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THEMATIC DOSSIER
TOWARDS A GLOBAL HISTORY OF ECLIPSES.
ENTANGLEMENTS OF DISCIPLINES, ACTORS, AND PRACTICES

A Global History of the 1919 Total Solar Eclipse

Ana Simões **Cristina Luís** **Hugo Soares** **Samuel Gessner**

Centro Interuniversitário de História das Ciências e da Tecnologia, Faculdade de Ciências, Universidade de Lisboa, Portugal

aisimoes@fc.ul.pt cmluis@fc.ul.pt hmsoares@fc.ul.pt shgessner@fc.ul.pt

Luís Miguel Carolino

CIES-IUL, Iscte-Instituto
Universitário de Lisboa, Portugal

luis.miguel.carolino@iscte-iul.pt

Abstract: In this paper, we are looking at the British expeditions that observed the 1919 total solar eclipse in Sobral (Brazil) and Príncipe island as scientific practice embedded in their geographical, social, and world-political context. This fresh look makes steps towards a "global history" of this eclipse, and reports on contextual elements of the expeditions that have been hitherto "eclipsed" in the narratives that concentrated on the exchange of scientific arguments in a "world of ideas." What it may mean to think of the globality of the 1919 eclipse is presented followed by an analysis of four main dimensions of this globality that include actors in context, observing totality, the eclipse lineage, and eclipse on paper.

Keywords: 1919 solar eclipse; global history; actors; eclipse lineage; newspapers

Introduction

The 1919 total solar eclipse is perhaps one of the most famous eclipses ever. It was a long eclipse observed in its totality in places that were faraway for the European astronomers who participated in the campaigns, in the city of Sobral, the second city of the state of Ceará in Brazil, a country preparing to celebrate its one hundredth anniversary of independence from Portugal, and in Príncipe, a small island off the west coast of Africa, then part of the Portuguese empire and one the world's top cocoa exporters (Figure 1).

Two British eclipse expeditions were prepared during war times on the initiative of the Astronomer Royal, Frank Dyson, and co-organized by the astronomer, physicist and mathematician Arthur Stanley Eddington, director of the Cambridge Observatory, who went to Príncipe together with the expert on clockwork mechanisms Edwin Turner Cottingham. Two astronomers from Greenwich Observatory—Charles Rundle Davidson and Andrew Claude Crommelin—went to Sobral. They intended to test one of the predictions of a recent unorthodox theory put forward during the years 1915-16 by Albert Einstein, a physicist from Germany, a country at war with Britain. They would be joined by two other teams. A Brazilian team from the National Observatory in Rio de Janeiro, led by director Henrique Morize, would also be stationed in Sobral: their aim was astrophysical and concerned the solar corona. A team of American magnetic observers from the Carnegie Institution, composed of Daniel Wise and Andrew Thomson, would be in Sobral to take measurements of terrestrial magnetism and atmospheric electricity.

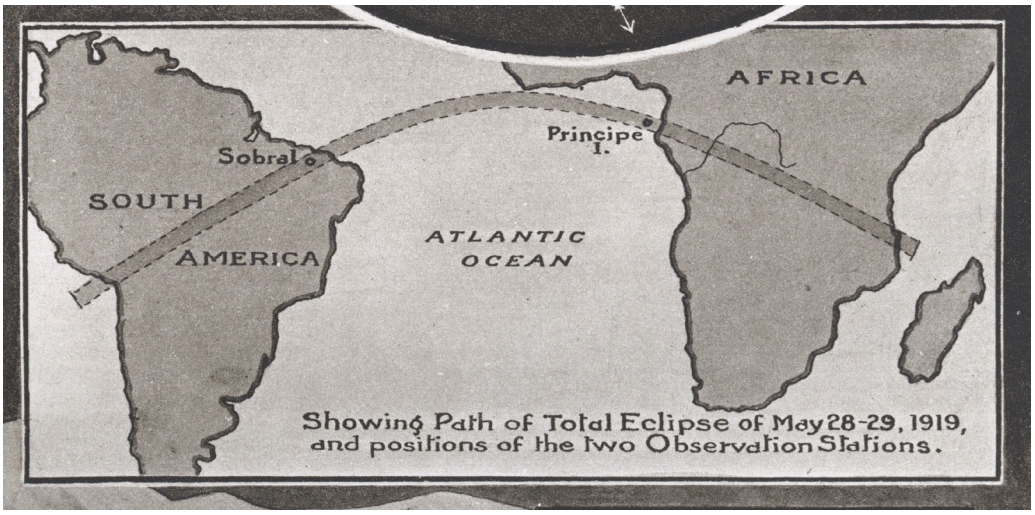

Figure 1. Map of the 29 May 1919 total solar eclipse totality zone and British eclipse expeditions and observations stations. Detail from "Starlight bent by the suns attraction", The Illustrated London News, 22 November 1919.

The success of the British teams in detecting the deflection of light rays passing close to the sun, showing agreement with a theory proposed by a German scientist, was immediately heralded as an illustration of collaboration among scientists beyond and above the political rivalries involving their countries. How this narrative was conceived and developed has been one of the aspects discussed at length in the historical literature.[1]

What the astronomers wanted to observe on the occasion of this eclipse were neither astrophysical properties of the solar corona or other solar effects, nor the presence of a hypothetical intra-mercurial planet, that were the typical topics of inquiry at the time. They wanted to record the background of stars behind the eclipsed sun as accurately as possible—which in this case included various bright stars of the constellation Taurus, in favourable positions for their objective. They intended to take pictures of the star background during totality, that is, when their light rays were passing in the vicinity of the Sun, and compare them with pictures of the same stars taken when the sun was not positioned between them and the earth. By comparing the pictures, they could check if apparent star displacements had occurred and quantify them to check to what extent these differences were in accordance with Einstein's quantitative prediction.[2]

In sum, this eclipse was singular in many respects: not only for its physical parameters such as duration—it lasted 302 seconds in Príncipe, 310 seconds in Sobral—, and the numerous stars in its field, but in particular because it was observed for reasons few astrophysicists cared about at the time. It would become the first successful experimental test of a groundbreaking conception of gravitation and spacetime, associated with an unusual mathematical formalism—general relativity replaced Newtonian gravitational force by the curvature of spacetime.

Thus, it is no wonder that historians of science in the past decades have devoted most of their attention to the eclipse's role in helping establish general acceptance of Einstein's general relativity in the aftermath of the observations. They have focused especially on Einstein's protagonism, on the intense discussions around his challenging new conception

[1] Matthew Stanley, "'An Expedition to Heal the Wounds of War': The 1919 Eclipse and Eddington as Quaker Adventurer," *ISIS* 93 (2003): 57-89; Matthew Stanley, *Practical Mystic: Religion, Science and A.S. Eddington* (Chicago: Chicago University Press, 2007); Matthew Stanley, *Einstein War* (New York: Dutton, 2019) and references therein; Daniel Kennefick, "Not only because of theory: Dyson, Eddington, and the Competing Myths of the 1919 Eclipse Expedition," in *Einstein and the Changing World Views of Physics,* eds. Christoph Lehner, Juergen Renn, and Matthias Schemmel, 201-32 (Basel, Switzerland: Birkhäuser, 2012); Alistair Sponsel, "Constructing a 'Revolution in Science': the Campaign to Promote a Favourable Reception for the 1919 Solar Eclipse Experiments," *British Journal for the History of Science* 35 (2002): 439-67.

[2] Frank Watson Dyson, Arthur Stanley Eddington, and Charles Davidson, "A Determination of the Deflection of Light by the Sun's Gravitational Field, from Observations Made at the Total Solar Eclipse of May 29, 1919," *Royal Society of London, Philosophical Transactions* A220 (1920): 291–333.

of gravitation, on alternative explanations of light bending as well as on the assessment of plate selection criteria and error measurements behind the presentation of results by Eddington and Crommelin at the joint session of the Royal Society of London and the Royal Astronomical Society on 6 November 1919.[3] This historiographical emphasis climaxed in books published in 2019, jumping on the centenary celebrations of the 1919 eclipse bandwagon, which synthesized former main arguments. Such was the case of Matthew Stanley's *Einstein War. How Relativity Conquered Nationalism and Shook the World*, which elaborated on his former argument that the peculiar war context has to be taken into account to assess Eddington's and Einstein's pacifism, the plea for internationalism in science and the reactions to relativity.[4] Or of Daniel Kennefick's *No Shadow of a Doubt. The 1919 Eclipse that Confirmed Einstein's Theory of Relativity*, which also expanded on his former analysis of the choices taken by both Eddington and Dyson in the analysis of plates to assess accusations of scientific bias.[5] The popular science book authored by Sylvester James Gates Jr and Cathie Pelletier, titled *Proving Einstein Right. The Daring Expeditions Which Changed How We Look at the Universe*, detailed the activities of German, American and British astronomers who proved Einstein right in what they dubbed "an epic tale of frustration, faith and ultimate victory." While all these books touched, in different degrees, on the two British expeditions and their pre-history, their main focus was on the agendas of Einstein and Eddington and the expeditions' impact on science and scientific consensus.[6]

Only a few studies have adopted different perspectives from the abovementioned publications. Also timed to appear during the centenary celebrations of the eclipse, the graphic novel *Einstein, Eddington and the Eclipse. Travel Impressions* opted to shift the focus of historical analysis from the expeditions' scientific repercussions to the eclipse itself and to the expeditions undertaken to test Einstein's claim.[7]

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[3] Among various examples we highlight: John Earman and Clark Glymour, "Relativity and Eclipses: The British Expeditions of 1919 and Their Predecessors," *Historical Studies in the Physical Sciences* 11 (1980): 49-85; Daniel Kennefick, "Testing Relativity From the 1919 Eclipse—A Question of Bias," *Physics Today* 62 (2009): 37-42; Daniel Kennefick, *No Shadow of a Doubt. The 1919 Eclipse that Confirmed Einstein's Theory of Relativity* (Princeton: Princeton University Press, 2019); John Stachel, *Einstein from B to Z* (Boston: Birkhäuser, 2002), 453-75; Stephen G. Brush and Ariel Segal, *Making 20th Century Science. How Theories Became Knowledge* (Oxford: Oxford University Press, 2015), 329-60.

