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The real distinction between essence and existence and the relation between information and energy

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Abstract

In the Thomistic development of the Aristotelian metaphysics a central role is played by the actual distinction between the essence (i.e. the totality of characteristics and capabilities) and the concrete existence of any being. Even if these two components of the being of any thing are truly distinct, nevertheless they are not separable, since one cannot observe the existence if not within the essence of a determined thing, nor the essence if not in a concrete existing object. Moreover, they depend to different orders of causation: internal to the physical world for the essence, transcendent as a First Cause for the existence. It is very interesting that a deep analogy can be found with the couple from the physical realm information/energy. In fact, even though information and energy are well distinct concepts, any information exchange requires energy transformations and energy never appears if not in a given form (kinetic, gravitational, heat, nuclear...). The two ever occur together; actually no physical process is possible without information and energy exchange. This paper is devoted to investigate this analogy, which bridges the gap between natural science and metaphysics.

1. Introduction

If we carefully look at the physical, chemical or biological processes, at every scale and in every field, we notice that a transformation of energy always happens. If this fact may be sometimes not apparent, it is due only to our description of the phenomenon, not to the phenomenon itself. For example, in the kinematics of a free falling body we focus our attention only in the square-dependence of the distance by the time, but in the real fall of a body its gravitational potential energy transforms into kinetic energy. A hypothetical process which could take place without any energy exchange would have the features of a *perpetuum mobile*, and therefore would violate

both first and second thermodynamics laws, two of the much better ascertained physical principles.

On the other hand, energy never comes if not in a determined form, depending upon the particular structure and features of the system it belongs to. We cannot have something like "pure" energy. Also, the possibility of a give energy exchange (and therefore the possibility for the corresponding process to be realized) strictly depends upon the features of the physical systems involved, or – in other terms – the information associated with their structure. So, the concrete possibility for a physical process to take place depends upon the availability of a proper energy amount, otherwise the process itself will remain a mere possibility.

So, we can individuate two main factors in every physical process: the structure of the systems involved which says how the process evolves, and the energy needed by the process to actually take place. Information is responsible for the way the process happens, energy determines if the process happens.

From these considerations there appears a strong analogy between the physical concepts of information and energy on one hand, and the metaphysical ones of essence and existence on the other. The actual distinction between the way the things are (*essentia, quidditas, natura*) and their concrete existence (*actus essendi*) is typical of St. Thomas Aquinas' doctrine[1]. The net of causality relations between beings completely determines the features of a given thing, but it is not sufficient to assure its actual existence, which comes instead from another (transcendental) order of causality.

So, the analogy between physical and metaphysical realms has the structure shown in figure 1. (See **Caption and Figures**)

The aim of this paper is to investigate in detail the structure of such an analogy, trying to get a real improvement in the understanding of the concepts involved in it. We will focus first on a horizontal reading of the two relations, within each ambit, and then we will analyse the vertical relation

[1] Gianfranco Basti, Antonio L. Perrone, *Le radici forti del pensiero debole. Dalla metafisica, alla matematica, al calcolo*, Il Poligrafo, Padova, 1996.

between physics and metaphysics. Finally, we will draw the conclusions of our reflections.

2. The "horizontal" relation between essence and existence

In the history of the western thought, since Parmenides, a rationalistic position has ever been present, which identifies the logical possibility with the real existence. Plato, for example, considered our world an imperfect copy of the world of ideas[2], so that the only possible knowledge is the deductive one (like Euclidean geometry) without any reference to empirical reality. In the middle age, Anselm of Aosta based his celebrated ontological proof of God's existence[3] on the argument that if God is the one about whom one cannot think anything greater (*Id quo maius cogitari nequit*) and if He would not exist, something greater could be thought, i.e. a being with the same characteristics plus existence. It is clear that Anselm considered existence just like a quality to be added to the other determinations of the subject, in order to make it actually existent. St. Thomas Aquinas did not agree to this position; in fact, even if he admits that for God – but only for God – the existence belongs to his essence, we cannot get this evidence since we do not know God's essence. In other words, the necessity of God's existence is only *in se*, while *quoad nos* that necessity is missing. In general, our knowledge of a being (not only of God) is never exhaustive, so a distinction can be made between *essentia*, being's complete determination, and *quidditas*, what we know of the essence[4].

