

Introduction to Prometheus: The Truth and Beauty in the Physics of Emilio Del Giudice

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“Human beings first feel, then become aware with a troubled and emotional soul and then they reflect with a pure mind”. This sentence from Giovanni Battista Vico, a Neapolitan¹ philosopher (1688-1744) is most likely the first thing that comes to my mind when I think to Emilio Del Giudice. I met him, when I was thirty, during a conference somewhere and I was touched by the sensation that he was speaking about something much deeper than the topic of the talk, something that cannot be represented by equations. After a few talks with Emilio, my feeling of being very ignorant in physics became a certainty, because it became clear to me that I had ignored, until then, the real meaning of what I pretended to know. Laughing, Emilio used to say to me to keep calm because “philosophy is a matter for old people”. He meant that it takes time and experiences to learn and to understand. We became very good friends and I owe to him all my philosophical education, as well as a brand new way to look at the physical world. I went along with Emilio on the way of understanding what the job of a scientist really is, and I started to consider the historical roots of our science as an essential piece of knowledge.

I gradually shared with Emilio my discomfort in seeing that contemporary science

1. Emilio Del Giudice was born in Naples in 1940.

has developed an attitude to consider nature just as an immense supermarket where every possible utility for modern life can be found or, at least, fit in order to improve its efficiency. Such an attitude stems from the scientific rationalism of the seventeenth century, when the scientific method opened the way to the flourishing of the exact sciences. Galileo has shown us how to extract laws of physics from empirical observations and how to describe those laws in a suitable language. He introduced a connection between nature and mathematics, making the objects of nature mathematically ordered.

This is probably the major achievement of his science: the Renaissance man recognized that nature is the realm of order and beauty, while, at the opposite, in the Middle Ages it was the reign of chaos and fear, because natural phenomena were obscure and almost always unfavourable. The quantitative description of physical laws leads to discovering their internal simplicity: “*simplex sigillum veri*”, simplicity is the sign of truth, and through simplicity humankind can again understand nature. Later on, Isaac Newton gave a mechanical explanation of the heavenly bodies and separated them definitely from superstition and religious beliefs. He was the first to introduce the concept of long distance action: gravity attracts the earth through the empty space

of the solar system. This space, in his view, was a vase deprived of all objects, without matter and motion inside, as according to the ancient Aristotelian philosophers.

The physics I learned at university was firmly established upon these concepts, even though the Riemann geometry and its complex variables had replaced the rigid Euclidean geometry in the description of macrocosmos and the theory of Relativity filled it up with the masses of the bodies, making it elastic and curve. I learned that is necessary to break into pieces, the quanta, fields and matter in order to understand their interactions. In this new vision of the world at the beginning of the twentieth century, the two irreducible systems of classical physics, particles and fields, fused into a “*unicuum*”, where the field continuity and the matter discontinuity turn one into the other. It follows that matter and motion are no more separate because the motion is an intrinsic property of the matter.

However, I was told that the consequence of quantum mechanics was the impossibility of knowing reality because the process of knowledge is a perturbation of reality, by itself. Such an interpretation is a consequence of the anxiety induced by the fall of certainties following the intellectual achievements of the twentieth century, when humankind had to abandon its three main philosophical pillars: the domain of man over matter, the domain over history and the domain over his own soul. In fact, the advent of quantum mechanics had swept away the success of thermodynamics, the science that gave man the prospect to rule over creation and to realize powerful machines, in order to win freedom from the slavery of manual work.

The revolutions of the beginning of the twentieth century and the great world wars had shown that history was a sort of flipped out variable out of the control of the single nation states and of the citizens. Last but not least, Sigmund Freud had shown that

even our soul is out of our control, because it is the dominion of our unconscious.

The Bohr interpretation of quantum mechanics, which dominated physics for almost a century, stems from a definite cultural paradigm. However, it has been taught in universities as a scientific truth. Different opinions such as the doubts of Albert Einstein about the completeness of the theory or the suggestion of David Bohm, who first proposed sacrificing the basic concept of reality made up by events localised in space and in time, have been discarded as oddities. Generations of physicists have been educated in the Copenhagen paradigm as the only possible interpretation of quantum mechanics, and the other readings have been softened or obscured.

Furthermore, in recent decades the habit of scientists to simplify composite problems in order to cope with complexity led to an extreme pulverization of knowledge and opened the way to the era of hyper-specialization, where the exact meaning of the physical laws seems to be lost. Especially the so called “hard sciences” such as mathematics, physics and engineering, are considered techniques devoted to the realization of discoveries useful to society: a new material to increase the velocity of an electronic device, a more efficient source of energy, a calculation method able to allow very fast financial transactions, in short, what is called “applied science”. The current framework programme for research is mainly aimed at driving economic growth and creating new enterprises and jobs, and the world of scientific institutions is driven in a frantic race aimed at achieving results faster than ever.

A further step in the mismatch between science and nature has been taken thanks to the availability of enormous amounts of powerful calculations, in the computer era. Physicists have left their laboratories to simulate reality in their computers, like

novel Ptolemaic scholars, very clever in reproducing the dynamic of numerable collection of particles, but unable to simulate the complexity of their collective behaviours.

In such a scenario the scientist is seen as a smart employee in an efficient organization. The mood in scientific institutions and universities is obsessed by the competitiveness for grants and scientists are slaves of “publish or perish” culture. Recently, the physicist Peter Higgs said: “When I was working on my 1964 paper [that first predicted the existence of the “boson” named after him, whose prediction gained him the Nobel award in 2013], nobody else took what I was doing seriously – nobody would have wanted to work with me.”

