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Abstract

This paper presents an artistic research project entitled *Double-slit*, which is based on the relationship between the kaleidoscopic image and the interference phenomenon both from conceptual and visual viewpoints. Through the combination of artistic practice and theoretical research, the kaleidoscopic interference is investigated considering a different involvement of the subject. In Cortazar's view, the kaleidoscopic image creation process would be closer to the observer experience than to the author's role when looking through the kaleidoscope. Consequently, the relationship between the author and the observer/reader is introduced with reference to kaleidoscopic image, producing an interference feeling between these different positions. Specifically, the present article refers to cases from Borges' literature, mainly related to the connection between reality and fiction within the observer position. The indicated approach corresponds to a kaleidoscopic narrative, since this type of image is virtually composed by real –the original motif– and fictional elements –the reflections/copies–. Therefore, Borges' thought will be discussed in this regard, specifically those characters that present both kaleidoscopic and quantum behaviour.

The results found in the process of developing the aforementioned project on the double-slit shows that this experiment –whose result in physics is the interference pattern– and kaleidoscopic image are significantly related to each other. In particular, concerning Feynman's sum-over-paths phase of infinite possible trajectories. This insight leads the article into a discussion on the impact that quantum physics and multiverse theory have in relation to our understanding of existence. This way, we see that a new paradigm is present regarding visuality. It implies accepting contradictory facts as constituents of reality. Likewise, even our notion of individual identity is transformed into the subject's juxtaposition of ubiquities, which produces the "to be and not to be" kaleidoscopic interference.

Keywords

Kaleidoscopic image, interference, double-slit, multiverse, ubiquity, Borges

La interferencia caleidoscópica y el proyecto de la doble rendija: el pensamiento de Borges, el comportamiento cuántico y la teoría del multiverso

Resumen

Este artículo presenta un proyecto de investigación artística titulado «Doble rendija», el cual se basa en la relación entre la imagen caleidoscópica y el fenómeno de la interferencia tanto desde un punto de vista conceptual como visual. Combinando la práctica artística y la investigación teórica, se propicia la investigación sobre la interferencia caleidoscópica considerando una implicación diferente por parte del observador. Desde la perspectiva de Cortázar, el proceso de creación de la imagen caleidoscópica estaría más relacionado con la experiencia del observador que con el rol del autor que mira a través del caleidoscopio. Por ello, la relación entre el autor y el observador/lector aparece en referencia a la imagen caleidoscópica, generando una sensación de interferencia entre ambas posiciones. En concreto, en el presente artículo se refieren casos de la literatura de Borges, donde el autor indica la conexión entre la realidad y la ficción en lo referente a la posición del observador. Este planteamiento remite directamente a una narrativa caleidoscópica, pues dicha imagen está virtualmente constituida por lo real –el motivo originario– y lo ficticio –las copias/reflejo–. Por lo tanto, el pensamiento de Borges se discutirá en esta línea, específicamente en lo referente a los personajes que presenten un comportamiento tanto caleidoscópico como cuántico.

Los resultados hallados en el desarrollo del referido proyecto sobre la doble rendija muestran que este experimento –cuyo resultado en física es el patrón de interferencia– y la imagen caleidoscópica están significativamente relacionados. En particular, en lo relativo a la fase de las trayectorias sumadas de Feynman y sus infinitas posibilidades. Dicho entendimiento llevará el artículo hacia una discusión acerca del impacto que la física cuántica y la teoría del multiverso tienen en relación con nuestro entendimiento de la existencia. Así, vemos cómo se presenta un nuevo paradigma sobre la visualidad. Ello conlleva aceptar hechos contradictorios como constituyentes de la realidad. De la misma manera, incluso nuestra noción de identidad individual se transforma en la juxtaposición de ubicuidades del sujeto, generando la interferencia caleidoscópica de «ser y no ser».

Palabras clave

Imagen caleidoscópica, interferencia, doble rendija, multiverso, ubicuidad, Borges.

1. The ubiquitous position of the author as reader/observer in relation to kaleidoscopic image

Firstly, it would be important to introduce the main characteristics that kaleidoscopic image has, in order to get an appropriate understanding of kaleidoscopic nature and narrative from a conceptual viewpoint of what we mean by “kaleidoscopic”. Inside the kaleidoscope, the viewed image is composed as a whole entity formed of identical and triangular repetitions. When analysing this *total image*, we realise that there is a unit that comes from reality, while the mirrors that are inside the kaleidoscope simultaneously generate the copies of the indicated motif of origin. Therefore, virtual images that come from the reflections constitute the existing and potentially infinite kaleidoscopic image, which is made of real –the motif of origin– and fictional components –the reflections that are present in the kaleidoscopic device¹. Consequently, this image is produced as a result of the fictional component related to the virtual space due to the mirrored symmetry². Usually, the existing cell is the fragment situated just in front of the viewer. However, there are situations in which the observer cannot guess which one is the original image, since the mirrors create the kaleidoscopic image simultaneously. In some cases, when we see these identical triangle-shaped fragments, we cannot find which one is the original fragment among all the copies, as it can be seen in the kaleidoscopic image presented in this section (Fig. 1).

