ARGUMENTOS
Revista de Filosofia

e-ISSN: 1984-4255

The confrontation between Schrödinger and Heisenberg on the status of Quantum Mechanics

O confronto entre Schrödinger e Heisenberg sobre o estatuto da Mecânica Quântica

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ABSTRACT

The article analyzes the confrontation between the quantum representations of Heisenberg and Schrödinger. While Heisenberg, aligned with the Copenhagen interpretation, proposes an anti-realistic, acausal and probabilistic view of microscopic reality, Schrödinger defends a realistic, continuous and visualizable interpretation of the wave function. The divergence between the two, however, goes beyond the methodological level and reveals philosophical tensions over the status of physical reality. Heisenberg rejects pictorial representation in favour of an abstract mathematical formalization. Schrödinger, on the other hand, insists on the space-time intelligibility of quantum phenomena. The clash expresses different worldviews and remains relevant in contemporary discussions about the status of quantum mechanics.

Keywords: Quantum Mechanics. Ontology. Heisenberg. Schrödinger. Visualization.

RESUMO

O artigo analisa o confronto ontológico entre as representações quânticas de Heisenberg e Schrödinger. Enquanto Heisenberg, alinhado com a interpretação de Copenhague, propõe uma visão antirrealista, acausal e probabilística da realidade microscópica, Schrödinger defende uma interpretação realista, contínua e visualizável da função de onda. A divergência entre os

dois, no entanto, vai além do nível metodológico e revela tensões filosóficas sobre o *status* da realidade física. Heisenberg rejeita a representação pictórica em favor de uma formalização matemática abstrata. Schrödinger, por outro lado, insiste na inteligibilidade espaço-temporal dos fenômenos quânticos. O confronto expressa diferentes visões de mundo e permanece relevante nas discussões contemporâneas sobre o *status* da Mecânica Quântica.

Palavras-chave: Mecânica Quântica. Ontologia. Heisenberg. Schrödinger. Visualização.

1 Introduction

This article examines the confrontation between two fundamental formulations of Quantum Mechanics: Werner Heisenberg's matrix mechanics and Erwin Schrödinger's wave mechanics. It is a clash that transcends methodological differences to reach the metaphysical roots of the conception of reality in modern physics. What is at stake is not only the most appropriate formulation for describing atomic phenomena, but above all the ontological status of quantum theory itself and its commitments to notions such as determinism, continuity, visualization and objectivity.

The epistemology underlying Heisenberg's uncertainty principle introduces a fundamental limitation on the simultaneous knowledge of certain physical properties, such as position and momentum. This limitation, which is epistemological and not merely instrumental in nature, suggests a probabilistic and relational description of reality, where the observer – as the one who performs a measurement and updates the description of the state after the interaction – plays a central role and mathematical language assumes a structural function. This perspective is part of the framework of the so-called Copenhagen interpretation, which emphasizes the anti-realistic and acausal nature of quantum processes, as well as the need to abandon pictorial representations of microscopic phenomena.

In opposition to this model, Schrödinger proposed a realistic and deterministic[1] reading of the wave function, conceived as an objective physical representation of the quantum system. In his wave interpretation, the wave function evolves continuously according to deterministic differential equations, and is endowed with spatio-temporal intelligibility - a characteristic he called *Anschaulichkeit*. Schrödinger strongly criticized the abstraction of the image of Quantum Mechanics proposed by Heisenberg, arguing that his conceptions compromised the intelligibility of the theory and its ability to describe a reality independent of observation.

By investigating the ontological and epistemological foundations of these two models, the article highlights the deeper philosophical implications of quantum physics, showing that behind the mathematical formalisms and empirical debates lies a dispute over the ultimate nature of physical reality. In this sense, the confrontation between Heisenberg and Schrödinger reveals itself not only as a historical episode in science, but as an epistemological turning point whose consequences still resonate in contemporary discussions about the interpretation of Quantum Mechanics.

