Science: the Unifying Factor for Humankind in the Future

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Abstract

Even though science achievements are undeniable through human history, there is a sort of disenchantment about its ethical and social consequences. Despite the fact that this is true, we question now on the validity of the approach between scientific models of the world and current and existential reality, because we think that the future of Humankind largely depends upon that. Scientific language is extremely powerful but it is not almighty; therefore, we review the serious limitations of proclaiming a unique code of expression about the real world, humans within, and instead we propose a polyglotism which not only recognizes there are other forms of telling the world, but opens its own horizon, accepting its needs, assuming then the unifier role that science is called to play, so that Humanity steer the future in an adequate way.

1 Introduction

Humankind is nowadays a monumental anthem of hope and longing, as well as eagerness and desire, self-confidence and selfishness, pride and shame. Sciences and technologies have a lot to do with such a point of view, outwitting us very frequently, ending either on naïve trusting attitudes or on desperate standpoints, verging in impossible issues about the future of Humanity. The 20th century pointed out the double role played by sciences both in human thought and in human actions; namely, it underlined the unavoidable feeling of admiration, facing the incredible ingenious methods, theoretically as well as experimentally, implemented by scientists to penetrate atomic and subatomic secrets, finally connecting them with the biggest cosmological questions. However, this awesome feeling became fearfulness and even panic as soon as nuclear energy, for instance, turned to be associated with dangerous wastes, massive destructive weapons, horrible diseases, and so on. In other words, sciences and its applications on a diversity of technologies turned out to be, in the collective imaginary, a synonym of alienation of humankind. Is it possible to recover the original glamour of science? Could we breathe once again the fresh air of a renewed inspiration propitiated by the sense of self-critique, as scientific thought was in pastime? Would the scientific community be prepared to review some of the grounds, which its edification is built on?

Is it affordable that science become a point of union for humankind, being more and more responsible of its presence in the world?[1]

2 The point of view of Thermodynamics

To answer those questions is equivalent to be able to steer the future. There is no doubt about the brilliant successes of classical science, from early 17th century up to the present time; nevertheless, already from the middle of the 19th century, thermodynamics showed that we couldn't manage all phenomena in the same way, this is to say, that not all processes in nature were equally possible, jeopardizing the current validity of deterministic descriptions of reality. There were even declared *impossible* situations according to the basic conservation principles; Boltzmann's H-theorem[2] was a sort of watershed between the permitted and forbidden evolutions of systems in nature: the thermodynamic potential *entropy*, S, should obey a monotonically growing rhythm,

$$\frac{dS}{dt} \geq 0$$

Of course we all know that this expression leads to the idea that the whole universe would evolve towards a thermal death, which means that all the material reality, all things would irremediably disappear as, precisely, being things.[3] However, in spite of this conclusion from the second law of thermodynamics, there was another crucial result, namely, the so-called Prigogine's theorem, concerning the *minimal* entropy production at a steady non-equilibrium state in a linear system[4]; such a state is stable and constitutes the *thermodynamic branch*.[5] What happens when we move away from the linear regime? At that moment non-linear aspects of the system become very important and, as a consequence, the thermodynamic branch becomes unstable: there appear thus the necessary conditions for a phase transition, this is to say, the system is forced to change its definition level for a different one. The new state is usually characterized by a different *structure* with respect to the preceding one; those new structures are called, after Prigogine's work, *dissipative structures*, "which are essential

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[1] There exist many texts presenting excellent reviews about these subjects. However we highly recommend Dyson, F., *The Scientist as Rebel*, New York Review Books, New York, 2006.