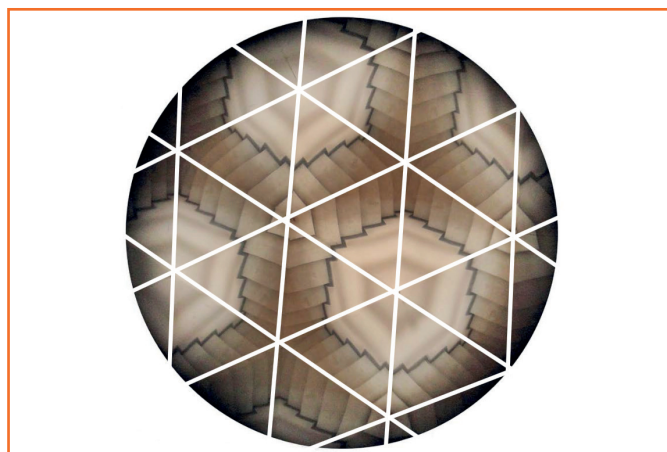


Fig. 1. Kaleidoscopic image composed by identical fragments and its structure marked in white.

In *Hopscotch*, written by Julio Cortázar, he considered the author as the first observer of kaleidoscopic image. Morelli, the character that works as Cortázar's *doppelgänger*, looks through the kaleidoscope to discover that paradoxically he was the first observer of the kaleidoscopic image that “he was creating”. Actually, this is not what we understand by a “traditional authorship”, since it is not the author but the kaleidoscope that creates the kaleidoscopic image automatically.

“That Morelli, the author, would be the first amazed observer of this world into its acquired coherence. [...] A crystallization where nothing would remain subsumed, but where a lucid eye might peep into the kaleidoscope and understand the great polychromatic rose, understand it as a figure, an *imago mundi* that outside the kaleidoscope would be dissolved into a provincial living room, or a concert of aunts having tea and Bagley biscuits”³ (Cortázar 1994, 647).

This view of what an author is avoids completely the traditional notion we have on this issue, changing the author's paradigm while giving the same importance to the reader/observer. *Hopscotch* was written considering an active involvement of the reader, who decides which one would be the structure that the book should take. This way, Cortázar proposes a different understanding through a kaleidoscopic perspective based on intertextuality, rather than a linear narrative. The authorship issue does not have the same meaning that we usually find in relation to what an author is supposed to be when kaleidoscopic image is involved. As we see, the author participates in the creation process by being closer to the observer experience than to the author's role.

In this sense, the ideas presented in Borges' essay about Pierre Menard are quite interesting. The main character, Pierre Menard, has the intention of writing *El Quijote*, a book written by Cervantes in 17th century. His purpose was to feel like the real author from Menard's perspective (20th century), not copying Cervantes but getting to the same book as a result (Borges 1971, 47-59). In fact, this statement is also present in the infinite monkey theorem, whose main topic is probability in relation to the infinite. Usually, this theorem refers to an infinite number of monkeys that are typing at a random keyboard infinitely. This way, “the infinite monkeys can be expected to reproduce the whole works of Shakespeare” (Yang, Chien & Ting 2015, 4). We also find this idea in other works of Borges like *The Library of Babel*, published in 1941. The library contains all the books and their possible combinations (1971, 93-94). In the next section, we will notice how this issue is highly related to the Feynman sum-over-paths in physics. We should also note that the library is organised like a kaleidoscope: “the symbol of the *library* admits the correct definition of a *ubiquitous and lasting system of hexagonal galleries*” (Borges

1. It should be noted that this image, although it is a virtual image, has a real existence to the observer who is looking through the kaleidoscope. This way, the fictional component that is present within the reflections of this image is also indicated in relation to the mechanisms that were involved in the creation of kaleidoscopic image. In other words, fiction will be understood as a constituent part of reality, as a consequence of the kaleidoscope mirrored condition. Therefore, we will have a visual access to a “fictional” space that does not exist in reality.

2. Some of these characteristics were also presented at the International Congress in Visual Arts Research ANIAV (2nd edition) in Spain, as well as published in the proceedings.

3. The citations whose bibliographical reference source is in Spanish were translated to English by the author of this article.

1971, 99). Analysing the library structure, we find that it is constituted by the conjunction of infinite hexagons. This is the structure we see through the kaleidoscope: a conjunction of triangles that at the same time compose an infinite number of hexagons, as we can see in the previous figure. Then, the library will be related to kaleidoscopic image both from a structural viewpoint and conceptually.

The idea of writing the same content that someone else did is quite similar to the appropriation practices in the field of art, as Martin Prada expressed, pointing out that Sherrie Levine cited the Pierre Menard essay in an article (2001, 56). If we test the notion of being embodied experiencing the same event that another person experienced, this issue would allow the creation of an identical work, producing a kaleidoscopic narrative. For instance, we find how this issue takes place in the scientific field from a visual viewpoint regarding “the synchronic experience” of the snowflakes, whose structure is kaleidoscopically fractal. Libbrecht said in relation to the growing process of the snowflake that “if you look at an individual arm, its shape reflects the exact history of its travels”. It is because of “the snowflake experience”, since “the six arms all travel together, so they all experience the same history. Thus they appear to grow in synchrony, even though no arm ‘knows’ how the others are growing” (Ray 2014). Both Menard and Cervantes experienced the same history in different contexts and periods, like Levine did when she decided to take the same photographs that Walker Evans took, in her work entitled *After Walker Evans*, produced in 1981 (The Met Museum, 2019). Consequently, kaleidoscopic image is not working as a representation, since it is connected to a simultaneous experience that takes place in-between reality (the original) and fiction (the copies). However, the “copies” are not copies at all, considering that every copy is potentially able to be the original fragment.

