FROM SUBATOMIC TO IMMENSE: ON THE INFLUENCE OF THE THEORY OF RELATIVITY AND QUANTUM MECHANICS ON THE FANTASTIC

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When I was asked to play the bongo in public,
the presenter did not mention that I devote myself
to theoretical physics. I think this is probably because
we respect the arts more than the sciences.

RICHARD FEYNMAN

This essay addresses two questions. The first was formulated by Professor David Roas on the title of his article "Can there be fantastic literature after quantum physics? New theoretical perspectives" (Roas 2009); the second was brought up for discussion by Professor Antonio Penedo (2012) during the *1st International Congress of Visions of the Fantastic in Spanish Culture* (Autonomous University of Barcelona, 19-21 November 2012): "If the fantastic really happens, can you still call it fantastic?" In the following pages I would like to reflect on both questions starting from a comparative study of the theory of the fantastic and of two branches of physics, the Theory of Relativity and Quantum Mechanics.

1. THE FANTASTIC

It cannot be, but it is

JORGE LUIS BORGES

I see the fantastic as a crack, an extraordinary irruption of the impossible in a fictional world that functions according to the physical laws and regularities of our paradigm of reality, which is meant to intimidate the character, the narrator and/or the readers with the intention of destabilizing and questioning the socially shared concept of reality. According to this interpretation, the fantastic rests on three fundamental pillars: first, Reality, or rather, the concept of reality shared by the social group that creates and interprets the narrative, film and other texts, and which indicates (approximately) what is considered possible or impossible within the physical framework we inhabit; second, Transgression, that is, a fact or group of facts whose causes cannot be explained according to the paradigm of reality handled by the community related to the text, and is thus considered impossible; and Fear, caused by the irruption of the impossible in a fictional world whose characteristics are the same as those of the world we inhabit. Thus, we can draw at least three conclusions from this brief synthesis. The first is that the fantastic is an epochal category that depends on the philosophical, scientific or religious interpretations of a particular socio-historical context; the second is that reality is not fixed and immutable, but constantly reread and, as such, understood as a sociocultural construct; the third and last is that the fantastic is necessarily a discourse that has an intertextual relation with the discourse of the reality of each epoch. In this case, it is the reader who must broadly establish parallels by comparing

the data offered by the text with his own knowledge of the real. Therefore, it is necessary to deepen the discussion of these three fundamental pillars in the following pages. We must delimit them accurately in order to establish a solid definition of the fantastic before we can enter into a discussion of its relation to the discourse of theoretical physics.

1.1 Reality

It is evident that trying to define the real in these pages goes beyond my (and probably anyone's) abilities, the available space and the purpose of this essay. However, a more modest (while still complex) goal would be to analyze the relationship between the fantastic and the real, or to be more exact, the concept of reality or *paradigm of reality* as per Lucio Lugnani (in Ceserani 1999: 85):

> Humankind dominates (or rather, perceives and interprets, and thus knows) reality through the laws that regulate it and the causality that determines it, and also through a genealogical grill of values meant to encompass the real and order and justify human behavior in relation to reality and with other humans […] This combination, determined through time and space, constitutes what we may call a paradigm of reality and, for all practical purposes, humankind has no other reality beyond its paradigm of reality.

That paradigm of the real, which is the social interpretation of reality, is therefore determined by religious, philosophical or scientific epochal variables of a cultural kind that attempt, as Nietzsche observed, to create an illusion of order and escape the fall into the terrifying void of ignorance. Thus, it seeks to establish the limits between the *possible* and the *impossible,* or between that which can be explained rationally and that which has no place in our world. This purely ontological question has had very different answers throughout centuries. For example, the existence of ghosts was recognized by Classical Greek and Roman communities, as well as Medieval ones, and hence it was unusual—yet entirely possible—to witness their apparitions. One only has to think about the treatment accorded to the specter in Pliny's letter "On Ghosts," in which, even though he describes the narrated visions as terrifying, he affirms that he believes those who told him the stories (Pliny 2011: 77-87).[1] Beginning in the seventeenth and eighteenth centuries, the rise of philosophical rationalism banished ghosts from the imaginary of the official culture and placed them in the realm of the impossible; for this reason, ghosts established themselves as prototypical characters in numerous canonical literary works of the fantastic genre.[2]

The fantastic operates precisely on the irruption of the impossible: "The fantastic story places the reader in front of the supernatural, not as an evasion, but rather, just the opposite— to make him explore it and lose his sense of security facing the world" (Roas 2001: 8). In order to make the receptor understand that a given fact, or group of facts, is supernatural, the narrator needs to relocate the socially shared paradigm of reality into the fictional framework: events must unfold in a world that corresponds to our concept of the real. Hence, although it may seem paradoxical, the fantastic story is built

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[1] When the original date is relevant, it will appear in the bibliography. In the text, I quote under the edition consulted.

