The early reception of Quantum Mechanics and Relativity in Mexico: Sandoval Vallarta's role and the Mexican Educative Context

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Received 4 December 2025; accepted 14 April 2025

It is often assumed that quantum mechanics reached Mexico only after the Faculty of Sciences was established at the National Autonomous University of Mexico (UNAM) in 1938. Archival evidence shows, however, that as early as the 1920s, Mexican engineers were already teaching and disseminating this field -just like relativity, as reported in the literature- through limited institutional resources such as the Schools of Engineers and Higher Studies, along with the "Antonio Alzate" Scientific Society. Manuel Sandoval Vallarta, a renowned MIT physicist and disciple of the founders of both theories, was part of this early diffusion. From MIT, he maintained communication with those Mexican engineers in the 1920s and, in the 1930s, guided Alfredo Baños, the first director of UNAM's Institute of Physics, and Carlos Graef Fernández, who introduced the first advanced courses in quantum mechanics and relativity in Mexico. At UNAM, Sandoval Vallarta also mentored Marcos Moshinsky, who later became a prominent quantum mechanical and theoretical physicist. This paper highlights the early introduction of these fields in Mexico, with Sandoval Vallarta's participation both before and after the Faculty's creation. His international stature enabled collaborations with eminent scientists, the advancement of theoretical physics, the founding of institutions, the training of distinguished disciples, and the inspiring future generations.

Keywords: Quantum mechanics and relativity in mexico; Manuel Sandoval Vallarta, Carlos Graef Fernández, Marcos Moshinsky, national autonomous university of mexico; faculty of sciences; national school of higher studies; national academy of sciences "Antonio Alzate".

DOI: https://doi.org/10.31349/RevMexFisE.23.020301

1. Introduction

Traditional historiography suggests that quantum mechanics in Mexico began with the establishment of the Faculty of Sciences at UNAM in 1938. However, this paper presents findings from a research project based on the hypothesis that the teaching and dissemination of quantum mechanics in Mexico actually started in the 1920s. This timeframe is similar to that of relativity, as documented in earlier studies, when these theories were still being developed and the country lacked both professional physicists and research institutions. During this period, Mexican engineers, who were the most highly trained in physics and mathematics, took the lead in this field. They worked within the principal educational and scientific institutions of the era, whose origin dates back to the 18th, 19th, and 20th centuries, as outlined in the following section. Furthermore, engineers played a crucial role in spreading knowledge of quantum mechanics, much like they did with relativity, through leading scientific societies. One such society, the "Antonio Alzate" Scientific Society, was founded in 1884 to connect Mexican science with international networks. In recognition of its national and global importance, the Mexican government transformed it into the National Academy of Sciences in 1930. Consequently, most studies in these fields were published in the society and academia journal, which was distributed across several Mexican states and internationally.

To investigate this hypothesis, a historiographical study was conducted by examining primary archival sources, including course programs, institutional records, correspondence, and contemporary publications. These UNAM Archives correspond to the National School of Higher Studies, the Faculty of Science, and the University Council. The results highlight the diversity of academic spaces in which quantum mechanics was introduced early in Mexico, as was relativity, too. The enthusiasm for disseminating this knowledge early can be partly attributed to the fact that these areas of physics were still developing [1]. It should also be noted that in the 1920s, Mexican professors maintained contact with Manuel Sandoval Vallarta (1899-1977), who earned his doctorate at MIT with research in these fields. He later traveled to Europe to study with the pioneers of modern physics. After returning to the United States, he became one of the few professors deeply knowledgeable in these cutting-edge areas of physics. Sandoval Vallarta continued his work in quantum mechanics and relativity at MIT for some years before shifting his focus to cosmic rays, a field he pioneered, which earned him international renown.

A cultural tradition among Mexican professors in physico-mathematical subjects was their dedication to closely following global scientific advancements. They acquired knowledge autonomously and later shared it with their students or published articles for a broader audience. This commitment, along with the fact that a young Mexican -who frequently visited them during his vacations- was working

at the forefront of physics worldwide, motivated these professors to persuade UNAM governing bodies to create degree programs in physics and mathematics. This goal was achieved in 1935, leading to the founding of the Faculty of Sciences in 1938. In this faculty, specific and advanced courses in quantum mechanics began in 1941 when Carlos Graef Fernández (1911-1988) returned to Mexico from MIT after completing his doctorate. This article also reveals, based on UNAM archives, that after Graef, the quantum mechanics course was taught by other professors, including his disciple Fernando Alba Andrade (1919-2021), as well as Marcos Moshinsky (1921-2009) and Alejandro Medina (1920-1972), who were both students of Manuel Sandoval Vallarta. Later, Luis Estrada Martínez (1932-2016), a disciple of Moshinsky, also taught the course. Adem did too. In 1942, Graef began teaching the advanced course on relativity, which -unlike quantum mechanics- he appears to have taught as the sole instructor from 1941 to 1960, the period examined in the second part of this study.

In summary, this paper underscores the roles of Mexican engineers, scientific societies, and Manuel Sandoval Vallarta in the early introduction of quantum mechanics and relativity, before and after the Faculty of Sciences was established. It highlights how the development of a national physics culture was intertwined with international connections.

2. Emerging scientific infrastructure in the Mexican capital in the late 19th and early 20th centuries

This section presents a historical overview of institutions that played a decisive role in the promotion of modern physics, and the professionalization of physics, mathematics, and chemistry in Mexico. Some trace their origins to the colonial period, such as the Escuela Nacional de Ingenieros (ENI - National School of Engineers), the country's first scientific and technical educational institution based on modern science. It emerged from the Royal Mining Seminary of Mexico, founded in 1792 during the Enlightenment. Developing independently, as was common at the time, the ENI became a cornerstone for the creation of other institutions, including the Escuela Nacional Preparatoria (ENP - National Preparatory School) in 1867. The ENP, in turn, was crucial for the establishment of the Escuela Nacional de Altos Estudios (ENAE - National School of Higher Studies) in 1910, which aimed to launch the first scientific degree programs, though this goal was not achieved. We will also see how instrumental was the ENP and also the ENAE (also ENI and other schools) in the founding of the Universidad Nacional de México (UNM - National University of Mexico) at the beginning of the XXth century, where physics and mathematics were finally professionalized in 1935, and where the Faculty of Sciences and the Institute of Physical and Mathematical Sciences were created in 1938 (the latter soon evolving into the Institute of Physics). Although this section provides the historical framework for the establishment of these pioneering institutions of physics in Mexico, readers may proceed directly to the second section, which addresses the early dissemination of quantum mechanics and relativity in Mexico through the institutional resources already mentioned.