[4] Stanley, *Einstein War.*

[5] Kennefick, *No Shadow of a Doubt.*

[6] Sylvester James Gates Jr and Cathie Pelletier, *Proving Einstein Right. The Daring Expeditions that Changed How We Look at the Universe* (NY: Public Affairs, Hachette book Group, 2019), 4.

[7] Ana Simões and Ana Matilde Sousa, *Einstein, Eddington and the Eclipse. Travel Impressions* (Lisboa: Associação Chili Com Carne, 2019)—a revised 2nd edition was published in 2024 and it will be the one referenced across this text. This is a bilingual edition in Portuguese and English which can be accessed at https://zenodo.org/records/7785783. The essay/graphic novel was followed by the paper Ana Simões, "In the Shadow of the 1919 Total Solar Eclipse: The Two British Expeditions and the Politics of Invisibility," *Berichte zur Wissenschaftsgeschichte*, 45, no. 2 (2022): 581-601.

In this paper, we pursue the direction of this publication and will look at the British expeditions as scientific practice embedded in their geographical, social, and world-political context. This fresh look makes steps towards a "global history" of the 1919 eclipse, and reports on contextual elements of the expeditions that have been hitherto "eclipsed" in the narratives that concentrated on the exchange of scientific arguments in a "world of ideas." What it may mean to think of the globality of the 1919 eclipse is presented in the first section, which is followed by sections that analyse four main dimensions of this globality: 1) actors in context, 2) observing totality, 3) eclipse lineage, and 4) eclipse on paper.

Why a Global History of the 1919 Total Solar Eclipse?

Our main idea is to centre the historians' attention on the 1919 expeditions themselves and look beyond those riveting aspects that are immediately relevant for the expeditions' aftermath—Einstein's rise to stardom and the musings over the general theory of relativity—, that have traditionally dominated the narratives. The case is well suited to explore what "globality" of scientific undertakings can mean: to address their spatiality, to map the networks of diverse actors involved and to argue for the need to think outside the framework of the nation-state.[8] It also shows the crucial role of places outside the European and Anglo-Saxon world and questions the meaning of the eclipse expeditions for the people in those localities visited by the travellers. It offers the opportunity to make a comparative assessment of the two British expeditions to Sobral and Príncipe in order to unveil the various interactions, established in time and space, which conditioned both expeditions.[9] For that reason, this paper puts centre stage the expeditions' preparations in Britain, the teams' voyage to Lisbon and Madeira on their way to the two observational sites, their settlement and installation in Sobral and on Príncipe, the climax in observing totality, and the expeditioners' return.

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[8] Sebastian Conrad, *What is Global History* (Princeton: Princeton University Press; 2016).

[9] So far, they have been studied separately mostly by Brazilian or Portuguese historians of science. Luís C.B. Crispino and Marcelo C. de Lima, "Amazonia Introduced to General Relativity: The May 29, 1919 Solar Eclipse from a North-Brazilian Point of View," *Physics in Perspective* 18, no. 4 (2016): 379-94; Luís C.B. Crispino and Marcelo C. de Lima, "Expedição Norte-Americana e Iconografia Inédita de Sobral em 1919," *Revista Brasileira do Ensino de Física* 40, no. 1 (2018): 1-8; Ildeu Castro Moreira, "A Recepção das Ideias da Relatividade no Brasil," in *Einstein e o Brasil*, eds. Ildeu Castro Moreira and António Augusto Passos Videira, 177-206 (Rio de Janeiro: Editora UFRJ, 1995); António Augusto Passos Videira, "Henrique Morize and the Eclipse of May 1919: The National Observatory of Brazil, the Solar Corona, and Pure Science," *Journal of Astronomical History and Heritage* 23, no. 2 (2020): 335-52; Elsa Mota, Paulo Crawford, and Ana Simões, "Einstein in Portugal. Eddington's 1919 Expedition to Principe and the Reactions of Portuguese Astronomers (1917-1925)," *British Journal for the History of Science* 42, no. 2 (2009): 245-73. An exception is Gates and Pelletier, *Proving Einstein Right.*

The natural consequence (of putting the expeditions centre stage) is a de-centring of the historical gaze from the main protagonists Einstein and Eddington. This in turn leads to the realisation that our knowledge of the four travellers' life trajectories is very asymmetrical. While Eddington's life has been well researched, we know little about the ways in which the participation of the three others in the expeditions impacted on their later careers. This holds not only for the Greenwich astronomers Davidson and Crommelin but also, and even more so, for Cottingham, the odd man out: he was not an astronomer but a technical expert. As we will see, religion came into play not only in the well-documented case of Eddington who, as a Quaker, registered as a conscientious objector in 1916 and could dedicate the war years to science. Whether through professional or religious ties, all the expeditioners' actions were embedded in a tight network including astronomers from the national observatories of the countries where the observations occurred, supporters among the local elites, local populations, workers, and anonymous people. As far as possible this paper will shed light on the participants in this network. And when all preparations were finally made, not everybody was invited on a par to witness the great moment of totality due the colonial and racialized context. The assessment of their differential agencies, roles and actions, which made the expeditions possible, will be treated in the section "Actors in contexts."

To understand these gradients of prestige of the various actors it is essential for the historian to depart from Eurocentric narratives. A first step is to take seriously into account the expeditions' localisation in South America (Brazil) and in Africa (Príncipe, then part of the Portuguese empire). The different geopolitical contexts of the places in which the travellers passed, stopped and observed, as well as the various regimes of labour practiced in those localities are embedded in the expeditions and must be thoroughly considered.[10] On the one hand, the colonial dimension of the Príncipe expedition, so far in the shadow, required exploration as forced labour prevailed in the island. On the other hand, the political, economic and social dimensions of the Sobral expedition taking place in Brazil, an independent South American nation, a republic since 1889, fighting to assert itself in the world chessboard, are important. In both instances, the connection between astronomical tasks and local labour shows interesting differences. This is the dimension addressed in the section "Observing totality."

[10] Gisa Weszkalnys, "Príncipe Eclipsed: Commemorating the Confirmation of Einstein's Theory of General Relativity," *Anthropology Today* 25, no. 5 (2009): 8-12; Roy Mawhinney, "Astronomical Field Work and the Spaces of Relativity: The Historical Geographies of the 1919 British Eclipse Expeditions to Príncipe and Brazil," *Historical Geography* 46 (2018): 203-38; Ana Simões, Hugo Soares, Luís Carolino, "The British and Brazilian Expeditions and the 1919 Total Solar Eclipse. Regimes of Labour and Degrees of Invisibility," *British Journal for the History of Science*, forthcoming.

Focusing on the expeditions themselves cannot help showing that there was already a long-established practice of global astronomical expeditions at least since the 1761 voyage to observe the transit of Venus, let alone during the nineteenth century. These were obviously dedicated to a variety of objectives according to different astronomical and later astrophysical questions.[11] At the beginning of the twentieth century these included the spectroscopic study of the corona, the search for an intra-mercurial planet to explain the shift of Mercury's perihelion, and electric and magnetic effects of an eclipse. It is well known that Freundlich, as early as 1911 planned to heed Einstein's call for a measure of light deflection in the sun's gravitational field,[12] enrolling other astronomers in the task. Expeditions in 1912, 1914 and 1918 included this effect together with other main astronomical tests. Also, the 1919 expeditions were not the last being dedicated to measure the effect predicted by Einstein: a flurry of local and international observers crowded to Australia in 1922. Retrospectively, the 1919 expeditions have "eclipsed" the earlier and later endeavours that have historically been part of the scientific enterprise. The record shows that different narratives have competed about which expeditions were the "first" or the "crucial" ones, as we will briefly show in the section "The 1919 eclipse and its lineage."

In the various geographical locations, at the time, the public perception of the expeditions differed, which highlights that many simultaneous narratives of the eclipse coexisted in that period. With the public announcement of 6 November 1919 that declared a "revolution in science" and the triumph of Einstein over Newton, daily newspapers in various European and American countries started to reframe the expeditions in terms of their contribution to Einstein's theory of gravitation, which also coincided with the privileged standpoint of most historical analysis. In the section "Eclipse on paper" we address this question by analysing newspaper articles published between 1919 and 1920 in five different countries.

The major challenges of a global approach stem from the variety of sources on which historians can potentially draw, crossing different material formats and languages, spanning extended geographies not always at the reach of a single historian. In recent years, however, increasing digitisation has improved access to many primary sources on a global scale. For the four dimensions addressed in this paper we were able to muster the corpus of sources described next.