[2] For a detailed study of this evolution see Leconteux (1999), Bueno (2003) and Ballesteros (2003: 7-28).

according to the rules of realism, which at a given moment are transgressed by the preternatural:

> In order to be considered fantastic, a story must be created in a space similar to the one inhabited by the reader, a space that will be assaulted by a phenomenon that will upset its stability. For this reason the supernatural will always represent a threat to our reality, which, until that moment, we believed to be governed by rigorous and immutable laws. (Roas 2001: 8).[3]

Doubtlessly, the existence of the fantastic depends on the fundamental role of the narrator, whose efforts should be geared towards winning over the expected credulity of the reader in order to guarantee that the impossible event is accepted even if it cannot be explained. Equally important is the role of the reader, whose active participation links the narrated tale with the sphere of the real beyond the text, and thus permits the assessment of the irruption of the impossible from his own codes of reality.

We know that, at least since E.T.A. Hoffmann, fantastic tales have fled from the fog-shrouded castles of gothic novels and have relocated their stories to spaces that are closer to the reader with the goal of imbuing the narrated facts with greater credibility and impact.[4] Roland Barthes reflected in his article of 1968 "The Effect of Reality" upon the superfluous and apparently unnecessary or useless details that appear in some descriptions from the novels of Flaubert which, in his opinion, indicate to the reader that he is talking about a reality beyond the discourse, or about a referent external to language. Barthes named it a "referential illusion." After the diffusion of the works of Hoffmann, fantastic tales have employed this kind of strategy to create in the reader the illusion that the events in fiction take place in a world identical to his. For instance, in "The Aleph" by Jorge Luis Borges (1983: 153-172), the narrator specifies the names of the streets of Buenos Aires, of other places in Argentina, and even of other countries, as well as the names of writers and works that the reader can identify as belonging to his world, and that lead him to establish a correspondence between the space and time of the Borgesian fiction and his own reality. In the words of Rosalba Campra, the fantastic text is "intrinsically weak pertaining to represented reality, so it needs to prove it and to prove itself. The fantastic genre, more than any other genre, is subject to the laws of verisimilitude" (Campra 2001:174).

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[3] As early as 1951, Castex observed: "[The fantastic] is characterized, on the contrary, by a brutal intrusion of mystery into the framework of real life" (1951: 8). Roger Caillois affirmed in that same decade that "the framework of the fantastic is not the enchanted forest of *The Sleeping Beauty* but the opaque administrative universe of contemporary society" (1966: 16), and a few years later, in 1960, Louis Vax wrote that that fantastic narratives delight in "presenting men like us, suddenly thrust in the presence of of the unexplainable, but within our real world" (1973: 6). Todorov as well, in his seminal *Introduction to Fantastic Literature,* tells us that "in a world like ours, the one we know, without devils, sylphs or vampires, occurs an event that cannot be explained by the laws of that same familiar world" (1994: 24). This realistic nature of the fantastic tale has been one of its basic traits in the different iterations of the fantastic.

[4] In a study dedicated to the work of Hoffmann, David Roas addresses this issue: "His stories depict daily life in detail, a world that is completely credible and familiar where it seems impossible that anything strange could ever happen. The irruption of the supernatural will mean a transgression against that normalcy and the evidence that reality does not function as well as the reader and the characters believe. That confrontation between the daily and the supernatural characterizes the fantastic genre since Hoffmann" (Roas 2002: 40).

However, parallel o the development of the fantastic we find the evolution of readings about the concept of reality from the fields of philosophy, science and religion. Postmodernism, and the different philosophical currents associated with it, have questioned the very existence of the real as independent from the human being. Clear examples of this are the work of Constructivists (Watzlawick 1988) or the reflections on "hyperreality" by Jean Baudrillard (1978 and 1991). It seems clear that, as David Deutsch said, "Our judgment about what is real or not always depends on the various explanations available at at any given moment […] Consequently, the list of admissible modes of explanation will always remain open, as well as the acceptable criteria of reality" (Deutsch 2002: 94). Therefore, the question is not whether or not the discourses on reality modify our relationship to it, since it clearly appears that they do, but rather how relevant they are to our daily lives, or whether we accept them (or not) as plausible and necessary explanations in order to assume the problematics of our daily lives and, ultimately, how they can be applied to the reading and interpretation of fantastic tales.

1.2 *The Impossible*

Irene Bessiere states that the fantastic tale uses the sociological frameworks and the forms of understanding that define the realms of the natural and the supernatural, the trivial and the strange "not to infer any kind of metaphysical certainty, but to organize the confrontation of the elements of a civilization that are relative to the phenomena that escape the economy of the real and the surreal, whose conception varies in different epochs" (Bessiere 2001: 85). Every fantastic tale is based on the transgression of a specific order: an event that we consider impossible according to the paradigms of reality of the concrete epoch in which it was written occurs mysteriously in a fictional world with characteristics that are identical to the one we inhabit. The impossible becomes possible and destabilizes the limits that give us safety, while questioning the validity of the systems we use to perceive the real:

> Fantastic literature proposes the discussions of limits as a privileged tool in the service of a model of the world according to which there is nothing that could not be susceptible to a logical explanation […] The uncertainty regarding the limits of the real causes a wavering of perspectives that until that moment we had believed to be immovable (Rotger 2007: 240-241).