[1] Deterministic in the sense that, for Schrödinger, the wave function evolves in a completely deterministic manner according to his equation, that is, without jumps, collapses, or fundamental probabilistic events. In short, given the initial state of the system (the wave function at time t_0), its future evolution at any time *t* is completely calculable without any intrinsic randomness.

2 Uncertainty and antirealism: the status of Quantum Mechanics according to Heisenberg

2.1 The anti-classical ontology of Heisenberg's matrix mechanics

Both matrix mechanics and the uncertainty principle, with few exceptions, are closely aligned with what later came to be known as the Copenhagen interpretation. Many opposed this interpretation, which Popper (1989, p. 54) called the "dominant dogma". Erwin Schrödinger was one of them.

The "mechanical variables" that Heisenberg conceived – and which Max Bonn recognized as matrices – corresponded to probabilities of atomic transitions or algebraic combinations and derivatives of these probabilities, more precisely, to probability amplitudes. When, in the spring of 1925, Heisenberg began working along the lines that led him to matrix mechanics, it was with an emphatic commitment to abandon pictorial atomic models. It was clear to the authors of matrix mechanics, for example, that it makes no sense to represent the motion of electrons – as a change of position over time – but also that it is impossible to assign a position to an electron at a given instant. Space-time exists only in the macroscopic domain. In matrix theory, its definition is purely formal and has no relation to evolution over time in a physical system. Matrix theorists considered that the positions of the electrons themselves were not observable: only the frequency, intensity, and polarization of the emitted radiation could be measured. In the atomic domain, "spatial points in the ordinary sense do not exist", as Born (1926a, p. 128) asserted. The conception of their non-existence, understood "in the ordinary sense," implies the definitive renunciation of the possibility of a visualizable physical interpretation of the new matrix mechanics. But what is the ontological significance of rejecting the visualization of space-time evolution as a frame of reference, according to the original philosophy of matrix mechanics? What were the developments, in terms of metaphysical principles, resulting from the development of this mechanics?

As a first consequence, matrix mechanics replaces classical space-time with an abstract and non-visualizable mathematical formalism. This approach implied the elimination of classical space-time as a container of movement that becomes as superfluous as unrealized mechanical movements.

> No one has been able to give a method for the determination of the period of an electron in its orbit or even the position of the electron at a given instant. There seems to be no hope that this will ever become possible, for in order to determine lengths or times, measuring rods and clocks are required. The latter, however, consist themselves of atoms and therefore break down in the realm of atomic dimensions (Born, 1926a, p. 69).

Another consequence of matrix mechanics is the elimination of unobservable entities – such as the position and orbits of electrons – from the theoretical structure. "Instead of such unobservable kinematic variables as the position. velocity, or period of revolution of an electron in an atom, Heisenberg incorporated experimentally observable spectroscopic data (frequencies and intensities of radiation) into the theoretical framework" (Beller, 1999, p. 52). As a result, this mechanics also denies the existence of an objective reality of trajectories and positions for subatomic particles. And the description of the atomic system is now made by radiation amplitudes instead of electronic trajectories.

> In the classical theory the specification of frequency, amplitude and phase of all the light waves emitted by the atom would be fully equivalent to specifying its electron path. Since from the amplitude and phase of an emitted wave the coefficients of the appropriate term in the Fourier expansion of the electron path can be derived without ambiguity, the complete electron path therefore can be derived from a knowledge of all amplitudes and phases. Similarly, in quantum mechanics too, the whole complex of amplitudes and phases of the radiation emitted by the atom can be regarded as a complete description of the atomic system, although its interpretation in the sense of an electron path inducing radiation is impossible (Heisenberg, 1933, p. 292).

