The Portuguese Academic Community and the Theory of Relativity[1]

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Abstract

The theory of relativity was a scientific subject that interested a small number of Portuguese scientists in the first decades of the twentieth century. Portugal was associated with the observational confirmation of general relativity — observations of the solar eclipse were carried out on the island of Príncipe; however, no Portuguese astronomers took part in the scientific expedition. International seminars, led by foreign scientists and held in Portugal at the beginning of the 1920s and 1930s, were important. A few Portuguese mathematicians, rather than physicists, were first attracted to this theory and the few academic papers dealing with it were published abroad by two members of this group.

Keywords

History of Science, Science in Portugal, Theory of Relativity

One of the areas of greatest interest to researchers in the field of the history of science is the study of the process of appropriation of new scientific theories in countries that can be classified as peripheral in terms of their scientific output. Peripheral countries are those whose academic community is distanced from advanced centers in terms of the research they produce and that have participated to a lesser extent in the process of scientific creation. Like many other countries, the Portuguese academic community finds itself in this situation. Recent studies on the history of relativity have extended to comparative studies on its early reception in various countries (GLICK, 1987 and EINSENTAEDT, 1992). In this article, we do not present a comparative study, but report the principle facts regarding the way in

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which the Portuguese academic community began learning about the arguments presented by the new theory of relativity, which gave rise to a new paradigm in contemporary physics. And what better occasion is there to do this than in the centennial year of 2005?

Introduction

At the beginning of the twentieth century, physics was taught at the only university in Portugal, the *Universidade de Coimbra*, an institution which jealously guarded its privileges and staunchly defended its monopoly on university education at the *Faculdade de Filosofia* and the *Faculdade de Matemática*. At the former, the physics course was phenomenological and experimental in character, which accentuated its applied nature, while the latter courses did not cover general physics, but only specific disciplines such as mechanics and its application to astronomy. Meanwhile, there were other schools of higher education in Portugal, the *Escola Politécnica* in Lisbon and the *Academia Politécnica* in Oporto, which trained engineers and taught physics and mathematics. During this period, the role of the university and the other schools of higher education was essentially to transmit knowledge, to train senior technical officers working in public administration and education, and to provide training to the standards required by certain professions. University professors were not expected to carry out scientific research as part of their job, and there were no incentives for them to do so.

With the advent of the Republic in 1910, important reforms were introduced in higher education: the Decree of 12 May, 1911 provided for the establishment of the two new universities of Lisbon and Oporto, and the creation of *Faculdades de Ciências* at both the new universities and at the old *Universidade de Coimbra*. The Lisbon Faculty of Sciences replaced the *Escola Politécnica*, and the Oporto Faculty replaced the *Academia Politécnica*; in Coimbra, the new Faculty brought together the former Faculties of Philosophy and Mathematics. Besides the creation of these new Faculties, the reforms aimed at fostering scientific research at the university level. Within a very short period, university teaching was reorganized to a certain extent. This arose from the need to grant scholarships to some teachers in order for them to update their scientific training at laboratories in scientifically advanced countries.

During the period between the two world wars, the theory of relativity was not ignored: various articles either referred to it or discussed it; the theory was the subject of academic reports, university courses, some papers presented at congresses and also a very small number of pieces of research carried out in the field of mathematics; ideas were expressed both for and against the theory.

Preliminaries of the Expedition to the Island of Príncipe

In a dissertation which was presented with his application in 1912 for the post of Lecturer in Philosophy at the new *Faculdade de Letras da Universidade de Lisboa*, Leonardo

Coimbra (1883-1935), a young mathematics graduate at the *Academia Politécnica* in Oporto, discussed Lorentz-Fitzgerald's transformation equations, accompanied by a discussion of the principle of relativity and the Michelson-Morley experiment (COIMBRA, 1983). His aim was not to produce a scientific explanation, but to provide material suitable for philosophical reflection. In this work, special relativity is discussed, on the basis of an article by Langevin (LANGEVIN, 1912). Leonardo Coimbra adopted the argument of the French scientist: the discussion developed around the principle of relativity and not around a new theory; the principle was not then understood as a postulate of a new theory but as an experimental fact resulting from the negative experience of demonstrating the movement of the Earth in relation to ether. Although his writings were always marked by philosophical arguments, this author later dealt with relativity in texts, also within the framework of philosophical speculation, which he published in the 1920s in the cultural journal, *Águia* (FITAS, 2000). No scientific or philosophical reaction to these papers was published in this journal or elsewhere.