For example, in *Horror in Literature* (1927) H.P. Lovecraft affirmed that the goal of the "preternatural tale" is "a malignant suspension or transgression of the *fixed laws of nature* which are our only safeguard against the attacks of chaos and the demons of unfathomable spaces" (1984: 11) [author's Italics.] According to this conception (more distinctive of eighteenth and nineteenth century writers) the limits between the possible and the impossible are clearly delimited: everything that falls within the "fixed laws of nature" is possible, while everything that cannot be explained according to these premises is impossible. Going back to the writer from Providence, Cthulhu belongs to the order of the impossible for us (the readers), and its appearance in the world of fiction is a crack, an apparition of the demons from unfathomable spaces.

Nevertheless, as we have seen in the preceding section, the evolution of certain areas of knowledge has not brought with it a better explanation of the real, as we would assume a priori. Instead, rather paradoxically, it has posed numerous questions and debates that have caused the crumbling of the putative ordered bewilderment that is reality (Nietzsche) and have been able to modify the limits

between the possible and the impossible.

Therefore, it may not be quite an exaggeration to admit, as David Roas has said, that the irruption of the abnormal in an apparently normal world in the modern fantastic does not seek to demonstrate the validity of the supernatural but to postulate a possible abnormality of reality: "we discover that our world does not function as well as we thought, just as the traditional fantastic tale had proposed, though expressed in a different manner" (Roas 2001: 37). Or, as the same author further states: "the authors from the twentieth and twenty first centuries, once the idea of an absolute level of reality has been replaced with a view of it as a sociocultural construct, write fantastic tales to belie the schemes of interpretation of reality and the self" (Roas 2011: 33). The fact that Gregor Samsa turns into an insect overnight and no member of his family is impacted by it does not seek to demonstrate the existence of unfathomable spaces from which dark forces emerge (as was the case with Bram Stoker's *Dracula,* although only eighteen years separate the two works). Rather, Kafka's story seeks to express, through the extraordinary or the impossible, that reality is an unknown and abnormal territory that hides demons perhaps more dangerous than the vampires and ghosts that traversed the fantastic tales of the nineteenth century: "With or without a motivation a superposition takes place that makes A and B coincide totally or partially, in a fleeting moment or permanently: all possibilities remain open and define a universe of meanings that vary according to the historical period and the author, but that convey a reality where certainty has disappeared" (Campra 2001: 167).

1.3 *Fear*

If, as I have previously formulated, the fantastic tale places us from the start in a world we know and think we control in order to introduce a phenomenon that escapes all rational explanations, the only reaction we can expect is fear, an uncontrolled emotion that can affect the characters, the reader, the narrator or all of them at the same time, and that is provoked by the appearance of an impossible in a fictional world whose characteristics are the same as those of the world we inhabit. H.P. Lovecraft was already going in that direction in *Horror and Literature* when he said that the only test of the truly preternatural is knowing "whether it awakens or not a profound feeling of dread in the reader and the awareness of having entered into contact with unknown spheres and powers" (1984: 11).

The fear that human beings feel returns us—from the promontory where we have become the biggest predator on the face of the earth—to the ancestral dread of the helpless creature that keeps the memory of the constant perils that stalked it: "it does not correspond to an actual threat, but it is modeled in its biological or anthropological ancestry after an imaginary with the footprint of an ancestral exposure to the outdoors" (Conte 2013: 59). These peculiarities are exploited in the fantastic, where fear, as effect and resource, is sustained over something that never quite appears, an open space where the capacity for dread of the terrifying lies in its unfathomable dimension" (Conte 2013: 59).

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1.4 *A Partial Conclusion*

Starting from the premises proposed up to this point, the great question of the fantastic seems purely ontological: What exists and what does not exist in our reality? That is to say: What is possible and what is impossible, but, especially, according to what? Do we consider that an event is impossible

according to the laws of physics, empirically proven, or in relation to our daily intuition of time and space? Following the line of thought of Teodosio Fernández, we lean towards the second option:

> The appearance of the fantastic does not have to reside on the alteration by strange elements of a world ordered by the rigorous laws of reason and science. An alteration of the recognizable, familiar order or disorder suffices. The suspicion of another, secret order (or another disorder) is sufficient to endanger the precarious stability of our world view (Fernández 2001: 296-297)

Therefore, the perceived reality is that of the senses, and that is a partial image: I see the column, the table or the folio but not the atoms that form them (Campra 2001: 167). However, it is not less certain that those daily visions of the real are sieved by epochal discourses that modify them: what was a creation of divinity centuries ago is now a product of a gigantic explosion of matter, for instance.

Theoretical physics is one of the sieves that has intended to answer thousands of questions, from the subatomic world to the immense regions of outer space. Doubtlessly, its premises, although at times far removed from our daily vision of the world, influence the collective imaginary. Had it attained or were it to attain its final objective, science would perfectly delimit the realms of the possible and the impossible and, therefore, we would have to ask how we could manipulate them in order to generate fantastic effects. Thus, a great question remains open, and I hope to answer it in the next pages: under the light of the propositions of theoretical physics in the twentieth and twenty first centuries, what relevance does the fantastic have and how has its formulation been modified?

