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Igor Garcia-Atutxa
UCAM Catholic University of Murcia
135, Jeronimos Avenue, Murcia, Spain, 30107
E-mail: igarcia839@alu.ucam.edu
https://orcid.org/0009-0002-1551-2685

Ekaitz Dudagoitia Barrio
University of Murcia
5, Teniente Flomesta Avenue, Murcia, Spain, 30003
E-mail: ekaitz.d.b@um.es
https://orcid.org/0000-0003-0990-3081

Francisca Villanueva-Flores*
Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada (CICATA Unidad Morelos), Instituto Politécnico Nacional
1036 Z-1, P 2/2, Technology Boulevard, Atlacholoaya, Morelos, Mexico, 62790
E-mail: fvillanuevaf@ipn.mx
https://orcid.org/0000-0001-6092-4211

*(correspondent-author)

The epistemological impact of Augustin-Jean Fresnel and his wave theory of light in the 19th century

Abstract. *Skepticism and critical inquiry play crucial roles in the scientific process, acting as safeguards against the "ad verecundiam" fallacy, where claims are accepted solely based on authority endorsement. This study thoroughly investigates Augustin-Jean Fresnel's challenge to Newton's corpuscular theory with his innovative wave theory of light. Supported by precise measurements and the "Fresnel integrals," Fresnel earned the Paris Academy of Sciences Prize in 1819. Despite staunch opposition from corpuscular theory proponents, his theory's validity was confirmed with Poisson's point paradox, where light waves from two sources interfere to create a bright spot in the center of a shadow, providing compelling evidence for the wave nature of light. This successful resolution of the paradox confirmed the validity of Fresnel's wave theory and contributed significantly to the acceptance of wave optics over the corpuscular theory. This conflict transcended a mere clash of explanatory models in the physics of light, prompting reflections on the nature of light, reality, and*

epistemological issues. Examining how Fresnel overcame challenges offers lessons on constructing scientific knowledge, emphasizing the importance of avoiding theory acceptance based solely on authority and focusing on empirical evidence and theoretical coherence. The case of Fresnel serves as a valuable example for teaching the history of science and understanding complex scientific evolution. Analyzing how Fresnel navigated challenges and opposition provides valuable insights into the development of scientific knowledge, emphasizing the intricate nature of scientific progress characterized by debates and efforts to gain acceptance. This study on Fresnel's groundbreaking wave theory of light not only illuminates the historical clash between competing scientific paradigms but also aims to contribute to modern science by emphasizing the enduring significance of empirical evidence and theoretical coherence in knowledge construction. Through an insightful exploration of Fresnel's triumph over challenges, we anticipate offering valuable insights that resonate with contemporary scientific methodologies, fostering a deeper understanding of the dynamic evolution of scientific thought.
Keywords: *Fresnel; corpuscular theory of light; Prize of the Paris Academy of Sciences; Poisson's point; diffraction*

Introduction.

The first theories to explain the nature of light date back to the 17th century. The initial one was the 'Cartesian Theory' in the 1630s, postulating that light was transmitted instantaneously through the matter of space with infinite speed (Descartes, 1633). This theory was discarded by Roemer in 1676 when he demonstrated that the speed of light was finite by observing Jupiter's moons, particularly Io. Roemer noticed that the eclipses of Io varied as the Earth moved away from or towards Jupiter in its orbit around the Sun. These variations in the eclipse times could be explained only if light has a finite speed, and Earth moves around the Sun (Roemer, 1676). Following this theory, the 'Wave Theory of Huygens' emerged in 1678, asserting that light consisted of waves emitted from a luminous body propagating through the elastic particles of the ether, which were emitters of spherical waves (Huygens, 1678). Subsequently, in 1699, Malebranche postulated that light was transmitted through the contraction and expansion of the particles composing the ether (Silliman, 1967)

In 1687, Newton published the Universal Law of Gravitation in his work titled 'Philosophiæ Naturalis Principia Mathematica,' which gained widespread acceptance in the scientific community of the time for its simplicity and universality. The Universal Law of Gravitation provided an explanation for the attraction between two masses anywhere in the universe. It enabled the precise mathematical prediction and calculation of the behavior of celestial bodies. The triumph of Newton's law of universal gravitation led the scientific community to contemplate the possibility of explaining all natural phenomena, such as electricity, magnetism, and reflection, among others, through the interaction of particles subject to forces of attraction and repulsion.