Since the 19th century, Mexico City has been home to the most important and prestigious preparatory and higher education institutions in the country, which operated independently, a norm at the time. Although the Royal and Pontifical University was closed in 1865, it remained separate from the leading professional schools, such as the ENI. Along with the Escuela Nacional de Medicina (ENM - National School of Medicine), established in 1833, the ENI and the ENM were among the most influential in scientific higher education in Mexico. The ENI featured the best professors in scientific subjects such as physics, mathematics, and chemistry, while the ENM excelled in biology and chemistry. Both institutions played a crucial role in professionalizing these scientific disciplines in the early decades of the 20th century, with chemistry becoming the first scientific degree program established in Mexico in 1916.

Beginning in 1867, a remarkable educational development unfolded in Mexico with the establishment of a secondary (preparatory) education institution. This initiative enabled unprecedented interaction with four professional schools, establishing the first successful systemic educational program. Teachers from various disciplines came together in its classrooms, many of whom also taught at the country's most prestigious higher education institutions. This collaboration proved particularly beneficial, as it united some of the nation's leading scientists and educators, many of whom held significant government positions. These educators were instrumental in promoting the formation of several scientific societies and the establishment of the country's first scientific institutions. The secondary institution in question was the ENP, which engaged in teaching exchanges with the ENI, the ENM, the Escuela Nacional de Bellas Artes (ENBA - National School of Fine Arts) - originally founded in 1781 as the Academia de San Carlos (Academy of San Carlos) - and the Escuela Nacional de Jurisprudencia (ENJ - National School of Jurisprudence), also established in 1867. Within just a few years, the ENP became an influential center for educational and scientific advancement [2].

The educational system that includes the ENP and the leading institutions of higher education, which I will refer to as the "ENP System," was established by Justo Sierra (1848-1912) when he founded the UNM in 1910. He added a newly created institution to this framework: the ENAE, established just a few months before the UNM. The goals of the ENAE included not only offering postgraduate courses but also initiating the professionalization of the scientific and humanistic disciplines necessary for the nation, coordinating existing research institutes, and providing teacher training courses at all educational levels. During those years, several research institutes operated, largely thanks to the contributions of professors from the ENI and the ENM. These institutes included the Instituto Médico Nacional (IMN - National Medical Insti-

tute), the Instituto Geológico Nacional (IGN - National Geological Institute), the Observatorio Astronómico Nacional (OAN - National Astronomical Observatory), and the Observatorio Meteorológico Central (OMC - Central Meteorological Observatory), among others. In summary, the UNM can be represented by the formula: UNM = "ENP System" + ENAE [3].

It is important to note that the ENP played a crucial role in the conception and planning of the ENAE. As early as 1867, the ENP was already teaching scientific and humanistic subjects that were not yet recognized as professions, such as physics, mathematics, chemistry, biology, history, philosophy, geography, literature, psychology, and social sciences, among others. Most of the ENP professors later joined the ENAE faculty, where they advocated for the creation of new degree programs. This initiative led to the establishment of the Philosophy program in 1924, the same year the ENAE was transformed into the Facultad de Filosofía y Letras (FFyL - Faculty of Philosophy and Letters), alongside two other entities. A similar situation occurred with the Chemistry program: many ENP professors who collaborated with the ENAE promoted its founding in 1916, the first scientific profession created in Mexico. However, its origins lay outside the ENAE, as it began as part of a technical education project by the Ministerio de Instrucción Pública y Bellas Artes (MIPBA - Ministry of Public Instruction and Fine Arts). This project was abruptly halted the following year due to the revolutionary movement that impacted the country and closed the MIPBA, leading to the school's integration into the UNM in 1917 [4].

With the dissolution of the ENAE into the FFyL and two other institutions, new degree programs in the humanities and in biology began to emerge. Simultaneously, efforts to promote studies in the physical sciences and mathematics continued, primarily promoted by engineers Sotero Prieto (1884-1935) and Alfonso Nápoles Gándara (1897-1992) in the so-called Science Section. However, this section was dissolved in 1935, after the death of Sotero Prieto, without successfully consolidating both degree programs. In 1927, engineer Ricardo Monges López (1886-1983) joined the UNAM. After a career in the oil industry, he decided to dedicate himself to academia. During his time in Europe, he observed significant advancements in the physical sciences and mathematics. Upon his return, he concentrated on creating degree programs in these fields, which he successfully established between 1934 and 1935 with support from the ENI. He also founded additional programs along with their respective research institutes. His contributions include the establishment of the Faculty of Sciences and the institutes of Physics, Mathematics, Chemistry, and Geophysics, as well as the overall organization of the institutional framework dedicated to scientific research at UNAM, which achieved autonomy in 1929 and was renamed the Universidad Nacional Autónoma de México (UNAM - National Autonomous University of Mexico). For these reasons, Monges López is recognized as a key figure in the development of the scientific infrastructure [5].