The essence is the way things are, the inseparable bond between form and matter that constitutes a being, completely determined by the whole of contingent causes, according to the Aristotelian four causes' doctrine. This doctrine defines

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[2] Plato, Re*public*, VII.

[3] Anselm of Aosta, *Proslogion*.

[4] There is a third interpretation of the essence, expressed by the term *natura*. The nature of a being is given by its typical operations; by observing these operations we can infer the determinations constituting the essence of the being (since *agere sequitur esse*).

four orders of causality for all the transformation processes, and in particular for the generation processes where a new being comes along:

1. material cause: the matter of a being, capable to receive its particular form;
2. agent cause: another being acting on the object causing it to change into the new form;
3. formal cause: the new form to be assumed by the changing being;
4. final cause: the purpose which will be reached with the transformation process or the generation of the new being (for not human being the formal cause and the final one coincide).

None of these causes can produce the existence of a being, they only are responsible of the way a thing is, but not whether it exists or not.

So, if existence is actually distinct from essence it must have also a different order of causality. This transcendental cause of the existence is to be identified with the only substance which does not receive its being from other things, but is its own being, i.e. the *Ipsum Esse Subsistens*, or – in other terms – God. It is very important to notice that, according to Aquinas' view, God's creative intervention does not force physical processes in some arbitrary way, but allows them to realize, making a concrete existence what would be otherwise only a mere possibility. In other terms, nothing must be added to positive science in order to explain the way the universe is; God is the answer to the question "Why?", not to the question "How?", so that there cannot be any conflict between science and theology.

Finally, the Cause of existence acts out of the time. It is a common misunderstanding, in fact, that creation happens at a timely moment, say the Big Bang. But, if creation is the beginning of time, it would be within the time, and could not be transcendent. Rather, creation is simultaneous with any instant of time, and the doctrine of a transcendent cause of the reality's existence is consistent either with an absolute beginning of time or with a world lasting since ever.

3. The "horizontal" relation between information and energy

Every physical process involves energy transformations. This is true up to the lowest level of reality. Consider a microscopic quantum system, say an atom. It is characterized by a number of energy levels whose values can be computed by means of Schrödinger equation[5]. If the atom occupies its ground state, corresponding to the lowest energy level, there is no way to establish the values of the other levels if one does not allow the system to interact with electromagnetic radiation or particles like, for example, electrons. Upper levels are in the possibilities of the system, but they are not realized without a proper energy transfer, according to the reaction:

$$A + \gamma \rightarrow A^*,$$

where A is the atom in its ground state, γ is a quantum of electromagnetic radiation (photon) and A^* the atom in the excited state[6]. Since the energy E of a photon is proportional to the frequency f of the electromagnetic wave which it belongs to, according to the well known relation:

$$E = h \cdot f \quad (h \text{ being the Planck constant}),$$

it is possible to measure upper energy levels by the frequency analysis of the electromagnetic radiation after its interaction with the atoms.

The inverse process is also possible, in which an atom in an excited state comes back to the ground state emitting electromagnetic radiation of proper frequency:

$$A^* \rightarrow A + \gamma .$$

[5] Lev D. Landau - Evgenij M. Lifšits, *Quantum Mechanics. Non-Relativistic Theory*, Elsevier, Oxford, 1958, ch. 3.

[6] Max Born, *Atomic Physics*, Blackie & Son, London-Glasgow, 1969, ch. 5.