We compared published and unpublished written sources (including private and official correspondence, minutes of meetings and publication drafts), visual sources (including

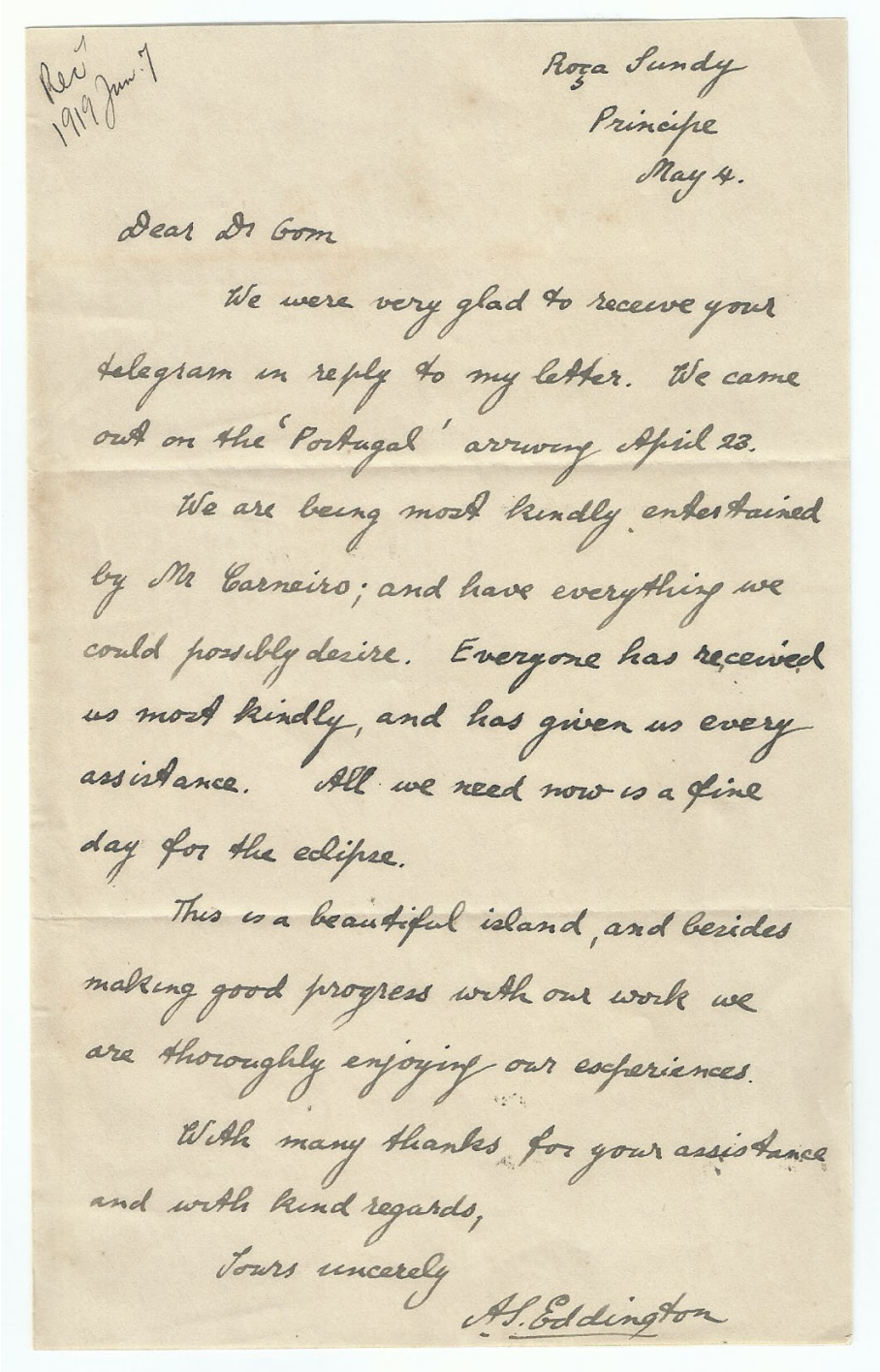
[11] For British expeditions organized during the Victorian period see Alex Soojung-Kim Pang, *Empire and the Sun: Victorian Solar Eclipse Expeditions* (Stanford: Stanford University Press, 2002).

[12] Albert Einstein, "Über den Einfluss der Schwerkraft auf die Ausbreitung des Lichtes," *Annalen der Physik*, 35 (1911): 898-908.

drawings, engravings, photographs, photographic albums and films), and generalist daily newspapers from a variety of countries, written in Portuguese, English and German. There is a striking disparity when one compares the available sources associated with the expedition to Sobral and the expedition to Príncipe. While there is a wealth of private correspondence for Príncipe, addressed by Eddington to his mother and sister, none exists for Sobral; it has also proven hard to locate the logistical correspondence exchanged between Eddington and Morize, while for the National Observatory of Lisbon exchange of official correspondence exists, mainly involving the deputy director Frederico Thomaz Oom (Figure 2).[13] In contrast, while there is ample photographic coverage for the eclipse station in Sobral, not a single picture exists for Príncipe, at least that we are aware of, nor of the location where observations took place or of the instruments setup.[14] While there is abundant newspaper coverage for Brazil, it is scant for Portugal.

[13] So far it has not been possible to access most of the logistical correspondence between Morize and Eddington. The official correspondence consulted in the case of Brazil is at the archives of the National Observatory (ON Historical Archive) or at the Museu de Astronomia e Ciências Afins (part of it is available at http://www.mast.br/sobral/img-documentacao.html). The official correspondence with the Observatory of Lisbon involving Eddington, is at the Arquivo Histórico dos Museus da Universidade de Lisboa, Observatório Astronómico de Lisboa, Universidade de Lisboa [AHMUL-OAL].

[14] Joana Latas, Duarte Pape, and Ana Simões, "Where Exactly did A.S. Eddington Observe the Total Solar Eclipse of 29 May 1919," *Journal of Astronomical History and Heritage* 23, no. 3 (2020), 614-27. A 3D reconstruction of the instruments set-up can be accessed at https://e3global.pt/outputs/3d/.



Rec'd
1919 Jun 7

Roça Sundy
Principe
May 4.

Dear Dr Oom

We were very glad to receive your telegram in reply to my letter. We came out on the 'Portugal' arriving April 23.

We are being most kindly entertained by Mr Carneiro; and have everything we could possibly desire. Everyone has received us most kindly, and has given us every assistance. All we need now is a fine day for the eclipse.

This is a beautiful island, and besides making good progress with our work we are thoroughly enjoying our experiences.

With many thanks for your assistance and with kind regards,

Yours sincerely

A.S. Eddington

Figure 2. Letter from A.S. Eddington to the vice-director of the Lisbon Astronomical Observatory, F. Oom. 4 May 1919, PT/MUL/OAL/C/240, AHMUL-OAL

This disparity becomes intelligible by taking seriously the different geopolitical contexts and regimes of labour at work in Sobral, Brazil and in Príncipe, then a Portuguese colony. That is why we have scrutinized them in tandem with the different agencies of British, Brazilian and Portuguese astronomers, and those of local elites and populations,[15] as well as assessing the processes of invisibilisation at play.

Indeed, the topic of invisibilisation and its various dimensions, as discussed e.g. by Olga Kuchinskaya, is one directly connected to the project of a global history.[16] By a self-reflective approach to history a global approach has the potential to render visible the historical actors whom historians may have overlooked or deemed irrelevant either consciously or unconsciously. In the case of the 1919 eclipse, invisibilisation concerned the actors/participants, geopolitical contexts, but also—maybe more surprising—natural events, such as previous and later eclipses.[17] The sections of this paper explore each of these dimensions: the first two (actors in contexts and observing totality) show what actors have often been erased from the historical record. Concerning the third dimension (eclipse lineage) past eclipses have been overshadowed by the 1919 eclipse and (de)coupled from their contexts of emergence, acquiring in the process extra lives. Finally, concerning the fourth dimension (eclipse on paper) newspapers enable us to zoom into aspects of public perception that are difficult to detect by other means.

Actors in Contexts

Concerning the first dimension, main actors include the British expeditioners, supporting actors were the astronomers of the national observatories Morize and Oom, and other

[15] Simões, "In the Shadow"; Simões, Soares, Carolino, "Regimes of Labour"; Luís Carolino and Ana Simões, "Behind the Scenes. The 1919 Total Solar Eclipse and the Invisible Labor of the Portuguese and Brazilian Observatories," *Centaurus*, 66, no. 1-2 (2024), 189–216.

[16] Olga Kuchinskaya, "Twice Invisible: Formal Representations of Radiation Danger," *Social Studies of Science* 43, no. 1 (2012): 78–96; Olga Kuchinskaya, *The Politics of Invisibility: Public Knowledge about Radiation Health Effects after Chernobyl* (Cambridge, MA: MIT Press, 2014). Olga Kuchinskaya uses the expression "politics of invisibility" in the sense of explicit or implicit actions of erasure, up to total effacement associated with specific scientific effects or processes, as was the case with the risks associated with radioactivity released following the Chernobyl disaster. Her analysis can be extended to the case of scientific minorities, anonymous actors and go-betweens who were unavoidable actors in the process of construction and circulation of scientific practices. We further argue that it should also be extended to an analysis of the reasons why, even today, many of these actors remain forgotten by historians of science despite decades of emphasis on the diversity of the scientific enterprise and its workers.

[17] Ana Simões and Hugo Soares, "The Many Faces of Prediction. Changing Aims of the Astronomical Expeditions Organized During the 1910s to Test the Deflection of Light," in *The Perils of Prediction*, ed. Theodore Arabatzis, forthcoming.

supporting actors include local elites, technical experts and workers under various regimes of labour (Figure 3).