Borges elaborated his work on the relationship between the real and the fictional components that constitute reality. When he wrote about Hamlet as the observer of the *Hamlet* theatre play, or including the main story in *One Thousand and One Nights* as one of the Scheherazade story tales that she narrated (Borges 2011, 210-211). This fact concerns us as observers from an identity viewpoint. It suggests that if the fiction character can be the real observer –the position where we are–, we could be fictions too. If Hamlet –a fiction character–, watches the representation of his own “life” in the theatre, this position no longer suggests a catharsis. Hamlet does not experience an identification feeling regarding the play, but a ubiquitous juxtaposition within the play. As we see, Hamlet is able to experience these positions, which refers to his own ubiquity. Paradoxically, the text of the play would be already written, because Hamlet is a fictional character in the play that watches its own life as spectator. This way, there would be a kaleidoscopic interference within the subject, who is able to be in two places at the same time, being both the actor and the spectator. As we will see in the next sections, these notions are highly related to quantum reality. The

conception introduced by Shakespeare in Hamlet, “to be or not to be” (Shakespeare 2007, 71), would change into the “to be and not to be” kaleidoscopic interference when the subject experiences a juxtaposition of ubiquities, as happens in kaleidoscopic image, where all the identical, ubiquitous and juxtaposed fragments are potentially able to be and not to be the original motif.

2. The double-slit and the kaleidoscopic “sum-over-paths”: an artistic research project that allowed a reflection on the connection between the experiment and Borges’ literature

As it was introduced in section 1, the “to be and not to be” interference is highly related to the kaleidoscopic narrative from a conceptual viewpoint. Within this section, an artistic research project on kaleidoscopic image whose result was the vision of a double-slit will be presented. In this sense, artistic practice will work as an accurate background to allow a theoretical reflection on different topics from the quantum physics field, specifically related to the double-slit experiment. Finally, these issues will be compared with Borges’ literature that refer to kaleidoscopic image and present a quantum approach to reality.

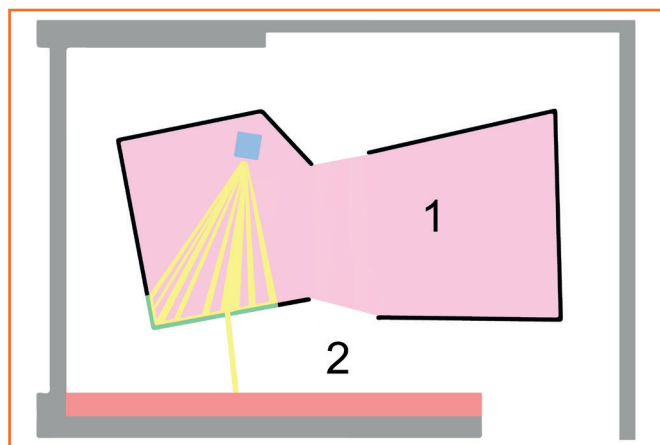


Fig. 2. *Double-slit*, 2014. Video installation schema. [Legend of the diagram] (1) In pink: projection room, workspace / (2) In white: exhibition space / In black: walls that constituted the projection as “an island” within the exhibition space, containing the projection room inside the exhibition space and two entrances in the indicated wall / In grey: exhibition wall / In red: false wall where the double-slit was projected / In green: the wall in which the kaleidoscopic video was projected over the real slit, working as an in-between space between the projection room and the exhibition space / Blue square: the video projector / Yellow rays: light that came from the video projector, finally projecting the video over the wall highlighted in green, and passed from the workspace to the exhibition space through the slit as it can be seen in the diagram.

The double-slit project is a site-specific video installation developed in 2014 at *Atelier* residency (*Retroalimentación* project) at the Young Art Center in Madrid (Spain) [Sala de Arte Joven de la Comunidad de Madrid]. Please note that for a better understanding of this section, the reading of the legend that is present in the video installation schema (Fig. 2), referring to the situation of the elements and some technical information, is needed. The aforementioned video installation presented different spatial levels: [1 in the schema] The projection room as workspace (Fig. 3) / [2 in the schema] The exhibition space (Fig. 4). As we see in the schema, the projection room was situated as “an island” within the exhibition space. Consequently, as it can be analysed observing the schema of the video installation, the observers could change their trajectory from the exhibition itinerary, to discover which was the mechanism applied on the other side of the wall where the real slit was located. Therefore, the slit was situated as an opening in the wall between two rooms, connecting the projection room and the exhibition space (Fig. 5).



Fig. 5. *Double-slit*, 2014. Image of the slit as an in-between that connected two different spaces [1 and 2 in the schema]. Photograph taken from the exhibition space.



Fig. 3. *Double-slit*, 2014. Video projection inside the workspace, projected over the slit.

