annalen der physik

www.ann-phys.org

The 100th Anniversary of Einstein's Nobel Prize: Facts and Fiction

Robert Marc Friedman

As the 100th anniversary approaches of Albert Einstein being awarded a Nobel Prize, questions remain about the motivation for the prize and about the absence of any specific mention of his theory of relativity. By revisiting and supplementing earlier scholarly studies, it will be shown that "Einstein did not receive, as often claimed, a prize for his theory of the photoelectric effect and that committee member Allvar Gullstrand's error in comprehending relativity was not the cause for rejecting this strongly nominated achievement." Rather, in their evaluations of relativity, "Svante Arrhenius (1920) and Gullstrand (1921 & 1922) brought to the task bias, if not prejudice; they incorporated arguments from the German ultranationalist experimental physicists' politically and racially motivated opposition to Einstein and his theories of relativity and gravitation. Only when Carl Wilhelm Oseen joined the committee in 1922, he nominated, evaluated, and proposed a prize for the discovery of the law of the photoelectric effect." The precise wording and deliberate silence about Einstein's quantum theoretical derivation of the law owes to Oseen's insightful understanding of the challenges facing any effort to award a Nobel Prize to both Einstein and Niels Bohr.

1. Introduction

On 9 November 1922, the Royal Swedish Academy of Sciences voted to award Albert Einstein the previously reserved 1921 Nobel Prize in Physics for "his services to theoretical physics, and especially for his discovery of the law of the photoelectric effect."[1] This decision prompted several decades of speculation, especially with respect to the reason for omitting Einstein's theories of relativity. When changes in the statutes (1974) eventually gave researchers access to official archival materials 50 years and older, historical scholarship could begin challenging conjecture and myth.[2] Yet, as the 100th-anniversary of this prize approaches, some confusion remains as to what actually transpired and what it means. The Academy of Sciences and related official Nobel sources have long represented this episode along a line that turns out to be incompatible with the historical record. Their version in part draws on physicist Abraham Pais's account how Einstein got a Nobel Prize while ignoring less congratulatory research.[3] Claiming Einstein received a prize for his *theory* of the photoelectric effect and attributing relativity's absence simply to an unfortunate error in committee member Allvar Gullstrand's evaluation, their narratives carry misunderstanding and oversimplification of a much more complex and troubling history.

2. A Swedish Prerogative

The Nobel Prize in physics may well be international in scope, but since its beginnings in 1901, the Royal Swedish Academy of Sciences has determined the outcome. During the first 50 years of proceedings that have been studied in detail, committee members relied largely on their own judgement.[4] No juggling of statistics related to nominations—number, frequency, or origin—explains the awards. Those entitled to nominate rarely provided a clear mandate for any single candidate. Regardless, the committee seldom selected those candidates who enjoyed a consensual or even majority status from the nominators. The Swedish committee members' own comprehension of scientific accomplishment, their own priorities as to what was important, and their own group dynamics all proved critical for the outcome. But reading committee reports requires a deeper understanding of the committee members in order to seek insight into decision-making. The committee's well-polished texts represent after-the-fact justification for its recommendations sent to the Academy of Sciences; the final reports are not repositories of the processes of trying to arrive at a consensus. The act of writing was also an act of erasing the at times contentious processes, marked by, let's name it, bias, arrogance, and even pettiness.[5]

3. 1920: Fame, Reactionary Foes, and a Surprise

At a joint meeting of the Royal Society of London and Royal Astronomical Society held on 6 November 1919, the retired Cambridge

R. M. Friedman
Institute for Archaeology
Conservation and History
University of Oslo
Oslo, NO 0315, Norway
E-mail: r.m.friedman@hf.uio.no

The ORCID identification number(s) for the author(s) of this article can be found under https://doi.org/10.1002/andp.202200305