As already mentioned, startlingly there is still much to know concerning the expeditions' impact on the lives of the Greenwich astronomers Davidson and Crommelin who observed at Sobral, while until recently not much was known concerning the inclusion of the technical expert on clockwork mechanisms Cottingham, who accompanied Eddington to Príncipe.[18] Besides the missing knowledge on the expeditions' impact on the life trajectories of most of the British travellers, the printed and private sources concerning this historical event do not openly discuss the reasons behind who went where, taking this division of tasks as a given: Eddington and Cottingham went to Príncipe and Davidson and Crommelin went to Sobral.[19]

Figure 3. The picture of the solar protuberance taken in Príncipe is one of the most widely disseminated pictures of the 1919 total solar eclipse. Yet it does not show any of the stars in the background astronomers wanted to photograph, symbolizing exemplarily those who contributed to the expeditions' success and still remain in the shadow or are anonymous. From the exhibition curated by Ana Simões, *Einstein, Eddington e o Eclipse. Um Encontro Improvável, Duas Expedições Memoráveis* (Universidade de Lisboa, 2019). Credit: Ana Simões, Vasco Ferraz, Universidade de Lisboa.

[18] Research on the various dimensions of E.T. Cottingham as technical expert and participant in knowledge construction is being undertaken by some of the co-authors of this paper; Gates and Pelletier, *Proving Einstein right* dedicates a chapter to biographical details of main actors, but they do not address how the expeditions affected participants' future life courses.

[19] Dyson, Eddington, Davidson, "A Determination." This is also clear from reading the minutes of JPEC, held at the archives of the Royal Astronomical Society related to the preparation of the expeditions.

The minutes of the Joint Permanent Eclipse Committee (JPEC) in charge of the preparation of the expeditions make it clear that the Jesuit astronomer Aloysius Cortie was supposed to go to Sobral and failed to do so due to professional duties associated with wartime contingencies. His allocation to Sobral was made not just due to his extensive experience as an eclipse observer, but also due to his connections with the Jesuit congregations in Belém do Pará and Fortaleza—capitals of the states of Pará and Ceará, respectively—and with the ecclesiastical authorities in Sobral where the eclipse was to be observed. The Jesuit network could help in logistic matters. Cortie was replaced by Crommelin who joined Davidson, but the religious connections were still guaranteed by him. In this way, two experienced astronomers from the national Greenwich Observatory observed together at Sobral. Surprisingly owing to the dominance of Protestantism in Britain, both were practicing Catholics, although not Jesuits. This fact, which is not mentioned in the minutes, has already been noted by Kennefick who dubbed the Sobral team a "Catholic affair," having in mind the religion embraced by Cortie, Davidson and Crommelin.[20] But Catholicism was more than just an "affair." Already hinted by Joyce Rodrigues,[21] Catholicism became central in the Brazilian context. It was appropriated by journalists and profusely explored in Brazilian newspapers' coverage as a way of uniting the British astronomers with the local population, which was suspicious of foreigners whose activities were alien to them. Catholicism thus became a public affair bridging the Sobral team to the locals. The analysis of Brazilian newspapers, mainly of Catholic inclinations, from the state of Ceará and Pará, leaves no doubt as to this connection.

On their way to Sobral, the British astronomers first stopped in Belém do Pará, where they were welcomed by local authorities, including Father Manuel Tavares, a Jesuit and confrère of Cortie.[22] At that time, the northern and northeastern regions of Brazil were experiencing a severe drought, which forced many of the poorest inhabitants to migrate from inland areas to coastal cities like Belém. Amid this crisis, tensions arose, with some critics expressing dissatisfaction that scientists were focusing on theoretical matters while countless people were suffering due to the drought.[23]

In this challenging context, the two Catholic astronomers decided to publish an article in the state's leading newspaper, *Estado do Pará*. Introduced as Catholic astronomers, Crommelin and Davidson used the article to engage with readers of the local community and foster a favourable attitude toward their scientific work. Their article, titled *O Próximo Eclipse Total do*

[20] Kennefick, *No Shadow of a Doubt*, 144.

[21] Joyce Mota Rodrigues, "Entre Telescópios e Potes de Barro: o Eclipse Solar e as Expedições Científicas em 1919/Sobral-CE." (master's thesis, Universidade Federal do Ceará, 2012), 71.

[22] "Para Observar o Eclipse do Sol," *Estado do Pará,* 24 March 1919.

[23] Paulino de Brito, "Repercussões. Novidades Scientificas," *Estado do Pará*, 22 April 1919.

Sol (The Next Total Solar Eclipse), offered insights into the state of eclipse observation in the late 1910s and the prospects for the upcoming eclipse of May 1919.[24]

In Sobral, Crommelin and Davidson found a more welcoming environment. Even before their arrival, the British astronomers were eagerly welcomed by civil and ecclesiastical members of the local community. Readers of *Correio da Semana*, a newspaper run by the Catholic Church of Sobral, learned in its first issue of March 1919 that the local bishop had received a letter from the director of the Stonyhurst Observatory, the Jesuit Cortie, informing that the British government had sent astronomers Crommelin and Davidson to observe the eclipse in Sobral.[25] It is no surprise, then, that the editorial board of *Correio da Semana* went to great lengths to extend a warm welcome to the astronomers. The newspaper praised both their scientific accomplishments and their devout Catholic backgrounds, even drawing comparisons to the nineteenth-century Jesuit astronomer Angelo Secchi, renowned for his studies of the sun.[26]

The British astronomers, in turn, showed their appreciation for *Correio da Semana*'s support by choosing the newspaper—and the actively engaged local Catholic community—as their primary channel of communication. As the newspaper proudly announced, they wrote "especially to *Correio da Semana*," contributing an article translated by their interpreter, the technical expert from the Ministry of Agriculture, Leocádio Aráujo, who accompanied them in all their activities. In the article, Crommelin and Davidson outlined the British team's research goals, explained Einstein's theory, provided details on the eclipse's timing, and noted that their mission was part of a larger expedition organized by the JPEC, which also included Eddington's and Cottingham's expedition to Príncipe island.[27] After the eclipse, the British astronomers returned to the Catholic newspaper to share additional details about their observations and preliminary findings.[28] Catholicism thus became a shared public endeavour, fostering a connection between the British astronomers' team and the local community.

Concerning Príncipe, since early November the JPEC minutes listed Eddington and Cottingham as team members.[29] Due to the leadership role of Eddington in organizing

[24] Andrew C.D. Crommelin and Charles Davidson, "O Próximo Eclipse Total do Sol," *Estado do Pará*, 20 April 1919.

[25] "O Eclipse," *Correio da Semana*, 1 March 1919. *A Lucta* published some days later the same letter received by the bishop, "O Eclipse," *A Lucta*, 12 March 1919.

[26] "Commissão Scientifica," *Correio da Semana*, 10 May 1919.

[27] Andrew C. Crommelin and Charles Davidson, "O Eclipse Total do Sol," *Correio da Semana*, 24 May 1919.

[28] "O Eclipse Total do Sol," *Correio da Semana*, 7 June 1919.

[29] Royal Astronomical Society Archive, JPEC Minutes, 8 November 1918.

the expeditions, together with Dyson, he might have chosen to head for Príncipe, because it was the more challenging location, due not only to more uncertain weather and hosting conditions, but also as there was no local support by any Portuguese astronomer, contrary to Sobral.[30] However, a further religious connection might have also played a role, adding an extra weight to the final decision.

While the details of the Catholic connection are new to this historical episode, this is not the case with the Quaker connection. Over 20 years ago Stanley pointed out that behind the organization of the expeditions was a religious dimension associated with Eddington's pacifism as a Quaker, and the necessity felt by Dyson to trade Eddington's exemption from military work for his leadership of the expeditions to test light bending.[31] But the Quaker link must be given extra attention. Eddington's Quakerism might have been also an additional reason for Eddington's choice to observe at Príncipe. The small island of Príncipe was then one of the top world cocoa suppliers, and the Cadbury's family their main buyers, and this has been already pointed out, but not explored in its full implications.[32] They shared Eddington's Quakerism, a factor of proximity among all that might have inclined Eddington to choose Príncipe. The Cadbury's had been behind a harsh diplomatic conflict which opposed Britain and Portugal in the first decade of the twentieth century over the British accusation of the practice of forced labour in the cocoa plantations.[33] Dyson referred to "slave cocoa," when suggesting Príncipe as a convenient observational site: It is a "well-developed Portuguese island which became celebrated a short time ago owing to the politicians interest in 'slave cocoa'."[34] While he did so during the quick-off discussion at the Royal Astronomical Society on 9 March 1917, there is no mention of forced labour neither in the official correspondence exchanged with Observatory of Lisbon nor in the private correspondence exchanged by Eddington with his mother and sister with whom he entertained strong affectionate ties.[35] The private correspondence is filled with

[30] Mota, Crawford, and Simões, "Einstein in Portugal."

[31] Mathew Stanley, "An Expedition to Heal the Wounds of War," *Isis* 94, no. 1 (2003): 57-89.

[32] Kennefick, *No Shadow of a Doubt;* Gates and Pelletier, *Proving Einstein Right.*

[33] Joseph Burtt and Claude Horton, *Report on the Conditions of Coloured Labour on the Plantations of S. Thomé and Principe. And the Methods of Procuring it in Angola*, 1907; Augusto Nascimento, *Poderes e Quotidianos nas Roças de S. Tomé e Príncipe. De Finais de Oitocentos a Meados de Novecentos* (Lousã: Tipografia Lousanense, 2002); Miguel Bandeira Jerónimo, *The 'Civilizing Mission' of Portuguese Colonialism, 1870-1930* (New York: Palgrave Macmillan, 2015); Marta Macedo, "Standard Cocoa: Transnational Networks and Techno-Scientific Regimes in West African Plantations," *Technology and Culture* 57, no.3 (2016): 557-8; Catherine Higgs, *Chocolate Islands: Cocoa, Slavery, and Colonial Africa* (Ohio: Ohio University Press, 2013); Maria Nazaré de Ceita, *A Curadoria Geral dos Serviçais e Colonos (S. Tomé e Príncipe 1875/1926)* (Lisboa: Editorial Novembro, 2021).

