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Towards a Global History of the Eclipse of 29th May 1919

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Abstract
In this talk I discuss the preparation, observations and impact of the two British expeditions headed by A.S. Eddington to observe the total solar eclipse of 29 May 1919, in Príncipe, then a Portuguese colony, and in Sobral, Brazil. Their joint consideration raises pertinent historical questions, whose answers, some still conjectural, cross science and technology, geography and colonial empires, politics and religion, and networks of scientific actors, local elites, anonymous actors and the general public. It is my contention that they enable us to move from past histories, of inestimable but partial value, towards a global history of the 1919 eclipse.

The Context
This year marks the centennial of the already famous total solar eclipse of 29 May 1919 observed, among others, by two British teams with astronomical aims which were very different from those that were common practice among astronomers at the beginning of the twentieth century. One team included the director of the Cambridge Observatory, the astrophysicist Arthur Stanley Eddington, and the clockmaker expert E.T. Cottingham. They went to Príncipe, an island on the west coast of Africa, then a Portuguese colony, now part of the Republic of São Tomé e Príncipe. The other team, including C.R. Davidson and A.C.C. Crommelin, two reputed astronomers from Greenwich Observatory, headed towards Sobral, Brazil. They both intended to test one of the predictions of Einstein's theory of gravitation, announced in 1915 and published in 1916. that is, the bending of light rays as they passed close to large gravitational masses.

The organization of these two expeditions, rather than one as usual, took place during the difficult times of the First World War, when Albert Einstein was not yet famous, and relativity theory was not yet generally accepted by the British scientific elite, particularly fond of ether theory. In fact, not only the physical make-up of relativity was counter-intuitive and at odds with long-time concepts of Newtonian classical physics, but also its mathematical apparatus, grounded on the "theory of invariants and (…) the calculus of variations," challenged the understanding of experts and lay people alike.[1] This was the gist of the reasoning of J. J. Thomson, the president of the Royal Society of London, who chaired the session of 6 November 1919, organized jointly by the Royal Society and the Royal Astronomical Society, announcing the results of the expeditions, in which he summarized the challenges ahead. As he predicted, if the first steps towards the acceptance of Einstein's general theory of relativity were ignited by the results of the British expeditions they were followed by a long and arduous process due mainly to relativity's physical and mathematical foundations. This process has been recently dubbed as the "Einstein War,"[2] and discussed thoroughly in a book with the same title by historian of science Matthew Stanley.

The difficulties of the process of acceptance included also the close scrutiny of the work of data reduction, which took place during the summer and autumn of 1919 and was mostly done by Eddington and the Astronomer Royal F.W. Dyson. From March 1917 onwards, Dyson played a crucial role in convincing scientific and governmental authorities of the expeditions' scientific worth, supporting the organization of two missions to double their probability of success. He had certainly in mind the failures of the two previous expeditions organized in 1912 in Brazil and 1914 in Crimea, when Einstein was still working on the extension of special theory of relativity but had already predicted light bending, even though with a wrong value for deflection.

What was at stake in the observations of the British teams was the comparison between the positions of stars registered on the photographic plates during the eclipse and in the so-called comparison plates, taken usually a month after the eclipse day, when the sun was not anymore between the observer and the stars so that their light was not subject to deflection by the sun's gravitational mass.

The reduction of data was a hard process, due to the minuteness of the effect, if it existed at all, which enabled to decide between Isaac Newton's and Einstein's theories of gravitation. Einstein predicted a deviation double than that based on Newton's classical theory, if one accepted a corpuscular nature for light, that is, it predicted a deviation of 1,75" seconds of arc instead of 0,87" seconds of arc accounted for by classical physics. The decisions taken were discussed at length in the joint article authored by Dyson, Eddington and Davidson, entitled "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,"[3] published in early 1920, a few months after the 6 November announcement.

Though not as enthusiastic as Eddington as to the theory of general relativity, Dyson quickly recognized the importance of the 1919 eclipse for testing light bending. He immediately anticipated its relevance to astronomy and British astronomers.[4] As early as 9 March 1917, at a meeting of the Royal Astronomical Society, in a communication entitled "On the opportunities afforded by the eclipse of 1919, May 29 of verifying Einstein's theory of gravitation",[5] he drew attention to the eclipse, pointing out that it was an excellent opportunity for astronomy to do a favor to a recent physical theory that explained the advance of Mercury's perihelion, an astronomical effect that had long afflicted astronomers. While aware that before the May 1919 eclipse there would be another total solar eclipse on 8 June 1918 in the United States, Dyson dismissed the involvement of a British team given the adverse political and astronomical conditions for verifying deflection.

So, contrary to Eddington who was, no doubt, inclined to confirm Einstein, as he soon confessed in the book *Space, Time and Gravitation*, admitting that he "was not altogether unbiased,"[6] Dyson was somewhat neutral towards relativity as a physical theory but sensitive to its astronomical consequences. If the degree of allegiance of both to relativity was very different, they worked jointly on the reduction of data, which required both great practical and mathematical expertise.