A perusal of domestic scientific journals shows that up to the end of the 1920s, there were practically no references to relativity, with the exception of a short article by Costa Lobo (1864-1945), a mathematician and professor of astronomy at the *Universidade de Coimbra*. Among other statements, Costa Lobo quoted Thomas J.J. See, an American astronomer, with the following words: "in Einstein's chimerical theory, gravitation is not a force but a property of space" (LOBO, 1917: 611). And, some lines below, he made a reference to his own theory which he intended as a physical explanation for gravitation, where "radiation produces the gravitational phenomena (…) [a theory] which has its foundations in facts ascertained about radioactivity" (LOBO, 1917: 612). This was a theory which Costa Lobo presented in lectures he gave in Spain. These statements are enough to understand his anti-relativistic positions and the presumption that his own theory explained gravitation without the presence of the Newtonian property of instantaneous action.

Portugal was linked indirectly to the important scientific tests confirming the predictions of the general theory of relativity; as is well-known, a group of astronomers led by Sir Arthur Eddington carried out observations on Príncipe, an equatorial island administered by Portugal. According to the report published by the English expedition (DYSON, 1920), there were previous contacts with the Portuguese scientific community, namely with those responsible for running the *Observatório Nacional da Ajuda*, and the names of Vice-Admiral Campos Rodrigues (1836-1919) and Dr. Francisco Oom (1864-1930) were mentioned. Two years earlier, in an article about the quality of observation of the future eclipse on the island of Príncipe, Dr. Oom had predicted that it would attract "(...) many of the astronomers who are especially interested in this type of phenomenon" (OOM, 1917: 97). Despite the interest manifested by this astronomer in the observation of the phenomenon that would occur in 1919, no Portuguese astronomer took part in the Eddington expedition (GAGEAN, 1992). Royal Society astronomers also visited Brazil in order to make observations; in contrast to Portugal, Brazil provided a team of astronomers who, besides carrying out their own observations, closely followed the work of the English expedition (EINSENSTAEDT, 1995).

The success of the verification by observation of the predictions of the general theory of relativity would thrust its author into the limelight, and men of culture from all over the world, and especially the scientific community, would shower praise upon him. In his paper in 1915 on the theory presented to the Prussian Academy of the Sciences, Einstein underlined that his success in discovering the written equations corresponded to "a true triumph of the methods of the general differential calculus developed by Gauss, Riemann, Cristoffel, Ricci (…)" (BOYER, 1991: 624). This recognition could explain, along with the dense mathematical theorizing used in constructing his theory, why it was that general relativity aroused greater interest among mathematicians than physicists.

The academic atmosphere existing in Portugal at that time reflected this general tendency, which explains the much greater degree of receptivity to the new theory among Portuguese mathematicians. The mathematical tradition in Portugal accorded special interest to certain domains of applied mathematics, such as mechanics, mathematical physics, astronomy and geodesy. This characteristic of our mathematics is clearly shown by the compilation presented by a historian of mathematics at the beginning of the 20th century (GUIMARÃES, 1900). Till the end of the 1930s, Portuguese mathematicians were always somewhat removed from subjects such as the set theory, mathematical theories of logic and topology, and they did not show any interest in methods relating to the foundation of mathematics. According to a Portuguese mathematician, when discussing the Italian school of mathematics (Volterra, Levi-Civita and Enriques), "besides the fact that one of the most important founders of mathematical logic was an Italian (Peano), all of them had an unlimited faith in intuition with a strong depreciation of mathematical logic" (SILVA, 1978: 519). Levi-Civita[2] was one of the most important members of the Italian mathematics school who at that time had intellectual relations with the best-known Portuguese mathematician Francisco Gomes Teixeira (1851-1933).[3] These connections can explain how the influence of the Italian school was decisive in determining both the mathematical thought and the topics of academic research engaged in by the large majority of Portuguese mathematicians and university teachers in the period before the Second World War.

A Lecture at the First Portuguese-Spanish Congress for the Progress of the Sciences

The first Portuguese-Spanish Congress for the Progress of the Sciences was held in Oporto in 1921. The guest speaker at the inaugural session of the Mathematics section was

[2] Tullio Levi-Civita, one of Ricci's most remarkable pupils, developed Absolute Differential Calculus into what we now call the theory of tensors, a fundamental mathematical tool for General Relativity; there was a very fruitful correspondence between him and Einstein.

[3] Levi-Civita published a paper in the *Universidade do Porto* scientific journal which was edited by Gomes Teixeira — Tullio Levi-Civita (1913). Sur les systèmes linéaires à deux inconnues, admettant une intégrale quadratique. *Anais scientificos da Academia Politécnica do Porto*, 7(4), 193-206).