DOI: 10.1002/andp.202200305

physicist J. J. Thomson announced the results of the now-famous British eclipse expeditions. Notwithstanding a number of inconclusive photographic plates, a sufficient amount of reliable data confirmed the minute bending of starlight by the sun's mass that Einstein had predicted based on his general theory of relativity.[6] In Europe still recovering from the horror of world war and anxious over political and social upheavals in its wake, news of a theory that overthrew the foundations of physics, and glimpses of its highly unconventional creator, attracted media attention. During the first half of 1920, not only did much of the scientific community recognize Einstein for his achievement, the ever growing mass media's attention helped generate a world-wide fascination with relativity. Scarcely understood by the general public, relativity nevertheless assumed an unprecedented role as symbol for the new uncertain era emerging from the ruins and upheavals of war and revolution. Political movements on both ends of the political spectrum began to embrace or attack relativity for their causes. Not necessarily to his liking, Einstein was transforming into an international celebrity the likes of which was unprecedented. Not all physicists accepted the British results as valid proof of Einstein's theory; and not all physicists were intellectually equipped or willing to understand the theory.[7]

Einstein was no stranger to the Nobel committee. He had been nominated as early as 1910; a trickle of nominations turned by 1917 into modest but substantial annual support.[8] Although for 1920 few nominators sent in proposals, Einstein dominated the sparse list. These included nominations from Niels Bohr and several Dutch physicists including laureates, H. A. Lorentz, Heike Kamerlingh-Onnes, and Pieter Zeeman.[9] No doubt, some eligible nominators did not participate as a protest over a German sweep of science prizes in 1919 – Max Planck, Johannes Stark, and Fritz Haber – seemingly in defiance of the Allied nations' boycott of German science.

The five-member Nobel Committee for Physics was dominated, as it had been from the start, by Swedish physicists with a strong commitment to an experimentalist creed that largely relegated sophisticated theory and mathematics to an insignificant role in the advance of physics. Bernhard Hasselberg (1848–1922), Gustaf Granqvist (1866–1922), and Allvar Gullstrand (1862–1930) held precision measurement and experiment as the crux of their discipline. They supported and at times also nominated candidates whose work mirrored their own orientations. Vilhelm Carlheim-Gyllensköld (1859–1934), a cosmic and mathematical physicist, had in 1911 protested the minimal number of prizes given to theoretical contributions in spite of nominations for prominent representatives, such as Ludwig Boltzmann, Oliver Heaviside, Lord Kelvin, Max Planck, Henri Poincaré, and J. H. Poynting. But he himself was largely marginalized on the committee. Although the fifth member, Svante Arrhenius (1859–1927) enjoyed great popularity in the Academy, and as an early pioneer in physical chemistry frequently played a crucial behind-the-scenes role for the Nobel Committee for Chemistry, he too frequently found himself in a minority position on the physics committee when advancing theoretical contributions. Having attempted many times to promote Planck's candidacy, which had long been strongly supported by international nominators, he finally succeeded in 1919, but not without some difficulties. Hasselberg and Gullstrand initially declared that the previously reserved prize for 1918 should go to Johannes Stark and the 1919 prize to Planck as this would underscore the primacy of experiment over "speculative theory." Chronology dictated otherwise. Arrhenius modified the motivation for Planck three times before the committee majority was willing to overcome its negative stance on quantum theory.[10]

Arrhenius tended to support awarding prizes to contributions to theoretical physics and was himself often accused of embracing speculative theoretical programs, especially in his cosmical physics and popular science writings. He had long held relatively liberal, and even radical political views, believing in secular scientific progress as the key to a better world. He entered a period of despair and pessimism during and after the war. His voluminous correspondence after 1914 reveal an increasingly shattered belief in progress; he assumed science would take at least 50 years to recover from the losses due to the war. By 1919, he bemoaned the prospects for recovery and in particular feared that the brilliance of German science would take decades to shine again; both political and economic obstacles threatened to strangle the sciences, in Sweden, Germany, and beyond. Even his plan in 1920 to jumpstart a renewal of internationalism in science at the first Nobel ceremony since 1913 fizzled. Imagining scientists from previously warring nations shaking hands and socializing, he learned quickly that emotions ran deep over German actions during the war. T. W. Richards and the Braggs refused to attend.

