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On the Foundations of Emergence

From pre-geometry to human life by using a generalized understanding of information

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Abstract: *It is the purpose of this contribution arguing that emergence, on the one hand, exists as something new in nature; on the other hand, that it is something transcending classical computation. To this end, it is suggested a careful generalization of the concept of agency, proposed by Stuart Kauffman as system able to perform at least one thermodynamic work cycle, throughout all the levels of complexity – from pre-geometry to social contexts –. We set off from the level of pre-geometry (described in terms of spin networks in the sense of Roger Penrose) leading up to social systems. At this higher level, we deal with agents who have self-reflection and try to reconstruct objects and situations from essentially limited information. To that purpose hermeneutical agency is introduced, in which the cycles defined by observation-representation can be seen in thermodynamic terms, and is the goal for such agent the reduction of the complexity of the related representation, generally linked to some pragmatic situation. At this level, innovation can be visualized, in the best case, as emergence in social contexts. But in order to move throughout all the latter of complexity, we propose as unifying principle that the pair energy-matter can be regarded alongside the pair information-structure (representing such bipolarity the difference and relation between potentiality and actuality). Whereas energy is conceptualized as potentiality to perform work (change), we claim that information can be visualized – from the outset – as potentiality to utilize such work in benefit of the organization of the system, being structure the actualization of such organization potential represented by information. Since the beneficial use of work is fundamental for defining agency, this general understanding of information facilitate the task of properly extending the concept of agency to the whole hierarchy of complexity and to visualize agents as playing natural games at the different levels. Using such viewpoint we shall map, on the one hand, agency dynamics through game theoretical applications; on the other hand, evolutionary system dynamics through mathematical category theory.*

Keywords: Emergence, evolutionary computation, pre-geometry, hierarchy of complexity, information, agency

Does emergence exists as something new in nature? As we have argued in several publications (Zimmermann and Díaz 2012a, 2012b; Díaz and Zimmermann 2012), emergence can be understood as the "real" consequence of agents' actions on its own level –extending the idea of minimal autonomous agency elaborated by Kauffman (2000-2006) as a system capable to perform thermodynamic cycles. This point of view allows us to speak of emergence as something ontologically irreducible to the parts constituting the agent. Since we are speaking of emergence in nature – in a general sense –, this requires a careful review of what is understood by agency throughout the different levels of complexity: from pre-geometry, to physics, to chemistry, to biology, to conscious life and to sociality. The consequences of this alleged agency – if they are really becoming something new – must be ontologically irreducible to the effects of the involved parts – regarded by themselves – and fundamentally dependent on the attained rules of interaction, i.e. to its organization (the "new order of existence with its special laws of behavior", using S. Alexander's expression (1920)). The problem is how to define the organizational means allowing on the one hand the agency on its own level; on the other hand, the constitution of new levels, which can be seen as both emergence of new agency and formation of new classicity (Zimmermann 2000). Such vision brings to the fore – considering the conditions for attributing agency and classicity – the need to derive the philosophical concepts of choice, meaning and normalization from the fundamental level of physicality and traced back to social contexts. Similarly a big picture of the roles ascribed to the fundamental attributes of energy, matter, information and

structure should be reviewed in order to overarch throughout the hierarchy of complexity within the universe as a fundamental and global system.

If aiming at computationally modeling emergence, we argue that emergence is something transcending classical models of computation, thus new computational approaches have to be achieved to visualize emergence as a result of a more sophisticated understanding of computation. Whereas classical computation is restricted within the limits of Turing's halting theorem or Gödel incompleteness, ontological emergence –as a consequence of its irreductibility– might be understood as the need to overcome the limitations of a given algorithmic closure referred to the relations governing the system, which can be in turn mapped to a Turing machine. Thus, the question can be redirected to what kind of computational model might represent a real case of emergence. Several candidates as quantum computation (), cellular automata (Wolfram 2002), computational ecologies (Mainzer 2004), etc. provide practical means to overcome classical limitations offering and, at the same time, models for mapping the computational sense of emergence in reality. In the human, the problems of perception, scientific discovery, etc. require creative abductions which represent a most distant case of classical computation as discussed elsewhere (Díaz 2011). Though these abductions could be regarded as epistemological emergences, since they actually occur in ontological closure – as proved by the author (2011b, 2011c) –, they represent indeed relevant cases of genuine emergence. Furthermore, by unfolding our viewpoint we shall also ask: How can we rephrase the relationship between physics, aesthetics, and ethics as visualized under the human perspective, in order to actually develop new, relevant viewpoints and practical applications derived therefrom?

1. Preliminary hypothesis

As stated above, we rephrase the quest on the nature of emergence to the proper understanding of agency throughout the hierarchy of complexity. To this purpose,

(1) An autonomous agent – following Stuart Kauffman (2000-2006) – is to be understood in a generalized sense as a system able to perform thermodynamic work cycles – or more specifically, able to achieve a new closure in a given space of catalytic and work tasks propagating work out of non-equilibrium states and playing natural games according to the constraints of their environment.

(2) Since we aim at developing a global picture in which the universe is understood as a global system, we cannot start from the fragmented vision of quantum vs. relativistic physics. To this end, we set off from the level of pre-geometry (described in terms of spin networks in the sense of Roger Penrose and considering the related developments in quantum gravity) leading up to social systems. At the fundamental level, the approach provided by Louis Kauffman´s knot theory offers a candidate to visualize spin networks as knots acting on knots to create knots in rich coupled cycles – similar to metabolisms –, therefore as fundamental agents. As we have shown (Zimmermann and Díaz 2012a), the Braunstein-Ghosh-Severi (BGS) entropy applied to spin networks allows us to put forward generalized conditions of autonomous agent in the sense of Stuart Kauffman.

(3) According to this viewpoint, on the one hand, agency dynamics can be mapped through *game theoretical* applications; on the other hand, evolutionary system dynamics can be mapped through mathematical *category theory*. By these means we expect a proper embracing of the hierarchy of complexity.

(4) Concerning the fundamental attributes of the universe, we consider that the pair *energy-matter*, can be regarded alongside the pair *information-structure* (representing such bipolarity the difference and relation between potentiality and actuality). Whereas energy is conceptualized as potentiality to perform work (change), we claim that information can be visualized – from the outset – as potentiality to utilize such work in benefit of the organization of the system, being structure the actualization of such organization potential represented by information. In other words, information can be regarded as potentiality for building the constraints and affordances that enables propagating work.

(5) In cognitive and social contexts, we deal with agents who have self-reflection and try to reconstruct objects and situations from essentially limited information (Díaz 2011a-c), in which the case of animal perception represents a basic level. To that purpose *hermeneutical agency* shall be introduced, in which the cycles defined by observation-representation can be seen in thermodynamic terms, and is the purpose for such agent the reduction of the complexity of the related representation, generally linked to some pragmatic situation.

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