[2] We shall notice that Boltzmann's H function is proportional to $-S$. Indeed, for a numerical density function $f\ (\vec{p}, \vec{q}, t)$, i.e. the number of particles contained in a volume element $\vec{p} \to \vec{p} + d\vec{p}$, $\vec{q} \to \vec{q} + d\vec{q}$ at a given time t, H is defined as

$$H(t) \equiv \iint d\vec{q}\, d\vec{p} f\ (\vec{p}, \vec{q}, t) ln f\ (\vec{p}, \vec{q}, t)$$

and it is established that the entropy function is such that $S = -k_B H(t)$, where $k_B = 1{,}38 \times 10^{-16} erg/°K$ is Boltzmann's constant. Cf. Reichl, L., *A Modern Course in Statistical Physics*, 2nd edition, John Wiley & Sons, Inc., New York, 1998, pp. 680-682.

[3] Cf. Ehrenfest, P., Ehrenfest, T., *The Conceptual Foundations of the Statistical Approach in Mechanics*, Dover Publications, Inc., New York, 1990, pp. 13 et seq., for a good comment about the consequences of the so called *Stosszahlansatz* (the molecular chaos hypothesis). This question is extremely important in order to understand how a reversible deterministic system, as the classical gas, comes with a non-reversible solution as the *H*-theorem. The original idea of *thermal death of the universe* can be explored in a foundational text by Lord Kelvin in Thomson, W., *On a Universal Tendency in Nature to the Dissipation of Mechanical Energy*, Proceedings of the Royal Society of Edinburgh for April 19, 1852.

[4] Cf. Prigogine, I., Nicolis, G., *Self-Organization in Non-Equilibrium Systems*, John Wiley & Sons, Inc., New York, 1977, pp. 42-45.

[5] Cf. Reichl, L., *A Modern Course in Statistical Physics*, 2nd edition, John Wiley & Sons, Inc., New York, 1998, pp. 721-722.

in the understanding of coherence and organization in the nonequilibrium world in which we live."[6]

3 What we want and what we achieve

So things, second law of thermodynamics and Prigogine's theorem allow us to understand, from this standpoint, that all the physical reality is organized in such a way that we observe "lumps" or "clots" of matter and energy, preventing their uniform distribution across the universe.[7] This kind of organization is strongly non-linear and it is based on the size of the "clots"; as they attain a critical size, they have a long-range consequence in the whole system.[8] From this point of view the scientific landscape obtained about nature is dazzling. Nonetheless, it is not good enough to encourage mankind to face the future with a certain degree of self-confidence; so, what is it lacking to do so? In some sense Johannes Kepler asked himself the same question once he discovered that planetary orbits around the Sun weren't circles, but rather ellipses, with the Sun at one of the foci (c. 1609): there was no simple explanation why those orbits were not circles, as it was quite well known that, according to scholastic theology, the *circle* was the perfect geometric figure and image of the eternal nature of the Creator of the world.[9] The internal conflict that Kepler had to face, at the very depth of things, was not the choice between circles and ellipses; instead of that, it was the unavoidable decision between the scholastic conception of *perfection* and the inevitable findings of measurable reality, which struggled his upright soul. One can hardly understand how difficult it became for him to give up his personal desire of fitting the five Platonic regular polyhedrons to the six planetary orbits around the Sun, in order to surrender, finally, to the observational evidence of "flattened" circles, i.e. ellipses, apparently violating all he knew about beauty and perfection.[10] Well, keeping distance from 16th and 17th centuries perspectives of thought, as 21st century human beings we find ourselves in the same dilemma: we try to understand reality, living accordingly with the knowledge so achieved because we expect, one way or another, to be ourselves part of the reality we currently study. How to get through it?

Among the best accomplishments of mankind we recognize *science*, *art* and *philosophy*, as they have in common, all three, that they can bring in question the blindly accepted state of things in the world, at any level. Art and philosophy, being

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[6] Cf. Prigogine, I., *From being to becoming: time and complexity in the physical sciences*, Freeman, San Francisco, 1980, p. 84.

[7] That is the so-called *nucleation* phenomenon. For a modern view of this theme it is worthwhile to read Sear, R.P., *Nucleation: theory and applications to protein solutions and colloidal suspensions*, *J. Physics Cond. Matt.* **19** (3): 033101, 2007.