José Maria Plans y Freire,[4] who opened his lecture with a special greeting to Francisco Gomes Teixeira and stated that "Einstein's theory is the scientific event with the greatest degree of transcendence at the present time, so it seems to me that this theory is the best choice as a topic for this lecture" (PLANS Y FREIRE, 1921: 24). And, at the end of his lecture, as a conclusion, he said: "Einstein's relativity and gravitation theory has rendered great services to absolute differential calculus, in the hands of Ricci and Levi-Civita, which is the most suitable discourse for studying space-time" (PLANS Y FREIRE, 1921: 40). At the beginning of 1921, in February, Levi-Civita visited Madrid and Barcelona, where he gave important lectures about "Classical and Relativistic Mechanics" and Plans y Freire is known to have attended these lectures (GLICK, 1986: 122). In the absence of regular contacts between Portuguese mathematicians and those abroad, the words of the Spanish colleague very probably provided a stimulus for the interest of Portuguese mathematicians in knowing more about Einstein's theory, carrying out mathematical research connected with general relativity and reinforcing mathematical links with the work of Levi-Civita. His lecture made such a profound impression on his Portuguese counterparts that, in 1922, a proposal was put forward that he should become a member and foreign correspondent of the *Academia das Ciências de Lisboa*. Pedro José da Cunha (1867-1945), Professor of Differential and Integral Analysis at the *Faculdade de Ciências da Universidade de Lisboa*, another mathematician, was responsible for making this written proposal (CUNHA, 1923).

The attention that some Portuguese mathematicians began to lavish on the new theory and the enthusiasm they began to show for it can be vividly and briefly illustrated by two events, described as follows. The first concerns a paper entitled "*L'enseignement des mathématiques doit être orienté pour l'étude de la Relativité*", which was written to be presented at the International Mathematics Congress held in Toronto in 1924; the author was Augusto Ramos da Costa (1875-1939), Senior Professor of Astronomy and Navigation at the *Escola Naval* and of Topography and Geodesy at the *Escola do Exército*, an enthusiastic supporter of the theory of relativity, who had already published two short books on the subject.[5] The second event is concerned with the Ph.D. dissertation presented to the *Universidade de Lisboa* in 1925 by Victor Hugo de Lemos (1894-1959), which, being a strictly mathematical work on tensorial calculus, contained in its foreword the following passage: "Thus, given the importance of a knowledge of tensorial calculus for the study of the general theory of relativity, justification for the presentation of this paper is based on the desire to further encourage the growing number of individuals who are participating in the informed discussion of the scientific worth of the theories of Einstein" (LEMOS, 1925: 2). Thus, if, on the one hand, the aim was to subordinate mathematics teaching to the demands

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[4] This Spanish mathematician won a prize awarded by the *Academia de Ciencias Exactas de Madrid* in 1919 for a piece of work in which "the new concepts of space and time" were explained: it was later published in 1921 under the title of "*Nociones fundamentales de Mecanica relativista*" (GLICK, 1986: 125). Besides having authored several works linked to General Relativity, José Maria Plans y Freire translated Eddington's book, entitled "*Space-time and Gravitation*", published in Spain in 1922 (the English and French editions were published in 1920 and 1921, respectively).

[5] A. Ramos da Costa (1921). *A Teoria da Relatividade*. Lisbon: Biblioteca Nacional. A. Ramos da Costa (1923). *Espaço, Matéria, Tempo ou a Trilogia Einsteiniana*. Lisbon: Imprensa Lucas e Cª.

of Einstein's theory, on the other hand, these same demands provided the *raison d'être* for studying certain mathematical themes.

At the 2nd Portuguese-Spanish Congress for the Progress of the Sciences, held in Salamanca, Costa Lobo gave a lecture in which he took advantage of the occasion to explain once more his own theory, already mentioned earlier, which was in obvious contradiction to the theory of relativity. He wrote: "The main purpose of this short paper is to make known a principle which, with an absolute formula, allows us to consider the constitution of the universe, and it is based on radioactive phenomena that can give an explanation of all observed phenomena" (LOBO, 1923: 481). This meant that "once the dissociation of matter is observed we should accept all the consequences (...) It is the disintegration of matter which is able to give all the elements that make up the universe, and it is based on this knowledge that we can explain all phenomena" (LOBO, 1923: 480). This is a new sort of ether in which all points of space are sources of radiant matter supporting all forces, especially gravitation; a sort of ether whose characteristic was diffusivity rather than vibration for wave propagation. The defeat of the concept of ether was the cornerstone distinguishing supporters of relativistic ideas from those who were opposed to them. Costa Lobo was a supporter of a very peculiar form of radioactive ether, and obviously he had an anti-relativistic position, which he persisted in exhibiting at international meetings. For Costa Lobo, as for other physicists and mathematicians, the important thing was to preserve the medium by which it was possible to transmit all forces or all actions; in a speculative way, he imagined a space full of "radiant matter", which supported all interactions.