Arrhenius' correspondence also reveal a pervasive interest in money matters and funding for science, especially for his Nobel Institute for Physical Chemistry. His letters show a fixation on the threat of Bolshevism as well as on the growing social-political marginalization and impoverishment of academics due to postwar democratic and social-democratic advances in Sweden, Germany, United States, and elsewhere. These issues provide some context to his initial attitude toward Einstein and relativity.

In its 1920 general report to the Academy, the committee dismissed Einstein based on Arrhenius' special report on the degree to which Einstein's predictions based on relativity theory had been confirmed (the bending of starlight passing near the sun, the irregularities in Mercury's orbit, and a shift toward the red end in the solar spectrum). Much of his brief seven-page report emphasized the negative claims against relativity, including those from some of Einstein's most ardent German detractors. Arrhenius completed his report during the first half of August 1920, just when German anti-Einstein agitation was becoming more public and more virulent.

To summarize briefly some of the detailed studies about the rise of the German antirelativity movement,[11] the long-standing disgruntlement with Einstein's 1905 special theory of relativity among many conservative physicists, took on new form and intensity in 1920, especially among ultranationalist experimental physicists. The confluence of political, social, economic, and cultural upheavals following Germany's military defeat and the collapse of Imperial Germany, coupled with many experimental physicists' dismay over their growing loss of prestige to theorists, resulted in heightened antagonism to Einstein and relativity theory. Both he and his theory seemed to embody all that was wrong with the emerging postwar era.

Although prior to August 1920, the public profile of the anti-Einstein forces tended to focus on scientific issues, private networks of communication engaged in increasingly reactionary political and anti-Semitic motivated antagonism. Relativity was

"un-German" and sickly Jewish, as Philipp Lenard, the most prestigious of the antirelativity physicists declared first privately and later publically. In most general terms, a critique began emerging on the political far-right that true German physics was practiced at the laboratory bench, based on honest disciplined craft skills. It provided common sense insight into physical reality based on experiment and precision measurement. Jewish physics, as exemplified by relativity, was abstract, speculative, overly mathematical, and having little to do with actual reality. Opponents blamed the extraordinary fascination with Einstein and relativity to conspiracies by the Jewish-owned liberal Berlin press and science publishing houses, in collusion with Einstein and his coterie of Berlin scientific supporters, such as Planck and Max von Laue. Among respected physicists, the most important opponents were Ernst Gehrcke and the two Nobel laureates Lenard and Johannes Stark.

Gehrcke, director of optics at the national physical and technical institute, had for many years appealed to the popular notion of "mass [crowd] suggestion" [*Massensuggestion*] to account for the ever-growing popular interest with first the special theory, and then after 1919, the general theory of relativity, both of which he rejected with scorn. Gehrcke, along with another tenacious critic of relativity, Lenard in Heidelberg, joined ranks for a while in 1920 with the engineer Paul Weyland who gave them and others hope for a concerted attack on relativity through his newly founded, openly anti-Semitic, anti-Einstein organization, "Working Association of German Natural Scientists for the Preservation of Pure Science." Weyland organized antirelativity rallies at Berlin Philharmonic Hall on 24 and 25 August 1920, aiming to unmask what he considered the "hoax" of relativity and the role of "a certain press" (that is, Jewish owned) that served Einstein's propagandistic goals to create the mass fascination. Gehrcke gave the proceedings scientific credibility, and provided a forum to spread his argument that relativity was nothing more than unproven "scientific mass hypnosis."[12] In addition to lectures, the rally also offered sale of anti-Semitic and anti-Einstein literature and Swastika pins and pennants.

Although Lenard's antirelativity pamphlet was on sale at the rally, he did not attend. At the time, he preferred to claim that his negative appraisals of relativity were based solely on scientific issues. Yet, all the while his private correspondence reveal an ever growing strident and racist disgust with Einstein and his theories. To various degrees, elements of his, Gehrcke's and others' critiques of relativity entered into Nobel proceedings.