The matrix mechanics, in its origin, was devoid of particles with their own individuality. It was not a theory of corpuscles before Born's probabilistic interpretation: an atom in the matrix approach was endowed with electromagnetic, not kinematic, meaning. The physical convictions of the Göttingen physicists underwent a significant change as a result of the need to deal with Schrödinger's success. From then on, the basic ontology of matrix theory came to consist of particles, or corpuscles. Thus, the theory adopts not only the concept of discontinuity, derived from the corpuscular conception, but also that of acausality, as a fundamental characteristic of atomic reality. According to Heisenberg, quantum theory is essentially a probabilistic theory, not because quantum laws, as opposed to classical laws, are statistical in Born's sense (this possibility is contradicted by the results of Bothe and Geiger), but because it is necessary to resort to probabilities to fully describe the state of the system. The future cannot be known in all its details, not because quantum laws are statistical, but because the present cannot be known in all its details and must therefore be described probabilistically (Heisenberg, 1927b).

However, the greatest dissent between Heisenberg's and Schrödinger's ontologies was involved with the abandonment of physical visualization (*Anschaulichkeit*) as a criterion for theoretical validity – an idea rejected by matrix mechanics. This was stated from the outset of his article "On the Quantum-Theoretical Reinterpretation of Kinematic and Mechanical Relations" (1925), in which a programmatic appeal for "give up any hope about the observation of hitherto unobserved quantities (like the electrons' position and period)" and, instead, "to try to construct a theory of quantum mechanics in which only relationships among observable quantities occur". This position is diametrically opposed to Schrödinger's views, who promptly articulates a response to his opponent.

3 The status of Quantum Mechanics according to Schrödinger

As is well known, Schrödinger was the founder of the wave interpretation of Quantum Mechanics. In 1926, he proposed this interpretation based on an equation that describes the temporal evolution of the wave function of a quantum system. In the wave interpretation, the wave function (Ψ) of a quantum system does not represent the particle itself, but rather the probability amplitude of finding a "particle" in a given state. This amplitude is quantified by $|\Psi|^2$, which is the square modulus of the wave function. In other words, the wave function provides information about the probability of finding the particle in a specific region of space or with a specific value of momentum, energy, or other physical property.

As stated, Schrödinger was an opponent of the ontology underlying Heisenberg's thinking. Heisenberg's thinking was in line with the "Copenhagen spirit" and states that the wave function does not represent physical reality itself, but only a probability of finding a particle in a given state. The collapse of the wave function, which occurs at the moment of measurement, is seen as a process of measurement based on indeterminacy, that is, it is not possible to infer a causal chain of events, thus requiring the intervention of the observer.

It is worth noting, however, that between 1927 and 1930, the notion of "observer" for Heisenberg (and Bohr) had nothing to do with anything resembling "human consciousness", "subjectivity", or even a "voluntary mental act". "Observing", in this context, meant being in front of a classical macroscopic system that performed a measurement and that, by definition, could not be described by a quantum wave function. The observer's intervention, in this context, is an interaction of measurement, not of the human mind. The result only makes sense within a classically defined experimental context.

However, Schrödinger did not agree with this dualism ("micro quantum/macro classical") and harshly criticized it, saying that it was inconsistent and philosophically superficial. He disagreed with this view because he considered it inconsistent with his beliefs about determinism and realism in physics. He therefore argued that the wave function represented physical reality and that the notion of its collapse was an indication that quantum mechanics was incomplete and that a more fundamental description of reality was lacking.

Schrödinger had serious reservations about the notion that a superposition of states corresponds to a literal physical reality, and the cat thought experiment[2] served to test this Copenhagen precept. Superposition implies that a system can be in a combination of different states with different values of an observable. At the moment of measurement, the wave function "collapses" to a single state, with a definite value of the observable.