If we call E_0 the energy of the ground state and E_1 the energy of the excited one, the energy of the emitted photon must equal the energy gap[7]

$$E_1 - E_0,$$

so that its frequency will be

$$f = \frac{E_1 - E_0}{h}.$$

So, the atom is potentially capable to emit photons of frequency f – we can say that such a capability is contained in the structure (the information) of the atom – but the actual emission of a photon of frequency f depends upon the fact whether the atom is in the excited state A^* after having received proper amount of energy (by means, for example, of electric sparks), or not. There are two fundamental conditions in order to obtain from a given atom a photon of frequency f:

1. in the structure of energy levels must be two levels E_m and E_n such that:

$$f = \frac{E_m - E_n}{h};$$

2. a proper amount of energy must be given to the atom in order to put it on the upper level.

If we turn our attention to macroscopic systems, the situation is exactly the same. A pendulum in vertical equilibrium position, for example, has the possibility to perform oscillations with a given period which can be easily calculated, if nobody gives it a push, no oscillations at all will occur.

Even phenomena of static and dynamic equilibrium require energy inputs; not to sustain the process, but to build the system. Let us consider for example a satellite following a circular orbit around Earth[8]. There is no variation of potential as well as kinetic energy during the motion, but a certain

[7] This condition can be generalized to any arbitrary couple of energy levels, so no need to consider only couples where the lower level is the ground state.

[8] Bruno Bertotti - Paolo Farinella, *Physics of the Earth and the Solar System. Dynamics and evolution, Space Navigation, Space-Time Structure*, Kluwer, Dordrecht, 1990, ch. 18.

amount of energy however must be supplied in order to put the satellite into its orbit.

It is finally worthwhile to notice that nothing like "pure energy" exists; energy transfers ever take place according to specific features of the systems involved in the processes.

4. The "vertical" relation between physics and metaphysics realms

After the discussion in the previous sections it should be clear that there is a strong analogy between the roles of information/energy in the occurrence of physical processes and essence/existence in the metaphysical constitution of beings. Let us analyse explicitly the main points of such an analogy.

Physical processes are dynamical transformations characterized by well defined variations of the parameters of the underlying systems. Once the system is given, kind and extent of the process(es) it can undertake are also fixed. In the same way, qualities and capabilities of a being are uniquely determined by the whole of the causes those constitute it. So, we can draw a parallel between the essence of a being and the set of the determinations of a physical system. Notice that the two concepts do not overlap, since, even if physical determinations are indeed parts of the essence, this one has a wider meaning, including proper ontological determinations. In both cases, however, the key concept is information. But, if we know exactly the features of the systems involved in a physical process, can we undoubtedly state if it will take place or not? And if we should know as much as possible of the essence of a being, can we affirm that it is actually existent? Clearly, the answers to both the questions are "no". In the first case a data is missing: if the system is in an initial state with enough potential energy to activate the process, or if proper quantity of energy is supplied by an external source. In the second case, the point is that a set of essential determinations consistent with each other and with environment is not enough to imply existence.

On the other hand, energy's manifestation is possible only within a given physical process, since there is no way to access directly to energy in any experimental situation (even if we find sometimes in textbooks sentences like: "Let us consider an amount of energy *E*..."), and according to the common accepted in modern physics position of operationalism[9], a physical definition which does not correspond to feasible operations makes no sense. So, energy does not appear but qualified by the particular process; we have energy of a body, of a system of bodies, of a field, but never energy without any further specification. Similarly, existence, though distinct from essence, never appears but as the existence of a given essence; in other terms existence is existence of something, never pure existence. There is however a major exception to this statement, i.e. God. In fact, according to Thomistic doctrine, God is the only being whose essence is its own existence. Its existence is necessary, while all other beings are indifferent to existence and not-existence, they may also not exist, while God must exist. Just as things receive their being, so God is His own being. Things become visible after they are lighted, while the Sun is the source of light. Similarly, God is the source of be, the *Ipsum Esse Subsistens*, which means that in God existence is not existence of something, but pure existence.