A singular course

It was in one of the disciplines - Mathematical Physics - of the Mathematics degree course offered by the *Faculdade de Ciências da Universidade de Lisboa* that this new theory was taught in Portugal for the first time, in the academic year of 1922-23. The disciplinary program taught by Professor António dos Santos Lucas (1866-1939) consisted exclusively of special relativity and general relativity. Thus, the new theory became the subject of lectures at Portuguese universities for the first time, and it was students of mathematics, rather than physics, who had the first contacts with the new theory.

At the *Museu de Ciência da Universidade de Lisboa*, there is a two-volume manuscript transcription of this course authored by one of the students who attended the lectures (PINTO, undated). The material contained in the first volume is divided into two parts: Lorentz's transformation and special relativity, where a good number of pages pay attention to the discussion of the "ether problem" and the Michelson-Morley experiment. The second volume is made up of three parts: in the first of these, there is an introduction with notions of tensorial calculus; the second deals with the theory of general relativity; and the third part deals with "confirmation of the theory".

At the end of the manuscript, there is a list of "books consulted", which can be regarded as a proposal for a bibliography; it overwhelmingly comprises works in French and there is a short comment next to each reference. The fact that this information has been handwritten by a student, along with the nature of the comments made, indicate that they were not the work of Dr. Santos Lucas. However, because it seems improbable that a student might know

all the books cited, one can guess that the professor contributed his opinions. The works which appear on the list, cited in the comments as being "the best of all" or "the Books by the Masters which everyone must read", are those by Eddington and Weyl (French editions). Three booklets by Einstein, also published in French, are referred to: "*La Théorie de la Relativité*", "*L´éther et la théorie de la relativité*" and "*La Géometrie et l'expérience*"; the works of W. de Sitter also feature: "*On Einstein's theory of gravitation and its astronomical consequences*"; Jean Becquerel's book, "*Le Principe de la Relativité et le Principe de la Gravitation*", is described as "very good", while "the book with the clearest explanation that I know of" is the epithet attributed to "*Initiations aux Théories de Einstein*" by Gaston Moch; Max Born's "*La théorie de la Relativité d'Einstein et ses bases physiques*" is classified as "very reasonable"; the book by Plans y Freire, entitled "*Nociones fundamentales de Mecanica relativista*" receives the following comment: "This was the book we used most in our course (…)". A note on this last comment: it reinforces the idea already expressed in this paper about the influence of the lecture by Plans y Freire on Portuguese mathematicians.
The predominance of French titles in the bibliography should be stressed, indicating the extremely powerful influence exerted by French culture at Portuguese universities, which was certainly also a factor that conditioned the way in which Portuguese university scholars gained knowledge about advanced scientific research works, especially those carried out in the fields of physics and mathematics. Among the works consulted, there are none in German and, even for works originally published in English, the French translation is often cited.

Comparing the outline of this course with the work of Plans y Freire, there is no doubt that Santos Lucas closely followed the latter: the organization and order of chapters is practically the same, although in many of his sections he clearly moves away from the more complex mathematical treatment employed by the Spaniard. Accepting the student transcription, Santos Lucas seeks to accentuate, beyond the physical interpretations of formulae, the physical reasons for the development of the theory and, with regard to this particular point, the influence of Jean Becquerel's course is manifest. These considerations should be regarded with some caution because nothing is known about the reconstruction work carried out on the lessons by the student "compiler".

This course can be regarded as being singular due to the fact that, although during the following decades both professors of physics and professors of mathematics included relativity as a topic in their courses, it was in this particular course that, over a period of many years, this theory constituted the sole topic of an annual disciplinary program.