2. THEORETICAL PHYSICS

Since its birth, the fantastic has been intimately linked to science. As early as 1958, Roger Caillois asserted that it could not have emerged until after the triumph of the scientific conception of a rational and necessary ordering of phenomena, that is, after the recognition of a strict determinism in the concatenation of cause and effect (Caillois 1966: 12). A few pages later he continued: “Only cultures that have attained the understanding of a constant and immutable order of phenomena have been able to usher, as if by contrast, a peculiar form of imagination that rejoices in contradicting precisely that perfect regularity: supernatural horror” (Caillois 1966: 20-21).

Until the rise of rationalism in the eighteenth century, three explanations of the real had coexisted: science, religion and superstition. Only in the following stage, when reason becomes the principal way of understanding the world, can the fantastic emerge: “it was born in a Newtonian, mechanistic universe, conceived as a machine that obeyed logical laws, and thus susceptible to a rational explanation” (Roas 2011: 15). Without forgetting Copernicus or Laplace, it would not be too adventurous to claim that a great part of pre-relativistic physics emerged from the ideas that Isaac Newton defended in *Philosophiae naturalis principia mathematica* in 1687. Classical physics was ruled by two fundamental principles that were not seriously challenged until the advances of Einstein: first, the objectivity of physical magnitudes that exist independently of the observer and have a definite value for each instant; second, the determinism of the temporal evolution of the system, that is, that by knowing the differential equations and the magnitudes of a system in time T it is possible to predict its value in T+. Hence, all facts that can be explained by virtue of these postulates and the equations that support them enter the realm of the possible, based on daily experience and common sense, thus

defining the separation between the two orders. This way, as per Susana Reisz, fantastic literature in Europe emerges as a compensation of this rigorous, imposed division between the spheres of the natural and the supernatural that religion had kept coherently unified until then (Reisz 2001: 194-195).

The acceptance of laws that modify the paradigm of reality of a particular time allows us to explain both the emergence of the fantastic and of all those works arising in the nineteenth and twentieth centuries from writers such as E.T.A. Hoffmann, Edgar Allan Poe, Guy de Maupassant or Henry James. The influence of these laws is so powerful that even H.P. Lovecraft speaks of "fixed laws of nature" in an essay from 1927, twenty-two years after the appearance of "On the Electrodynamics of Bodies in Movement" by Albert Einstein, the work that blows up classical physics and forever modifies the notions of space and time.[5]

2.1. *Albert Einstein and the Theory of Relativity*

$E=mc^2$

Albert Einstein

Albert Einstein enunciates two postulates of the special theory of relativity in 1905. The first one, called principle of relativity, goes as follows: "If two systems of coordinates are in a relative movement of uniform parallel movement, the laws that determine changes in a physical state do not depend on which of the two systems is related to those changes" (Einstein 2003a: 1030). Einstein affirms the equivalence of all inertial referents, that is, those objects that do not possess rotation and move in relation to others with uniform movements.[6] In other words, the notion of an absolute system of reference is banished, since it becomes impossible to determine absolute velocity as it depends on the position and speed of the observer. The second, called the invariability of the speed of light, goes thus: "Every ray of light moves in a system of coordinates at rest with a fixed speed V, independently of whether the ray of light is emitted by a body at rest or in movement" (Einstein 2003a: 1030). That is, the speed of light is always constant (in a vacuum), independently of the movement of the emission source and the observer. These principles mean little for someone who does not possess an extensive knowledge of physics. However, they are the basis or some implications that disrupted the vision of the universe as it had been understood since Newton.

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[5] Einstein, however, saved Newton's ideas from the pyre and vindicated his importance in modern physics: "Let no one think that with this or any other theory we can eliminate intrinsically the great creation of Newton's theory. His ideas will continue to maintain their eminent significance in the field of natural philosophy, as a foundation of our modern formation of concepts" (Einstein 1985: 119).

[6] Although it is true that Newton had already established this hypothesis, it was not valid in the field of electromagnetism because of the incompatibility with the supposed existence of ether, which according to pre-relativistic physics was a kind of fluid that occupied all spaces. When Einstein discovered that the principle of relativity was valid for all physical phenomena without restrictions, he was able to formulate a new theory of electrodynamics that would not be sustained by the existence of ether: "The introduction of ether will prove to superfluous since according to the concepts to be developed it is not necessary to introduce a space in absolute repose, nor is it associated with a velocity vector towards any of the points in empty space where electromagnetic processes take place" (Einstein 2003a: 1028).