[8] This is the main nuance on the treatment of the phase transition problem. Cf. Prigogine, I., Stengers, I., *Order out of chaos: man's new dialogue with nature*, Bantam Books, New York, 1984, pp. 187-188.

[9] Johannes Kepler (1571-1630) used to be a fervent Christian and he knew very well the theological and even philosophical bases of his beliefs. The idea of the circle being the geometric image of God's beauty and perfection comes from the idea that circles are immutable, in contrast to linear motion or other sorts of curvilinear non-circular motion. Cf. Aristotle, *On the heavens*, I and II, Aris & Phillips, Warminster, 1995, book I 269a 20.

[10] Of course, neither Kepler nor anyone else knew, at that time, that a circle is indeed an ellipse with both foci coinciding on the same place, now named *center* of the circle. The remarkable efforts by Descartes (analytical geometry) and Newton (triangulations on tangential points of an ellipse) showed the intellectual battle in order to replace metaphysics by mathematics. Cf. Goodstein, D.L., Goodstein, J.R., *Feynman's lost Lecture*, W.W. Norton & Company, New York, 1999; cf. Koyré, A., *Galileo and the Scientific Revolution of the Seventeenth Century*, The Philosophical Review, Vol. 52, No. 4 (Jul, 1943), pp. 333-348; cf. Caspar, M., *Kepler*, Dover Publications Inc., New York, 1993, pp. 60-65.

extremely relevant, as they justify most of the peculiar characters of humans, they hardly generate new technologies for human living; that doesn't mean that art and philosophy are simply useless, certainly not. The development of new technologies is not part of the goals such disciplines should attain in their performance; this is to say, that the way they think about reality does not need to incorporate the sort of things art and philosophy would have to possess in order to be what they are. In fact, they are activities as vital to human life as sciences themselves. However, the situation of basic sciences is quite another.

The presuppositions and the initial conditions of scientific thought are essentially the minimum requirements in order to proceed in research, that is to say that reality is *intelligible* (rationality with *ontological* weight, i.e. the stage of *being*), that mankind possesses the *capability* to approach that reality with his understanding, even though it is impossible to exhaust (*epistemology*) and, finally, that the knowledge of reality has an inevitable associated *value* (*ethics*). It is easily noted that the common "zone" of these three dimensions (ontological, epistemological and ethical) is *reality* itself, and its foundations are in the concrete manner the human brain *perceives* and *interprets* such reality[11]. Neuroscience has been working out these topics from about twenty years and has revealed the unexpected complication of the interpretative fact; nevertheless, philosophy or, more precisely, *epistemology*, a much older practice, has little by little unveiled the paths of reasoning within our minds. In other words, neuroscience and epistemology share a huge intersection area, namely, *hermeneutics*. These assumptions made by every scientific research are the distinctive manner utilized by sciences in order to approach reality. Therefore, it should not sound strange if we say that the epicenter of knowledge and human life is reality as it manifests to us, as such, not the way we would like it to be and the way ideality forges it. That is the key to answer the question for the steering of the future.

4 Is reality necessarily mathematical?

We all know about the "edict" proclaimed by Galileo that *mathematics* is the natural language of the world; so that whoever wants to hold a conversation with nature, this is to say, asking her questions, one has the interest of having a certain domain of that language, otherwise her answers would never be understood. No doubt such idea was tremendously important for the future of science performance; no matter how relevant this was in history, it led to a sort of selfishness, elitism and arrogance in the scientific task. Moreover, Galileo's perspective of interactions between men and nature was a little bit blind. How was that possible? Perhaps the origin of such disjunctive comes from the very image everyone has about his or her own body.[12] French phenomenologist Michel Henry is one of the foremost thinkers in this subject as he

[11] As a matter of fact, nobody can separate *perception* and *interpretation*. Hermeneutics, which is the discipline studying the interpretation of reality (beyond the use generally attached to that term, this is to say, no necessarily related to the study of "inspired" texts), is necessarily present in every human act; in fact, simplifying, we might declare that *knowing is interpreting*, since human understanding is *a fortiori* the filter through which any sort of stimuli (either internal or external) shall pass. This doesn't mean that such understanding shall exhaust interpretation itself. Indeed, to pretend that the whole reality can be totally interpreted is equivalent to emptying it from its content. Isn't it that what Freud makes, perhaps, when he thinks he understands the undertone of dreams, exhaustively interpreting them?