Seventeen years later, in 1704, Newton published the Corpuscular Theory of Light. According to Newton's corpuscular theory, the interaction between the ether and light provided a comprehensive explanation for all-optical phenomena, including refraction and reflection. These phenomena arose due to density variations in the ether caused by the presence of material bodies. Additionally, Newton introduced the concept of inflexion, which occurred when the attraction or repulsion of bodies curved light particles. Robert Hooke's work supported this theory by proposing that light behaves similarly to sound waves, bending when encountering obstacles (Hooke, 1665). With the notable acceptance of Newton's Universal Law of Gravitation, the Corpuscular Theory gained wide recognition, especially in countries like Holland and the United Kingdom (Newton, 1833; Newton, 1704; Fitz Gerald, 1889). In contrast, in France, the adoption of Newtonian theory did not occur until 1720 and 1730, following the publication of Voltaire's "Elemens de la Philosophie du Newton" (Pimentel, 2015). Although there were notable detractors, such as Leonhard Euler, who expressed skepticism about the propagation of light without a particle medium (Euler, 1746), the Corpuscular Theory remained the predominant explanation of light behavior for over 100 years. Finally, with the definitive rejection of Cartesian and Wave theories (Cantor, 1983), the Corpuscular Theory became established.

The present article focuses on a comprehensive review of the pioneering work of Augustin-Jean Fresnel in the development of the wave theory of light. The epistemological relevance of his contribution is particularly addressed as he challenges the prevailing corpuscular theory of light proposed by Newton. The main objective of this research is to analyze how Fresnel's innovative work not only revolutionized the understanding of light and optics in his time but also provided fundamental lessons on the construction of scientific knowledge by questioning and overcoming established paradigms.

Research Methods.

Literature Search: A systematic exploration was undertaken on Google Scholar, employing Boolean operators to refine the search query: ("Augustin-Jean Fresnel" OR "Fresnel") AND ("wave theory of light" OR "light theory" OR "optics") AND ("corpuscular theory of light" OR "Newtonian theory of light").

Inclusion and Exclusion Criteria: The search encompassed primary sources, scholarly articles, and historical documents about Augustin-Jean Fresnel's contributions to the wave theory of light and its impact on challenging Newton's corpuscular theory. Non-academic sources, duplicate publications, and studies diverging from the research focus were excluded. Studies in both English and French were included to capture the historical significance of Fresnel's work within the context of French scientific literature.

Quality Assessment: The credibility and reliability of selected sources were rigorously evaluated, considering the reputation of journals, authors, and the coherence of presented arguments. A critical examination of the literature identified gaps, contradictions, and controversies in the historical narrative of Fresnel's contributions to the wave theory of light.

Ethical Considerations: Stringent adherence to copyright laws and meticulous citation practices were employed to ensure ethical handling of the literature, respecting intellectual property rights and acknowledging the origin of all extracted information.

Results and Discussion.

Historical Context in France in the 19th Century.

At the end of the 19th century, France experienced a tumultuous period due to the French Revolution of 1789, a key event that marked the end of the Old Regime. This revolution ushered in a new era that culminated in a coup led by Napoleon Bonaparte in 1799. During this time, France was embroiled in conflicts with several nations, including Austria, Prussia, Russia, Spain, and England. Amidst this constant belligerence, Napoleon recognized the importance of science in current and future conflicts. As part of his ambition to establish a vast empire, he promoted the study of applied science, instituting awards such as the annual prize for the most innovative work in electricity starting in 1802. This connection between Napoleon and science was reflected in the fact that two scientists, Chaptal and Laplace, held the position of Minister of the Interior in France (Lentz, 2013).

In the decades of the 1770s and 1780s, science in France progressed thanks to Lavoisier, who conducted research without government financial support. Subsequently, scientific organizations with government backing emerged, such as the Institute of France, established in 1795, with the participation of notable scientists like Lagrange, Laplace, Berthollet, and Guyton (Crosland, 2002). This institute brought together various French academies, including the Academy of Sciences, focused on physical and mathematical sciences. At the beginning of the 19th century, the Arcueil Society was formed in 1806, a group of French scientists who gathered in Arcueil on Sundays to discuss and analyze publications from the Academy of Sciences. The meetings were often held at the homes of Laplace and Berthollet. Prominent members included Laplace, Berthollet, Malus, Gay-Lussac, Biot, Pyramus de Candolle, Collet-Descotils, Humboldt, Thénard, Arago, Bérard, Chaptal, Dulong, and Poisson. For the most part, they shared the Newtonian view of light, influenced by Laplace and Berthollet. Laplace admired Newton, while Berthollet argued that chemical reactions depended solely on the masses of the reactants, similar to Newtonian mechanics, where the force between two objects depends on their masses (Buchwald, 1989).