Monges López held the opportunity presented by the university's restructuring after it gained autonomy to advocate for the establishment of degree programs in physics and mathematics-fields that were not of interest to university authorities. In light of this lack of support, he leveraged his role as the president of the "Antonio Alzate" National Academy of Sciences (ANCAA - by its acronym in Spanish) to publish a series of articles in the capital's press, highlighting the importance of these sciences for Mexican society. He cited the achievements of renowned Mexican physicist Manuel Sandoval Vallarta, who had earned international recognition at MIT for his contributions to the study of cosmic rays, even though his early work focused on quantum mechanics and relativity. Ultimately, Monges López discovered a legal loophole that permitted him to establish the Physical and Mathematical Sciences Section in 1934 at the Engineering Faculty (previously ENI), rather than in the Humanities program. This section subsequently became a Department in 1935, evolved into the National School of Physical and Mathematical Sciences in 1936, and was finally transformed into the Faculty of Sciences in 1938 [6]. The initial project for the Faculty of Sciences integrated the existing main scientific disciplines. Additionally, the program included that the head of the corresponding department within the Faculty would also serve as the director of the associated institute [7]. In this way, the institutional infrastructure was established to begin the formal teaching of the first courses in quantum mechanics and relativity in Mexico.

3. Initial dissemination of Quantum Mechanics and Relativity in Mexico

As quantum mechanics and relativity began to develop worldwide, Mexico's scientific infrastructure was still quite limited as has just been shown, lacking dedicated positions or research institutes in physics and mathematics. The closest research entity for these disciplines was the OAN, founded in 1878. The educational institutions most interested in these fields during the early 20th century were the ENP, the ENI, and the ENAE. In the first decades of the 1900s, none of these institutions offered full-time positions, so professors often worked across multiple academic settings. A notable example is Sotero Prieto, who worked at the OAN, ENP, ENI, and ENAE. He was one of the few instructors capable of teaching advanced mathematics courses without having completed postgraduate studies, a role he fulfilled with great success at ENAE. His influence was significant in shaping the education and aspirations of many young Mexicans, including Manuel Sandoval Vallarta, whose trajectory will be explored further [8].

The initial promoters of quantum mechanics and relativity in Mexico were professors from the ENP and the ENAE, and, primarily, from the ENI (where most of them studied), along with Manuel Sandoval Vallarta, who published the results of his research conducted at MIT. These academics

TABLE I. Relativity articles published between 1921 and 1941 in Mexican journals.

Year	Author	Affiliated Institution	Article Title	Mexican Journal
1921	Sotero Prieto	ENP, ENI, ENAE, OAN	La Teoría de la Relatividad	*El Maestro*
1921	Miguel Bustamante	ENI	Teoría de la Relatividad	*Boletín de la Secretaría de Comunicaciones y Obras Públicas*
1922	Elpidio López	OAN, OAC	La Teoría de la Relatividad	*Memorias de la SCAA*
1922-1923	Sotero Prieto	ENP, ENI, ENAE, OAN	Diversos temas de la Teoría de la Relatividad	*El Maestro*
1924	Manuel Sandoval Vallarta	MIT	La teoría relativista de la estructura fina de rayas espectrales	*Memorias de la SCAA*
1926	Ricardo Monges López	ENI	Breve estudio acerca de los fundamentos filosóficos de la Teoría de la Relatividad de Einstein	*Memorias de la SCAA*
1927	Manuel Sandoval Vallarta	MIT	Sobre la Teoría Relativista de la Mecánica Ondulatoria	*Memorias de la SCAA*
1931	Manuel Sandoval Vallarta	MIT	Investigaciones sobre la relación entre la Teoría del Quantum y la Teoría de la Relatividad	*Memorias de la SCAA*
1941	A. Romero	ENI, Faculty of Sciences	La ley de radiación de Planck, origen de la mecánica ondulatoria	*Memorias de la SCAA*

Source: Prepared by the author [10].

used a few journals that survived the turmoil of the Mexican Revolution, including the *Memorias y Revista de la Sociedad Científica "Antonio Alzate"* (Memories and Journal of the "Antonio Alzate" Scientific Society), which began publication in 1887. In 1930, this journal changed its name to *Memorias y Revista de la Academia Nacional de Ciencias "Antonio Alzate"* (Memoirs and Journal of the "Antonio Alzate" National Academy of Sciences), following the transformation of the "Antonio Alzate" Scientific Society (SCAA - by its acronym in Spanish) into the "Antonio Alzate" National Academy of Sciences (ANCAA). Because this society became the most prominent scientific organization in Mexico, gaining significant international recognition, it was honored with an elevation of status to the National Academy of Sciences [9]. The journal circulated throughout Mexico and was also distributed worldwide, allowing many of the early articles on relativity and quantum mechanics to be published in its pages and widely disseminating these important topics both in Mexico and internationally, as shown in Table I.

On the other hand, Juan Mateos, a professor at ENI and ENP, published the book *Explicación elemental de las teorías de Einstein sobre la relatividad y la gravitación* (Elementary Explanation of Einstein's Theories on Relativity and Gravitation) in 1923. It is noteworthy that all the authors of these works were members of the SCAA. The SCAA also included prominent international scientists such as Henri Poincaré (1854-1912), Lord Kelvin (1824-1907), and Harlow Shapley (1885-1972), along with several Nobel Prize winners in Physics: A. A. Michelson (1852-1931), Erwin S. Schrödinger (1887-1961), Arthur Holly Compton (1892-1962), and Werner Heisenberg (1901-1976). Some of these physicists were founders of quantum mechanics. As shown in Table I, these fields were disseminated early through journals and books; they were also shared at conferences. In 1921, Sotero Prieto and engineer Agustín Aragón (1870-1954) delivered lectures for the SCAA, and in 1922, Elpidio López presented at both the SCAA and the Society of Civil Engineers of Mexico [11].

The ENAE occupied a prominent position as an educational institution in the country despite being marginalized by the revolutionary movement. It was the only higher education institution that focused on innovative scientific topics not addressed elsewhere. Due to limited financial resources, many professors-primarily in the humanities-offered free courses, which eventually contributed to the development of the first curricula in that field, leading to the establishment of the FFyL. In the exact sciences, only a few instructors, such as Sotero Prieto and Valentín Gama, taught without remuneration. Most teachers expected to receive the corresponding salary at the end of the course, and when that payment did not materialize, they stopped attending. Notably, Sotero Prieto was one of the few self-taught engineers who conducted ad-

vanced mathematics classes at ENAE. He also offered a winter course on relativity in 1922 [12]. He was a strict teacher, he emphasized seriousness and dedication from his students, recognizing that these subjects were unique in the country. This approach likely influenced Manuel Sandoval Vallarta, one of his students at the ENP.