[12] All we are going to say on this subject is inspired on a couple of speeches given by Michel Henry in 1995 in Brussels, called *Le corps vivant*, the living body. There exists a transcription in the original French one can consult in http://es.scribd.com/doc/8589474/Michel-Henry-Le-corps-vivant . There is a translation in English at http://www.academia.edu/5595141/The_Living_Body_by_Michel_Henry .

asserts that "the disaggregation of the traditional conception of the body is at the origin of modernity, this is to say, at the epistemological world we all belong to."[13] However, it was Galileo who considered that body as mere illusion, since that "real" body, a body one can see, one can touch, with colors, odors, tactile qualities, and son on, does not represent the matter the universe is made of and, by extension, cannot be subject to the laws of nature in the same way the *inert* matter is. The sensible knowledge of sensible bodies changes from one individual to another and, as a consequence, it is not susceptible to be a universal one.

It might be useful to remember a crucial citation, once more, by Alexandre Koyré, namely, "that is the reason why we think that the intellectual attitude of classical science might be characterized by these two moments, otherwise intimately tied: the geometrization of space and the dissolution of Cosmos, this is to say, the disappearance, at the interior of scientific reasoning, of every consideration beginning with the Cosmos itself (except in the case of Kepler, vide ad supra); in other words, it's all about the substitution of the *concrete space* of pre-Galilean physics by the *abstract space* of Euclidean geometry. This replacement lent the invention of the law of *inertia* by Descartes."[14] The geometrization of space is equivalent to prioritize the unchanged matter over the mutable reality[15]; the onerous toll one has to pay in order to obtain a universal description of reality is, precisely, the loss of concreteness and therefore the alienation of human interference. But, in such case, what does it mean "knowledge" without a concrete brain that actually "knows"? Do we have to give up all our aspirations for universality in order to be able to say something about concrete individuals? Is the "Holly Grail" of science to immolate uncertainty, as strictly associated with the human nature, so that it can attain truth about reality? We think that it is not so at all: there exists a third choice, namely, the coincidence between the *concrete universal* and the *universal concrete*. It may even sound like a pun, a play on words; nonetheless, such a coincidence announces rather the encounter between the *difference* and *sameness*. To put it in simpler terms, more alike to basic sciences, it is on the *frontier* of real systems, not on their apparent border, where reality stands: there it is the definite answer to the fundamental question about the steering of the future from mankind hands.

This third choice, indeed, has always been there for the very simple reason that we all live *in* the present, not at its margins, even though our perception in unavoidably past. Present is an *open system* and "it is extraordinary that an idea as fundamental as that of an open system has been so late and locally emerged (which proves the point that the most difficult to perceive is the evident)."[16] It is then in the nature of *time* where the future can be foreseen and the proper attitude in order to face it as well. The language to deal with this is *complexity*, as deterministic models, like Galileo's, have already produced many fruits but they cannot go further anymore. In few words complexity refers to *entangled* situations or *mixed* structures in such a way that it is impossible to confine them to simple principles, this is to say, to reductionism; this doesn't mean that the pursuit of basic principles is worthless, not at all, but the fact of believing that reality is a sort of chess game and that it suffices to know the simple movements of the

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[13] Ibid.

[14] Cf. Koyré, A., *Galileo Studies*, Brill, New Jersey, 1978, pp. 184 et seq.

[15] Cf. Prigogine, I., *From being to becoming; time and complexity in the physical sciences*, Freeman, San Francisco, 1980, p. 9.