Especially from the 1970s onwards doubts about the rigor of observations and of data analysis were put forward both by physicists as well as by philosophers of science.[7] Criticisms encompassed accusations of elimination of data that favoured Newton's theory based on Eddington's early advocacy of Einstein's theory. But inclination towards a result is not equivalent to data manipulation. And one should also mention that most important decisions concerning the initial elimination of plates were done by Dyson, upon noting that at Sobral, the main telescope with the astrographic lens lost focus during the eclipse due to heating of the celostat.[8] The historian of science Daniel Kennefick has addressed the question of scientific mal-practice for over a decade now, discussing thoroughly the steps taken by the British astronomers, and arguing in their favour and against contemporary accusations. His detailed analysis has recently come out in a book fittingly titled *No shadow of a doubt*.[9]

The Argument

The British expeditions were mathematical in a variety of ways. I have briefly addressed the most relevant, in order to show that mathematics was dominant at both ends of the spectrum, that is, as an integral part of Einstein's prediction of light bending which the expeditions set out to verify, and as a vital component of the process of data analysis which proved Einstein right. The use of mathematics was instrumental to the expeditions' success. But mathematics was always irrevocably intertwined with astronomy and with physics.

In this talk, I change the focus of analysis from the astronomical, physical and mathematical pillars of Einstein's prediction and the expeditions' impact in proving general relativity theory, already discussed at length in the literature. I opt instead for a joint discussion of the two expeditions in order to show that their scientific consequences - astronomical, physical and mathematical – were grounded on a number of people, events, and decisions, which are often bypassed in standard narratives, and which are essential, although often invisible, to the success of the scientific enterprise.

To do so, I rely on printed sources – scientific communications, discussions and publications - and mostly on private sources: Eddington's and Crommelin's more or less detailed accounts of their travels. Authored by experienced expeditioners, they offer a glimpse into landscapes, places, peoples and experiences unrelated to their authors' daily routine. They are revealing both for what they refer to and for what they omit. I also rely on printed and manuscript sources related to the two localities visited. They include the exchange of correspondence with the direction of the Astronomical Observatory of Lisbon as well as with the National Observatory of Rio de Janeiro, as well as newspaper news and visual sources, which exist in profusion for Brazil, and are surprisingly meagre or altogether non-existent in the Portuguese case.

Taking into account the geographical and geopolitical asymmetries of the two selected sites of observation, first I focus on a discussion of different “invisibilities” in the expeditioners’ published accounts associated with the active role of local people, especially during the observation of totality; secondly I ponder on the inexistence of photographs of the experimental apparatus and of travellers in Príncipe, in sharp contrast with Sobral; and finally I discuss “invisibilities” related, directly or indirectly, to Portugal's condition of colonial power and the accusations of slave labour in Príncipe, a very complex and controversial issue.

Archives:
PT/MUL/OAL - Arquivo Histórico dos Museus da Universidade de Lisboa, Observatório Astronómico de Lisboa, Universidade de Lisboa.
TCL: EDDN A4/2 - Trinity College Archives, Eddington Correspondence. Letters from Eddington to mother/sister.

Notes:

[1] “Joint eclipse meeting of the Royal Society and the Royal Astronomical Society”, *Observatory* 42 (1919), 389-98, p. 394.

[2] Matthew Stanley, *Einstein war* (New York, Dutton, 2019).

[3] F.W. Dyson, A. S. Eddington, C. 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* (1920), A220, 291–333.

[4] According to John Stachel, “Eddington and Einstein” in *Einstein from B to Z* (Birkauser, Boston, 2002), pp.456-7, Dyson was aware of the article by astronomers Lindemann, father and son, who in 1916 used a special photographic technique invented by them to photograph stars close to the sun, circumventing the occurrence of eclipses. Apparently, the meeting between Lindemann's father and Einstein in Brussels in 1913 provided the occasion to discuss light bending.

[5] F.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 (512) (1917), 153-157. The deputy director of the Astronomical Observatory of Lisbon, Colonel Frederico Thomaz Oom published also in the journal *O Instituto* of the University of Coimbra, on January 3, 1917, an article pointing to the favourable conditions of Príncipe and urging astronomers to study its weather conditions.
Frederico Oom, “O eclipse total do Sol em 29 de Maio de 1919 visível na Ilha do Príncipe”, *O Instituto* 64 (1917), 97–8.

[6] A.S. Eddington, *Space, Time and Gravitation. An Outline of the General Relativity Theory* (Cambridge: CUP, 1920), p. 116.

[7] S. Hawking, *A brief history of time* (NY: Bantam Books,1988), John Earman, Clark Glymour, “Relativity and eclipses: the British expeditions of 1919 and their predecessors,” *Historical Studies in the Physical Sciences*, 11 (1980), 49-85.

[8] Stars presented streaks that made it very difficult to correctly calculate their displacement relative to the positions on the comparison plates taken two months later with the instrument back in focus. Even before this eclipse there were doubts about the performance of the celostat of the astrographic telescope. See D. Kennefick, *No shadow of a doubt. The 1919 eclipse that confirmed Einstein’s* (Princeton, Princetion University Press, 2019), p.201.

[9] D. Kennefick, “Testing relativity from the 1919 eclipse – a question of bias”, *Physics Today*, 62 (2009) 37-42; Kennefick, *No shadow of a doubt* (ref. 8).