[34] Frank W. Dyson, "On the Opportunities Afforded by the Eclipse of 1919, May 29 of Verifying Einstein's Theory of Gravitation," in "Minutes of the Meeting of the Royal Astronomical Society," *The Observatory. A Monthly Review of Astronomy* 40, no. 512 (1917): 153-7.

[35] Letters to Mother and Sister, Eddington Correspondence, TCL: EDDN A4/2, Trinity College

descriptions of the natural and social environment but forced labour is rendered totally invisible. However, having in mind the public dimension of the "slave cocoa" incident, Eddington's active participation in the Society of Friends, and the spatial organization of the Sundy plantation in which he and Cottingham were housed, it is virtually impossible for him to be unaware of the presence of circa 600 black workers under forced labour. Astronomy, religion and empires were deeply intertwined, but these entanglements were eclipsed by astronomers. In fact, in most accounts concerning the expeditions, Príncipe is just mentioned by its geographical localisation, not by its political status as a colony of the Portuguese empire. Portugal and Portuguese authorities were not mentioned.[36] These entanglements have also escaped extended analysis by historians.

However, the Portuguese colonial network played a pivotal role in the success of the British expedition. On 11 November 1918, upon receiving a letter written by Eddington on behalf of the JPEC, in which the British astronomer outlined the mission's objective on Príncipe Island, Thomaz Oom, the deputy director of the Lisbon Observatory, devised a plan to facilitate the British endeavour. Oom's plan included several key actions, such as contacting the Portuguese steamer company *Empresa Nacional de Navegação*, which operated regular trips to Príncipe, to secure transportation and provide the necessary logistical support for the British team. To ensure accommodations on the remote island, Oom reached out to the *Colonial Centre* (Centro Colonial), a private association of planters headquartered in Lisbon. Through this connection, he arranged for the British team to stay at Sundy Plantation, hosted by Jerónimo Carneiro, the largest landowner on Príncipe. Additionally, Oom secured a local translator and customs assistance to further support the British team.[37]

Despite his crucial role in enabling the successful observation of the 1919 total solar eclipse on Príncipe, Oom's engagement in promoting science awareness during this event contrasts markedly with his involvement in previous astronomical events. During the 1900 total solar eclipse observed in Portugal, in which a JPEC team, including Dyson, was present, Oom emerged as a central figure, coordinating a network that included an official commission, professional and amateur communities, and the general public. By doing so, he played an active role in generating significant public interest and awareness of the eclipse.[38] This time, matters were different for reasons explained in what follows.

Archives. Eddington's mother and sister played a pivotal role behind the scenes. The correspondence exchanged with both functioned as private correspondence exchanged among family members and as a sort of scientific notebook registering important data to be used later by Eddington in scientific publications. The invisibility of women in this case study is notorious and deserves to be addressed in future studies.

[36] Simões, "In the Shadow"; Carolino and Simões, "Behind the Scenes."

[37] Carolino and Simões, "Behind the Scenes."

[38] Luís Miguel Carolino and Ana Simões, "The Eclipse, the Astronomer and his Audience: Frederico

The director of the National Observatory of Rio de Janeiro also played a pivotal role in providing logistical support to the expeditioners, which was crucial for the success of their observations. Morize effectively secured governmental and federal assistance, including financial support, to facilitate transport, accommodation, and translator services for the foreign teams. Additionally, he leveraged this support to enhance the national and international visibility of Brazilian astronomy. This included preparing his own team of astronomers for the expedition, setting up his own camping observatory to observe the solar corona and disseminating its results through the press and appropriate academic forums.[39]

Morize's proactive efforts stand in stark contrast to Oom's response to Eddington's requests for assistance. These differing approaches can be attributed to the distinct political contexts in which each found themselves. On the one hand, Brazil was a thriving young republic in economic terms vying for international recognition. It was in this context that Morize's agenda of affirmation of science in Brazil unfolded, amply illustrated by professional photographs often including the foreign observers among the Brazilian team.[40] On the other hand, Portugal, although an old nation, found itself in stringent social, political and economic circumstances due to the recent (1910) instauration of a republican regime. In this context Oom had little leeway for his actions despite his longtime experience in similar situations. While both Morize and Oom followed established protocols of astronomical cooperation among astronomers, affording all logistical help to secure the expeditions' success in observing in their countries, their activities stayed mostly behind the scenes, often effaced by themselves as if not an integral part of the astronomers' practice.

Local elites at Sobral (civil and ecclesiastical) and colonial authorities in Príncipe helped by preparing the visits of travellers and providing accommodation during their stay.[41] They also supplied astronomers with support materials—clay pots in Sobral or ice in Príncipe—necessary for the success of on-site revelation of photographic plates.[42]

Besides the participation of local elites both in Príncipe and in Sobral many other actors helped. As expressed in the 1920 joint paper, travellers were offered "ample resources of labour."[43] Local manual workers provided the manpower to transport equipment, to build

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Oom and the Total Solar Eclipse of 28 May 1900 in Portugal," *Annals of Science* 69, no. 2 (2012): 215-38

[39] Carolino and Simões, "Behind the Scenes"; José P.S. Lemos, "Shadow of the Moon and General Relativity: Einstein, Dyson, Eddington and the 1919 Light Deflection," *Revista Brasileira de Ensino de Física* 41, suppl. 1 (2029): e20190260.

[40] Antonio Videira, "A Participação Brasileira no Eclipse Solar Total de Maio de 1919: Observando a Coroa Solar para Melhor Defender a Ciência," *Ciência e Cultura* 71 (2019): 23-26.

[41] Simões, Soares, and Carolino, "Regimes of Labour."

[42] Rodrigues, *Telescópios e Potes de Barro*, 99; Simões, "In the Shadow," 595.

[43] Dyson, Eddington, Davidson, "A Determination," 313.

supports for the instruments or protective structures for the whole apparatuses, and to help in whatever was necessary. They worked under different regimes of labour, including forced labour in Príncipe. Their identification is impossible, so they remain forever anonymous.

Observing Totality

Concerning the second dimension—the observation of totality—the expeditions' high point, one should note that there are pictures of the localization of tents and of the instruments' setup for Sobral, but no photographs have been located for Príncipe.[44]

Printed sources, including but not limited to the long paper authored by Dyson, Eddington and Crommelin published in early 1920, which detailed the expeditions and their results, give information about the observation of totality in Sobral.[45] They refer explicitly to the help of Leocádio Araújo. He spoke English and accompanied the astronomers during their stay helping them whenever necessary. They also acknowledge his active role during totality in the following terms: "When the crescent disappeared the word 'go' was called and a metronome was started by Dr. Leocádio, who called out every tenth beat during totality, and the exposure times were recorded in terms of these beats."[46] The article does not make reference to locals' participation during totality in Príncipe. Local help was essential in Sobral, as each British astronomer handled by himself a coelostat, a telescope and photographic plates, to take pictures of the star background. The eclipsed sun and surrounding star field were reflected by a coelostat, an instrument that directs a sky image to a telescope while compensating for the earth's rotation, thus maintaining the celestial plane fixed in the telescope's field of view.

Concerning the observation of totality in Príncipe, Eddington's descriptions addressed it with varying details.[47] In the letter to his mother written already on his way back from Príncipe, on 21 June and 2 July, Eddington discusses at length the observation of totality, detailing weather conditions, timings and astronomical tasks. But this is the only place in which he lists seven participants who joined the observers: "Mr Carneiro, the Curador, Judge, Mr Wright, three Doctors came over."[48] Jerónimo Carneiro was the owner of

[44] There are also several photographs in which British astronomers are depicted together with the Brazilian team, including some women family members, and the American team, Wise and Thomson. They reveal the relevance for Morize to secure for posterity the depiction of this astronomical event.

[45] Dyson, Eddington, and Davidson, "A Determination;" Andrew C. Crommelin, "The Eclipse Expedition to Sobral," *The Observatory. A Monthly Review of Astronomy* 42 (1919): 368-71.

[46] Dyson, Eddington, and Davidson, "A Determination," 299.

[47] Dyson, Eddington, and Davidson, "A Determination"; Arthur Stanley Eddington, *Space, Time and Gravitation. An Outline of the General Relativity Theory* (Cambridge: Cambridge University Press, 1920).

[48] Letter to mother, 29 April - 2 May 1919, Letters to Mother and Sister, Eddington Correspondence,

Sundy plantation where the travellers were accommodated and where they observed. He made sure they were given all help and entertained them, with tours to the island, picnics and dinners, and sojourns at the city of Santo António, when not busy with preparatory work. The Curador, whose name he did not mention, was the member of the local elite in charge of "imported" labour, that is, who supervised the acquisition of workers coming from the African mainland, mostly Angola, or from Cabo Verde islands, to work on the plantations under a regime of forced labour. Therefore, Eddington could not be oblivious of the regimes of labour at work in all plantations. Wright was one of the two British black men from Sierra Leone who worked at the cable station. He spoke the same language as the travellers and might have helped during the observations.[49] In any case, and despite uncertainty as to the role Wright might have played in astronomical tasks during totality, the social status of local elite members was recognized by the distinction to be invited to witness eclipse totality, in turn granting extra weight to the expeditions' climax. The colonial and racial dimensions of the eclipse cannot be decoupled from its climax. However, they are not found in the existing printed sources (Figure 4).[50]

TCL: EDDN A4/2, Trinity College Archives.

[49] In Simões, "In the Shadow," it is argued that Wright, the British telegrapher, might have helped at quick note taking.

[50] It is now represented in Simões and Sousa, *Einstein, Eddington and the Eclipse* on page 179.