Inside the projection room, a kaleidoscopic video previously made for the exhibition was projected over the wall using just a single projector. This experimental video contained a series of images about kaleidoscopic nature as it can be seen in the video frames (Fig. 6), since it was filmed through an analogical kaleidoscope. It also presented interference patterns in green and pink that could be seen through said device and were filmed too (Fig. 7), as well as the hand of the author/observer twisting the kaleidoscope, which corresponds to the shadow areas that are visible in the video frames.

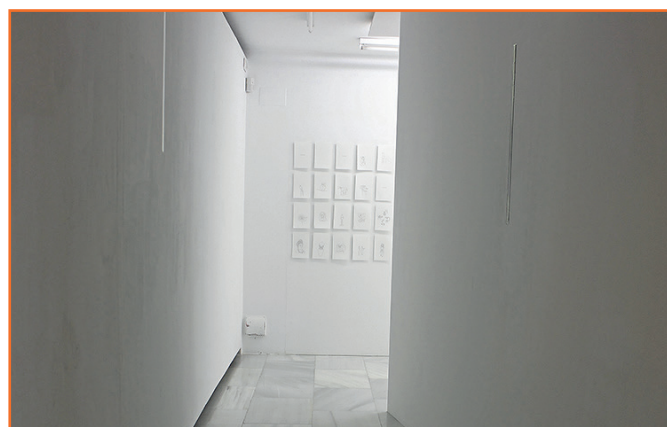


Fig. 4. *Double-slit*, 2014. The exhibition space, where the real slit –on the right– and the projected slit –on the left– can be partially viewed.

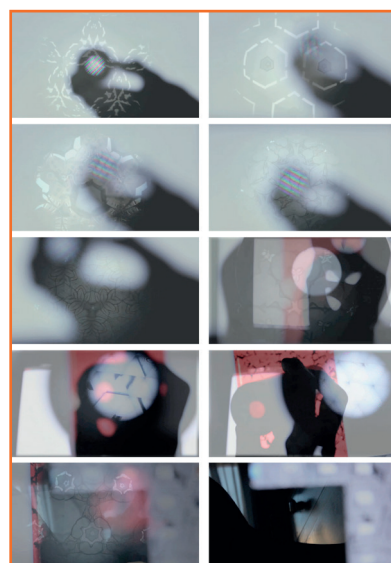


Fig. 6. *Double-slit*, 2014. Frames of the kaleidoscopic video that was projected over the slit.

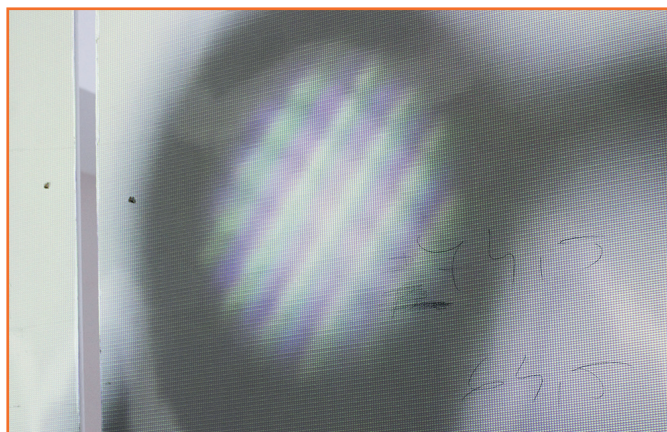


Fig. 7. *Double-slit*, 2014. Pink and green interference pattern in the kaleidoscopic video.

The mentioned video projection also involved the slit, since it was located as an opening space in the wall where the kaleidoscopic video was projected. Therefore, part of the projected video could pass through the slit generating a second projection in the exhibition space, as can be consulted in the schema. At this point, the observer that was in the exhibition could see two projected slits in front of the real slit, like a double-slit projected image (Fig. 8). The double-slit image was produced thanks to the light that came from the aforementioned video, which was projected on the other side of the wall where the real slit was located (Fig. 3).



Fig. 8. *Double-slit*, 2014. Video projection of the double-slit in the exhibition space over the false wall and getting into a third spatial level in the ceiling, at a 90° degrees angle with respect to the projection over the wall.

As we see, this condition created the second spatial level of the video installation, since the real slit generated the image of a double-slit projecting its own shape as a frame. One of the slits was projected over a false wall situated in front of the real slit, while the second one was located in the ceiling at a 90° angle with respect to the primary slit. It should be noted that the false wall had an opened upper area where the second slit was located, seeming to be entering inside a third spatial level that was hidden, as can be seen in the image. The second projected slit was generated on account of the light projection that came from the kaleidoscopic video, which passed through the real slit creating the double-slit projection over the mentioned false wall. Actually, the view of the projected slits depended on the video frames projected over the real slit. Occasionally the projected slits disappeared completely, with the result that there were no projected images in the exhibition space.

At the beginning, the presented artistic project was entitled *Double-slit* in order to describe what happened within the video installation when the double-slit was projected in the opposite false wall and the ceiling. Serendipitously, this name also belonged to a well-known experiment in the physics field. The double-slit experiment was carried out by the physicist Thomas Young in the early 19th century, having been closely related to other experiments developed in 20th century with the double-slit as experimental method. In fact, the physicist Richard Feynman stated that “quantum mechanics can be gleaned from carefully thinking through the implications of this single experiment” (Greene 2018, 118).