Fresnel’s Early Investigations.

In this historical context, Augustin Fresnel was born in Broglie, France, in 1788. Fresnel studied at the École Polytechnique and worked as an engineer until 1814 when he lost his job due to Napoleon's return to power. It was at this time that Fresnel began his investigations in the field of optics. Fresnel aimed to demonstrate the wave nature of light, contrary to the prevailing Corpuscular Theory of his time (Cooper, 1970; Boutry, 1948).

In 1815, Fresnel investigated the diffraction of light. The experiments were conducted with sunlight directed through a window into a darkened room, where it was projected onto a white screen. Diffraction was observed by placing a narrow diffractor (an obstacle or aperture) in front of the screen, causing the sunlight to disperse. These experiments required heliostats to keep the focused sunlight, compensating for the sun's movements (Fresnel, 1866). This allowed for prolonged experiments without constant adjustments. Although heliostats were not common, limiting the research, Fresnel used a powerful lens at the window as an alternative to create a unidirectional beam of light and overcome the lack of heliostats in his diffraction experiments.

The key innovation in Fresnel's measurement method was to add a lens to the conventional screen for observing diffraction patterns (Fig. 1) (Shetty & Bingi, 2020). This improvement offered significant benefits: scientists no longer had to worry about blocking rays with their bodies while measuring diffraction fringes, and they could track these fringes back to their point of origin more easily. With this new technique, Fresnel achieved a precision of 1/40 mm in his measurements, a milestone none of his predecessors had reached. To measure the position of the diffraction fringes, Fresnel improvised in the absence of a micrometer; he used two silk threads knotted at one end (forming a "V") and a piece of cardboard as a slider (Fresnel, 1866).

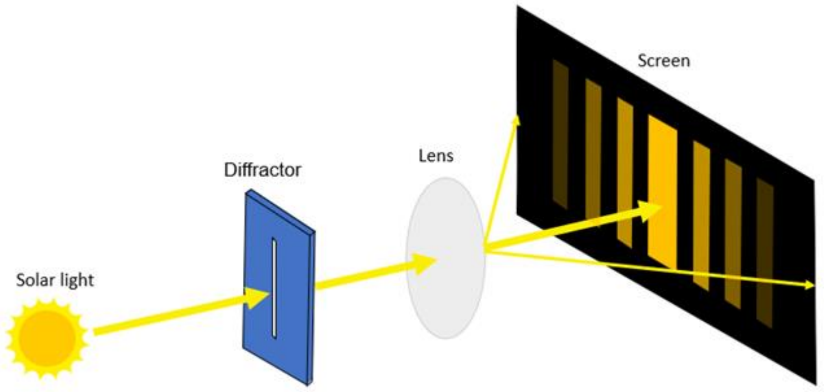

Figure 1. Fresnel Diffraction Experiment. Sunlight passes through the diffractor and creates diffraction patterns captured on a screen after being magnified by a lens. (Own elaboration).

Initially, Fresnel studied diffraction, focusing on the region near the diffractor, where attractive and repulsive forces were stronger. According to Newton's universal law of gravitation, these forces depend on the mass of the involved objects, such as the diffractor and light particles. Examining the diffraction fringes near the diffractor, Fresnel observed that they seemed to emanate directly from the corners of the diffractor, contradicting Newtonian theory. This observation marked his first experimental evidence of the inaccuracy of Newton's theory. As a result, Fresnel decided to investigate this phenomenon under the assumption that the nature of light was wave-like.

Rediscovering Interference.

The results of Fresnel's research on diffraction directed him towards the study of the wave nature of light. His understanding was clarified with the rediscovery of the principle of interference. In discussions with Arago about Young's works, there was no reference to Young's most significant discovery: the interference phenomenon.

Fresnel's lack of prior knowledge about these works led him to dedicate time to an already established phenomenon. Young demonstrated interference through the double-slit experiment detailed in Fig. 2a (Beléndez, 2015; Geesink & Meijer, 2018).