Einstein himself affirmed that to understand relativity is to discard common sense and open the doors of imagination. Starting from these principles, he arrives at some shattering conclusions: absolute space and time, in Newtonian terms, do not exist; both are relative concepts that depend on the position and speed of the observers. In other words: two observers in relative movement with each other will have different perceptions of time and distance, which means that the proverbial absolutes of physics become malleable. According to the special theory of relativity, space-time can be torn, contract or expand, according to the speed of the bodies, which implies, according to Michio Kaku in the following fragment, a complete revolution in our paradigm of reality:

> The equations of Einstein, in a certain sense, are like a Trojan horse […] Inside them lurk all kinds of demons and elves that postulate the possibility of interstellar travel through worm holes and time warps. The price we had to pay for peering into the darkest secrets of the universe is the potential collapse of our most commonly held beliefs about our world: that space is connected in a simple way and that history is inalterable. (Kaku 1996:127)

Einstein realized that the special theory of relativity clashed with Newton's postulates. For the British physicist, gravity was a force that acted instantaneously, which means, for instance, that in the case of the putative explosion of a celestial body such as the Sun, the bodies attracted by it (in this case the planets, satellites, etc., of the Solar System) would immediately shoot out of their orbits. However, further explorations in this field allowed Einstein to contradict the ideas of Newton in his general theory of relativity. We are interested in the postulate about the curvature of space-time: "The metric character (curvature) of the tetradimensional time-space continuum is defined at each point by the matter at that point and the state of matter" (Einstein 2003b: 1116). The curved matter of space-time exerts an attraction that is named gravity, which acts at the speed of light in a vacuum. In order to imagine this, we should think of an elastic bed with a heavy circular object at its center (the Sun) that would bend the elastic. Any object smaller than that the one placed at the center that would enter into its sphere of influence would be attracted until it crashed against it, unless it gravitated around it (the way planets do). These warps, by virtue of the intrinsic relation between space and time, could provoke space-time transformations in cases where gravity attains very high values.

Nevertheless, the conditions for being observers or participants of such alterations are extreme. In the case of speed, if an object is motionless (in relation to us), says Brian Greene (2011: 67), all its movement is used to travel through a temporal dimension, that is, its dilation factor is equal to 1, which means there is no space-time alteration.[7] However, let us assume that the object accelerates progressively until it it almost reaches light speed, so that its dilation factor would be almost infinite and it would use all (or almost all) its energy in moving through space. As a result, its movement through time would slow down and it could travel in time towards the future. For example, if a person would spend a year (according to her perception of time) in taking a round trip to Earth at the speed of light, she would realize upon landing that centuries have gone by in our planet. Something similar happens with gravity. While in a gravitational field like the Sun "the lateness experienced by clocks is rather small […] stronger gravitational fields, such as those found at the edge of a black hole, slow down the flow of time even more" (Greene 2001: 94). Hence, there is a possibility to tear the space-

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[7] For an explanation of the equations that allow such numbers see Lightman (1995: 151-163)and Einstein (1985, 1993, 2003a and 2003b).

time fabric, either by reaching speeds close to that of light, or by subjecting a body to increased gravity.

Albert Einstein himself realized that although his theory of relativity explained movement at great speeds and the effect of gravity better than any other, and although it was the theory that definitely modified classic mechanics, it had no direct effect on daily life:

> It only affects, in essence, the laws pertaining to rapid movement, in which the speed of matter are not too small in relation to the speed of light. Such fast movements are only experienced in the case of electrons and ions; for other movements, the deviations according to the laws of classic mechanics are too reduced to be perceptible in practice. (1993: 31)[8]

If events have to be framed in a fictional world comparable to the world beyond the text in order to achieve the fantastic effect, connection with the theory of relativity become complicated. Physicist John D. Barrow asserts in one of his books that daily experience cannot truly reveal how the universe truly functions—a hundred years after Einstein, even professional physicists still do not have a visceral grasp of relativity (1999: 109), which is not surprising at all, since "you would have difficulty finding what advantages for survival are offered by a solid idea of relativity" (1999: 109).

Therefore, we observe a disconnect between the socially shared paradigm or reality (based on daily life) and the theories of physics that explain the world around us. Perhaps because of this it is difficult to apply the postulates of relativity to the fantastic with the goal of providing a rational explanation to what we considered impossible until now. One option to try to solve the problem is to think about some of the possibilities that the theory of relativity leaves open, such as the existence of worm holes that link two regions of space-time. Thus, for instance, we could explain the tale by Félix Palma "Venco a la molinera" (1998) saying that the plane in which Ernesto had traveled fell into one of those worm holes and he traveled to another region of the universe that is a copy of Earth, with the only and terrifying difference that they have *venco* instead of chicken. Or apply the same justification to *The Last Flight* (Claxton 1960), episode 18 of the first season of *The Twilight Zone*, scripted by Richard Matheson. Throughout its twenty five minutes it narrates the story of an aviator who is lost among the clouds in 1917, during an aerial combat in World War I, and later lands on the same base but in 1959, saving himself from death, but also causing an alteration in the present that can only be solved by getting lost again among th clouds and accepting his fatal destiny. However, it is not possible to consider both tales from th point of view of physics, since worm holes have an approximate length of about Planck (10^{-35}), "so small that they simply wold resemble the anomalous appearance and disappearance of some elemental particles in an experiment of particle physics" (Barrow 1994: 125).

