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The Reception of Relativity in Mexico

Abstract

When Albert Einstein published his first works on the Special Theory of Relativity in 1905, Mexico did not yet have scientific institutions dedicated to physics research, nor did it have schools for educating physicists. Consequently, the spread of both General Relativity and Special Relativity began in 1921 as a result of the work and talent of various Mexican physics and mathematics professors (most of them engineers) who taught courses at the Escuela Nacional de Ingenieros (National School of Engineering) and the Escuela Nacional de Altos Estudios (School of Higher Studies), both part of the Universidad Nacional de México (National University of Mexico) as founded in 1910.

Key Words

Special Theory of Relativity, reception, Mexico

When Albert Einstein published his first works on the Special Theory of Relativity in 1905, Mexico did not yet have scientific institutions dedicated to physics research, nor did it have schools for educating physicists. Consequently, the spread of both General Relativity and Special Relativity began in 1921 as a result of the work and talent of various Mexican physics and mathematics professors (most of them engineers) who taught courses at the Escuela Nacional de Ingenieros – *National School of Engineering* – and the Escuela Nacional de Altos Estudios – *School of Higher Studies* –, both part of the Universidad Nacional de México – *National University of Mexico* – (founded in 1910). The first academic program in physics was founded in the 1930s, and the first research institute, in 1938.

In 1905, Mexico's scientific infrastructure was favorable for natural sciences and earth sciences, but not for physical and mathematical sciences. What did exist, however, were scientific societies that promoted this field (such as the *Société Scientifique "Antonio Alzate"* – Antonio Alzate Scientific Society – and the Asociación de Ingenieros Civiles Mexicanos – *Mexican Association of Civil Engineers*), scientific institutions related to this field (Observatorio Astronómico Nacional – *National Astronomical Observatory* – and Observatorio Meteorológico Central – *Central Meteorological Observatory*), and educational institutions where physics courses were taught, such as at the Escuela Nacional de Ingenieros – *National School of Engineering* – and the Escuela Nacional Preparatoria – *National Preparatory School*. The University was not founded until 1910 and with it, the Escuela Nacional de Altos Estudios – *National School of Higher Studies*.

In 1905, Albert Einstein published his first works on the Special Theory of Relativity; in 1916 he published articles related to the General Theory of Re-

lativity; in 1919 observations were made that pointed to the veracity of the Theory of Relativity; and in 1922 Albert Einstein received the Nobel Prize for 1921, for his work on the photoelectric effect.

In Mexico, the spread of Relativity began in 1921, and took place in three different ways:

- 1) The Antonio Alzate Scientific Society (SCAA) purchased books on Relativity for its library, and published some notes on other works on Relativity in its journal, *Memorias de la Sociedad Científica Antonio Alzate – Mémoires de la Société Scientifique “Antonio Alzate”*. It is worth mentioning here that this society was linked to the international network of scientific societies, and consequently was updated on what was being produced around the world in the area of science, and through its journal, it also brought attention to the works published in Mexico.
- 2) Some Mexican professors began to publish articles and a book on Special and General Relativity. These same professors were those who succeeded in creating an academic program in physics and a research institution in the 1930s.
- 3) Mexican professors began to make public presentations on this topic and include the topic in courses on the history of science, which were not specialized courses, since a career in physics was not yet offered.

With regard to the first point, the Antonio Alzate Scientific Society disseminated information on this topic and even acquired some books such as:

A. S. Eddington, *Espace temps et gravitation avec un exposé théorique de l’oeuvre d’Einstein et de la generalization*, 1920; De Drumaux, *L’evidence de la théorie d’Einstein*, 1923; T. De Donder, *Gravitation Einsteinienne*, 1921; Lucas Mie, *La théorie Einsteinienne de la gravitation*.

Since the physics and mathematics professors who spread the Relativity in Mexico were members of this Society, we can assume they used information from these writings to develop their own publications. The spread of Relativity in this country began in 1921, and Mexican professors in physics and mathematics were those who disseminated information regarding Special and General Relativity through public presentations, articles published, books written and courses given on the history of science.