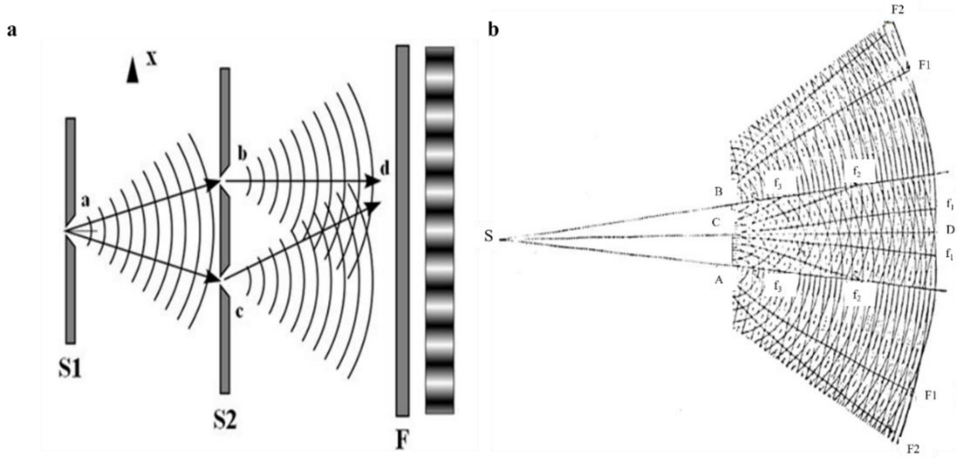

Figure 2. Fresnel Interference Experiments. (a) Fresnel's double-slit interference experiment. The waves from the sources (b) and (c) interfere, resulting in the diffraction pattern on screen F. Adapted from (Geesink & Meijer, 2018).
(b) Interference of waves emitted from the source S as they pass through obstacle AB. S is the light source, A and B are the ends of the diffracting body, C is the midpoint between A and B, and D is the geometric shadow of point C. Circles are drawn from points S, A, and B as centers, continuously increasing the radius by half a wavelength. Modified from (Fresnel, 1866).

By placing a narrow slit in front of a source of sunlight (a), the light beam impinged on an opaque screen with two narrow and closely spaced slits (b and c). The waves passing through these slits, with a wavelength λ and separated by a distance ab, create two new focal points of waves. These waves interact, generating a diffraction pattern on the screen F. Constructive interference produces bright fringes (maxima), while destructive interference creates dark fringes (minima). The intensity of light at a point d on the screen is determined by the difference in the distance traveled by these two waves.

Later, Fresnel further investigated by adding a sheet of black paper to one corner of the diffractor as an obstacle (Fig. 2.a), observing the disappearance of the inner fringes. He concluded that these fringes depended on the intersection of divergent rays from both edges of the diffractor, while the outer fringes seemed to arise from an intersection of direct rays from the light source and the reflection from the edges of the diffractor. These results were not explainable by the principles of corpuscular theory but fit well with wave theory. Fig. 2.b shows a diagram that Fresnel created to explain this experiment, with lines representing the inner fringes (f1, f2, and f3) and the outer fringes (F1 and F2) of destructive interference.

Fresnel validated his theory by comparing experiments and formulas, achieving a maximum error of 7%. A notable consequence was the formation of curved fringes when modifying the distances between the diffractor and the screen, contradicting corpuscular theory. Despite initial progress, Fresnel still needed to address details, such as the discrepancy between the theoretical and experimental positions of the outer fringes. To tackle this, he proposed that rays from the edge of the diffractor experienced a half-wavelength delay $\left(+\frac{\lambda}{2}\right)$, considering that it did not affect the general validity of the theory.

Fresnel's report presented in October 1815.

Fresnel presented his research in the field of optics on October 15, 1815, before the Academy of Sciences, which included his discoveries on diffraction and the hyperbolic propagation of waves. He apologized for potential writing errors due to the rush to be the first to present his findings. Despite his results, he noted that "Newton's theory was generally accepted" (Fresnel, 1815).

However, Fresnel was unaware of the prior work by the English physicist Thomas Young in 1801, which addressed similarities in the behavior of light and sound (Young, 1802; Robinson, 2023). According to Young, light deviates less than sound when propagating in a straight line, due to the greater elasticity of the ether compared to air. Based on these observations, Young discovered the principle of light interference. According to this principle, the resulting light wave from the interaction of two or more waves is a combination of their effects, known as the principle of wave superposition. These resulting waves have maxima and minima based on the phase difference between the interacting waves (Gbur & Visser, 2022).