What we have in Schrödinger's equation is a description of the temporal evolution of the wave function of a quantum system. This evolution is deterministic, meaning that the future state of the system can be completely determined by its initial state and the laws of physics. The collapse of the wave function seems to introduce a random element, violating the determinism of temporal evolution. The temporal evolution governed by Schrödinger's equation is completely deterministic. The collapse process is intrinsically probabilistic and cannot be predicted deterministically. Even if we know the exact wave function before measurement, we can only predict the probabilities of possible outcomes, not the specific outcome of an individual measurement. This probabilistic aspect introduces a fundamental randomness into quantum mechanics, which contrasts with the deterministic evolution of the wave function between measurements. How can randomness and determinism be reconciled if such concepts are contradictory?

Schrödinger does not propose to reconcile these notions and, instead, opposes such perspectives. The question that must be asked, however, is: what is the motivation behind Schrödinger's opposition to the ontology underlying the doctrines of Heisenberg and his colleagues? This is a difficult question to answer, but at its core, it seems that the motivating factor is the need to deconstruct the notion of discontinuity and indeterminism associated with the image of elementary particles in the explanation of quantum phenomena.

Heisenberg (1958) was an advocate of the idea that "the element of discontinuity that is found everywhere in atomic physics; any scintillation screen or Geiger counter demonstrates this element at once" (Heisenberg, 1958, p.143). And, according to him, "when the old adage 'Natura non facit saltus' is used as a basis for criticism of quantum theory, we can reply that certainly our knowledge can change suddenly and that this fact justifies the use of the term 'quantum jump'" (Heisenberg, 1958, p. 54). Discontinuities are associated with the corpuscular

[2] This is the thought experimente published in 1935 by Schrödinger in na article intitled "The Present Situation in Quantum Mechanics", which questioned the orthodoxy of Copenhagen on three fronts: the notion of superposition, the colapse of the wave function, and the privileged status of th observer.

image in Quantum Mechanics because, in this theory, many physical quantities are not continuous but quantized, that is, they occur in discrete packets (*quanta*).

But Schrödinger did not agree with this thinking and, as Bitbol (1996, p. 68-69) rightly noted, for him, "the only reason why his Göttingen-Copenhagen colleagues thought they were bound to abandon the dream of framing a picture of the physical processes in space-time, was that the corpuscularian representation, with its well-defined trajectories of individual material points, had failed". Schrödinger (1948, p. 202) reinforces this:

> [...] the only reason for the iconoclastic uproar is the following: the corpuscle concept has, it is true, become the unquestioned and inalienable possession of the physicist who continuously uses it as a mental construct [...] but [...] it leads to considerable embarrassment because we have not yet succeeded in fusing it with the wave concept.

As is well known, Schrödinger was one of the most persistent and eloquent critics of the standard interpretation of Quantum Mechanics, of which Heisenberg was a part. Together with Einstein (and De Broglie before 1928), he always opposed this interpretation, which they called the current "dogma". And why did the Copenhagen dogma bother him? Was it because of the professed indeterminism? Did it have anything to do with the positivism or anti-realism it defended? Were notions such as the collapse of the wave function, criticized in the cat thought experiment, what troubled him? Or was it the idea that the quantum wave function represents a probability and only becomes "real" in the act of measurement that seemed incomplete and unsatisfactory to him? In fact, as it turned out, all these items are part of a broader criticism, that is involved with the demand for a lack of objective realism in the orthodox interpretation, made by Schrödinger. For him, physical reality should exist in an objective and concrete way, represented by wave functions that describe quantum systems with real and continuous properties, regardless of direct observation or measurement. The uncompromising defense of a wave ideal is a guarantee of continuity, ensured by the possibility of visualization (*Anschaulichkeit*).

Schrödinger's goal, from the outset, was not a return to the descriptions of classical physics, and he made this clear in a letter to Planck shortly after writing his second article in February 1926. The image of space-time he sought could not be drawn in a purely classical way. According to his account to Planck, "I obviously do not mean, that these Ψ-oscillations are perhaps mass oscillations in the sense of ordinary mechanics. On the contrary. They or something similar to them appear to lie at the basis of all mechanics and electrodynamics" (Meyenn, 2011, p. 190). However, according to Wessels (1983), the maintenance of a wave perspective was due to a specific view that Schrödinger had of scientific endeavor.