The first articles published by Mexicans on the topic of Relativity were the following:

Year	Author	Title of article (translated)	Journal
1921	Sotero Prieto	The Theory of Relativity	<i>El Maestro</i> –The Teacher-
1921	M. Bustamante	Theory of Relativity	<i>Boletín de la Secretaría de Comunicaciones y Obras Públicas</i> – Bulletin of the Secretary of Communications and Public Works
1922	Elpidio López	The Theory of Relativity	Memorias de la SCAA Journal of the SSAA
1922–23	Sotero Prieto	Various topics in the Theory of Relativity	<i>El Maestro</i> –The Teacher
1924	Manuel Sandoval Vallarta	Relativist theory on the fine structure of spectral lines	Memorias de la SCAA Journal of the SSAA

Year	Author	Title of article (translated)	Journal
1926	Ricardo Monges López	Brief study on the philosophical grounds for Einstein's Theory of Relativity	Memorias de la SCAA Journal of the SSAA
1927	Manuel Sandoval Vallarta	On the relativist theory of wave mechanics	Memorias de la SCAA Journal of the SSAA
1931	Manuel Sandoval Vallarta	Research on the relationship between Quantum Theory and the Theory of Relativity	Memorias de la SCAA Journal of the SSAA

The first book on Relativity was published in Mexico in 1923, written by a Mexican engineer, Juan Mateos, and entitled: *Explicación elemental de las Teorías de Einstein sobre la Relatividad y la Gravitación* (An elemental explanation of Einstein's Theories on Relativity and Gravitation).

The Journal of the Mexican Society of Civil Engineers reproduced some articles published in other countries such as: "The theory of relativity" by L. Bolton, and "The validity of Einstein's doctrines" (1923), Engineer publishers, London. The first won an award for the best article spread on the Theory of Relativity in the United States, and the second is a critique on the truthfulness of observations that apparently confirm the theory of Relativity. The latter concludes by stating that men of science have accepted relativity, not because of its rationality, but because it offers a means of escaping from this intangible, confusing and complicated fluid (ether).

Returning to our list of articles published by Mexican professors, we find that most articles were published in the *SCAA Journal* during the 1920s and into the 1930s, and that they analyze both Special and General Relativity. Also, most are articles that do not question, but rather explain the theory of relativity. Most of these articles cite references from books published in other countries, to explain clearly and in the simplest way possible the concepts, philosophy, mathematics and theoretical models required to understand this theory.

We can classify the articles at two levels: first, those written for a non-specialized audience and in which great efforts were made to avoid including mathematics tools, and rather, to explain the theory at a conceptual level. The second group includes writings for a group of people who are very familiar with concepts of classic physics as well as the necessary mathematical tools for understanding relativity (for example, differential equations). The articles for dissemination cite references such as: John Haldane, "Reino de la Relatividad" and Herman Mikowski, "Raum und Zeit" (Space and Time).

We can see that the research articles were written by a single author, a Mexican physicist, Manuel Sandoval Vallarta, who did not reside in Mexico but instead, was completing his graduate studies (since 1917) at the Massachusetts Institute of Technology (MIT). Sandoval Vallarta was the first Mexican to conduct research in the field of Relativity. He finished his doctorate in 1924 with a thesis entitled *Bohr's Atomic Model from the Standpoint of the General Theory of Relativity and of the Calculus of Perturbations*. In 1927 he traveled to Germany and studied with Einstein, Planck, Schrödinger, von Laue, Reichenbach, von Harnack, Heisenberg and Debye. And there, he met J. Von Neumann, E. Wigner, and others. He returned to MIT the following year, and was hired as a professor's assistant, and later as a professor until 1943. His contact with the creators of physics in Europe and the United States made it possible for him to begin a brilliant academic career, and explains why