Another option is to think about tales about space-time alterations. However, the vast majority are framed in science fiction, since they utilize technologies not existing in our present to achieve leaps through time. Such is the case of *Back to the future* (Zemeckis 1985), "A Sound of Thunder" (Bradbury 1996) or *The Time Machine* (Wells 1952; Hyams 2005). In other cases, there is no possible rational explanation. For instance, in the film *A Matter of Time* by Richard Curtis (2012) we are told that a youth named Tim Lake has the gift of traveling through time, like all the men in his family, only through the power of his mind. However, although relativity allows alterations, cases like this remain inexplicable because the characters are not exposed to great speed or gravity.

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[8] Although Einstein here refers to the special theory, what he says is perfectly applicable to the general theory; we only need to keep in mind that what he says of the speed of light needs to be applied to a gigantic force of gravity.

In summary, the equations of relativity allow the alternations of space-time, but under conditions so specific and alien to our daily experiences of time and place that even if we accept that this is the theory that best explains physics at a great scale, we cannot include its formulations in our paradigm of daily reality, which is the playground of the fantastic, as Teodosio Fernández observed (2001: 296-197) as previously quoted. Therefore, it is difficult to explain a fantastic tale from these premises.

2.2 *Quantum Mechanics or Subatomic Chaos*

God not only plays dice, but he rolls them where we cannot see them

Stephen Hawking

Richard Feynman used to say there was a time in which only Albert Einstein understood relativity because he was the only one who knew about it, but that after reading his articles most physicists undeniably understood it. However, he went on, "I think I can safely say that nobody understands quantum mechanics" (1985: 129). If Einstein proposed abandoning common sense in order to imagine the space-time alterations predicted by relativity, quantum requires not only this already complicated step, but also demands that you blast away all logical knowledge with the goal of peeking minimally into the workings of particles at the atomic and subatomic scales. At these levels of matter, it is not even possible to say where something is, or at what speed it is moving, or to predict exactly what will happen, nor to guess when an atom is going to emit a light or, in case there are several atoms, which one is going to do so (Feynman 2002: 65-67):

> Unlike the framework established by Newton or even the one established by Einstein, in which the movement of a particle is determined by by its location and speed, quantum mechanics shows that at the microscopic level *it is not possible to know at the same time both characteristics with total precision.* (Greene 2001: 134-135)

At this level, matter does not behave like anything of which we have direct experience. Because this complexity would render impossible a detailed explanation of the theory, I think the most useful approach is to start with some phenomena or principles that show clearly the radical difference between the macroscopic world in which we act on a daily basis and the microscopic world of the particles. These are Heisenberg's uncertainty principle, the tunnel effect and the levitation of bodies.

The world view under pre-quantum physics was deterministic, which meant that the future position of any given object could be predicted once its initial conditions were given: "The world of Laplace, how it is sometimes called, was nothing more than a machine. A photograph of the machine in an instant, plus knowledge of its functioning, could determine its future at any moment" (Lightman 1995: 223). However, Werner Heisenberg demonstrated in 1927 that in the quantum world nature prohibits the precise measuring of the initial conditions of the particle or of anything else:[9] "it is impossible to measure the speed and the position of a particle because we need to light it with a photon, which causes a disturbing effect that modifies its speed and its position" (Greene 2001: 133). The implications of

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[9] For detailed examples see Lightman (1995: 222-254); Feynman (2002: 149-173) and some chapters in Greene (2001 and 2006).

this are much more radical than we could initially imagine, since not knowing exactly where an electron is means (nothing more and nothing less) that it exists in several parallel states at the same time (Kaku 1998: 459).[10]

In this case, we can think of the motif of the double, someone who can be in two places at the same time. Cases such as the film *The Student of Prague* (Stellan Rye and Paul Wegener 1913), the tale "The Other" (Borges 2014) or the film *The Double Life of Veronique* (Kieslowski 1991) are prototypical in studies of this motif. However, we know they cannot be explained rationally according to the principles of quantum mechanics, since the movement of a macroscopic body does not respond to the wave-particle duality, as is the case with microscopic bodies. Thus, the double continues to be problematic since it escapes the margins of daily life. Therefore, the implications of the uncertainty principle remain within a philosophical framework as affirmed in 1961 by Czech-American philosopher Milik Capek in his still timely study *The Philosophical Impact of Contemporary Physics*: if, according to the uncertainty principle, both the concept of location and that of speed lose their meaning, "the concept of 'the state of the world in a given instance' also loses a perfectly defined language" (1973: 295). Furthermore, if we begin with the axiom "Observation disturbs the observed," it is not difficult to deduce that the reading of a phenomenon is always subjective, and that the received impression is never the real behavior of the observed, which brings these disquisitions closer to the reflexions of Consructivist philosophers or to the notions of Jean Baudrillard on *simulations* or *hiperreality.*

If there was an imbalance between Einstein's equations for relativity and the logic of daily life, this first example clearly shows that in the case of quantum mechanics everything is far more pronounced. We cannot understand quantum behavior as well as we would like, and that is perfectly reasonable "because all human experience and direct intuition applies to large objects, yet objects on a small scale do not act that way" (Feynman 2002: 151).