Metaphorically comparing the experiment to the double-slit artistic project presented in this article, we find much in common. There are almost three different levels that work simultaneously with the projection of light—in the case of the video installation—or light photons—in the experiment—, along with the double-slit as a motif and key aspect—in any case, both for the experiment and the video installation—. Although this idea was initially based on speculative thinking, to investigate in this regard led to discovering issues that connected kaleidoscopic image and the double-slit experiment. Intuitively, a connection between the double-slit scientific experiment and kaleidoscopic image was found, since the basis of the *Double-slit* video installation was the kaleidoscopic video frames projected over the real slit that generated the projection of a double-slit in the exhibition space. As a consequence of producing the *Double-slit* artistic project, the research on the relationship between this experiment and the kaleidoscopic image was proposed, specifically in relation to the kaleidoscopic structure from visual and conceptual perspectives.

Firstly, the experiment that Young developed will be presented. Thanks to this experiment, Young demonstrated that light has wave properties. The experiment consisted in two slits as openings in a solid wall, while the light was passing through the double-slit. On the other side, in front of the double-slit, there was a photographic plate. The prediction in Newton’s conception was that light, when passing through the slits,

would generate the shape of two slits in the image as a consequence of the corpuscles of light passing through the slits. However, the result was quite different: not two slits, but an “infinite” interference pattern was showing the light wave function. Years later Einstein recovered Newton’s theory by introducing and analysing the photons –the light particles–, showing the dual behaviour of light both as wave and particle. But also when the experiment was done with individual photons “being fired one by one at the barrier”, still the result was an interference pattern. Hence, “how can individual photon particles that sequentially pass through the screen and separately hit the photographic plate conspire to produce the bright and dark bands of interfering waves?”. This event happens because light photons have similar characteristics to the wave function, even when they may be constituted as particles: they have both wave and particle properties (Greene 2018, 117-123). Similarly, in 1923 De Broglie asserted that not only wave-particle duality could be applied to light, but also to matter. To show this, Davisson and Germer carried out the double-slit experiment with electrons, which were “the solid matter” at a subatomic scale. One more time, the result was the interference phenomenon: “as with photons, individual electrons ‘interfere’ with themselves in the sense that individual electrons, over time, reconstruct the interference pattern associated with waves” (Greene 2018, 125). This fact is due to a dimensional sight: how can something that is supposed to be solid also present a wave function? Our macroscopic reality works differently if we compare it to the microscopic dimension. Actually, in the second half of 20th century Feynman claimed that the electron passes through the double-slit ubiquitously, specifically meaning that the electron quantum nature allows passing through the double-slit at the same time. Afterwards, the electron goes simultaneously through all possible paths collapsing in one, or has the probability of being in any of those paths, as can be seen in the double-slit experiment diagram (Fig. 9). Surprisingly, this characteristic quantum behaviour has been found in characters written by Borges, if we compare the next citations from Borges’ literary work with Greene’s statement on quantum theory.

“Each individual electron actually traverses every possible trajectory simultaneously [...]. Simultaneously “sniffs” out every possible path connecting its starting location with its final destination. [...] The probability that the electron [...] arrives at any chosen point on the screen is built up from the combined effect of every possible way of getting there. This is known as Feynman’s “sum-over-paths” approach to quantum mechanics. At this point your classical upbringing is balking: How can one electron simultaneously take different paths –and no less than an infinite number of them?” (Greene 2018, 130-131).

“The phrase ‘to various future times, but not to all’ suggested the image of bifurcating in time, not in space. Rereading the whole work confirmed this theory. In all fiction, when a man is faced with alternatives he chooses one at the expense of the others. In the almost unfathomable Ts’ui Pen, he chooses –simultaneously– all of them. He thus creates various futures; various times, which start others, that will in their turn branch out and bifurcate in other times” (Borges 1971, 111-112).

“Everyone agrees on how to use the equations of quantum theory to make accurate predictions. But there is no consensus on what it really means to have probability waves, nor on how a particle “chooses” which of its many possible futures to follow, nor even on whether it really does choose or instead splits off like a branching tributary to live out all possible futures in an ever-expanding arena of parallel universes” (Greene 2018, 128).

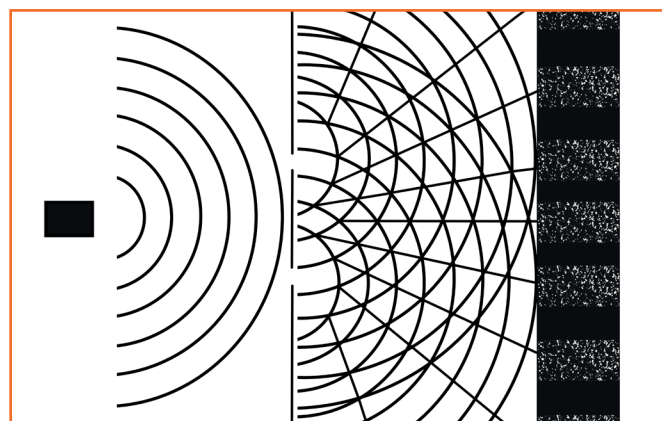


Fig. 9. Double-slit experiment diagram recreation, showing the double-slit in the wall, the sum-over-paths phase and the interference pattern as result.