in his articles he cited, not books for dissemination, but rather transcendental articles published in specialized journals such as: Abraham, M., “Theorie der Elektrizität”, vol. 2, Leipzig 1920; Bohr, N., “Quantentheorie der Linienspektren”, Braunschweig 1923; De Donder, T., “La Gravitique Einsteinienne”, Paris 1921; Eddington, A. S., “The Mathematical Theory of Relativity”, Cambridge 1923; Einstein, A., “Hamiltonsches Prinzip and allgemeine Relativitätstheorie, *Berichte der preussischen Akademie der Wissenschaften*, vol. 42, 1916; Grossmann, *Astronomische Nachrichten*, vol. 214, *Zeitschrift für Physik*, vol. 5, 1922; Gehreke, E. Lan, “Ober die Feinstruktur der Balmerserie”, *Annalen der Physik*, vol. 67, 1922; Jaffé, G., “Bemerkungen über die relativistische Keplerellipse”, *Annalen der Physik*, vol. 67, 1922; Lenard, P., *Über Aether und Uräther*, Leipzig 1921; Longo, C., “Legge elettrostatica elementare nella teoria di Einstein”, *Il Nuovo Cimento*, vol. 15, 1918; Lorentz, H. A., “Het beginsel van Hamilton in Einsteins theorie der zwaartekracht”, *Verslag koninklijke Akademie van Wetenschappen te Amsterdam*, vol. 23; Nordström, G., “On the energy of the gravitational field in Einstein’s Theory”, *Verslag Koninklijke Akademie van Wetenschappen te Amsterdam*, vol. 26, 1918; Paschen, F., “Bohrs Heliumlinien”, *Annalen der Physik*, vol. 50, 1916; Sandoval Vallarta, M. (Tesis de doctorado), “Bohr’s Atomic Model from the Standpoint of the General Theory of Relativity and of the Calculus of Perturbations”, MIT, 1921; Schwarzschild, K., “Ober das Gravitationsfeld eines Massenpunktes nach der Einsteinschen Theorie”; Sommerfeld, A., “Ober die Quantentheorie der Serienspektren”, *Annalen der Physik*, vol. 51, p. 53, 1916; Sommerfeld, A., “Atombau und Spektrallinien”, *Berichte der preussischen Akademie der Wissenschaften* 1916; , Braunschweig 1922; Vanderlinden, H., “Sur la théorie gravitique de l’électron de Poincaré”, *Bulletin de l’Académie Royale de Belgique*, 1921; Van der Berg, W., “Vraagstukken uit Einsteins gravitatiethorie”, Diss. Haarlem, 1920; Weyl, H., “Zur Gravitationstheorie”, *Annalen der Physik*, vol. 54, 1917; Weyl, H., *Raum, Zeit, Materie*, Berlin, 1923; Wittaker & Watson, *Modern analysis*”, Cambridge, 1916; De Broglie, Louis, *Ondes et Mouvements*, Paris, 1926; De Donder, T., *The Mathematical Theory of Relativity*, Cambridge, 1927; De Donder, T., *La gravifique Einsteinienne*, 1921; Epstein, P. S., *Proc. Nat. Academy of USA*, 1927; Fock, V., *Zeitschrift für Physik*, 1926; Richter, C. F., *Proc. Nat. Academy of USA*, 1927; Sandoval Vallarta, M., *Journal of Mathematics & Physics*, 1925; Sandoval Vallarta, M., *Memorias de la Sociedad Alzate*, 1924; Schrödinger, *Abhandlungen zur Wellenmechanik*, Leipzig, 1926; Sommerfeld, A., *Atombau und Spektrallinien*, Braunschweig, 1924; Struik, D.J. & Wiener, N., *Nature*, 1927

Sandoval Vallarta’s knowledge of several languages – including French, English and German – allowed him to consult original articles written by the creators of science. From 1924 to 1932 he published several articles on Relativity in the most prestigious physics journals in the world, including: “Sommerfelds’s Theory of Dynamic Stresses in Rotating Gear Pinions”, *Journal of Mathematics and Physics* (1924); “Unified Field Theory of Electricity and Gravitation”, *Nature* (1929); with N. Wiener: “On the Spherically Symmetrical Statical Field in Einstein’s Unified Theory: A correction”, *Proceedings of the National Academy of Sciences. U.S.*, (1929); with N. Wiener “The Unified Field Theory and Schwarzschild’s Solution: A Reply”, *Physical Review* (1930); with N. Rosen “The Spherically Symmetrical Field in the Unified Theory”, *Physical Review* (1930); with N. Rosen “Relativity and the Uncertainty Principle”, *Physical Review* (1932). In 1932, when Sandoval Vallarta was in Mexico on vacation, he helped Arthur Compton to make measurements and observations of cosmic rays radiation, since the nature of these

rays had not yet been determined. This area of study captured his attention to such a degree that he decided to dedicate his academic career to developing this field, working together with Georges Lemître. In a very short period of time, both had obtained international fame for their contributions. His prestige also influenced the way in which physics developed in Mexico, and for many years, the main line of research at the Institute of Physics was precisely Cosmic Rays.