Another interesting possibility is the *Tunnel Effect.* Let us imagine that a particle is launched with kinetic energy X against a barrier whose kinetic resistance is higher than X. It seems evident that the particle will bounce and will remain on the side from which it was launched. However, quantum mechanics affirms that we can envision the particles in their wave function, which contains the information relative to the probability of finding the particle in a specific position (as we explained in note 10). When the described particle finds the barrier, the wave function divides into two: one part is reflected and remains on the starting side, while the other is transmitted and manages to go beyond the barrier, even though the energy with which it had been launched is lesser, even much lesser than that which would have been necessary to do so. In Brian Greene's words: "quantum mechanics unambiguously shows that wave functions—that is, the waves of probability—of the particles that make up an object contain a diminutive part that goes beyond the wall" (2001: 136). This means, in everyday and macroscopic terms, that when we throw a tennis ball against a concrete wall, a portion of its particles go beyond it, so that if all its elements find their way across the ball will reappear intact on the other side of the wall.

We can think of the story "The Man Who Walked Through Walls" by Marcel Aymé (2004: 112-120),

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[10] This is caused by the wave-particle duality. For example, if we free an electron, it will behave as a wave (similar to sound, and as such, it will be in various positions at the same time), but when it bumps against a body it will do so at one point only, since we have freed only one electron. Thus, the elementary particles in quantum mechanics exhibit dual characteristics that are inconceivable in the macroscopic world.

which narrates the story of Dutilleul, a third-tier employee in a registration office that because of an ironic illness is capable of traversing walls like ghosts. Hence, the apparently impossible invades a fictional world that the reader recognizes as an analogous iteration of the world he inhabits. I say apparently because the tunnel effect shows that it is possible for a body to go through a wall. Nevertheless, even though physics confirms that possibility, can the reader consider that the narrated phenomenon falls within his paradigm of daily reality? Brian Greene has the answer:

> As the objects we study become more and more complex, because they are composed of ever increasing particles, this tunnel effect can continue to occur, but it becomes very improbable since *each and every particle* must have the chance to open their path together […] the laws of probability in quantum mechanics […] show that if we tried every second to walk towards the inside of a solid wall in the real world, we would need more time than the total present age of the universe in order to have a good probability of traversing it in one of our attempts. However, with infinite patience (and great longevity) we could—sooner or later—come out on the other side (Greene 2001:138)

Theoretical physics affirms that it is possible to traverse a wall, but the probabilities that it will happen in our daily life are so scarce that we discard them as a plausible explanation. In this case, again, we interpret the facts in the tale by Aymé from the postulates of classical physics (which are, by and large, the ones that rule our day to day lives) and we suppress the postulates of quantum physics since we consider them too far removed from macroscopic logic.

A similar case deals with the levitation of bodies: "levitation is compatible with the known laws of physics, in the sense that if all the molecules in my body decide to displace in an upward direction, I will become separated from the ground. No law of physics forbids this" (Barrow 1999: 204). It is possible for objects to levitate with the correct use of magnets, variations in pressure, electric charges or intense soundtracks. However, we are concerned here with phenomena that do not involve technology. This is the case of "Levitation" by Joseph P. Brennan (1988: 85-91): the Morgan Traveling Circus performs in Riverville, where the monkey-boy and the tattooed man elicit the laughter of not too demanding spectators. Everything happens normally until the hypnotist appears onstage and requests the presence of a young volunteer. When the hypnotist sits on the chair prepared for the show, a bag of popcorn flies towards his face. The hypnotist, annoyed, asks the culprit to climb onto the stage, and he obeys defiantly. The inexplicable then happens: the young man, named Frank, falls asleep and is forced to levitate by the hypnotist. When he has risen a few handspans above the ground, the hypnotist falls dead to the ground. The audience approaches the stage in throngs while the young man continues to rise above their heads until he disappears among the clouds.

The interpretation in this case is complex, since we must accept that according to quantum mechanics it is possible, although highly improbable, that a body can levitate, but also that either the hypnotist had an unknown power that causes all particles in Frank's body to rise in flight, or else that both events take place in the same place and time purely by chance. Again, the phenomenon, although possible according to physics, would not be included in our paradigm of reality (even if we omit the hidden powers of the hypnotist) since the probability that such an event would happen in our everyday life "is so low that we can be sure that any report stating it has occurred is much more likely to be

wrong than right" (Barrow 1999: 204).[11]