Between 1922 and 1923, the ENAE offered a course titled "History of the Exact Sciences." This course covered the development of classical mechanics up to the early 20th century and included topics such as relativity, quantum mechanics, and the history of disciplines such as chemistry and physical chemistry. The instructors divided the course into two parts. The first part was taught in 1922 by Álvaro L. Espino, a graduate of ENAE -known as the Faculty of Higher Studies from 1916 onward. The second part, offered in 1923, was taught by Daniel Castañeda, a civil engineer who graduated from ENI. In 1924, when ENAE became the FFyL, the number of courses in the exact sciences was reduced, and they remained only in the science section until its closure in 1935. In 1932, a group of ENI students requested the establishment of a special course on modern physics, which would include relativity and quantum mechanics. They proposed Ricardo Monges López, Carlos Luca, and Juan S. Agraz- who was the founder of the first chemistry school in Mexico -as potential professors. Both Monges López and Carlos Luca were teachers at ENI. However, the authorities rejected the proposal due to insufficient financial resources to cover the professor's salary. That same year, Monges López, a member of the UNAM University Council and supported by Manuel Sandoval Vallarta, sought to persuade the university authorities of the necessity to professionalize physics and mathematics. Finally, in 1935, Monges López created the Department of Physical Sciences and Mathematics with a curriculum that included a course on the History of Physics. This course remained part of the first physics degree program offered by the Faculty of Sciences in 1939. It was still mentioned in 1946 for students of theoretical physics [13], the year when the degree program was divided into two branches: theoretical physics and experimental physics [14].

4. Manuel Sandoval Vallarta, a central figure in the development of quantum mechanics and relativity

Although relativity and quantum mechanics were first introduced at ENAE during the 1920s through the History of Physics course, they gained more focus in the 1930s at the Faculty of Sciences. The Palacio de Minería of the ENI (Engineering Faculty) housed this Faculty until 1952. This Faculty taught the first specialized courses for students pursuing careers in physics and mathematics. In 1941, the course titled "1st of Quantum Mechanics" was launched, followed in 1942 by another course called "Theory of Relativity". Carlos Graef Fernández, a graduate student of Manuel Sandoval Vallarta from MIT, taught both courses [15]. Sandoval Vallarta was a notable figure who shaped the development of physics both before and after the creation of the Faculty of Sciences. His significant contributions included publishing the first results of his research in quantum mechanics and relativity in the Memoirs and Journal of both the SCAA and the ANCAA. He and Monges López played a crucial role in establishing the fields of physics and mathematics in Mexico. The two were close friends, and since Sandoval Vallarta frequently spent his vacations in Mexico, he often took the opportunity to deliver lectures at the SCAA -later ANCAA- where he was a member [16].

To understand the origins of quantum mechanics in Mexico, it is essential to highlight the figure of Manuel Sandoval Vallarta, one of the country's most influential 20th-century physicists and internationally recognized for his contributions to the study of cosmic rays [17]. His career was closely linked to the global rise of modern physics, beginning with quantum mechanics and relativity before shifting to cosmic rays. In 1924, he obtained his doctorate at MIT under the supervision of Edwin Bidwell Wilson (1879-1964) (a disciple of Josiah Willard Gibbs (1839-1903)) with the thesis "Bohr's atomic model from the point of view of general relativity and perturbation theory" [18], in which he addressed fundamental aspects of electromagnetism and the emerging quantum theory. Thanks to the wholeness and originality of his contributions, and to the fact that he was among the few physicists in the United States specializing in quantum mechanics and relativity, Sandoval Vallarta established himself as a leading figure in the theoretical physics of his time [19].

In 1927, Manuel Sandoval Vallarta received a scholarship from the Guggenheim Foundation, enabling him to continue his studies in Germany, particularly in Berlin and Leipzig. There, he worked alongside leading figures in quantum mechanics and relativity, including Albert Einstein (1879-1955), Max Planck (1858-1947), Erwin Schrödinger (1887-1961), Werner Heisenberg (1901-1976), and Peter Debye (1884-1966). Upon returning to the MIT, where he was appointed as a full-time professor, Sandoval Vallarta played a pivotal role in revitalizing the physics department. He contributed to the establishment of a modern Department of Physics, where the first courses in theoretical physics, relativity, and electromagnetic theory were offered. Additionally, he began publishing articles in these fields until 1932, when he shifted his research focus to cosmic rays, a field in which he became a leading authority [20].

It is worth noting that Sandoval Vallarta's last work on quantum mechanics and relativity, co-authored with Nathan Rosen in 1932 and titled "The Relativistic Thomas-Fermi Atom," has been the most cited of his publications, even in recent years. This article served as a bridge that established the connection between Rosen and Einstein, which ultimately led to the famous EPR (Einstein-Podolsky-Rosen) paradox published in 1935. By that time, Vallarta had shifted his focus away from quantum mechanics and relativity. In 1933, he published his first article on cosmic rays, titled "On Compton's Latitude Effect of Cosmic Radiation," in collaboration

with Georges Lemaître (1894-1966). This work is now considered the second-most-cited piece in his scientific production. In addition to his collaboration with Lemaître, Vallarta worked with various research teams across Europe and the United States until World War II shifted the efforts of MIT's physics laboratories toward military research. As a result, he lost access to the facilities and equipment necessary for his calculations. Given these circumstances, and because he refused to become a U.S. citizen, Vallarta decided to return to Mexico [21].

From 1943 to 1946, Sandoval Vallarta divided his time between the United States and Mexico. In the final year he decided to remain in his country, at a moment when scientific research was rapidly becoming more professional and institutionalized [22]. From that point on, he actively promoted the development of science and technology not only in Mexico but also in several developing countries. His role in Mexican scientific diplomacy was crucial in strengthening connections between scientists and institutions from Canada to the Southern Cone, leading to the implementation of various international projects. One notable initiative he supported was the establishment of laboratories and observatories across the American continent, especially in Mexico, dedicated to the study of cosmic rays [23]. As expected, his scientific productivity decreased significantly as he devoted much of his time to numerous managerial and diplomatic responsibilities both nationally and internationally. These included his appointment as the first president of the Comisión Impulsora y Coordinadora de la Investigación Científica (CICIC), a federal commission established to promote scientific and technological research in Mexico. He also served as the former Director General of the Instituto Politécnico Nacional (IPN - National Polytechnic Institute) and was a member of the Comisión Nacional de Energía Nuclear (CNEN - National Nuclear Energy Commission) starting in 1956. In addition, he held numerous other positions at the national level [24].