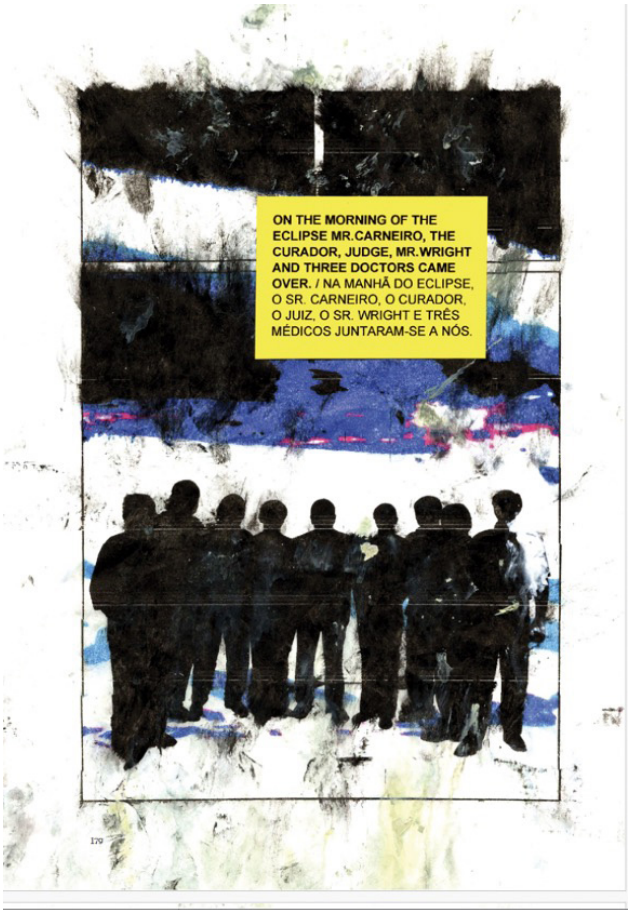

Figure 4. The witnesses of totality in Príncipe. Source: Simões and Sousa, *Einstein, Eddington and the Eclipse*, 179.

Securing the success of observations of totality in Sobral and Príncipe was the culmination of choices and decisions which depended on collaborative practices among astronomers, on information from the local elites and on the help of local manual labourers. The exact localisation where the instruments set-up was mounted with a specific disposition of tents and instruments were all ascertained beforehand with utmost detail. For Sobral, pictures and printed sources enable visualization of the observational site, tents and apparatuses. For Príncipe there are no pictures, so that reasoning by comparison is the best historians' guide. Having in mind that the huts were standardized by the JPEC since the end of the nineteenth century,[51] and that the arrangements for both expeditions were centralized at

[51] The authors thank Richard Dunn for pointing out that this tent design, which became standard, was first used on an expedition to observe an eclipse in Japan in 1896. Kennefick, *No Shadow of a*

Greenwich, they were certainly identical to those used in Sobral. However, some historical reconstruction is needed to figure out their relative orientation, keeping in mind that just one coelostat and one telescope was used in Príncipe. Identifying with precision the spot where the expeditions' climax occurred is not only important in historical terms but also for memory purposes: local populations' recognition that their ancestors participated in a landmark astronomical episode can be used to enhance scientific education and popularisation of science among different generations of locals. This was done in Príncipe during the 2019 celebrations.[52]

Crucial to the observation of totality was the choice of the localization where the instruments setup was to be mounted. Although there is information on the printed sources as to its approximate localization and constitution, there is no record of official pictures having been taken, contrary to Sobral, and no other pictures have been found. Concerning the localization of the observational site, the 1920 paper gives its coordinates in the following terms: "Our telescope was erected in a small walled enclosure adjoining the house, from which the ground sloped steeply down to the sea in the direction of the sun at eclipse. On the other side it was sheltered by a building. The approximate position was latitude 1°40'N, longitude 29m 32s E."[53] The latitude 1°40' N, given without specification of arc seconds, together with the longitude expressed in time, is insufficient to identify the precise localization where the telescope was mounted.

The only way to arrive at an unequivocal localization, not a range of probable locations, results from crossing this information with information from other sources. One is Eddington's letter to his mother dated 29 April-2 May 1919. Crucial extra information is given there concerning details stemming from the perspective from the travellers' bedroom, indicating geographical orientation. Eddington declared: "There was little difficulty in deciding that this was the most favourable spot; and there happened to be an enclosed piece of ground close to the house which just suited us. *We look straight on to it from our bedroom window*. It is sheltered on the *east* by a building and is open towards the sea *on the west and north* - just right for the eclipse."[54] The other missing piece of information can be recovered from architectural knowledge on the evolution of the main building of the Sundy plantation where the British were installed, fundamental to locate the expeditioners bedroom.[55] Taking into account all these information, one arrives at the following specification of the

Doubt.

[52] Latas, Pape, and Simões, "Where Exactly."

[53] Dyson, Eddington, and Davidson, "A Determination," 313.

[54] Letter to mother, 29 April - 2 May 1919, Letters to Mother and Sister, Eddington Correspondence, TCL: EDDN A4/2, Trinity College Archives. Italics ours.

[55] Duarte Pape is the architect whose knowledge of the evolution of the buildings of Sundy plantation was crucial to come to this conclusion.

coordinates of the observational site: latitude 1°40'13''N, and longitude 7°23'00''E.[56] That is, this precise spot obeys all criteria stemming from the joint consideration of printed and manuscript sources, and the architectural features of the main building. Since 2019, this spot is now signalled by a floor painting by the local artist Eduardo Malé.

Having identified the exact localization of the observational site, a reconstruction of the tents, the telescope and the coelostat, together with the bedroom shared by the observers, which served also as a domestic "temporary laboratory" for the revelation and comparison of photographic plates was made (Figure 5 and 6).[57]

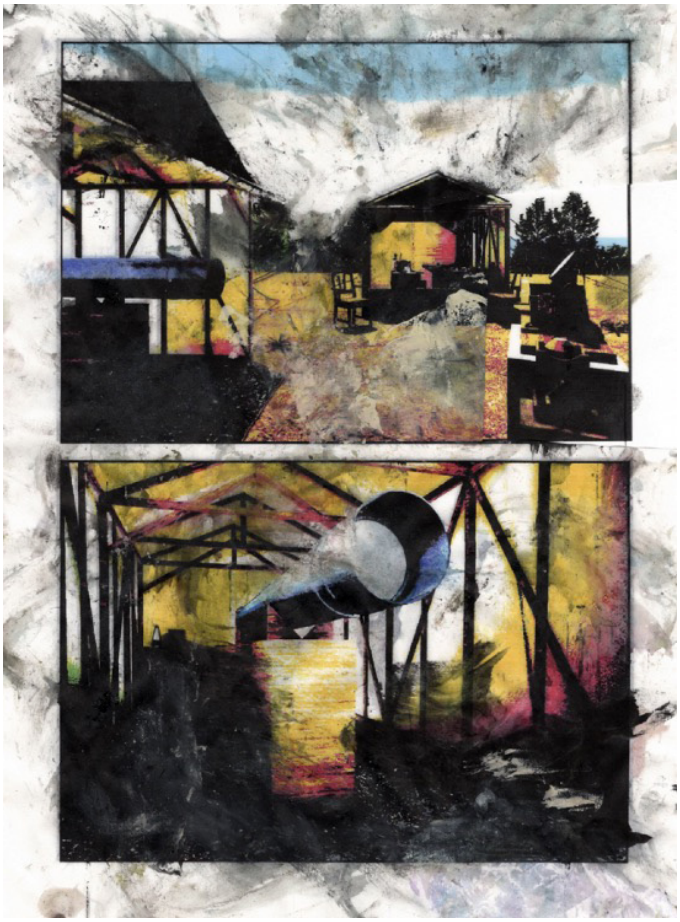

Figure 5. Illustration based on the 3D reconstruction of the instruments set-up. Source: Simões and Sousa, *Einstein, Eddington and the Eclipse*, 181.

[56] Latas, Pape, and Simões, "Where Exactly."

[57] A group of architects oversaw the 3D reconstruction of these two spaces. It is now represented on Simões, Sousa, *Einstein, Eddington and the Eclipse* on pages 181-184, and it can be experienced at https://e3global.pt/outputs/3d/, accessed on 16 May 2025.

Figure 6. Aerial view of the Sundy Plantation, Príncipe Island, administration house and 1919 expedition observation camp. 3D rendering, Paralelo Zero, 2024.

Eclipse Lineage

The third dimension to be discussed has to do with the protagonism bestowed on the 1919 eclipse. Our argument is that the impact of the observations of the 1919 eclipse cannot be adequately understood unless this eclipse is included in a lineage of eclipses that were observed to test light bending, before and immediately after 1919.