Portuguese Physicists and the New Theory: Two Disputes Arise

José de Almeida Lima (1859-1930), an academic and professor of physics at the *Faculdade de Ciências da Universidade de Lisboa*, presented a paper on relativity at the plenary sessions of the *Academia de Ciências de Lisboa* on 7 and 13 July 1921. This paper had the purpose of conducting a very general and philosophical discussion about Einstein's theory, a discussion completely free of mathematical language and carried out in a speculative form around the new concepts. The author quotes the main authors of the new theory: Lorentz, Fitzgerald, Michelson, Morley and Einstein and, on Lorentz's conclusion

on the contraction of space, he writes: "My common sense as an ordinary individual tells me that such a conclusion would be considered as absurd (...) however, this conclusion was accepted by Einstein, and even considered as fundamental for his theories" (LIMA, 1923: 101). A few lines further on, he writes, "in truth, it is difficult for me thus to view the march of progress mercilessly advancing in a construction that I have always considered as the most beautiful that human genius has created" (LIMA, 1923: 101), referring to the disappearance of the concept of ether, which he refused to accept. To support his belief that the concept of ether was needed to understand physical phenomena, he defended the concept of Costa Lobo (LIMA, 1924: 102). He did not mention any references and from the nature of his text we are led to believe that his knowledge of the theory was not based on publications of an assumedly scientific nature. It is not difficult to understand that he advocated common-sense opinions as against Einstein's conclusions; he was a great supporter of ether as a fundamental concept of all physics, a concept that the theory of relativity completely cast aside.

It was in the 1930s that physicists began to turn their attention to the theory in a more concentrated fashion. Portugal had to wait until late 1929 for a visit by an illustrious physicist and a pioneer in the debate involving relativistic ideas, Paul Langevin. This visit and the return from different European countries of the first physicists holding scholarships from the *Junta de Educação Nacional* together provided a stimulus for the topic of relativity to begin to be included, slowly and sporadically, in physics teaching, although during this period it was never the subject of any research on the part of physicists.[6] Only mathematicians attempted to carry out some research.

Paul Langevin traveled to Portugal under the aegis of the *Instituto Francês de Portugal* and represented the *Collège de France* at the ceremonies held to mark the third Jubilee of the *Academia de Ciências de Lisboa* (ACADEMIA, 1931: 432), and his presence was taken advantage of for the holding of conferences at the Universities of Lisbon, Coimbra and Oporto.[7] At the *Faculdade de Ciências da Universidade de Lisboa* he gave four lectures.[8] It should be underlined that in his first lecture Prof. Langevin emphasized the philosophical aspects of relativity. A reporter for an influential Lisbon daily newspaper wrote the following about the first lecture in Lisbon: "(...) Many students and academics gathered to hear his speech (…) Admiral Gago Coutinho represented Portuguese scientists from outside the laboratories of knowledge: the universities (...)".[9]

Following this visit, an interesting exhibition was held in Lisbon at the *Biblioteca Nacional*, inaugurated in April 1930, although it was "supposed to have opened sooner, between 5 and 15 December 1929, coinciding with the visit of Paul Langevin to this country" (RUA, 1997: 161). It was entitled the "Physics Exhibition" and, in the catalogue, the Director of the National Library wrote that at this institution "(...) there arrived orders for books in the domain of physics covering the new fields of the theory of relativity,

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[6] The "National Board of Education" was a body established in 1929 with the aim of promoting and funding academic research, as well as providing grants for study at home and abroad.

[7] *O Século*: 3/12/29, 5/12/29, 6/12/29, 7/12/29, 10/12/29, 11/12/29.

[8] "Valor filosófico da teoria da relatividade", "A nova mecânica e a inércia da energia", "A confirmação da relatividade restrita" and "Os desenvolvimentos recentes da Relatividade Generalizada".

[9] *O Século*: 3/12/29.

ondulatory mechanics and quantum theory" (BIBLIOTECA, 1930: 6). This demand and the fact that the Director of the National Library was an old army officer and engineer with sound scientific training justified an exhibition of scientific papers in these domains. The catalogue contains the titles of the articles and books exhibited, which were written by a range of authors, including: Einstein, Poincaré, Langevin, Broglie, Cartan, Schörodinger, Whitehead, Bertrand Russell, Jeans, Planck, Sommerfeld, Bohr, Levi-Civita, Enriques, Eddington, Klein, Weyl, Minkowski and Lorentz. Relativity was thus established as a scientific theme that occupied a position of great prominence. The exhibition was inaugurated with due pomp and circumstance by the President of the Republic; however, we do not know what kind of impact it had in terms of the number of visitors. One curious note about the publications on display: none of the works by José Maria Plans y Freire that had so greatly impressed Portuguese mathematicians during the previous decade were included.