> He believed that in addition to predicting correctly the results of experiment, a physical theory must include a spatio-temporal picture of the physical systems that give rise to these experimental results, and the mathematical laws of the theory must give an account of the behavior of these systems in space and time (Wessels, 1983, p. 269).

So much so that in the first stage of his work (1921-1924), Schrödinger had a model of the microsystems underlying atomic and molecular phenomena. In the second stage (1925-1928), in his work on wave mechanics, he attempted to develop a theory based on his equation in order to relate it to a model of microsystems. Schrödinger's work was based on the familiar resource of differential equations, similar to classical fluid mechanics and an easily visible and suggestive representation. The central idea was that microsystems, such as atoms and subatomic

particles, could be described by a wave function, governed by the famous Schrödinger equation, which allowed predicting their probabilistic and evolutionary behavior over time. From 1928 onwards, impacted by the various criticisms he received, Schrödinger resigned himself to teaching quantum mechanics according to the conventional Copenhagen interpretation (Bitbol, 1996). But in 1935, a few weeks after the publication of the Einstein-Podolsky-Rosen article, a series of correspondences with Einstein marked a return to his realistic perspective, resulting in the publication of the "cat paradox" as well as a more technical article on the "entanglement" of wave functions. Both publications were marked by his demand for a space-time description that was intuitive and mathematical. In 1952, in his article "Are There Quantum Jumps?", we still see him persisting in questioning the inconsistency of ontological descriptions that make use of entities that cannot be individualized and whose identity over time is also doubtful. There he answers the widely expressed doubts about the ability of the wave model to replace the particle model. He says, "I am aware of these questions. They are no longer as embarrassing as they were, before we had gained the insight we have now gained into what a particle certainly is *not*; it is *not* a durable little thing with individuality" (Schrödinger, 1952, p. 241). Finally, in one of his last articles, from 1958, entitled "Might perhaps Energy be a merely Statistical Concept?", Schrödinger remains faithful to the ideas he began in 1922, stating that "as long as the state vector plays the role it does it must be taken to represente 'the real world in space and time'" (Schrödinger, 1958, p. 169).

The question remains: why Schrödinger's persistence in these space-time descriptions? Was it just to safeguard the description of the temporal evolution of a quantum system in a continuous and deterministic way? Or were there additional justifications?

Bitbol (1996) offers us an interesting justification. According to him, "this association of a thorough criticism of the atomistic pictures with a promotion of the wave picture, provides us with a very striking example of Schrödinger's own way of associating Mach's positivistic influence with Boltzmann's Bild-conception of physical theories" (Bitbol, 1996, p. 69). From Mach, Schrödinger had inherited the conception that the "'real world around us' is nothing more than "sense perceptions, memory images, imagination, thought" (Schrödinger, [1948] 2014, p. 94) and that "natural science does not vouchsafe any explanations, that it aims only at, and is unable to attain to anything but, a complete and (Mach) economical description of the observed facts" (Schrödinger, [1948] 2014, p. 91). From Boltzmann, Schrödinger inherits the notion that an image that has not been freed from the need for strict imitation of experimental facts is therefore in great danger of becoming "obscure". According to Boltzmann, "it is precisely the unclarities of the principles of mechanics that seem to me to derive from not starting at once with hypothetical mental pictures but trying to link up with experience from the outset" (Boltzmann, 1974, p. 225).

This emphasis on the visualization (*Anschaulichkeit*) of images played an important role in Schrödinger's perspectives, leading him to propose wave mechanics, even though he was perfectly aware of Heisenberg's matrix mechanics, which he found too "axiomatic and without pictorial correspondence". Regarding matrix mechanics, Schrödinger states: "I naturally knew about his theory, but I was discouraged (*abgeschreckt*), if not repelled (*abgestoßen*), by what appeared to me as verry difficult method of transcendental algebra, and by the want of perspicuity (*Anschaulichkeit*)" (Schrödinger, 1928, p. 46).