The Academy of Sciences commissioned Arago to review the paper presented by Fresnel, and he concluded that it contained "a great number of interesting experiments, some of which have already been conducted by Dr. Thomas Young, treating this phenomenon in a similar manner" (Fresnel, 1866). However, Arago supported the innovative idea of the hyperbolic propagation of diffraction fringes. Arago encouraged Fresnel to continue his work on diffraction to strengthen his theory.

In 1816, Fresnel learned that Young was investigating diffraction. Following Arago's suggestion, he decided to refocus on the topic, drafting a new paper published in Annales de chimie, excluding what had already been published by Young. Upon reading it, Young informed Fresnel that he had already disclosed those findings. Although Fresnel initially claimed priority, he later acknowledged Young's precedence. Fresnel wrote to Young expressing his joy in supporting the latter's theory. Thus, Young gained recognition after a decade of being ignored, and Fresnel secured independent confirmation of his work.

Double Mirror Experiment.

Fresnel sought to demonstrate interference with his experiments, but Newtonian theory followers could still attribute the results to attraction and repulsion caused by the edges of the diffractor. To refute this argument, he conducted the double mirror experiment, eliminating the diffractor. He placed two mirrors forming an angle slightly less than 180 degrees and a light source at point S in front of them, isolated by a plate. The rays reflected by the mirrors and reaching the screen could be considered as originating from the virtual sources S1 and S2. In conducting the experiment, Fresnel observed bright fringes on the screen, a result of interference between the rays reflected by both mirrors. Using the analogy between the width of the diffractor and the distance between the virtual sources S1 and S2, he calculated the path difference and estimated the values for the fringe positions with previously obtained formulas (Fig 3.a). The results demonstrated that the theoretical values matched the experimental ones, ruling out the explanation of inflection as the cause of the fringes (Rossi, 1978).

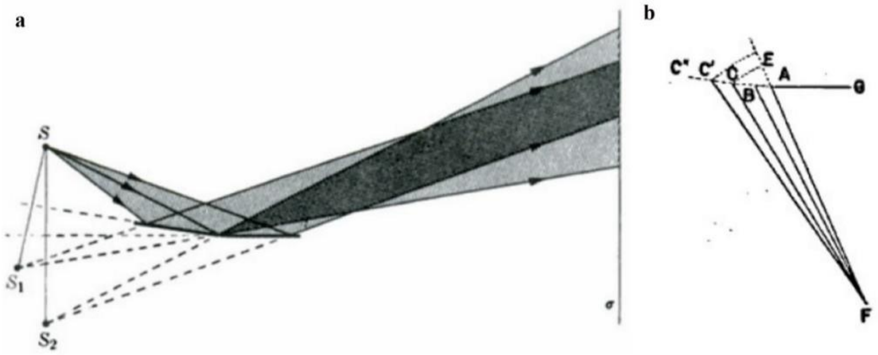

Figure 3. Fresnel's Double Mirror and Effective Rays Experiment. (a) Double mirror experiment. Rays originate from the light source S and reflect off both mirrors, reaching the screen σ. S1 and S2 are the virtual sources of the reflected rays. Taken from (Rossi, 1978). (b) Diffraction analysis at point F (within the geometric shadow), with A as the edge of the diffractor AG. To trace different points (B, C, C', and C"), representing each point of emission of a secondary wave, multiples of λ/2 are added to the distance AF (EF = CF = AF + EA). Taken from (Fresnel, 1866).

With the Double Mirror Experiment, Fresnel departed from his original idea that the center of inflected light was at the edges of the diffractor. Instead, he proposed that the inflected rays could originate at a certain distance from the diffractor, thus solving the problem of fringe inversion by introducing additional differences in the path length between interfering rays on the screen. Fresnel argued that when spherical waves (primary waves) intercepted light, new spherical waves (secondary waves) were generated at each point of interception. These secondary waves, when interfering, were only perceptible in directions where they mutually reinforced, providing a robust explanation based on the wave paradigm, albeit requiring complex mathematics.

Effective Rays Experiment.

