s(n,t) + F_b(n,t)\Big)\dot{r_n} \pm \dot{\mathbb{Q}}_s. \quad (2)$$

An aggregated multi-body equation in the social field leads to an implicit multivariate Fokker-Planck equation. We propose Eq. (2) as a stopgap to knowledge about "equations of motion for social systems" Wolfgang Weidlich [13] claimed non-existent in the literature. Lotka-Volterra type equation can be derived from it when some additional assumptions are made. One of the field theorists in sociology, Pierre Bourdieu has implied three major forms of capital [14]. Accordingly, we propose to contract the n-dimensional social field to $\mathbf{R}^3$. These three reduced dimensions are i) economic ii) cultural and iii) social. This contracted description may provide a logical reasoning to interpret the trends in social capital [15] in many societies.

5. IMPLICATIONS: PHYSICS AND ECONOMICS

The social field theory claims to formalize a new form of energy, and hence it may help break the glass ceiling of utilizing thermodynamics to study social dynamics. Many scholars [16, 17, 18, 19, 20] including ET Jaynes, trusted thermodynamics to bridge the well-lit roads on each side of the natural and social science divide. A good theory can inform what there is to actually measure for a research question. This paper may provide what to look for in the sea of big data for some testable hypothesis in relation to the dynamics of human society. Ideas embedded here may provide a clue to understanding turbulence in fluid dynamics as well as the chaos in social dynamics that takes place in some parts of the world. We will address these issues in the future and as we do so we will develop further confidence in this under-explored territory of social energetics. For the time being, here are some implications for physics and economics.

5.1 Physics: Implications

Is a Social Field Theory plausible? Or is it just another fantasy? Physicists are probably in the best position to evaluate these questions. An analysis of open systems may have to go beyond a narrow lens of the conservation laws. An overarching assumption such as the conservation of money takes us nowhere in our efforts to deepen our understanding of 'What is money?' The SFT is expressed here in natural units, hence it demands a "Cavendish experiment" this time in the social science domain. Such an experiment may pave the way to quantify the capabilities (PE) of an individual in a given social field. How can these ideas, if plausible, inform policy decisions, especially to help catalyze development under real circumstances on the ground?

The social field theory comes along with two fundamental postulates. One is an extension of Bohr's postulates, and the other is based on the review of the repository of knowledge developed by progenitors. These postulates need to go through rigorous experimental testing in order to prove that they can stand on their own. It is our hope that these postulates will survive because convergence is the ultimate nature of science. One measure of progress in the development of any science is its ability to make close contact with other sciences [21, 22]. We need to discover a generally acceptable conceptual framework and a language that will facilitate communication and stimulate further coherent research across the natural and social sciences beyond econophysics [23] as it exists today. Economic science may benefit most from such a framework, and ongoing synergy of physicists and economists may escalate to another level of cooperation in order to better understand the issues challenging humanity.

5.2 Economics: Implications

Money is a concept of paramount significance to economic science. The energetics framework conceives of money in accordance with original insights of Howard Odum, see Chapter 4: Energy and Money [24]. Money flows in circles, but energy flows through a system and ultimately out in a degraded form. To sum up, energy and money flow hand in hand but in opposite directions. For further details, we refer readers to Howard Odum [25] and Frederick Soddy [26]; we decided not to duplicate their original insights in this short paper.

It is our hope that SFT may provide a new physically-oriented underpinning of economic science. Economics through the lens of energetics is a science up in the air, above an abstraction layer. Economic science tends to abstract many things human beings value in pecuniary terms. Such an abstraction facilitates exchanges and efficiency, but obscures a lot of dynamics important to comprehending a social system. "All non-trivial abstractions," says Spolsky, "to some degree, are leaky." Abstraction facilitates the building up of complex systems such as the global economic system. A system based on

abstraction, however, is bound to fail sooner or later to some extent. A recession may be an instance of the abstraction's failure. Let's not go too far out of our comfort zone. Economic science, we admit, is much more complex than physics because it is dealing mostly with the non-living world and active matters only very recently.

The SFT may provide a clue toward a non-overlapping definition of capital and capabilities. A credit is a stake on the capabilities. Poverty relates to the energy state of an individual in a society. If an individual migrates to a new society, he can well be at another energy level than in his native society. The business cycles result from an interplay between capital and capabilities in an autonomous society which can generate a source term of its own. We witness inequality in a modern society as a possible consequence of pseudo-forces in the non-inertial social field. There may be alternative physical reasons for wealth inequality. A recession, like the one in 2008, may be a by-product of polarization of some sort. Equally, it could trigger a bandwagon effect influencing trust vectors among varieties of people in the global economic society. We have established here a logical explanation of why the social field is an autonomous field. The social field neither requires an external intervention to break a symmetry nor does it necessitate an 'Invisible Hand' to prescribe a function.

6. CONCLUSION

Nature doesn't differentiate sciences but we do for good and bad reasons. In this theoretical approach based on the energetics, we argue human society evolves following the same laws of energy along with underlying forms and structures human ingenuity develops and sustains over time. We hope that this study will provide a stopgap for our knowledge about "equations of motion for social systems" Wolfgang Weidlich has long sought for, both at the micro and macro level. The article presents how classical mechanics and quantum mechanics (especially Atomic Theory) may complement each other to make some more sense of social dynamics and the evolution of human society.

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