Internationally, he was a member of the Pontifical Academy of Sciences and served as Mexico's representative to the United Nations Atomic Energy Commission, which he chaired in 1946. He also represented Mexico at the International Atomic Energy Agency and chaired several international commissions on cosmic radiation. Additionally, he headed the Review Commission of the Bose Institute in Bombay, India, in 1948, and was part of the founding committee of the School of Theoretical Physics at the University of Trieste. This committee included prominent figures such as J. Robert Oppenheimer (1904-1967), Victor Weisskopf (1908-2002), Niels Bohr (1885-1962), V. Soloviev (1853-1900), and Abdus Salam (1926-1996). Their goal was to support high-level theoretical physicists in developing countries [25].

In Mexico, Sandoval Vallarta joined the academic staff at UNAM, first at the Institute of Physics, where he became the interim director, and later at the Institute of Geophysics. He collaborated with the Faculty of Sciences and supervised students' theses in the program. Under his guidance, Marcos Moshinsky graduated in 1944 with the thesis titled "Propagation of a plane wave through two elastic media separated by a cylindrical surface." Alejandro Medina Meléndez also graduated in 1953 with the thesis "Theory of homogeneous nuclear reactors." Moshinsky, of Ukrainian origin and later a naturalized Mexican citizen, emerged as one of the leading promoters of quantum mechanics in Mexico, with an influence that extended beyond Latin America to the international stage. After completing his postgraduate studies at Princeton University under the mentorship of Nobel Prize-winning physicist Eugene Paul Wigner (1902-1995), Moshinsky revolutionized calculations in nuclear shell models by using mathematical methods known as Moshinsky brackets [26]. His conceptual and mathematical contributions significantly enriched the study and development of quantum mechanics in particular and in theoretical physics in general.

5. The Faculty of Sciences, birthplace of the first formal courses on relativity and quantum mechanics in Mexico

In 1938, UNAM established the Faculty of Sciences as part of an ambitious project led by Monges López. It was initially envisioned as the central element in the reorganization of schools, faculties, and scientific research institutes. This structure also included a Coordination and Technical Council for Scientific Research. The Humanities section would later mirror this institutional restructuring, ultimately shaping the current configuration of the Máxima Casa de Estudios. To understand the significance of this development, it is important to note that in 1929 -the year university autonomy was achieved- the University lacked a defined structure and consisted of the following academic entities: the Faculties and Schools of Agronomy; Chemical Sciences and Industries (the only institution that had professionalized the field of chemistry at that time); Commerce and Administration; Law and Social Sciences; FFyL; ENI; ENM; Dentistry; ENBA (which included painting, sculpture, and architecture); Physical Education; Veterinary Medicine; the Higher Normal School; and the ENP. Additionally, there were the National Library, the Institutes of Biology and Geology, and the OAN [27].

In 1939, the Faculty of Sciences implemented its first curriculum, which included teaching quantum mechanics in the History of Physics course. This course was taught by Valentín Gama (1868-1942), a geographer and engineer who graduated from the ENI. Gama was a prominent figure in both government and academia; he held various positions, including Minister of Development and Director of the OAN. At the university, he served as a professor at several schools within UNAM (ENAE was one of them), director of the ENP and the ENI, and rector of the UNM from 1914 to 1915. Thanks to Gama's efforts, undergraduate students interested in quantum mechanics and relativity had the chance to begin their studies in these fields. Unfortunately, he passed away in January 1942, after only three years of teaching this subject. However, the course continued under the guidance of another

TABLE II. Quantum mechanics courses offered at the Faculty of Sciences of the UNAM (1939-1960).

Year	Name of the subject	Name of the professor
1939-1941	Historia de la física (as part of the general syllabus)	Valentín Gama
1941	Mecánica cuántica	Carlos Graef
1948	Mecánica cuántica	Fernando Alba
1949	Teoría cuántica de los campos	Marcos Moshinsky
1949	Métodos matemáticos de la mecánica cuántica	Alejandro Medina
1950	Electrodinámica cuántica	Fernando Alba
1951	Métodos matemáticos de la mecánica cuántica	Marcos Moshinsky
1953	Mecánica cuántica	Fernando Alba
1954	Métodos matemáticos de la mecánica cuántica	Adem
1956	Mecánica cuántica	Luis Estrada
1957-1960	Mecánica cuántica	Marcos Moshinsky

Source: Prepared by the author.

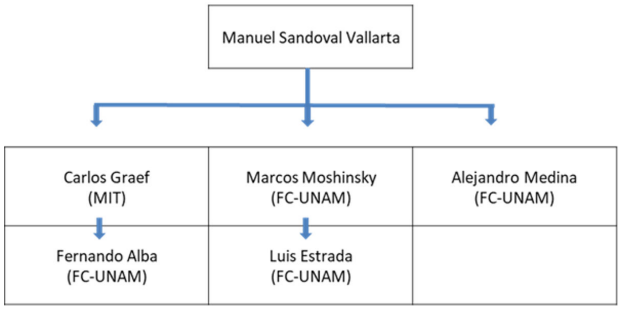
of another professor [28]. In 1941, Carlos Graef Fernández returned to Mexico after completing his postgraduate studies at MIT working in cosmic rays, under the supervision of Manuel Sandoval Vallarta, and conducting astrophysical research at Harvard University. He later collaborated with the mathematician David Birkhoff on an alternative mathematical formulation of general relativity. Sandoval Vallarta and Alberto Barajas joined this project [29]. He is remembered for the memorable call Albert Einstein made to him in 1944 to discuss that theory at his home, though they ultimately reached no agreement [30]. Beyond his work on the theory of relativity, Graef founded and presided over several institutions and societies - among them the Mexican Physical Society and the Mexican Society of Radioisotopes - and dedicated a significant part of his time and effort to advancing physics and nuclear energy in Mexico [31].