[16] Cf. Morin, E., *Introduction à la pensée complexe*, Éditions du Seuil, Paris, 2005, p. 32. We could not find an English version of this book, so we present a free translation from the original French: « Il est extraordinaire qu'une idée aussi fondamentale que le système ouvert ait aussi tardivement et localement émergé (ce qui montre déjà à quel point le plus difficile à percevoir est l'évidence). »

different pieces or components, so that the complete landscape of the universe will at once become evident, well, that is a fairy tale. All the rules we found as the laws of nature are not simply false; they are rather oversimplified conceptions of local behavior, both in space and in time, which means that knowledge itself obeys evolution dynamics. Those rules imply that what we usually consider as stable and universal behaviors, in reality they simply are *steady states* or transient situations, yes, provisionally stables, but no more than that. So, talking about science, what is the name of the game?

Among the many possible answers to that question, it seems to us that the concept of *dissipative structure*[17] certainly is the more interesting one, because without denying the validity of the second law of thermodynamics, it allows the possibility of organization of things, this is to say, the *thermodynamic branch* (vide ad supra). If this scientific bet leads us to a compromise with all nature, including humanity, we will know how to behave, as a reasoning species, being at least responsible for our immediate environment. No matter how beautiful all this might sound, it depends on our readiness in changing our usual criteria for choosing behavioral patterns. That is the aim of science, namely, to make humans more human; to do so, the language of scientific task has to begin accepting that it is not the only one, even at the interior of science itself. To miss the mark on this theme can signify a quite serious disadvantage for future generations, becoming more and more disappointed about scientific promises. In that sense, science *must* be in close contact with arts and philosophy, admitting that she is not capable by herself of seeking the good for man; the needs of humans includes all sort of securities, concerning mainly health, food, job and, above all, hope. Surely all this can sound like preaching, but it is simply the congregation of thoughts present almost in every human soul; therefore, sciences have to do something about it.

5 The language or the languages of science

Concerning the *language of science*, as we already said, requires mathematics as a code of choice, to express the abstract issued from reality, so that models can be built, models conceived to predict future behaviors in natural systems. It is precisely that "pruritus" we must put aside because complexity and openness of those systems, and they are all open, shall grant a place for unexpectedness, which is not equivalent to just anything. The precision of uncertainty is the transitory state of things we usually name steady state.[18] Nobody else but sciences have meditated so largely on these nuances and they reveal today as the precautious wake up call to manfully accept, not the fate, but the meaning of life through the effort to speak as many languages as possible.

This *polyglotism* refers specially to an acquired capacity of understanding the others, not only concerning the actual tongues they utilize, but the particular manners of considering reality. The history of science is a gorgeous example of that in many of her

[17] The concept of *dissipative structure* was first formulated by Ilya Prigogine and it actually earned him the Nobel Prize in Chemistry, 1977. A quick comment on dissipative structures can be read in the site http://en.wikipedia.org/wiki/Dissipative_system and a deeper development, though as a popular science book, is Davies, P., *The Cosmic Blueprint: New Discoveries in Nature's Creative Ability to Order the Universe*, Templeton Foundation Press, Philadelphia, 2004, pp. 83-85. It is quite remarkable that the very first epigraph cited by Davies is a Prigogine's phrase: "God is no more an archivist unfolding an infinite sequence he had designed once and forever. He continues the labour of creation throughout time" in Prigogine, I., 'The Rediscovery of Time', in Sara Nash (ed.), Science and Complexity (Northwood, Middlesex, Science Reviews Ltd, 1985), p. 11.