The 1919 British expeditions were not the first organized to measure the effect of the sun's gravitational field on light. Some historians, among whom Jeffrey Crelinsten stands out, have discussed this history with varying details.[58] In 1911, Einstein was still relatively unknown outside a restricted circle of scientists. Then, he was already at work extending relativity to account for gravitation and predicted the existence of light-bending although with an incorrect value. Einstein immediately called the attention of astronomers to test this prediction.[59]

Until the completion of general relativity in 1915-16 and the occurrence of the 1919 eclipse, just a handful of scientists (astronomers and physicists) were aware of Einstein's call

[58] Jeffrey Crelinsten, *Einstein's Jury. The Race to Test Relativity* (Princeton: Princeton University Press, 2006); Gates and Pelletier, *Proving Einstein Right*; Simões and Soares, "The Many Faces of Prediction;" Alan Batten, "Two Eclipses, a Theory, and a World War," American Astronomical Society, AAS Meeting #225 (2015), id.90.02; Nick Lomb and Toner Stevenson, *Eclipse Chasers* (Melbourne: CSIRO Publishing, 2023); Kennefick, *No Shadow of a Doubt.*

[59] Einstein, "Über den Einfluss."

for an experimental test of light bending. Some astronomers, including the German Erwin Finlay Freundlich, from the Berlin Observatory, the Americans Charles Dillon Perrine, from Cordoba Observatory, Argentina, William Wallace Campbell, and Heber Doust Curtis, from the Lick Observatory in Mount Hamilton, USA, were directly involved in testing light bending for different reasons, theoretical as well as practical. Freundlich was the only one attracted to relativity theory for theoretical reasons due to his strong mathematical background. On the contrary, the other astronomers were not proficient in advanced physics (and mathematics of Riemann manifolds and Ricci's tensor calculus), furthermore they were not interested in a physical theory *per se* let alone in one that was then still under construction and contested. They were involved due to practical reasons: their practice as eclipse hunters in the search for the intra mercurial planet Vulcan, and then in finding explanations for perihelia anomalies when Vulcan was proved to be inexistent, involved astronomical observations and measurements—photography of heavenly objects in the vicinity of the eclipsed sun—that were similar to those behind the test of light bending. They excelled in such measurements and as such, they agreed to append this test to their astronomical agendas. Attempts were made in Cristina, Brazil, in 1912, in Crimea, Russia, in 1914, and in Goldendale, USA, in 1918.[60] They were all unsuccessful due to inadequate meteorological conditions, in the first case, or due to the political context tied to the onset of the Great War, in the other two cases. The direct reason for the failure of 1918 was the lack of proper instruments due to the confiscation of the main instruments in Crimea, which had been stored in the Pulkovo Observatory since the 1914 expeditions.

Concerning the observations of the 1919 total solar eclipse, war-related reasons account for the absence of all these precursors—Freundlich, Perrine and Campbell. Therefore, for contingent reasons, when the British finally entered the scene, they were the only ones to test the 1919 eclipse for light deflection. Additionally, one should also emphasize that their astronomical agenda to test Einstein's theory, orchestrated by Eddington, an early advocate of relativity, was clearly at odds with the agendas which guided former tests. Thus, the British were the first to be successful in proving light deflection.

Moreover, we argue that the common historical narratives of these expeditions should be expanded, and this convoluted story should not stop in 1919. The subsequent total solar eclipse of 1922 was observed in several locations in Australia and raised high expectations for the reconfirmation of light bending as the star background involved more than one hundred stars and the eclipse was a very long one, lasting for about six minutes.

Many teams from various countries observed in Australia, including those astronomers who had been involved in the tests of light bending prior to 1919. Observing at Wallal, the

[60] Crelinsten, *Einstein's Jury;* Simões and Soares, "The Many Faces of Prediction."

Lick expedition headed by Campbell, and seconded by the astronomer Robert Trumpler, who later became an outspoken advocate of relativity theory, was prepared with extreme care. It was by far the most successful. Their measurements of extreme detail and precision surpassed the 1919 results, but calculations took several years to be published due to the large number of stars registered on the plates (Figure 7). However, preliminary assessments left no doubt about the confirmation of light bending and Campbell made sure to cable the good news to Dyson on 12 April 1923: "We need not repeat the Einstein test next eclipse."[61]

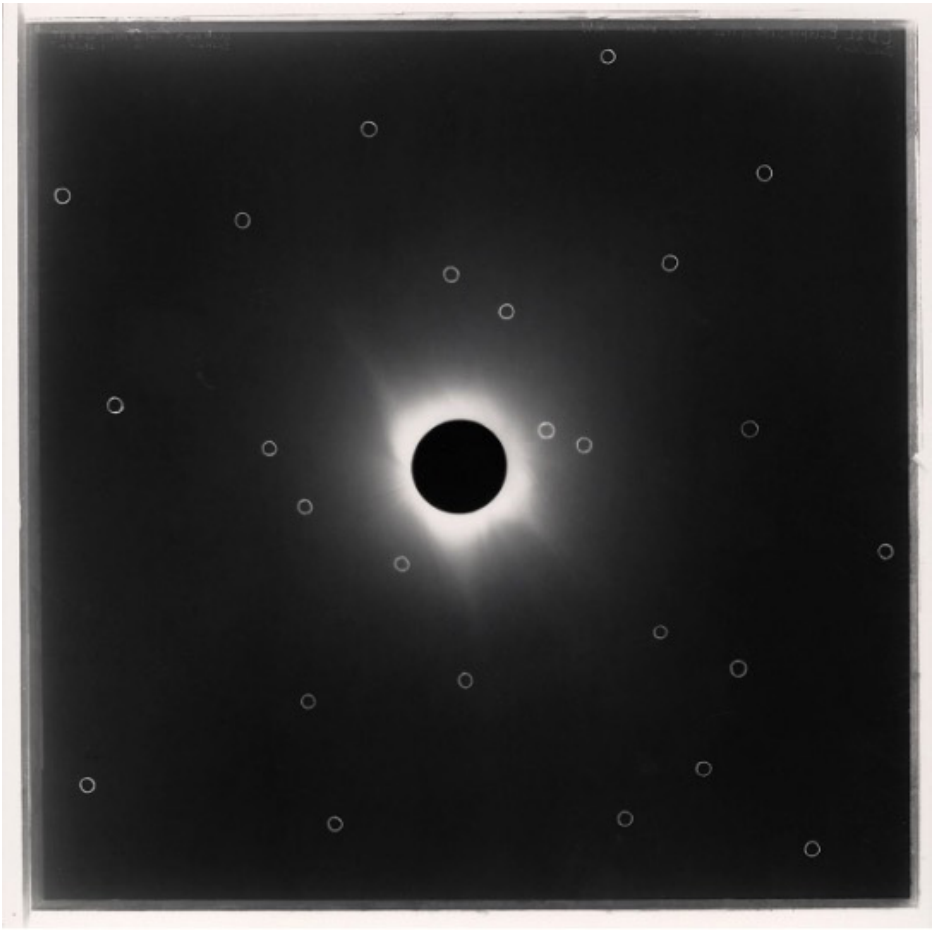

Figure 7. Einstein Plate of Australia Eclipse (Wallal, Australia), 1922. Lick Observatory Photographs UA36 Series 7/ Special Collections and Archives, University Library, UC Santa Cruz. Accessed at https://digitalcollections.library.ucsc.edu/concern/works/w9505347d?locale=en

[61] Anika Burgess, "The 1922 Eclipse Adventure That Sought to Confirm the Theory of Relativity. It Took 35 Tons of Equipment and a Lengthy Voyage to Remote Western Australia" *Atlas Obscura* (2017), https://www.atlasobscura.com/articles/the-1922-eclipse-expedition-to-remote-western-australia, accessed on 25 March 2023.

Following the observations, various actors began to shape historical narratives by emphasizing their prior roles. During 1923, first Campbell and then Perrine reclaimed priority for their failed attempts to test light bending in 1914 (and 1918) and 1912, respectively. Campbell recalled Lick's pioneering efforts for what he renamed as the "Einstein test." Perrine stated that: "I am not aware that any other expedition attempted such observations at the 1912 eclipse, or previously. It appears, therefore, that *the Córdoba Observatory made the first definite attempt to secure observations at an eclipse* [that of 1912], for the relativity problem and that was done at the instigation of Dr. Freundlich."[62] What is evident from former statements is that in this reconstruction process, astronomers involved in attempts to test light deflection before 1919 eliminated references to the main motivations for their past excursions which had nothing to do with relativity. Unwittingly they reinforced the visibility of the 1919 results, which was the first to take the test of light bending as its sole aim.

Therefore, by this reconstruction process, participants flattened a complex narrative, which they linearized perhaps unconsciously for priority purposes. But no linear historical narrative can pay due credit to their work. Only a narrative attentive to the variability of astronomers' allegiances enables one to detail the contours of their involvement, the different motivations behind their acceptance to test light bending before 1919, as well as the reasons why they were so eager to reclaim priority for their attempts after 1922.

Eclipse on Paper

The fourth and last dimension to be discussed in this paper investigates public representation and perception of the eclipse expeditions of 1919.[63] To do so we examined the circulation of knowledge from the astronomical to the public realm by using newspapers as historical sources. This allows us to assess to a certain extent how different audiences, as newspaper readers, in different countries around the world became aware of the 1919 eclipse and the importance of proving Einstein right. A first step stemmed from looking at newspapers in Brazil, Portugal, UK, USA and Germany in the period from 1 January 1919 to 31 December 1920, to characterize how media coverage differed among them, and to contrast

[62] Charles Dillon Perrine, "Contribution to the History of Attempts to Test the Theory of Relativity by Means of Astronomical Observations," *Astronomische Nachrichten*, 219 (1923): 281-84, italics ours.

[63] So far newspapers' sources have not been much explored. Examples include: Ildeu de Castro Moreira, "O Eclipse Solar de 1919, Einstein e a Mídia Brasileira," *Ciência e Cultura* 71, no. 3 (2019): 32-8; Milena Wazeck, *Einstein's Opponents. The Public Controversy about the Theory of Relativity in the 1920s* (Cambridge: Cambridge University Press, 2014); Milena Wazeck, "Einstein in the Daily Press: a Glimpse into the Gehrcke Papers" in *In the Shadow of the Relativity Revolution*, eds. Jurgen Renn, Matthias Schemmel and Milena Wazeck, 67-85 (Preprint 271, Max Planck Institute for the History of Science); Katy Price, *Loving Faster than Light: Romance and Readers in Einstein's Universe*, 16-41 (Princeton: Princeton University Press, 2012).

the emphasis on news centred on the eclipse expeditions, which we named "eclipse on paper," from those centred around their impact in relation with the acceptance of the theory of relativity, which we named "Einstein on paper."[64] In doing so, it was possible to get a first picture of the circulation of news about the eclipse around the world as seen through the press, reflecting its percolation through various layers and audiences in several countries of Europe and America.