Upon attempting to hold a seminar at the *Laboratório de Física da Universidade de Coimbra*, during the academic year of 1930-1931, Mário Silva (1901-1977), one of the scholarship holders who had returned to Portugal after three years in Paris, having obtained a Ph.D. with Mme. Curie, declared his intention to "launch a discussion within the tiny Coimbra scientific community (...) of some new doctrines such as the quantum and relativity theories" (SILVA, 1971: 148). He invited Manuel dos Reis (1900-1993), a mathematician working in the field of mathematical physics, to give a speech entitled "*A Nova teoria do campo de Einstein*", which had not been published. In the book entitled "*Lições de Física*", a general physics textbook published at the beginning of the 1930s, Mario Silva explains the principles of relativist kinematics and makes reference to Langevin's visit to Coimbra (SILVA, undated: 49).[10] Throughout the decade, the principles of special relativity would be presented by Mário Silva in his mechanics and electromagnetism courses.

In the period between the two world wars, these were the main interventions made by physicists regarding the theory of relativity. It should be added that the lectures given by Langevin in Lisbon and the seminars held by Mário Silva in Coimbra would lead to the first two public confrontations between anti and pro-relativists in this country.

In 1930, Admiral Gago Coutinho[11] (1869-1959), who had already heard Einstein speak in Brazil (VIDEIRA, 1995), attended the lectures given by Paul Langevin in Lisbon, and was doubtless one of the most attentive individuals in the audience, as he wrote two articles for the journal *Seara Nova*[12] (COUTINHO, 1930a, 1930b), in which he reiterated the anti-relativist stance he had already taken up in Brazil and had also made known in a

[10] Taking place on 10 December and including a lecture entitled "*Teoria da relatividade restrita, suas consequências físicas e astrofísicas.*"

[11] Admiral Carlos Viegas Gago Coutinho, a well-known figure who, along with Sacadura Cabral, was the first person to fly from Europe (Lisbon) to South America (Rio de Janeiro) in 1922. Coutinho was an expert in aerial astronomy, a geographer and a hydrographer.

[12] *Seara Nova*, a journal of doctrine and criticism, was founded in Lisbon on 15 January 1921, and continued to be published until 1979 (no. 1599). Despite its political opposition to the Salazar dictatorship, censorship was not able to halt its publication.

domestic publication.[13] *Seara Nova* published the articles, having first engaged, for their scientific assessment, the services of the mathematician Manuel dos Reis, who manifested his complete disagreement with and total opposition to the views of Gago Coutinho. The cultural journal did not follow the scientific opinion of Manuel dos Reis and published the two articles by Gago Coutinho. Following these articles, *Seara Nova* published the critique by Manuel dos Reis (REIS, 1930).

The essential arguments of the Admiral were: he did not accept the synchronization of clocks only by means of electromagnetic signals, insisting on the existence of an absolute time; he accepted the existence of ether as a fundamental concept for the isotropic propagation of light; the principle that the velocity of electromagnetic waves is constant was denied because there was no experiment which confirmed this statement. In his writings, we immediately understand that he never refers to one crucial point: an electric body's movement did not obey the laws of Newtonian mechanics or, in other words, he never referred to the important contradiction between electromagnetism and mechanics. As regards the observational proofs of general relativity, Coutinho argued as follows: firstly, the deflection of the light from a star by the sun was not real and was an optical effect resulting from a special kind of atmosphere near the sun; secondly, for the motion of Mercury's perihelion, he sustained the hypothesis that gravitational law should have a different formula for greater distances.

In response to Gago Coutinho, and after a historical introduction to the special theory of relativity, Manuel dos Reis wrote: "in your critique there is no allusion to general electro-dynamics, which is the cornerstone of Einstein's theory" (REIS, 1930: 268). Judging by the nature of the arguments put forward, the anti-relativist position was refuted; however, the argumentation seems not to have been sufficient to shake Gago Coutinho's firm belief in Newtonian mechanics. Both men produced another article in response to the other's attacks, but the debate was not prolonged further.

Invited to the seminars organized by Mário Silva, Professor Costa Lobo spoke on a "*New Physics Theory Based on the Phenomena of Radioactivity*". The same topic would later be presented at the meeting of the British Association for the Advancement of Science in London on 30 September 1931, where he represented the homonymous Portuguese association. This paper in London was written and published in English. In his lecture and paper, Costa Lobo stated that he was merely recalling what he had already written some years earlier. And Costa Lobo, well-known for his rigid Newtonian stance, had manifested his opposition to relativity and quantum mechanics, repeating his arguments and writing that "in my opinion, however, there is an important fact which ought to guide us, which is the universality of Newton's laws" (LOBO, 1931: 62). He started by writing about "the disintegration of the atom into elements of matter, very small in relation to the atom and at considerable speeds" (LOBO, 1931: 64), which was enough to explain the reason why "gravitation leads us to admit enormous speeds in comparison with that of light; it is a