As we see, Borges’ character Ts’ui Pen behaves like the electron does in quantum mechanics. In addition, it should be noted that Borges published *The Garden of Forking Paths* in 1941, while Feynman’s theory is dated in 1948. Principally with the aim of comparing the experiment with kaleidoscopic image, we should be focus on one phase: when the electrons are fired one by one, after passing simultaneously through the double-slit but before getting to its final interference pattern destination. This phase is named as Feynman’s “sum-over-paths”, since there is an infinite possible trajectory that the electron takes when considering “every possible way of getting there”. The probability in quantum physics is infinite (Greene 2018, 140), like the kaleidoscopic image or Borges’ writings such as *The Library of Babel* –which is structured as a kaleidoscope, as was already stated in section 1– or *The Garden of Forking Paths* infinite bifurcation. These examples are part of Borges’ kaleidoscopic publication named *Fictions*, where he worked on the infinite mirrored image mainly using a kaleidoscopic narrative and different motifs that referred to this image. According to this issue, there are many characteristics that the quantum infinite possible trajectory and the infinite sense in kaleidoscopic image share from a conceptual viewpoint. Nevertheless, there are unexpected similarities between kaleidoscopic image and the infinite “sum-over-paths” that the electron is supposed to take simultaneously. In the images we see that the kaleidoscopic structure and the double-slit experiment diagram, concretely the “sum-over-paths” phase, are quite similar from a visual viewpoint. Visually comparing the kaleidoscopic structure (Fig. 1) and the sum-over-paths phase in the double-slit experiment diagram (Fig. 9) –in-between the interference pattern and after the electron passes through the double-slit within the part in which we find a curved triangulated structure–, we see that they present visual similarities. Even though the sum-over-paths triangulated structure we see in the diagram seems to be more

curved than the image created in the kaleidoscope, they share a significant visual correspondence. For instance, we find this type of curved kaleidoscopic structure in other examples as can be seen when we search “triangulated curved structure” in *Google images* (Fig. 10).

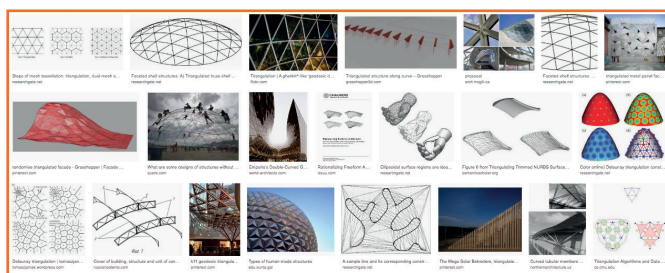


Fig. 10. *Triangulated curved structure*. Screenshot from the search results in *Google images*.

In the sum-over-paths phase the electron takes simultaneously every possible path after passing through the double-slit at the same time. The interference would be *the consequence* of the sum-over-paths phase in the double-slit experiment. In this way, the electron is interfering within “the self” if we “personify” it, as Borges put forward with characters like Ts’ui Pen. Conceptually, this type of kaleidoscopic interference was also present when Hamlet watched the representation of his own story and he felt like being in two different places at the same time: both as spectator and actor of the theatre play—real and fictional components within reality, producing the kaleidoscopic interference feeling—. According to Bohr, in quantum mechanics “the observation act [...] is not only reduced to be the spectator of a theatre play, but also to be the actor of the theatre play” (Miret Artés 2015, 14), just as Hamlet does. When the electron passes through the double-slit, at the same time it creates its own juxtaposition of ubiquities. Both the electron and Hamlet, by being at two different spaces at the same time—the double-slit and the theatre, respectively—are related to a ubiquitous condition. In addition, Bohr’s statement can be understood as a way of explaining the wave function collapse, which refers to the electron when it “chooses” one of the infinite states. Specifically, it illustrates how the observer is also the “actor of the theatre play” regarding the measurement of the electron state. To conclude this section, a final specification is needed. Please note that the kaleidoscopic interference is referred to with a conceptual approach, as it was already introduced in the previous section. Kaleidoscopic image is composed by identical images of the same motif. Therefore, the use of the term “kaleidoscopic interference” to refer to this condition within the subject—like Borges characters that are able to access infinite possible lives or being in different spaces at the same time like the electron—is closely related to the kaleidoscopic condition from a conceptual viewpoint. As was introduced in the

beginning of the present section, developing the double-slit artistic project in an artistic research context was what allowed the initiation of a theoretical reflection on the connection between kaleidoscopic image, Borges’ literature and quantum behaviour.

We can summarise that the double-slit experiment sum-over-paths phase and the kaleidoscopic image share a similar structure, which is composed by identical triangles that are expanded simultaneously having the possibility of doing this infinitely. The kaleidoscopic image is composed of identical images that are repeated in the kaleidoscope. It produces an in-between space where the viewer is able to visualise the ubiquity of the same motif, like the ubiquitous condition of the electron concerning the infinity sum-over-paths. Also, the sum-over-paths phase is in some way an in-between phase, when the electron passes through the double-slit simultaneously and before generating the interference pattern as a result. It also outlines the connection within the kaleidoscopic interference feeling from a conceptual viewpoint, regarding the electron’s ubiquitous behaviour, whose result is the interference phenomenon. As was already discussed, this issue is present regarding Borges’ characters that are experiencing a kaleidoscopic interference within the self and/or the infinite trajectory of the possible lives. For example, Ts’ui Pen behaving like an electron or Hamlet being both the spectator and the actor of the theatre play, as is the case in quantum mechanics.