So an important question to be raised is: “What is the real aim of science?” Does the comprehension of the real meaning of scientific theories belong only to philosophers while the physicist’s task is just to calculate reality, or is it a duty of scientists to understand what social, political, economical, or historical aspects their work has? Often the young scientist is told to calculate and not think, because everything is already known, and that knowledge can be finally used to subdue nature to humankind’s willing. Is it really so?

Scientists such as Emilio Del Giudice and his friends, Herbert Fröhlich, Giuliano Preparata and Peppino Vitiello have focused their interest just in the field of complex systems. They used Quantum Field Theory (QFT), which has been developed for the field of high energy physics, and applied it to condensed matter. QFT was born in order to answer the requirements of a space where particles can be created and annihilated, facing the growing amount of results of high energy experiments. This new formalism implemented on condensed matter allowed them first to imagine, and then to prove the existence of a different ground state, generated by the condensation of the

particles into a state where they acquired a unique frequency and phase and are described by a single wave function. This ground state is the real fundamental one, the lowest energy state differing from the conventional ground state (known as perturbative ground state) by the onset of coherence. The formalism is common to laser physics where the oscillation of the electrons between two energetic levels can trigger coherent oscillations of the electromagnetic field, provided that it is forced into an optical cavity.

However, in condensed matter no cavity exists and the coherent EM field is trapped spontaneously. It is known that, in laser physics, this requirement is fulfilled by the rotating wave approximation according to that only photons having a frequency ω close to the oscillation frequency of the electron between the two levels ω_0 can interact significantly with the matter, provided that the conditions for the onset of the coherence are fulfilled (*i.e.* density higher than a critical density and temperature lower than a critical temperature). Giuliano Preparata showed that, without making this approximation, the frequency ω of photons is found to be lower than ω_0 . Thus, in Coherent Ground State the strong coupling between matter and EM provides a sort of “total reflection mirror” for the EM field that is naturally trapped in the matter [G. Preparata, QED Coherence in Matter, 1995, World Scientific, Singapore, p.50].

The next question is: where is the electromagnetic field (essential to let the condensed matter exist) from? The answer is astonishing: it comes from the vacuum. Vacuum is not just an empty jar but it is instead a reservoir of energy and momentum, as has already been pointed out by Nernst and Einstein during their discussions about the specific heat problem arising at the beginning of the twentieth century. Emilio used to resort to a metaphor: “Classic vac-

uum” – he said – “is a black night while quantum vacuum is a black night enlightened by flashes.” - flashes of energy and momentum, which lend to the objects their quantum fluctuations. At once, Giuliano Preparata and Emilio Del Giudice saw that such a structure of condensed matter has a powerful philosophical implication: the field trapped into the matter act as a mattress, which connects all the bodies (atoms or molecules), furthermore the existence itself of the condensed matter is due to the fact that the vacuum is not vacuum at all. In such a view the concept of an isolated body, the actual base of classical mechanics, became meaningless. It is simply an abstraction useful for very diluted systems and/or high temperature. The concept itself of the dynamic evolution of complex systems is renewed: the motion of an isolated particle is reversible in time, however, only the appearance of an interaction introduces a time arrow. It follows that there is no history for a set of isolated individuals.

Emilio was able to reach such unexpected connections better than anyone else. He stressed that there are two different mechanisms of interaction among particles: a chaotic one, where single particles move in a lonely motion between collisions, this is typical of gases, and a collective one where sets of particles share the same dynamics and behave as a whole, in a coherent way. The decision to prefer the former as a basis for the description of condensed matter is not only due to the mathematical difficulties in handling the many-body problems but probably hides confidence in individualism. At the present time, this collective behaviour is at the base of the science of complexity, not only in condensed matter physics but also biology, social sciences, ecology share this principle, and discoveries in recent years suggest that coherent quantum processes may well be ubiquitous in the natural world [Philipp Ball, *Nature* 2011, vol. 474, 272]. However, it is still hard

for physicists to accept the theory of coherence.

Once Emilio gave a talk titled “A Theory Without Errors is Certainly Wrong” where he supported the thesis that the actual job of a scientist is to evaluate errors, because knowledge comes through understanding of these errors. He explained that to unearth errors is the unique way to avoid prejudices. This is why the discovery process is often far from rational, because it is based in the emotional soul of the scientist, as Vico said in a masterly manner, whilst rationality and order are required to communicate the results and to formulate a theory. I dare to say that the processes of discovery grow from emotional roots much more than from rational processes. This is actually the reason why errors are unavoidable and why large efforts and severity must be used by scientists to correct them. Technical competence and rationality have to prevail after the emotional soul has been perturbed, when it is time to reflect with a pure mind. This is the meaning of what Emilio called “the passionate soul of scientific reason”.

Drawing on his wide classical culture, Emilio was able to connect so many facts and thoughts so that a beautiful picture of reality emerged from his writings, to depict a beautiful fresco where everything finds its place: not only the description of the matter but also the occurrence of life, the emergence of a psyche from the matter, the sense of human societies and the intelligence of History. He shared with another great Neapolitan² philosopher, Giordano Bruno (1548-1600) the belief that the search for the truth is an act of love.

In his perspective the work of a scientist became an experience of pure joy, at enmity with the gravity of many colleagues who refused to face new ideas for fear of errors. ■

2. Giordano Bruno actually was born in Nola, 20km away from Naples.