[13] On arriving back in Portugal, Gago Coutinho published an article in a Coimbra university journal based on the opinions he had expressed in Brazil, which was not contested by the Portuguese academic community. Its publication was perhaps owing to the anti-relativist complicity of Costa Lobo, the editor of the journal at that time (Gago Coutinho (1926). Tentativa de reinterpretação simples da Teoria da Relatividade Restrita. O *Instituto*, nos. 73 (3)-73 (4)-73 (5): 354-374, 540-565, 637-670).

consequence of the fact noted from the instantaneousness that is now admitted" (LOBO, 1931: 65) it was the diffusiveness of his "ether". And with this same ether, where there were no vibrations for wave propagation, he stated, some paragraphs earlier, that "the luminous ray is a suite of spheroidal corpuscles of very different dimensions (…) the luminous phenomenon is produced by the shock given to the retina due to corpuscular radiations of certain velocities and dimensions (…)" (LOBO, 1931, 62). Costa Lobo presented his theory about ether without any mathematical calculations, supporting his argument only with qualitative and speculative reasoning.

Facing the "new theory" brought to the public attention by this Portuguese scientific journal, which had appeared very recently – a theory of grotesque ingenuity in its reasoning, which went against the grain of the scientific developments of the previous hundred years – the professors of physics and chemistry at the *Faculdade de Ciências da Universidade de Coimbra* resolved at a meeting to write an article criticizing the stance adopted by Costa Lobo. Costa Lobo's theory was analyzed in detail and demolished point by point with mathematical arguments (BASTO, 1932). And so the debate petered out. One question remained, however: Mário Silva very probably knew the anti-relativistic positions of Costa Lobo, so why did he invite him to give such a lecture?

Research work

In Portugal, during the period between the two world wars, the only pieces of research associated with the theory of relativity were concerned with its mathematical bases, namely differential geometry, a subject that fell under the influence of Tullio Levi-Civita. The mathematician Aureliano Mira Fernandes (1884-1958), a graduate and doctor of the University of Coimbra, and a professor from 1911 onwards at the *Instituto Superior Técnico*, where he held the chair in rational mechanics, was the main author of this research. The results obtained were published from 1928 onwards in the prestigious Italian journal of the *Academia dei Lincei*. From 1928 to 1929, he published various brief notes linked to this theme.[14] Mira Fernandes was in contact with the Italian mathematician Levi-Civita, who acted as an intermediary for the presentation of various papers to the Italian Academy. These articles by Mira Fernandes were included in the "Physics Exhibition" at the *Biblioteca Nacional*, in the section entitled "*Teoria da relatividade e suas bases matemáticas*", and was accompanied in this section by the anti-relativist article by Gago Coutinho published in *O Instituto*, as well as by the two above-mentioned works by Ramos da Costa. The research

[14] A. Mira Fernandes, 'Sur l'écart géodésique de la courbure associée de Bianchi', *Rendiconti della R. Academia Naz. Dei Lincei*, 1928, (6), 7: 482-486; A. Mira Fernandes, 'Transports isoclines et directions associés', *Rendiconti della R. Academia Naz. Dei Lincei*, 1928, (6),8: 676-679; A. Mira Fernandes, 'Transports superficiels', *Rendiconti della R. Academia Naz. Dei Lincei*, 1929, (6), 9: 203-205; A. Mira Fernandes, 'Tensori associati ad un'ennupla vettoriale', *Rendiconti della R. Academia Naz. Dei Lincei*, 1929, (6), 9: 858-860. In his first note, Mira Fernandes based his work, as he wrote, on a publication of "Levi-Civita, published in 'Mathematische Annalen"' (vol.97, 1926)".

carried out in the 1920s by Mira Fernandes[15] was thus a solitary and singular act among Portuguese mathematicians and physicists. It is appropriate to remember that Mira Fernandes was not a teacher at a faculty of sciences but at an engineering school, which prevented him from forming a group of research students in his own school to carry out research into topics relating to General Relativity.

And he would continue to follow this path in the following decade, as a contributor to the development of General Relativity. Three memoirs were published in the *Rendiconti* in 1931, two in 1932, one each year in 1933, 1934 and 1935, and a further two in 1937. In the papers published in 1932[16] and 1933, he "develops and generalizes a unitary theory initially put forward by Infeld and Straneo (…) This "Unitary Theory of Mira Fernandes" was cited, among other publications, in "Synge's Treatise on General Relativity" (1960) (…)" (GAGEAN, 1991: 502). The compiler of his complete works, Vicente Gonçalves (1896-1985), wrote that "despite its possibilities, the unitary theory that Mira Fernandes conceived met the same fate as time has reserved for the other many similar attempts; but the analytical virtuosity of the author and his research should be noted" (GONÇALVES, 1971: XII).