According to our paradigm of reality, nothing can be in two places at the same time or modify its position when it is observed. Nor do we have experiences of bodies that traverse walls or levitate without the use of technology, and if we have ever attended a magic spectacle, we are conscious that a part of reality is being hidden from us, no matter how surprised we are in the end. Nevertheless, according to the equations of quantum mechanics all this is perfectly possible. Therefore, we could think that, starting from its principles, it is possible to give a rational explanation of the events in some fantastic tales. Still, these readings do not hold, and the events that generated fantastic effects on the reader before passing through the quantum sieve, continue to produce them. In one of his reflexions, Michio Kaku warned us: "there is an invisible wall that separates the atomic world from the familiar and everyday macroscopic world. While the atomic world obeys the strange laws of quantum theory, we live our lives outside of the wall, in a world of well defined planets and stars where the waves have already decomposed" (2008: 125). At this point emerges a paradox that still has not been answered: the universe is a continuum. Nevertheless, even though the building blocks of the matter with which we interact are the particles studied by quantum theory, the physics that explains the atomic and subatomic world makes no sense when it is applied at the macroscopic level.[12]

In conclusion, quantum physics determines that particles have specific behaviors that can explain some facts held to be impossible a priori. However, as Barrow observes, although according to its laws any event could take place with a certain degree of probability, "the possibilities of witnessing things that we are tempted to define as miracles (such as human levitation) are so low that probably it would not be seen in our corner of the world during the entire history of the human race" (Barrow 1999: 302-303). For this reason, the options offered by quantum theory to explain some tales cannot be applied, since we ourselves cannot apply them in our daily construction of the real, which is, let us remember, the playground of the fantastic.

3. CONCLUSIONS

I started this essay saying it had been born from the reflexions by Professors David Roas and Antonio Penedo. […] The answers by Penedo and Roas are apparently contradictory; yet, as in a quantum paradox, both are correct, and the answer I propose as a conclusion is precisely the apparently contradictory combination of both. From Roas I keep his idea that that the paradigm of reality from which we judge the fantastic responds to the Newtonian model. The quotes from the British physicist […] reveal that the notions of time and space that delimit the real in our everyday reality are more closely aligned with definitions tied to daily experience than to the transgressive visions of Einstein and quantum physicists […].

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[11] Even though Barrow is thinking about historical narratives such as those of the mystic Saint Joseph of Cupertino, whose process of canonization attributed to him more than seventy cases of levitation, this quote can also be applied to fictional narratives.

[12] There are more recent theories, such as M Theory that tries to give a total explanation of the universe unifying Relativity and Quantum Theories. Even though they have succeeded at the theoretical level, empirical proof has not been possible for two reasons: first, the mathematics on which it is based are so new and difficult that it will take decades to get to know them (Glashow and Ginsparg, 1986); and second, the accelerators that we would need to fathom the distances in which strings supposedly exist would have the size of our galaxy (Greene 2001: 240).

However, our paradigm of reality has changed necessarily in some aspects. Mili Capek had already observed in the sixties that "no component of the Laplace model of nature remained unaffected by the contemporary storm of physics" (1973: 361).[13] So it is, and not only at the level of philosophy and physics. Hence the positive aspect of Penedo's view: we accept the views of relativity and quantum mechanics, assuming that certain facts that are impossible according to our experience are nevertheless theoretically possible according to physics. However, we do not incorporate those views as part of our daily lives—we do not assimilate them or grasp them the way we have done with the failed Newtonian conceptions of absolute space and time, which work strikingly well at the low speeds and moderate gravities that we encounter in daily life. Our senses are not under any kind of evolutive pressure to develop a relativistic or quantum perspicacity (Greene 2006:109).

Therefore, fantastic effects are not and have not been discarded by the evolution of theoretical physics in the twentieth century, since this development has taken place under conditions that are far removed from our daily lives. The impossible event that unchains the fantastic element is not measured in relation to the laws of nature as framed by quantum and relativity theories, although these are empirically certain; rather, it responds to logical intuitions that may not be quite correct in many aspects. For instance, knowing that quantum physics has proven that a body can traverse a wall and reappear unscathed on the other side does not dismiss the effect on the reader of "The Wall Crosser" by Marcel Aymé (2004: 112-120). Similarly, knowing the existence of worm holes does not change the reader's perception of "Venco a la molinera" (Palma 1998). Both tales, just as the other references to works of fiction I have included in these pages, still produce that impression that is characteristic and unique in the fantastic genre, and that arises when our convictions about the real cease to function and give rise to what David Roas has named *metaphysical dread* (2011: 95).

Yes—the fantastic still holds. Its formulations have been modified, not so much at the explanatory level, but rather at the creative level. As in the case of eighteenth century rationalism, new advances in physics, in their attempt to explain reality with greater accuracy, have revealed hidden and inaccessible spaces, prolific fields to cultivate new fantastic fictions. Relativity and quantum theories do not confine or dislocate—rather, they broaden the margins and open new paths into the occult. The fantastic definitely survives. It is no longer the same. It will never be the same. And yet, that which makes it unique remains immutable.

[The bibliography can be found on the pdf document, which I cannot copy: http://revistes.uab.cat/brumal/article/view/v3-n2-molina/pdf_6]

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[13] Translator's note. Prior to Capek's study, Werner Heisenberg, the father of the Uncertainty Principle and Nobel laureate for 1932, had himself raised this issue in his study from 1958 *Physics and Philosopy. The Revolution in Modern Science.*