Between 1934 and 1952, physics and mathematics careers were offered in the Palacio de Minería. In this building, starting in 1938, one room was designated for the Faculty of Sciences office, while another housed the Institute of Physics. When the Faculty opened its doors in 1939, the only professor at UNAM with postgraduate studies in physics was Alfredo Baños, a former student of Sandoval Vallarta at MIT. As a side note, the National Polytechnic Institute had physicist Dr. Marietta Blau (1894-1970), who fled Austria in 1938 due to the Nazi persecution of Jews. She remained there until 1944, when she moved to the United States. Turning back to the Faculty of Sciences, the remaining members were primarily from ENI, including Valentín Gama. In 1939, only four professors taught physics: Baños, who taught courses in atomic physics and introductory theoretical physics; Perrusquía, who taught electronics; and Uribe, who taught two laboratory courses (mechanics and heat). Additionally, mathematics courses were offered by Alfonso Nápoles Gándara, Nabor Carrillo (1911-1967), Alberto Barajas (1913-2004), Alfonso Quijano, Anfossi, and Hernández. The first three, Nápoles, Carrillo, and Barajas, were also students of Sotero Prieto and had completed postgraduate studies abroad [32].

In physics, Alfredo Baños was the sole professor until 1941, when Carlos Graef Fernández joined the faculty. He took on the responsibility of teaching various subjects in physics and mathematics. That year alone, Graef taught courses in Differential Geometry, Introduction to Mathematical Analysis, Modern Algebra, Calculus of Variations, Mathematical Methods in Theoretical Physics, and the first course dedicated explicitly to Quantum Mechanics. Notably, the Quantum Mechanics course was not at the undergraduate level, but rather at the doctoral level, where he also taught Theory of Relativity beginning in 1942 [33]. In addition to his teaching activities, Graef was actively involved in promoting nuclear energy in Mexico. He served as the country's diplomat at various international forums. He held several important positions, including director of the Mexican Nuclear Center and general coordinator of both the National Institute of Nuclear Energy and Mexican Uranium, among others [34].

In 1955, the Faculty of Science reformed the physics curriculum to include a quantum mechanics course at the undergraduate level. Eventually, this course was also offered at the graduate level and has remained in place at both levels since then. Table II presents the names of the professors who taught the quantum mechanics courses at this Faculty from 1939 to 1960. It is relevant to note that, in contrast to the Quantum Mechanics courses taught by several professors, the course on the Theory of Relativity was taught solely by Graef during the period mentioned [35].

The information in Table II does not suggest that quantum mechanics topics were covered solely in the listed courses; they were likely also addressed in other subjects, such as theoretical physics and atomic physics, which Alfredo Baños taught since 1939. These courses were the first modern physics offerings at the Faculty of Sciences [36]. However, Table II only includes subjects whose titles explicitly mention quantum mechanics. It is important to note that although Manuel Sandoval Vallarta's name does not appear on the list, his influence is evident. Figure 1 illustrates this. Note that, in parentheses, the institution where the first generation of



Source: Prepared by the author.

FIGURE 1. Disciples of Sandoval Vallarta who taught courses in quantum mechanics at the Faculty of Sciences from 1941 to 1960.

professors developed their theses is indicated. Notably, the first generation of professors were his students, and the second generation were the students of his students, except for Adem.

Fernando Alba Andrade was the first physicist to graduate in Mexico in 1943, completing his studies under the supervision of Graef with the thesis titled "Relaxation time of a stellar system." He also became the first individual to obtain a doctorate in physics from UNAM in 1956 [37]. Luis Estrada Martínez graduated with a degree in physics in 1955, under the supervision of Moshinsky, with his thesis focused on "Electric quadrupole and magnetic dipole of deuterium considering velocity-dependent forces."

Table II and Fig. 1 illustrate that from the establishment of the Faculty of Sciences until 1960, the most dedicated professors in the quantum mechanics course were Fernando Alba -a disciple of Graef- and Moshinsky himself, because in the course of time, Graef focused on teaching the theory of relativity. He was unable to maintain consistent participation due to his numerous commitments to promoting nuclear energy. This situation later mirrored that of his student, Alba, who followed a similar path and fully dedicated himself to nuclear physics. Like his mentor, Alba held several significant positions, including director of the Institute of Physics, president of the National Nuclear Energy Commission, and director of the Institute of Nuclear Energy. He also represented Mexico in various international forums [38]. Alba's career reflects a continuous effort to secure scholarships that enable young people to study abroad, as well as to secure resources to equip laboratories and a mechanical workshop. His efforts were so impactful that the workshop eventually became independent of the Institute of Physics, establishing itself as the Center for Instruments, a research center known for years, and is currently referred to as the Institute of Applied Sciences and Technology.

In addition to being one of the most dedicated professors in the Faculty of Science, Moshinsky carried out his scientific work from what were often referred to as "Third World" countries, remaining firmly committed to advancing physics despite the scientific and economic challenges of the time [39]. Moshinsky, who had been appointed to the Institute of Physics in 1942, pursued graduate studies at Princeton University under the guidance of Nobel laureate Eugene Wigner (1902-1995). Upon his return in 1949, he set himself three goals: to demonstrate that he could be an independent researcher by publishing articles of international relevance; to contribute to the formation of a school of Mexican physicists capable of competing with any trained abroad; and to ensure that Mexico would join the global development of science and its applications, as was happening in other regions [40]. Without doubt, he built an excellent school, and his contributions soon placed Mexico on the world stage of science. His other contributions included [41]:

1. He was a founding member of the Mexican Physical Society in 1950, and served as its president between 1967 and 1969. This society followed the short-lived Mexican Society of Physical Sciences, chaired by Sandoval Vallarta in 1943.