3. Is the moon there when nobody looks? “To be and not to be” interference and the juxtaposition of ubiquities in the kaleidoscopic multiverse theory

“The main topic of discussion was quantum physics [...]. We often discussed his notions on objective reality. I recall that during one walk Einstein suddenly stopped, turned to me and asked whether I really believed that the moon exists only when I look at it. The rest of this walk was devoted to a discussion of what a physicist should mean by the term ‘to exist’” (Pais 1979, 907).

“From his immersion in the quantum world, where contradiction and truth are near neighbors, Niels Bohr drew the lesson of complementarity: no one perspective exhausts reality, and different perspectives may be valuable, yet mutually exclusive. The yin-yang sign is an appropriate symbol for complementarity, and was adopted as such by Niels Bohr. Its two aspects are equal, but different; each contains, and is contained within, the other” (Wilczek 2016, 334-335).

In the early 20th century, discussions on the paradigm shift in physics were introduced thanks to the discovery of quantum physics. It was really important, since it took place when the new modern physics paradigm changed classical thought. Due to the quantum behaviour in subatomic scale particles, there were many contradictions when an electron could be both a wave and a particle, or potentially get into different spaces at the same time. Einstein did not accept quantum behaviour completely, essentially based on the contradictions in the understanding of reality or the observer’s role. On the other hand,

Bohr introduced the complementarity principle to allow both the corpuscular and wave functions to understand the quantum world (Miret Artés 2015, 64), producing a new conception of reality. Certainly, in our scale the complementarity principle makes no sense, since quantum mechanics contradictions do not exist in the macroscopic scale. However, in the quantum physics subatomic scale many things that seemed to be illogical or even impossible in our scale were, in fact, being tested experimentally.

For a long time, Einstein, Bohr and other physicists discussed the contradictions that appeared along with quantum physics. Bohr accepted these contradictions by focusing on the observer's role. According to him and other physicists like Heisenberg, Dirac or Pauli, we are not only spectators, but also actors when we observe in quantum mechanics experimentation. Due to this statement, they did not accept the classical physics causality admitting the observable phenomena apart from an objective perspective (Miret Artés 2015, 74), even though quantum mechanics phenomena were contradictory. From the opposite position, Einstein and other physicists defended the existence of an objective reality apart from the observation process (Miret Artés 2015, 108-109). Finally, Bohr and the referred physicists, named as the Copenhagen group, proved their interpretation at the Solvay Conference in 1927, constituting the interpretation system in quantum mechanics to the present day (Miret Artés 2015, 74-75). Then, a new formula was introduced due to the quantum superposition and Bohr's thought: something can occur *and* not occur at the same time. Years later, Einstein formulated an intriguing question: do you really believe that the moon exists only when you look at it? (Pais 1979, 907), still wondering about the position that the observer should take in quantum physics. Apart from the physics paradigm shift in this period, which separated physics into classical physics and modern physics, this was such an important paradigm shift regarding the visual perception. Certainly it was a revolutionary approach regarding our understanding of reality, by finally accepting that events that are contradictory also constitute reality. In Bohr's words: "Everything we call real is made of things that cannot be regarded as real" (Diem-Lane 2014, 23).

The question on the moon was a metaphor among others, like the Schrödinger's cat experiment –a cat that can be dead and alive at the same time, also depending on the observer's action– (Miret Artés 2015, 87-88). Through all of these paradoxes the physicists were trying to understand and explain the subatomic contradictions by bringing them to our everyday scale and context. Is the moon there when nobody looks at it? To formulate this question opens a new view focusing on the observer that tests reality, getting us close to the real knowledge through the experience –even if it sounds like an impossible reality–, which is quite interesting if we extrapolate this notion to the field of art.

Nowadays we find another popular theory that is unverified: the multiverse theory, firstly proposed by Hugh Everett, where quantum physics affects the macroscopic scale. This theory relies on the veri-

fication of string theory, which is unverified because it is not possible to verify it empirically at present. It would be very interesting to test Agamben's idea of potentiality in this context, since in multiverse theory all the possibilities are able to happen also in the macroscopic scale similarly to the quantum physics behaviour.

"If what is at issue in a scientific experiment can be defined by the question "Under what conditions can something occur or not occur, be true or be false?" what is at issue in Melville's story [Bartleby] can instead be formulated in a question in the following form: 'Under what conditions can something occur *and* (that is, at the same time) not occur, be true *no more than not* to be true?'" (Agamben 1999, 260-261).

If in our universe Schrödinger's cat is dead, at the same time the cat could be alive in a sister universe. However, the multiverse theory goes further, suggesting that all the possibilities are potentially possible –like the electron's sum-over-paths–, since there would not be two possibilities or states, but *an infinite number of cats*.