Mira Fernandes was also responsible for putting forward a proposal that was approved at the session of 17 March 1932 of the *Academia de Ciências de Lisboa*, at which Einstein and Levi-Civita were nominated as corresponding members. The letter of thanks from Einstein is kept in the archives of the Academy.

In 1935, Rui Luís Gomes (1905-1984), a doctor in mathematical physics and a professor at the *Universidade do Porto*, who enjoyed a close relationship with Mira Fernandes, published a paper about special relativity (GOMES, 1938a). He was to include relativity as one of the themes taught in his mathematical physics course, and, in connection with an extra-curricular course at the *Instituto Superior Técnico*, he later wrote the first scientific textbook on special relativity published in Portugal (GOMES, 1938b). The introductory chapter shows the author's concern with considering the philosophical ideas underlying the construction of a theory of physics, and he adopts a neo-positivist stance (FITAS, 2000). In the citations, there is a particular preference for Reichenbach, the well-known neo-positivist philosopher.

After the publication of this book, a text by Admiral Gago Coutinho appeared in which he counter-attacked Rui Luís Gomes, "I thought, therefore, that I would not be forced to attack it (relativity) again; but the fact that a few months ago a university professor in Lisbon presented a paper on special relativity, just as Professor Langevin did some years ago, proved to me that the so-called new mechanics still has supporters (...)" (COUTINHO, 1937: 118). This citation gave rise to a series of articles in which contesting the theory of relativity figured as the central question, its immediate cause being the lectures given by Rui Luís Gomes in his extra-curricular course.

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[15] At the 4th Portuguese-Spanish Congress for the Progress of the Sciences (Cadiz, 1927) the inaugural lecture in the field of mathematics was given by Mira Fernandes and, although the term "relativity" is nowhere mentioned, his aim was to discourse on the evolution of the concept of space.

[16] A. Mira Fernandes, "Sulla teoria unitaria dello spazio físico", *Rendiconti della Real Academia dei Lincei*, 1932, 15: 797-804.

And Gago Coutinho's opposition continued to focus on two points: the speed of light as a constant, which had no experimental confirmation, and the impossibility of the isotropy of light without dragging the medium. Or, in other words, he did not accept one of the relativistic principles and, once more in a very concealed way, he did not accept the non-existence of ether. Rui Luís Gomes then published a paper criticizing Coutinho's anti-relativistic point of view (GOMES, 1938c). What had happened in the case of Manuel dos Reis was repeated, except that the debate extended over ten editions and a period of four months, and the journal was obliged to call a halt to it. The impact of this controversy led to *Seara Nova* publishing its own editions of the texts written by the two adversaries in popular book form.

Final Remarks

Firstly, the huge importance of the visit by the foreign scientists, Plans y Freire and Langevin, should be stressed as far as awakening an interest in relativity in the academic community. The Spanish scientist was responsible for arousing genuine scientific interest among the mathematical teaching community, while the French scientist, through his articles and lectures, helped influence the way in which the new theory was disseminated in the fields of physics and philosophy.

From an analysis of the range of papers, articles and books written, it is clear that the response of the Portuguese university community was initially centered above all on the comments made by professors of mathematical physics and astronomy, who were more closely linked to mathematics than physics. It was also mathematicians who first presented the new theory in university course programs and who carried out some research into aspects of mathematics related to general relativity. In the research topics that were developed, it is important to underline the influence of Tullio Levi-Civita.

Until the 1930s, relativity seems not to have interested Portuguese physicists scientifically and some of them were highly skeptical of the theory. However, from the 1930s onwards, thanks to the young researchers who had recently completed periods of training in scientifically more advanced European countries, physicists became more interested in the theory; this interest was evident at some seminars and led to its inclusion in university course programs in physics.

As far as the anti-relativistic reaction is concerned, it is important to mention the following points: firstly, the medium used for discussion was in particular a cultural journal published outside the accepted scientific or university circles; the common issue for all anti-relativistic interventions was their inability to conceive of a physics without ether and their misunderstanding of the role of electromagnetism in the foundations of special relativity; all their arguments were mainly qualitative and full of speculation, overlooking the need for one essential detail to prove conclusions with mathematical calculations; this controversy was useful for transmitting relativistic ideas to a wider audience the readers of these journals.

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