Clearly, this fact represents a difference in the analogy between energy and existence, since no exception is allowed to the rule that energy ever comes in a particular form, depending upon the system involved.

There is another important difference between existence and energy, i.e. the conservative character of the second one, not shared by existence. In fact, one of the better tested physical laws is the conservation of energy: in every physical process energy never disappears or is created, instead it changes continuously from a form to another. Typically, in macroscopic processes potential energy, associated to system's structure, is converted partially or totally into kinetic energy associated to the motion of the parts, and eventually this one is fully converted into heat. The initial amount of

[9] Percy W. Bridgman, *The Logic of Modern Physics*, Macmillan, New York, 1961.

energy required to constitute complex structures like nuclei, atoms and molecules is taken from gravitation. In fact the energy associated to gravitation is ever negative, so we can gain energy simply letting gravity to act. This, for example, is what actually happens in stars cores, where, due to the overwhelming pressure of the external shells, nuclei are subjected to fusion reactions in which electromagnetic radiation is produced. Moreover, the fact that potential gravitational energy is negative is fundamental to explain the origin of the universe. In fact, both the models based on an absolute beginning of time[10] and the ones stating a repetitive evolution[11] explain the appearance *ex nihilo* of matter at the Big Bang as a process in which the positive energy associated with matter and radiation is exactly compensated by the negative contribution of gravitation; so there is no need to postulate a violation of physical laws in the initial singularity.

Clearly, nothing similar to energy conservation holds for existence. Existence is not conservative, there is no need for the generation of a new being to be compensated by the corruption of another one (even if in the case of living beings, and more generally whenever resources are limited, death of present individuals is necessary to free space and resources for next generations).

5. Conclusions

The real distinction between *essentia* and *actus essendi* characterizing the metaphysics of St. Thomas Aquinas suggests a strong analogy in the physical realm with the concepts of information (the structure of a system) and energy (the concrete possibility that a process take place). However, the two couples of concepts do not overlap, since they apply to different subjects (ontology the first, physics the second) and there are important differences, especially between existence

[10] Alan Guth, *The Inflationary Universe. The Quest for a New Theory of Cosmic Origins*, Basic Books, New York 1997.

[11] Paul J. Steinhardt - Neil Turok, *Endless Universe. Beyond the Big Bang*, Doubleday, New York 2007.

and energy. In fact, while Aquinas' ontology states that essence of God is His own existence, no physical object is fully identified by only an amount of energy. Moreover, the energy conservation principle holds, while for existence, conservation is not strictly required (even if matter cannot sustain but a finite number of different beings at once).

The analogy discussed in the present paper may be impressive, but it is important to stress that any mixing between the two fields may be dangerous; scientific research has to follow its own positive methods and philosophical reflection must be as free as possible from aspects contingent upon material world. Nevertheless, as a consequence of a wider perspective, a better insight in each field may be obtained. In this sense, all the above considerations can be of some help for a better understanding of concepts usually thought with no reciprocal relation, so representing a fecund case of mutual enrichment between theoretical philosophy (and theology) and natural sciences.

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Caption for Figures

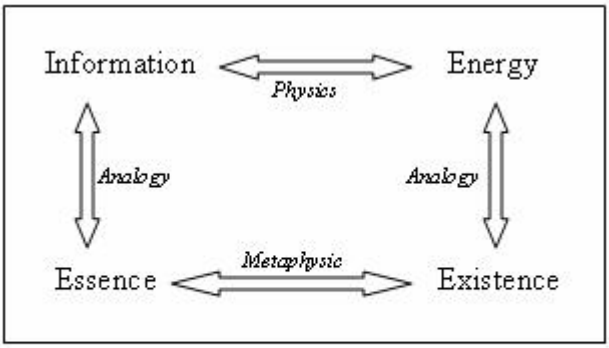

Figure 1. Relations between the concepts of information, energy, essence and existence