Given that the path of totality crossed Brazil and the outskirts of the extended Portuguese empire, it comes as no surprise that almost all news in both countries focused on contents falling into the category eclipse on paper. However, a major asymmetry contrasts the scarce amount of news in Portuguese newspapers with an enormous variety of news in Brazilian newspapers of national, state, regional, and local circulation. The absence of news from colonial newspapers in Portugal is also noticeable. It resulted from censorship measures taken against the Portuguese colonial press during the Great War, in which Portugal participated. However, in Portugal, the island of Madeira is an interesting exception to the general scarcity of eclipse-related news. Located in the Atlantic, Madeira experienced the 1919 solar eclipse as a partial event. It also served as a stopover for all the British expeditioners: Davidson and Crommelin on their journey to Sobral, and Eddington and Cottingham even stayed for several weeks on the island before heading to Príncipe. This combination of local astronomical observation of the partial eclipse and the passage of the expedition members provided a particular context that stimulated interest and led to increased eclipse coverage in the island's press, with articles being published in the regional newspapers *Diário da Madeira* and *Diário de Notícias da Madeira*. It is also interesting to note that the local astronomical observation of the eclipse, whether total, in Sobral, or partial, in Madeira, led to the appearance of news with some satirical social content (Figures 8 and 9).

[64] News items were obtained from national, regional and local newspapers, mostly available on digital archives, by using keywords related to the eclipse, Einstein and the expeditions. The articles were then categorised according to source, typology (e.g. editorials, interviews) and themes (eclipse on paper, Einstein on paper or both). This structured approach allowed for a semi-quantitative analysis of the press coverage.


HOJE

A NOITE

HOJE

Redacção, Largo da Carioca 14, sobrado — Officinas, rua do Carmo, 29 e 31

Os escandalos em torno do ultimo governo

A necessidade de um inquerito rigoroso

O Sr. Wenceslão Braz defende-se

O telegramma do ex-presidente

O ECLIPSE DE AMANHÃ

SERÁ ECLIPSADO PELO FOOTBALL

PENSAR, SENTIR, ACTUAR

EM TORNO DA QUESTÃO DO ADRIATICO

GLORIFICAÇÃO DE UM DEMOCRATICO,

EM PORTUGAL

NOVAMENTE A GUERRA?

O FLAGELLO DAS SECCAS

Populações famintas que abandonam os sertões do nordeste brasileiro

O IMPOSTO DE 5 o/o

Uma consulta ao ministro da Fazenda

AINDA VAE SER INSPECTOR DE LINHAS DO LLOYD ?!

NOTICIAS DE PORTUGAL

HIPPOLYTO COLLOMB VAE EXPOR ALGUNS TRABALHOS SEUS

Figure 8. The front page of the May 28, 1919 edition of *A Noite*. On May 29, the day of the eclipse, another event captured the attention of Rio de Janeiro's newspaper readers: the final of the third South American Football Championship of Nations, held in Rio. On the eve of the game, the newspaper *A Noite* anticipated that "Tomorrow's eclipse will be eclipsed by football." Source: Hemeroteca Digital, BNDigital, Fundação Biblioteca Nacional, Brazil.


Contra o eclipse

Lampada «Electrigia»

Por ser brilhante e intensiva é a unica que pode illuminar o espaço, por occasião do eclipse de hoje.

Vende-se na «Electric». - Rua de Dr. Vieira 81, B 253

Figure 9. "Against the Eclipse. 'Electrigia' Lamp. Because it is bright and intense, it is the only one that can illuminate space, during today's eclipse. Sold at the 'Electric' [shop]." *Diário de Notícias da Madeira,* 29 May 1919.

Contrary to the exclusive emphasis in former historical publications on how Einstein was seen through the German press following the test of light bending during the 1919 solar eclipse,[65] news circulating in German newspapers were distributed among Einstein on paper and eclipse on paper, with a predominance on the first. Those in the British and American newspapers analysed were also distributed among both thematic areas, with a predominance of news on Einstein on paper in the USA case, and an almost even distribution among both categories in the British case.

The different distribution of news among the two broad categories in each of the countries analysed is also reflected in their monthly distribution, with a predominance of news about the eclipse on paper in the months preceding the eclipse and in the following months, and a predominance of news on Einstein on paper following the announcement of the expeditions' results at the joint meeting of the Royal Society and the Royal Astronomical Society on 6 November 1919, igniting discussions on relativity as an explanation for light bending and the advancement of alternative explanatory proposals. In the case of Brazil and Portugal, for which most news concerned eclipse on paper, news concentrated in the first half of 1919, with a monthly increase climaxing in May, and then decreasing.

The role of the British astronomical community in organising the expeditions and publicising their discoveries is reflected in the even distribution of British news between the eclipse on paper and Einstein on paper. However, this distribution changed somewhat over the course

[65] Wazeck, *Einstein's Opponents;* Wazeck, "Einstein in the Daily Press."

of 1919. Until the eclipse date, news covered the travels of the British teams in much more detail than in newspapers from other countries. After the joint meeting of the Royal Society and the Royal Astronomical Society, during which the expeditions' results were announced, news articles propagated the idea that a "revolution in science" had occurred for which the British teams had been instrumental (a kind of revenge for the missed opportunity of the discovery of Neptune in 1845, that was made by the Germans). They also propagated the view that Einstein's unfamiliar prediction could be communicated to the public by using the metaphor that "light has weight." Alternative explanations of the observed apparent star displacement were also discussed especially in their relation to the ether theory.

In the cases of Germany and the USA there is a predominance of news on Einstein on paper, again following the public announcement of results in November 1919. News on the eclipse on paper appeared around May in both countries but for very different reasons: in Germany due to Einstein and his prediction of light bending which the British travellers were testing; in the United States due to the failed attempt by the American astronomer David Todd to observe the eclipse by plane.

Taken together, differences reflect the utmost relevance of national contexts in framing news' contents. In what concerns the contrast between Brazil and Portugal, their geopolitical situation was a fundamental factor. Concerning Germany, UK and USA, their connection with main actors involved in the 1919 eclipse expeditions, in previous discussions about the use of total solar eclipses to test light bending, or in former failed expeditions to test light bending, played a role.

Concluding Remarks

In this paper we explored a global history of the 1919 eclipse to take a measure of the practice of astronomy in the early twentieth century. "Global" means here taking seriously the extra-European entanglements of the story. But even more it means looking into the less obvious conditions and actors that support and sustain scientific practice in terms of material, social, and political cooperation. To shape this global history, we focused on the two British expeditions that highlight the decisive contingencies and the complex environment surrounding astronomical practice. On the one hand this meant considering the extended network of involved protagonists across the globe and paying attention to the diverse social and political contexts they were exposed to. The diverging contexts became especially apparent when comparing the expedition to Sobral with the one to Príncipe. On the other hand, we looked at the variety of changing public representations and historical narratives of the expeditions. Both representations and narratives turned out to depend on the specific countries and the authors.

As a result, the former narratives became complexified in that the global history unveiled a multiplicity of actors working under various regimes of labour, and who in different degrees made the expeditions possible, but have often remained or were left invisible. The spatial and (geo)political dimensions, so far not taken seriously into consideration, were also emphasized. The eclipse's public dimension built on the circulation of news in the press around the world began to be scrutinized. And although this paper is centred on the 1919 total solar eclipse, the de-construction of its protagonism was done by unveiling a lineage of inter-related eclipses, starting with the 1912 total solar eclipse and going up to the 1922 total solar eclipse. In the process various invisibilities were revealed.

In conclusion one might say that for the 1919 eclipse to make history ultimately depended on the deep intertwining of astronomy, religion and empires, although these entanglements were bracketed out in the astronomers' own accounts of their work. Likewise, the supportive action by astronomers and other collaborators in Portugal and Brazil for these expeditions stayed behind the scenes, as if this customary protocol of assistance were not an integral part of the astronomers' practice. While the photographic plates recording totality occupy centre stage in the internalist accounts of the eclipse, the humans who together witnessed the moment of totality, both in Príncipe and Sobral, are distributed according to a colonial and racial hierarchy that the climax of the eclipse makes particularly visible. And yet, the realization of the task depended on all to a certain degree.

Moreover, this paper showed that the eventual "fame" of the 1919 eclipse was not inescapable. On the contrary, competing narratives on the importance of various eclipse expeditions circulated in the 1920s and later. The view of this affair among the community of astronomers offers a case in point. It is up to historians to de-construct their assessments to highlight the various contours of their involvement in testing light bending before 1919, their different motivations, as well as to contextualize their will to reclaim priority for their attempts after 1922. The global history presented here reintroduces the full sequence of eclipses both before and after the 1919 event.

While these narratives were mainly debated among twentieth century astronomers and later among historians of science, the representation of the eclipse, the expeditions and its impact on the spread of relativity theory concerned a wider audience. Based on the analysis of the daily press in the countries most involved in the 1919 eclipse—Britain, Portugal, Brazil, Germany and the US—, this paper also showed how different such representations were. The highlighted differences bring to light the importance of national contexts in framing news' contents even for such seemingly "universal" topics as scientific expeditions.

Finally, identifying invisibilities comes hand in hand with a discussion of the reasons behind them. They involve not only contemporary events and decisions taken by historical actors themselves but also by historians of science. This last intellectual endeavour is still underway.

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Competing interests

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