[18] It surely is this aspect of thinking which lies at the origin of poetry, from this point of view, the most precise of all human disciplines, because it speaks the unspeakable through the magic of metaphors. These are the transcript of *analogies* elsewhere.

golden pages written throughout the centuries. Just to mention two of them, we have, for instance, the explanation of thermodynamics in terms of a mysterious fluid named "caloric"[19]; on the other hand the two mathematical explanations on quantum gravity, namely, quantum loop gravity (QLG) and string theory, as part of a more general context, the so called Super-Symmetry theories (SUSY).[20] Needless to say that what we mean by "language", in the present context, is any form of expression, not only human, but any parcel of reality showing itself through morphology, function, relation with other parcels, briefly in its particular place in space and its particular action in time, this is to say, its *history*. So, for instance, a forest is in itself a discourse, a vegetal speech; the "simple" fact of being there suffices to remind us that things, matter, energy, minerals, trees, animals, humans, have escaped, we don't know how, from nothingness. Human history, particularly the 20th century history, is filled up with stories of blood, hunger, injustice, nasty social contrasts, amazing technologies usually sponsored by and oriented for armies, medical techniques of astonishing precision and, at the same time, millions of people, mainly children, dying of preventable infectious diseases, and so on. The solution starts down here, amongst humans, learning to learn from others and declaring from their inner part of their minds, that it will never again happen to humans to set over human dignity the ambitious perspective of racial superiority, of fanatic wrights, of apocalyptic views. No, the future of Humanity must take into account the open unity in diversity.

6 Conclusions

Epistemic polyglotism is a privileged road towards the accomplishment of our most cherished dreams. That is why we shouldn't spare efforts in order to implement a true interest in other fields of knowledge, because they are indeed extremely interesting, passionate and indispensable for our daily work, either it is in a scientific field or not. This is the beginning of crossroads between *educational programs* and the epicenter of scientific skills, namely, *open-minded* attitude.[21] The conviction of the complex nature of the world begins at early ages; children better than anybody can understand that everything is interrelated with everything, so that they truly have a glimpse of reality and, hopefully, can contribute to change our views of the world we live in. Modifying,

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[19] Cf. Mendosa, E. (February 1961), "A sketch for a history of early thermodynamics", *Physics Today* **14** (2): 32–42. The actual term *caloric*, employed to work out a "caloric theory", was originally introduced by French scientist Antoine Lavoisier in his *Réflexions sur le phlogistique, pour servir de suite à la théorie de la combustion et de la calcination, publiée en 1777* (Reflections on the phlogiston, in order to be useful afterwards in the combustion theory and in the calcination theory, published in 1777). Sadi Carnot in Carnot, S., *Reflection on the Motive Power of Fire*, Dover, New York, 1960, develops a successful application of this erroneous theory.

[20] Another beautiful example is the well-known case of Heisenberg representation of quantum mechanics in terms of matrix algebra (matrix mechanics), and Schrödinger picture in terms of wave mechanics, by means of time-dependent wave functions (Schrödinger equation). Cf. Dirac, P.A.M., *The Principles of Quantum Mechanics*, fourth edition, Clarendon Press-Oxford, Oxford, 2004, pp. 89-94, 111-116. It is a remarkable event in the history of physics that both appearances showed to be equivalent, though their differences in expression remain. Cf. Penrose, R., *The road to reality: a Complete Guide to the Laws of the Universe*, Jonathan Cape, London, 2004, pp. 869-957, to have a brief but very rich presentation of the main ideas in string an QLG.

[21] Let us quote once again the beautiful book by Dyson, F., *The Scientist as Rebel*, New York Review Books, New York, 2006, pp. 320 et seq. In those pages Dyson remembers the thoughts of John Polkinghorne and Richard Feynman; that wonderful chapter called *Is God in labs?*, explicitly shows the urgent need of open-minded people in dealing with other people, with different origins, creeds, traditions, certainties and fears.

this is to say, amplifying and extending the interests of science, accepting different perspectives, it is sure that mankind will be fully capable to steer the future. "The more powerful the general intelligence, the greater the ability to treat special problems."[22]

[22] Cf. Morin, E., *Seven complex lessons in education for the future*, UNESCO, Paris, 2001, p. 15. The original French says: « Plus puissante est l'intelligence générale, plus grande est sa faculté de traiter des problèmes spéciaux. »

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