2. He founded the *Revista Mexicana de Física* (Mexican Journal of Physics) in 1952 and remained its editor until 1969. This Journal became the most significant publication in the discipline in Latin America at that time.

3. He organized the Summer School in 1956, and three years later he established the Escuela Latinoamericana de Física (ELAF - Latin American School of Physics), which continues to operate today [42].

4. Founding member of the Academia de la Investigación Científica (Academy of Scientific Research) in 1959, and his president between 1862 and 1963. At present, it is the Academia Mexicana de Ciencias (Mexican Academy of Sciences).

5. He undertook many other responsibilities and received numerous awards, most notably the Prince of Asturias Prize (Spain) in 1988.

In 1950, Mexico had only three PhD in physics: Moshinsky, Graef, and Sandoval Vallarta [43]. However, thanks to collective efforts, the number of specialists affiliated with both the Faculty of Sciences and various institutes at UNAM increased significantly within a few years. In particular, quantum mechanics courses were enhanced by the arrival of academics who had fled from Spain, among them Juan de Oyarzábal (1913-1977), who stood out. Once UNAM established the first physics program, it began to expand to other institutions of higher education in the capital, such as the Universidad Autónoma Metropolitana Iztapalapa -where Graef played a key role in its creation- and the Instituto Politécnico Nacional. This expansion also reached different states across the country. For instance, in Puebla, engineer Luis Rivera Terrazas (1913-1989) was a pioneer in physics education, founding the School of Physics at the Autonomous University of Puebla and serving as the first professor of quantum mechanics [44].

6. Overall conclusions

The early dissemination of quantum mechanics and relativity in Mexico began in the 1920s at the ENAE of the UNM, later UNAM. During this period, the journal that published the most articles in the field was *Memorias y Revista de la SCAA*, which later became *Memorias y Revista de la ANCAA*. In 1941, Carlos Graef taught the first formal graduate-level course of quantum mechanics and in 1942 another about the theory of relativity at the Faculty of Sciences. By 1955, following a curriculum reform, an undergraduate course in the subject was also introduced. These courses were taught by the few physicists in Mexico with doctoral degrees at the time: Graef, Moshinsky, and their students. Sandoval Vallarta and Baños were both PhD holders, but Baños moved to the United States in 1943. In this context, the figure of Manuel Sandoval Vallarta is fundamental for understanding the early reception of quantum mechanics and relativity in Mexico. His training at the MIT and his direct contact with the founders of these fields made him a privileged bridge between international physics and the Mexican scientific community during the 1920s and 1930s. Through his academic work and his ties with institutions and prominent disciples, Sandoval Vallarta contributed decisively to consolidating a space for the teaching and development of theoretical physics in Mexico and other countries. Much remains to be investigated. Among the pending tasks is the analysis of courses content and the way it evolved over time. Another challenge is to carry out a historiographical study on how quantum mechanics was introduced in other Mexican universities, in order to highlight the similarities and differences with the process developed at UNAM. For instance, in the School of Physics in Puebla it is known that this field was initially promoted by engineers, although much research is still needed. This endeavor involves both physicists and historians. I trust that in the coming years more studies will be produced that shed light on the introduction of modern physics in Mexico.

The university archives references

- Archive of the National School of Higher Studies, UNAM.
- Faculty of Science Archive, UNAM.
- Historical Archive of the University Council, UNAM.

1. E. Vokan K., The Birth of Quantum Mechanics: A Historical Study Through the Canonical Papers, arXiv: 2503.13630v4 (2025), https://doi.org/10.48550/arXiv.2503.13630
2. M. P. Ramos-Lara, La Escuela Nacional Preparatoria. Un sistema complejo adaptativo (Universidad Nacional Autónoma de México, 2018), https://ru.ceiich.unam.mx/handle/123456789/4390
3. M. P. Ramos-Lara, La Escuela Nacional Preparatoria. Primer programa educativo sistémico exitoso del México decimonónico y sólido cimiento en la creación de la Universidad Nacional de México, In Perspectivas, desafíos y trascendencia de la Escuela Nacional Preparatoria hasta los albores del siglo XX. Homenaje a 150 años de su fundación (Universidad Nacional Autónoma de México, 2022) pp. 231-250.
4. M. P. Ramos-Lara, La Escuela Nacional Preparatoria fundamental en la profesionalización de la química en México (in print).
5. M. P. Ramos-Lara, Figuras y entidades pioneras de la física en México, *Rev. Mex. Fis. E* **61** (2015) 93-103, https://www.redalyc.org/pdf/570/57048163006.pdf
6. M. P. Ramos-Lara, En los 75 años de la Facultad de Ciencias, semblanza de su fundador Ricardo Monges, *Revista Ciencias* **115-116** (2015) 140-149, https://www.revistacienciasunam.com/pt/199-revistas/revista-ciencias-115-116/1921-en-los-75-a%C3%B1os-de-la-facultad-de-ciencias,-una-semblanza-de-su-fundador-ricardo-monges-l%C3%B3pez.html
7. J. M. Lozano Mejía, F. E. Prieto, El Instituto de Física y la Facultad de Ciencias, *Ciencia y Desarrollo, XIV*, **83** (1988) 23-36.
8. UNAM Archives. Also, R. Domínguez, J. Lozano, Sotero Prieto y la enseñanza de las matemáticas en la Universidad Nacional, In La saga de la ciencia mexicana. Estudios sociales de sus comunidades: siglos XVIII al XIX (Universidad Nacional Autónoma de México, 2011) pp. 133-143.
9. J. C. Gallardo, J. M. Lozano, M. P. Ramos-Lara, Publicaciones sobre temas de física en las Memorias de la Sociedad Científica Antonio Alzate, *Revista Ciencia Ergo Sum*, **12** (2005) 97-104, https://www.redalyc.org/pdf/104/10412111.pdf
10. UNAM Archives. Also, M. P. Ramos-Lara, Participación de los ingenieros en la difusión de la Relatividad en México, In La Relatividad en México (Universidad Nacional Autónoma de México, 2008) pp. 21-33.
11. The renowned international scientists were commonly invited to become members of the SCAA. M. P. Ramos-Lara, En torno a la Relatividad en la Biblioteca de la Sociedad Científica "Antonio Alzate". In, La Relatividad en México (Universidad Nacional Autónoma de México, 2008) pp. 143-156.
12. E. Navarro, Antecedentes de la investigación y de los altos estudios de física y matemáticas en México (fines del siglo XIX, principios del siglo XX), Master's thesis in Mathematics from FC-UNAM (1997).
13. UNAM Archives. Also, pages 25 and 26, in Ramos-Lara, Participación de los ingenieros en la difusión de la Relatividad en México, In La Relatividad en México (UNAM, 2008) pp. 21-33.