In the summer of 1816, Fresnel began developing the mathematical framework to formalize his theory, exploring the concept of "effective rays." Fresnel analyzed diffraction at point F, where secondary waves arrive at different phases after interacting with the obstacle AG, which intercepts the wavefront of the primary wave (AC´´). From point F and taking a radius equal to AF plus half the wavelength (λ/2), he described the arc EC, which intersects the wavefront at C. Rays CF and AF differ by λ/2, and C'F is equal to CF plus λ/2: $\left(C'F = CF + \frac{\lambda}{2}\right)$. The secondary waves from CC' destructively interfere with those from AC due to a path difference of λ/2. Except for AC, secondary waves from other arcs will mutually destroy each other. Thus, considering half of arc BC as an effective contribution, where B is the midpoint of AC, the "effective ray" BF covers λ/4 more than the edge ray A (Fig. 3.b). Although the hypothesis of "effective rays" mitigated the discrepancy between theory and experimental observation, it lacked mathematical precision by simplifying the influence of all rays to those in arc AB. Aware of this limitation, Fresnel requested the Academy of Sciences to frame his results within a more comprehensive theory that was under development.

Paris Academy of Sciences Award in 1819.

Fresnel's submission to the Paris Academy of Sciences summarized his research over the past three years. It began with a general overview of diffraction phenomena and their contradiction with the theory of inflection, then introducing the principle of interference as the most natural explanation. The second section presented his new theory with relevant mathematical considerations and addressed the problem of interference, determining the intensity of light at convergence points of multiple waves. He then focused on the concept of "effective rays," combining the interference principle with Huygens' concept of elementary waves. He innovated by using λ/4 phase-shifted waves to generalize intensity across the entire wavefront, grouping contributions into two large sets through Fresnel integrals. He solved these integrals through series of partial integrals and documented the results in his submission. Subsequently, he concentrated on comparing theoretical and experimental values of first-order maxima and minima for various configurations of obstacles and rectangular geometry openings. Fresnel compiled 125 experimental measurements, showing a discrepancy of 5/100 mm in one measurement, 3/100 mm in three measurements, 2/100 mm in six measurements, and 1/100 mm or less in the remaining 115 measurements, forming the basis of the submission for the 1819 award.

In 1817, the commission formed by Laplace, Biot, Berthollet, and Charles of the Academy of Sciences selected the topic for the upcoming Physics prize. On February 10, 1817, Biot proposed diffraction as the prize topic. The commission members were announced on July 27, 1818: Laplace, Biot, Poisson, Arago, and Gay-Lussac. The first three believed in corpuscular theory, causing apprehension in Fresnel about an unfriendly reception. Arago, on the other hand, supported Fresnel's wave theory, and Gay-Lussac, with no interest in optics, was expected to maintain an impartial stance. Candidates remained anonymous through an epigram. After the submissions, they had the freedom to persuade the jury about the merit of their research. Fresnel seized the opportunity to persuade the three members of the jury who supported corpuscular theory. In the meetings, the outcomes were varied: Laplace showed no interest, while Biot and Poisson were willing to discuss optical phenomena as they had some doubts about corpuscular theory (Silliman, 1967).

In the initial verdict of the Academy of Sciences jury, two submissions were considered as potential winners. The first lacked the necessary precision and did not satisfactorily analyze optical phenomena when light passed through obstacles or openings, also appearing to be unaware of the works of Young and Fresnel. As for the second submission, Fresnel's under the epigram "*Natura simplex et fecunda,*" it was more precise and provided a more detailed explanation of some luminous phenomena, although it was noted to have conceptual errors due to its non-corpuscular approach.

During the review of the submission, Poisson suggested that Fresnel's experiments could be applied to additional situations, such as the case of a circular obstacle. Poisson proposed that, according to Fresnel's theory, directing light towards an opaque circular obstacle should result in the observation of a bright point in the center of the screen, known as Poisson's Spot. Fresnel faced the challenge of demonstrating the existence of such a point to win the prize. In the preliminary report of the jury, the value of Fresnel's submission was recognized due to the extensive series of calculations and experiments performed. The commissioners pointed out Poisson's inference about the Poisson's Spot. The decision on the prize was postponed until Poisson could perform the theoretical calculations and Arago could experimentally verify them. After Poisson completed the calculations, Arago demonstrated the existence of the spot. With this demonstration, any opposition from the jury to Fresnel's theory lacked a basis. The final report of the commission, without explicitly mentioning the word "wave," emphasized the accuracy of Fresnel's results and acknowledged the utility of Fresnel integrals for diffraction, although it omitted their foundation in the wave theory of light.