But what was the basis for Schrödinger's idea that a physical theory must be visualizable (*Anschaulich*)? According to De Regt (2017, p. 239), "Schrödinger was strongly committed to the thesis that *Anschaulichkeit* is a necessary condition for intelligibility of theories". He valued the possibility of describing physical phenomena in a way that was visually or conceptually

accessible, unlike pure mathematical abstraction, which does not necessarily translate into visual concepts. Matrix mechanics, for example, did not allow any visualization of the structure of the atom, restricting itself to describing relationships between measurable quantities, such as frequencies and intensities of spectral lines. *Anschaulichkeit*, therefore, is deeply linked to the idea that physical theory must be understandable in terms of space-time images or concepts familiar to human intuition. For Schrödinger, the wave function was not just an abstract tool, but rather a direct and visualizable interpretation. Its intelligibility was directly linked to the visualization of atomic processes as wave phenomena in space and time. And as Schrödinger rightly said, "we cannot really alter our manner of thinking in space and time, and what we cannot comprehend within it we cannot understand at all," and a renunciation of the space-time description should be understood as a "complete surrender" (Schrödinger, 1928, p. 27).

With a formalism based on partial differential equations, Schrödinger won over the physicists of the time, as his method had "the advantage of using the familiar mathematical forms only" (Gordon, 1927, p. 117). Although these two theories were very different in character, Schrödinger demonstrated the mathematical equivalence of both (Schrödinger, 1928), but defended the superiority of his *Anschaulich* theory. On the one hand, there was a physical, visualizable, and realistic mechanics, and on the other, one that was mathematical, non-visualizable, and positivist. However, the battle between these two divergent positions went beyond the problem of *Anschaulichkeit*. What we saw here was a dispute between ontology and epistemology to see which was more relevant. In this sense, Schrödinger opposes Heisenberg on the main points of matrix epistemology. What, then, were the differences?

First, Schrödinger's wave function represents the physical reality of the system, and is not just a mathematical tool, as was matrix mechanics. If, for Heisenberg, the reason for revising the usual concepts of physical reality is rooted in the "typical discontinuities" of atomic processes, for Schrödinger the wave function described physical reality objectively, thus rejecting its interpretation as mere probability.

> It is, of course, strongly suggested that we should try to connect the function Ψ with some *vibration process* in the atom, which would more nearly approach reality than electronic orbits, the real existence of which is being very much questioned to-day. I originally intended to found the new quantum conditions in this more intuitive (*Anschaulichian*) manner, but finally gave them the above neutral mathematical form, because it brings more clearly to light what is really essential (Schrödinger, 1928, p. 9).

So much so that Schrödinger criticizes Born's statistical interpretation of the wave function, observing:

> Born [...] overlooks that [...] it would depend on the taste of the observer which he now wishes to regard as real, the particle or the guiding field. There is certainly no criterion of reality if one does not want to say: the real is only the complex of sense impressions, all the rest are only pictures (*apud* Moore, 1989, p. 225).

If we use the image of a wave that evolves over time, this means that the physical process must be described continuously, without sudden quantum jumps. And it is also against the notion of quantum jumps that Schrödinger stands in his wave interpretation. Schrödinger rejected sudden quantum jumps and proposed continuous transitions between states, such as changes in the form of vibration. For him, the quantum jumps of electrons between orbits are in no way subject to spatiotemporal description, and this makes any attempt at visualization impossible. His ontology privileges, as mentioned, the need to preserve a visualizable

description of quantum phenomena, as opposed to abstract formalism. This physics must maintain links with intuitive forms of representation (*Anschaulichkeit*).