Because of his popularity in Mexican academic circles, he won the admiration of various students, including a young engineering student, Carlos Graef Fernández, who decided in 1937 to study in a physics graduate program at MIT under his direction. Graef wrote his doctoral dissertation on cosmic rays and upon his return to Mexico (in 1941), he began to hold posts with responsibility for directing scientific research departments. In Mexico in 1943, Graef met (in Puebla, at a conference) with a great US mathematician, G. D. Birkhoff, who only the year before had proposed a new theory of gravitation as an alternative to Einstein's general theory of relativity.

As a result of this meeting, Graef dedicated the rest of his life to working in the field of Relativity and Gravitation. Another consequence was that Sandoval Vallarta collaborated with Graef, Birkhoff and the Mexican mathematician Alberto Barajas to work on Birkhoff's theory, however he left this work when Birkhoff died in 1944. Together, they had published an article that became very popular, "On Birkhoff's new theory of gravitation", *Physical Review* (1944). Even Einstein became interested in this theory, and invited Graef to his home to discuss arguments around this theory. At that time Graef was teaching a course at the Harvard University. Based on this experience, Graef published a 1956 article entitled "My tilt with Albert Einstein" in *American Scientist*.

In Mexico, Graef was a pioneer in developing Relativity and Gravitation as fields of research; he taught undergraduate and graduate courses at the Facultad de Ciencias – *School of Sciences* – at Mexico's National Autonomous University; he incorporated Relativity as an area of research at the Institute of Physics; he published various articles in both national and international journals; he was an advisor for various theses; etc. Nevertheless, the impulse he gave to this field of study was never comparable to the great effort and attention given to the development of science and the nuclear industry in Mexico. Perhaps for this reason, the first research groups in the field of Relativity and Gravitation were not established until the 1960s, when new researchers with doctorates from other countries joined Mexico's National Autonomous University and National Polytechnic Institute.

Conclusions

The spread of Relativity began in Mexico in 1921. Mexican professors (in physics and mathematics) were those primarily interested in, and those who spread the Relativity. Most articles were written for public dissemination and describe both the Special Theory and General Theory of Relativity. The articles written for public dissemination are based on books written by foreign authors for a broad audience. The Mexican physicist Manuel Sandoval Vallarta was the first to publish research articles in 1924, and cite publications by the creators of physics, some of who were his professors in Germany. The Mexican physicist Carlos Graef Fernández, one of Sandoval Vallarta's students, was the first in Mexico to promote the development of Relativity and

Gravitation as areas of research. Graef and Einstein spoke to each other on one occasion at Harvard. Einstein did not come to Mexico, although he was invited.

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Die Relativitätsrezeption in Mexiko

Zusammenfassung

Als Albert Einstein 1905 seine ersten Abhandlungen über die Spezielle Relativitätstheorie veröffentlichte, gab es in Mexiko noch keine wissenschaftlichen Einrichtungen für Physik, auch keine Schulen für die Ausbildung einschlägiger Fachleute. Deshalb begann die Rezeption der Allgemeinen Relativitätstheorie und der Speziellen Relativitätstheorie erst 1921 als Ergebnis der Arbeit und Begabung zahlreicher mexikanischer Physiker und Mathematiklehrer (vorwiegend Ingenieuren). Sie hielten ihre Vorlesungen und entsprechende Kollegs an der Escuela Nacional de Ingenieros (Nationale Ingenieurschule) und der Escuela Nacional de Altos Estudios (Nationale Hochschule). Beide gehörten der Universidad Nacional de México (Nationale Universität Mexiko) an, gegründet im Jahre 1910.

Schlüsselwörter

Spezielle Relativitätstheorie, Rezeption, Mexico

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Réception de la relativité au Mexique

Sommaire

Quand Albert Einstein a publié ses premiers travaux sur la Théorie de la relativité restreinte en 1905, au Mexique il n'existait point d'établissement de recherches en physique ni d'établissement qui formeraient des physiciens. Par conséquent la diffusion de la théorie de la relativité générale et de la théorie de la relativité restreinte n'a commencé qu'en 1921 grâce au travail et au talent de nombreux physiciens mexicains, de professeurs de mathématiques (pour la plupart ingénieurs) qui tenaient leurs cours à l'Escuela Nacional de Ingenieros (Ecole Nationale des Ingénieurs) et l'Escuela Nacional de Altos Estudios (Ecole des Hautes Etudes), les deux écoles faisant parties de l'Universidad Nacional de México (Université Nationale du Mexique) fondé en 1910.

Mots clés

Théorie de la relativité restreinte, réception, Mexique