On March 15, 1819, Arago read the final resolution and awarded the prize to Fresnel, whose submission was highlighted as the best. Augustin Fresnel was honored with the 1819 Academy of Sciences prize, marking a milestone in modern physics by surpassing Newton's corpuscular theory. Despite the recognition, Fresnel faced indifference from his colleagues, such as Laplace, Biot, and Poisson, who resisted accepting his theory. Over the following decades, new generations of physicists, including Airy, Ampère, and Cauchy, gradually embraced Fresnel's wave theory, solidifying it in the 1830s through mathematical advances. Despite the lasting impact of his theory, Fresnel did not live to witness its widespread acceptance.

Conclusions.

Fresnel's work marked a paradigm shift in the understanding of light, as the acceptance of his wave theory over the corpuscular theory had a significant impact on optics and laid the groundwork for the subsequent development of the electromagnetic theory of light. The contemporary relevance of Fresnel's wave theory is undeniable, playing a fundamental role in fields such as quantum optics and the theory of electromagnetic waves. Analyzing how Fresnel overcame challenges and resistance in his time provides valuable insights into the construction of scientific knowledge, highlighting the complexity of scientific evolution through debates and struggles for acceptance.

The case of Fresnel illustrates the importance of avoiding the “*ad verecundiam*” fallacy (appealing to authority, Newton in that era) in the historical context of resistance to the wave theory, offering valuable lessons for critical thinking today. It also emphasizes the importance of factors such as empirical evidence, theoretical coherence, and the ability to explain observable phenomena in shaping scientific theories. Furthermore, it underscores the interaction between theory and experimentation in scientific progress.

Studying how Fresnel developed his theory and overcame obstacles provides an enriching example for teaching the history of science, inspiring students to understand the complex and often nonlinear dynamics of scientific evolution.

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Ігор Гарсія-Атутха
Католицький університет Сан-Антоніо-де-Мурсія, Іспанія

Екайц Дудагойтія Барріо
Університет Мурсії, Іспанія

Франсіска Вільянуева-Флорес
Центр досліджень у сфері прикладних наук та передових технологій, Національний Політехнічний Інститут, Мексика

Епістемологічний вплив Огюстена-Жана Френеля та його теорії хвиль світла в XIX столітті

Анотація. *Скептицизм та критичне дослідження відіграють важливу роль у науковому процесі, діючи як засоби захисту від логічної помилки, коли твердження приймаються виключно на підставі авторитетного підтвердження. Це дослідження ретельно вивчає виклик Огюстена-Жана Френеля корпускулярній теорії Ньютона за допомогою його інноваційної теорії хвиль світла. Підтриманий точними вимірюваннями та "інтегралами Френеля", Френель отримав Премію Паризької академії наук в 1819 році. Незважаючи на тверду опозицію прихильників корпускулярної теорії, валідність його теорії була підтверджена парадоксом точки Пуассона, де світлові хвилі з двох джерел взаємодіють, щоб створити яскраву точку в центрі тіні, надаючи переконливі докази про хвильову природу світла. Це успішне рішення парадоксу підтвердило валідність хвильової теорії Френеля та внесло значний вклад у прийняття хвильової оптики над корпускулярною теорією. Цей конфлікт перейшов далеко за межі простого зіткнення пояснювальних моделей в фізиці світла, спонукаючи до рефлексій над природою світла, реальністю та епістемологічними питаннями. Дослідження того, як Френель подолав виклики, пропонує уроки з конструювання наукових знань, акцентуючи важливість уникання прийняття теорії лише на підставі авторитету та акцентуючи на емпіричних даних та теоретичній узгодженості. Справа Френеля слугує цінним прикладом для викладання історії науки та розуміння складного наукового розвитку. Аналіз того, як Френель долав виклики та опозицію, надає цінні інсайти в розвиток наукових знань, акцентуючи складну природу наукового прогресу, що характеризується дискусіями та зусиллями отримати прийняття. Це дослідження про проривну хвильову теорію світла Френеля не лише проливає світло на історичний конфлікт між конкуруючими науковими парадигмами, але також має на меті сприяти сучасній науці, акцентуючи вічне значення емпіричних доказів та теоретичної узгодженості у конструкції знань. Шляхом проникливого дослідження перемог Френеля над викликами, ми очікуємо надати цінні інсайти, які резонують з сучасними науковими методологіями, сприяючи глибшому розумінню динамічного розвитку наукової думки.*

Ключові слова: *Френель; корпускулярна теорія світла; Премія Паризької академії наук; точка Пуассона; дифракція*

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