Another ontological entity against which Schrödinger took a stand was the notion of material particles. For him, particles should be understood as regions of high intensity of a continuous wave, not as localized objects. His ontology predicted, for example, that electrons were not localized particles, but dense regions of a wave function that spreads through space. The corpuscular view, in this sense, is an illusion. The only thing that really exists are waves. The superposition of a group of them "produces" the particle.

> […] atomism has proved infinitely fruitful. Yet the more one thinks of it, the less can one help wondering to what extent it is a *true* theory. Is it really founded exclusively on the actual objective structure of 'the real world around us'? Is it not in an important way conditioned by the nature of human understanding – what Kant would have called '*a priori*'? It behoves us, so I believe, to preserve an extremely open mind towards the palpable proofs of the existence of individual single particles, without detriment to our deep admiration for the genius of those experimenters who have furnished us with this wealth of knowledge (Schrödinger, [1948] 2014, p. 88-89).

Schrödinger's ontological positions reveal a classical and deterministic conception of the world, despite the new demands of quantum physics. His formulation reveals a strong attachment to the deterministic tradition of classical physics, despite the probabilistic demands introduced by the new theory. There is an explicit attempt in his thinking to preserve the intelligibility of the physical world, even at the atomic level. His notion of waves would be in accordance with the classical requirements of determinism, presenting itself continuously in space and time and still being describable by the mathematical method of field equations.

4 Final considerations

As we've seen, Schrödinger was ahead of his time and didn't bow down to the orthodoxy established by the prestige and influence of Niels Bohr and Werner Heisenberg. He stuck to his realism until the end, debunking his image as an anti-realist or quasi-realist, as Bitbol (1996) called him. His position was clear, and his commitment to visualization remained until the end of his career. The justification for this commitment, as mentioned, was due to the need to maintain the perspective of shaping an image of physical processes in space-time, ensuring continuity and determinism. To this end, there was nothing better than deconstructing the image of established notions such as elementary particles, superposition of states, and quantum jumps, since such images did not ensure conformity with the classical requirement of complete determinism. Discontinuity was therefore, for Schrödinger, something to be overcome, a limitation of quantum theory that should be worked on in order to approximate a more faithful description of reality.

Schrödinger's realism is thus articulated with the attempt to unite the images of classical and quantum physics, proposing a view of the subatomic world that still preserved a certain continuity and predictability. His criticism of his opponents' approach reflects a deep desire to restore confidence in a description that could be visually accessible and, at the same time, true, in the sense of corresponding to the objective reality of physical phenomena. His insistence on maintaining an "image" of waves is therefore linked to his commitment to a world where processes are, in fact, continuous and deterministic.

However, Schrödinger's contributions should not be seen as a simple return to classical determinism. Rather, they reveal an attempt to integrate the discoveries of quantum mechanics into a more cohesive worldview, in which the continuity of wave functions provides a bridge between the invisible and the visible, between the micro and the macro. From this perspective, quantum physics does not present itself as a complete break with known reality, but rather as a modification of our way of conceiving the nature of theoretical entities such as the wave function.

Schrödinger's deconstruction of the image of elementary particles, with its focus on continuity and visualization, opens up fertile ground for rethinking the philosophical and methodological implications of modern physics. Contrary to the orthodox view that tends to regard quantum mechanics as an area removed from everyday experience, Schrödinger's proposal suggests that the subatomic world can still be accessed, in a way, by our imagination ("the image is not only a permitted tool, but also an objective"), as long as we adopt a new way of "seeing" and understanding reality.

In short, Schrödinger's legacy is that of a thinker who, rather than conforming to the official interpretation of his time, sought alternative ways of understanding and representing the quantum world. His work remains a vital reference for those who, like him, believe in the possibility of a physics that is simultaneously rigorous, visually comprehensible, and, above all, faithful to the underlying reality of phenomena.

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Recebido em: 3/7/2025
Aprovado em: 15/12/2025

Received in: 7/3/2025
Approved in: 12/15/2025