14. L. Plascencia Gaspar, M. P. Ramos-Lara, J. M. Lozano Mejía, Semejanzas y diferencias entre las carreras de físico y de astrónomo en la UNAM (1939-1967), *Rev. Mex. Fis. E* **54** (2008) 216-225.
15. UNAM Archives.
16. A. Mondragón, Manuel Sandoval Vallarta y la física en México, *Revista Ciencias* **53** (1999) 32-39.
17. R. Gall, El profesor Vallarta: Científico y Humanista, In Manuel Sandoval Vallarta. Homenaje (Instituto Nacional de Estudios Históricos de la Revolución Mexicana, 1987) pp. 77-85.
18. F. Del Río Haza, Destellos del cosmos. Ensayo biográfico de Sandoval Vallarta (El Colegio Nacional, 2018).
19. A. Mondragón y D. Barnés, Manuel Sandoval Vallarta. Obra científica (Universidad Nacional Autónoma de México e Instituto Nacional de Energía Nuclear, 1978).
20. J. A. Stratton, Manuel Sandoval Vallarta (1899-1977), In Manuel Sandoval Vallarta. Homenaje (Instituto Nacional de Estudios Históricos de la Revolución Mexicana, 1987) pp. 99-104.
21. M. P. Ramos-Lara, G. Carreón, R. M. Mendoza, E. Acatitla, Mapping Manuel Sandoval Vallarta (1899-1977) scientific contribution, *Foundations of Science* (2022) 1-28. https://doi.org/10.1007/s10699-022-09872-y https://pubmed.ncbi.nlm.nih.gov/36187324/
22. His scientific work is divided into the following areas: electrical circuits and Heaviside's operational method, quantum mechanics, relativistic quantum mechanics, general relativity, and cosmic radiation. M. Moshinsky, Un precursor: Manuel Sandoval Vallarta, In Manuel Sandoval Vallarta. Homenaje (Instituto Nacional de Estudios Históricos de la Revolución Mexicana, 1987) pp. 43-58.
23. A. Minor García, Cruzar Fronteras. Movilizaciones científicas y relaciones interamericanas en la trayectoria de Manuel Sandoval Vallarta (1917-1942) (Universidad Nacional Autónoma de México y Colegio de Michoacán, 2019).
24. E. Mendoza Ávila, Semblanza Dr. Manuel Sandoval Vallarta. Ex Director del Instituto Politécnico Nacional (Instituto Politécnico Nacional, 1995).
25. A. Mondragón, La obra científica de Manuel Sandoval Vallarta, In Manuel Sandoval Vallarta. Homenaje (Instituto Nacional de Estudios Históricos de la Revolución Mexicana, 1987) pp. 13-31.
26. A. Frank, Semblanza del doctor Marcos Moshinsky In Forjadores de la Ciencia en la UNAM (Universidad Nacional Autónoma de México, 2003) pp. 33-35.
27. UNAM Archives.
28. UNAM Archives.
29. M. J. Yacaman, Carlos Graef-Fernández, *Physics Today* (1988) 103.
30. G. Arciniega, Einstein, Graef, and a clash of theories, Physics Today (2019).
31. E. Piña-Garza, Carlos Graef Fernández, UAM-Iztapalapa (n/d). Also, M. P. Ramos-Lara, Nabor Carrillo: Visionary of nuclear science in Mexico (in print).
32. UNAM Archives. Also, M. P. Ramos-Lara, Pioneering women in nuclear physics in Mexico (in print).
33. UNAM Archives.
34. J. L. Fernández Chapou, A. Mondragón Ballesteros, Carlos Graef Fernández. Obra científica (Universidad Autónoma Metropolitana Azcapotzalco e Iztapalapa, 1993).
35. UNAM Archives.
36. J. L. Díaz-Cruz, E. Sadurní, México cuántico. Historia de una ciencia en desarrollo (Benemérita Universidad Autónoma de Puebla, 2024).
37. E. Adem, J. Miranda, J. Rickards, Fernando Alba Andrade: el primer físico de la UNAM (Universidad Nacional Autónoma de México, 2002), edición digital 2010.
38. A. Dacal Alonso, Fernando Alba Andrade, In 100 UNAM Universidad Nacional de México 1910-2010: Nuestros maestros (Universidad Nacional Autónoma de México, 2010).
39. L. Gottdiener, Marcos Moshinsky: La lucha por la ciencia desde el Tercer Mundo (Juan Pablos Editor, 2017).
40. M. Moshinsky, Mi vida, In Forjadores de la Ciencia en la UNAM (Universidad Nacional Autónoma de México, 2003) pp. 15-32.
41. M. Moshinsky, Reflexiones sobre educación, ciencia y sociedad (El Colegio Nacional, 1995).
42. S. Ortega Esbri, M. P. Ramos-Lara, J. M. Lozano Mejía, La primera escuela de verano de física en México, *Boletín de la Sociedad Mexicana de Física* **21** 4 (2007) 215-220.
43. The physics research projects focused on cosmic rays, gravitational theory, quantum mechanics, nuclear physics, and particle accelerators. R. G. Barrera, La Mecánica Cuántica en México desde la Ciencia de Materiales, In La mecánica cuántica en México (Universidad Nacional Autónoma de México, 2003) pp. 57-81.
44. L. De la Peña, La Mecánica Cuántica en México. La visión desde la Física, In La mecánica cuántica en México (Universidad Nacional Autónoma de México, 2003) pp. 21-44.