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Outline of a unified Darwinian evolutionary theory for physical and biological systems

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ABSTRACT

The scheme of a unified Darwinian evolutionary theory for physical and biological systems is described. Every physical system is methodologically endowed with a classical information processor, which turns every system into an agent being also susceptible to evolution. Biological systems retain this structure as natural extensions of physical systems from which they are built up. Optimization of information flows turns out to be the key element to study the possible emergence of quantum behavior and the unified Darwinian description of physical and biological systems. The Darwinian natural selection scheme is completed by the Lamarckian component in the form of the anticipation of states of surrounding bio-physical systems.

Contents

1. Introduction

There are certain frameworks, like universal Darwinism (Dawkins, 1983) or generalized Darwinism (Aldrich et al., 2008), that apply the essence of Darwinism (evolution under natural selection of systems possessing the properties of variation, selection and retention) to different domains of knowledge. Darwinism has been also applied in physics as a possible mechanism

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explaining different fundamental problems (Smolin, 2006; Zurek, 2009). In this article a theory in progress (Baladrón, 2010, 2014; Baladrón and Khrennikov, 2016) is reviewed whose aim is to explore the possibility of unifying Darwinism for the physical and the biological realms. In a certain sense, it can be considered an extension of Darwinism to the physical domain, but at the same time, in a deeper level, a unification of the physical and biological descriptions under a generalized Darwinian perspective in which information would play a central role applied to the specialized physical and biological domains. In the end, biological systems are built with matter. Therefore, biological systems must also comply with physical laws, and a connection between matter and life is already established in the physical realm. However, might there be a deeper connection? The function of life is to continue to exist, in a constantly changing environment (Eigen, 2013; Hill and Nowak, 2014). Could this be also asserted for the function of matter from the perspective of quantum mechanics? Thus, the question arises as to whether Darwinism could be a unifying approach for the description of matter and life under the overarching framework of information.

This theory studies the possibility of implementing quantum-like behavior in classical dynamical physical systems that are methodologically endowed with a probabilistic classical Turing machine (see Encyclopedia of Mathematics, 2013. Turing machine), i.e. basically an information processor plus a random number generator −for biological systems, which will be explicitly considered in Section 3, the information processor would be the network of the processors associated to their physical constituents.[1] Every physical system would then be governed by a program that would have been developed under the action of Darwinian evolution starting at the Big Bang ($t = 0$) in the physical space and a corresponding initial information state of minimal content coding the initial conditions. These initial conditions in the information space would be the following: initial state and algorithm defining the random number generator; the basic set of abstract elements and operations that defines the Turing machine (see Barker-Plummer, 2016; and Section 2.1); the connecting rules between the information space and the physical space of the bare system; and finally at $t = 0$ the blank state for the information about the physical space (surrounding systems). In this way every fundamental system would become an agent in an evolutionary scenario in which there would be no universal laws, but systems driven by programs that would evolve submitted to natural selection pressure (see Fig. 1 for a representation of the self-interaction process in a system resulting from the interplay between the bare material system and the probabilistic classical Turing machine). This information-theoretic Darwinian scenario would provide meaning to the information conveyed by every agent. The meaning of information would be its utility for the stability or survival of the agent. Quantum-like behavior would result from the optimization of past, present and anticipated classical information flows for the stability of the system. Therefore, this theory might shed new light (Baladrón and Khrennikov, 2016) on the concept of quantum information (Nielsen and Chuang, 2000; Jaeger, 2007) and its relation with classical information.

In our model, bio-physical systems demonstrate the ability for anticipation of states of surrounding systems. This ability is the output of functioning of Turing machines associated with systems.[2]

This information-theoretic physical Darwinism, which would explain the emergence of quantum behavior and would underlie the unification of the evolutionary description of physical and biological systems, would represent a solution to the conundrum of the meta-laws (Unger and Smolin, 2015), which is intrinsically associated to the analysis of the possibility of changing laws in cosmology (Unger and Smolin, 2015), since, once the possible variability of the laws is admitted, this mutability could also affect the manner in which the natural laws change −i.e., the meta-law–, and the problem of explaining the historical change of laws would have just been transferred to a higher level (the conundrum of the meta-laws). The proposed information-theoretic physical Darwinism would solve this problem acting as a natural self-generated meta-law, therefore eliminating the necessity of a recurrent explanation to higher levels.

The interaction between the world of ideas and the material world —or in a more physical terminology between information and matter— has been present in the history of physics from the Ancient Greece (Pombo, 2010, 2015). Since then the connections and interplay between these two worlds have been analyzed by certain schools of thought as a possible alternative key element in the understanding of nature.

The article is organized as follows. The theory and model for a fundamental physical system are analyzed in Section 2. The model for a biological system is described and the results discussed in Section 3. Finally, the conclusions are drawn in Section 4. The paper also contains the extended Appendix devoted to interconnection of our evolutionary model with Whiteheadian metaphysics.

2. Information-theoretic Darwinian model for a fundamental physical system

An information-theoretic Darwinian approach (Baladrón, 2010, 2014; Baladrón and Khrennikov, 2016) applied to classical physical systems is presented in this Section. It is expected to explain the emergence of quantum mechanical behavior. Darwinism is going to play the role of the self-generated meta-law that determines the evolution of the programs —which in turn govern the behavior of the fundamental physical systems— stored on the probabilistic classical Turing machines from the initial informational state of minimal content —corresponding to the Big Bang in the physical space— in which the physical systems are under the control of their respective randomizers.

The two main characteristics of this approach are influenced by two famous sayings of Wheeler. First, the weight of information as a fundamental element shaping matter behavior is deeply swayed by Wheeler's dictum "*it from bit*" (Wheeler, 1990). Second, an appealing answer to the challenging Wheeler's question "*why the quantum?*" is tentatively supplied by the usage of Darwinism in order to explore the possibility that quantumness might emerge from classicality as an efficient solution leading to steady physical systems. In other words, if the world is going to present regularities, then it must be quantum.

[1] In animas this probabilistic Turing machine is physically based on the nervous system; for plants this is the system of signaling between cells representing a kind of distributed cognition; for individual cells, the Turing machine like computational device is composed of epigenome and the network of molecular signaling. The quantum-like signatures of network functioning were discussed in De Barros and Suppes (2009), and De Barros (2012).

[2] The anticipation component of the evolutionary dynamics can be compared with the active information field interpretation of the wave function, see Bohm and Hiley (1993). Such a component also plays the fundamental role in theory of partially directed evolution which was developed in the works Melkikh (2014), and Melkikh and Khrennikov (2015, 2016) and it was based on exploring the mathematical formalism of quantum information theory. This anticipation dimension can be treated as the Lamarckian element of the model, see Asano et al. (2014, 2015) for extended discussion.