"Multiverse theory claims that there are billions of unobservable sister universes out there in which all possible values of these constants can occur [...] Billions of universes –and of galaxies and copies of each of us– accumulate with no possibility of communication between them or of testing their reality. But if a duplicate self exists in every multiverse domain and there are infinitely many, which is the real 'me' that I experience now?" (Ellis and Silk 2014, 322).

Comparing the kaleidoscopic image nature in relation to these theories, we find they share many similarities. When looking at the kaleidoscopic image, we see it is composed of identical repetitions of the same motif. These images constitute a potentially infinite space inside the kaleidoscope that are simultaneously separated and integrated, as would happen in the multiverse. There would be an infinite echo into this kaleidoscopic multiverse theory, since billions of sister universes are supposed to exist as copies of our universe and "copies of each of us". Hence, what shall we admit by "original", "real" or "existing" being? In this case, the subjects should ask themselves the next question: am I real instead of "my copies" in the infinite sister universes just because I am experiencing my life? If multiverse theory is finally verified, all the copies must have the same certainty to be real. It happens in the same way regarding the identical images that compose the kaleidoscopic image. Given this circumstance, what we understand as "real" or "original" will be changed in turn, since all the possibilities are supposed to have an existence. Reading *The Garden of Forking Paths*, Borges' story previously referenced, we find passages that refer to a kaleidoscopic multiverse within the reality that the characters are living: "It seemed to me that the dew-damp garden surrounding the house was infinitely saturated with invisible people. All were Albert and myself, secretive, busy and multiform in other dimensions of time" (Borges 1971, 115). This way of employing the concept of time illustrates the implications that quantum behaviour could present concerning macroscopic reality, similarly to Feynman's sum-over-paths of infinite possibilities. Although the publication of *Fictions* is prior to Feynman's theory, there are many issues that show how Borges was surely influenced by the discussions on quantum physics. For example, we find a statement in *The Garden of Forking Paths* that is quite similar to the Schrödinger's cat issue: "This time you arrived at my house but, in a different one, after going through the garden, you have found I was dead" (Borges 1971, 114).

The multiverse theory is still unverified and, consequently, not demonstrable. Nevertheless, it opens many discussions on identity and reality as quantum physics did. This issue could be tested experimentally in quantum mechanics, which is quite different from the multiverse theory situation at present. In any case, it would be interesting to consider the issues related to the kaleidoscopic interference in the context of multiverse theory. How can we interpret the subject juxtaposition of ubiquity in relation to the possible explanation of a multidimensional reality? Regarding the kaleidoscopic perspectives that Borges introduced, a ubiquitous feeling would appear when the subjects are in front of their “copies”, as is the case inside a kaleidoscope. Actually, Bohr’s idea of being both the observer and the actor of the theatre play when analysing quantum phenomena is similar to Borges’ suggestions, as discussed. Returning to Borges’ conception, if the copies can be real, we could be fictions too, as is the case in kaleidoscopic image composed of real and fictional elements. Regarding a kaleidoscopic interference, the subject would feel the juxtaposition of ubiquity within the self: I am where I am not in a heterotopic way, so which one would be “the real ‘me’ that I experience now?” (Ellis and Silk 2014, 322). Coming back to Einstein’s question: what should we mean by the term “to exist” in multiverse theory? Every copy is potentially able to be as real as the subject you are. All of them could be real, since they would have an existence within these different but supposedly identical universes. In fact, this conception corresponds to the ubiquity inside the kaleidoscopic infinite reflection, which is generated by the conjunction of identical images. Therefore, the kaleidoscopic interference within the self in multiverse theory would be manifested into the subject’s juxtaposition of ubiquities, as is the case when the electron passes through the double-slit simultaneously and the kaleidoscopic sum-over-paths of infinite trajectories is produced.

Conclusions

- Regarding kaleidoscopic image, the author participates in the creation process closer to the observer experience than to the author’s role. It allows an embodied author within reality, where fiction is also accepted as part of it.
- There are significant similarities between the double-slit experiment and the kaleidoscopic structure, both from visual and conceptual viewpoints, in relation to the Feynman sum-over-paths phase. For example, concerning the electron behaviour or kaleidoscopic characters like Ts’ui Pen that interferes within the self and manifests his own juxtaposition of ubiquity.
- The Borgesian thinking presented in this paper leads to a kaleidoscopic interference and ubiquity feeling within our identity conception in relation to reality. In quantum physics (microscopic scale) and the multiverse theory (macroscopic scale), there is a ubiquity and interference feeling when considering that all the potentialities could be real, which also changes our identity conception as we see in Borges’ characters.
- The discussions resulting from the appearance of quantum mechanics initiated a new vision that changed the notion of the involvement that the observer should have. Even the existence of an objective reality was questioned, changing the focus on the observer who tests reality. Extrapolating this issue to the field of art introduces a new paradigm on visuality. It allows a reflection on representation regarding the connection between the kaleidoscopic interference feeling and the multiverse theory.
- The “to be or not to be” paradigm has changed into the “to be and not to be” way of perceiving reality, as it could be seen regarding multiverse theory and its connection to the kaleidoscopic interference or the identical copies that compose kaleidoscopic image. A quantum understanding that assimilates contradictory events as part of reality. In turn, this “new formula” allows a better understanding of the kaleidoscopic interference as a consequence of the juxtaposition of ubiquities within the subject.

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