Arrhenius refers to some of the extremist antirelativity literature in his seven-page special report for the Nobel committee.[13] After briefly noting general relativity's ability to account for the minute irregularities in Mercury's perihelion motion that Newtonian mechanics fails to explain, he then devotes over a half-page to Gehrcke's criticism of Einstein on this largely undisputed success for relativity. According to Gehrcke, this anomaly had already been resolved decades earlier by a little-known German researcher, Paul Gerber. Based on classical aether-physics, Gerber's achievement meant there was no need to accept Einstein's revolutionary reformulation of space and time to account for this puzzling phenomenon. When Einstein had earlier refused to respond to these claims, Gehrcke began to accuse Einstein of plagiarism, which in turn, became a common charge by the far-right against him and relativity. Arrhenius failed however to mention that von Laue and others had earlier decidedly refuted and repeatedly dismissed Gehrcke's argument, by having demonstrated serious errors in Gerber's calculations.[14]

Turning to the British eclipse results, Arrhenius accepted the skeptics' argument that the margin of experimental error was larger than the effect to be measured. He declared that these results cannot be admitted as evidence as questions remain about their degree of exactness. He then notes that all efforts to identify a redshift in the solar spectrum had failed.

Arrhenius closed his report, dated 17 August 1920, with several references to literature by various anti-Einstein writers. In a highly unusual practice, he cites articles published in newspapers, largely the ultranationalist *Deutsche Zeitung*. These included contributions from scientifically and politically dubious authors, such as Hermann Fricke and Johannes Riem, the latter an openly anti-Semitic Christian opponent of what he considered "Jewish materialism." Also mentioned are the "fanciful and fanatic publications" of Rudolf Mewes, a reactionary anti-Semite who supported restoring the Kaiser and opposed the alleged conspiracy to replace true German science with Jewish abstract, derivative knowledge.[15] Arrhenius includes a comment that for the upcoming national meeting of German natural scientists at Bad Nauheim in September, preparations were underway for a "neutralizing [*oskadliggörande*]" of Einstein from "all layers of all the natural-science disciplines." Toward that goal, both Gehrcke and Lenard, among others, were expected to be the main presenters.

Arrhenius was here quoting almost verbatim from a letter from Weyland in which the latter describes his plan to combat what he considers Einstein's sickly and un-Germanic influence, that through enormous advertising from "a certain press," had become "a scandal for German research."[16] Upon receiving this letter Arrhenius seems to have turned to Lenard for advice about the unknown Weyland. Lenard's reply approves Weyland's plans to counter the "excesses" of relativity and provides a positive recommendation of this enthusiastic young man.[17]

Arrhenius concludes his evaluation with a quotation from Lenard's recently reprinted polemic against relativity followed by an abrupt ending consisting of Lenard's assertion that much of Einstein's theory must be recognized as "untrustworthy [*ovederhäftig*]."[18]

The report takes little notice of what the nominators and others found valuable in Einstein's work. While he wrote his report, the full-extent of the extremist political and racist background to much of the German anti-Einstein movement may not have been clear. Still, Weyland and Lenard's letters coupled with the fact that Lenard and Gehrcke had long been highly critical of relativity were clear indicators of the evolving situation in Germany. Moreover, he met officially and privately in June 1920 with Einstein-supporters Planck and von Laue, as well as with the ultranationalist relativity-opponent Stark, when they all attended the Nobel ceremony. With his deep concern for German science, it is inconceivable that Arrhenius did not discuss current events with them. He enjoyed especially good relations with both Planck and Stark, the latter had recently arranged an honorary doctorate from Greifswald University in which he emphasized Nordic Arrhenius's role in helping German science and the common racial, religious, cultural, and political heritage of their nations.[19]

It remains puzzling why Arrhenius included this literature in his report and why when he shortly thereafter must have understood the unsavory political and racial views expressed by many of the major German opponents of relativity, he remained silent. What Arrhenius actually thought of Einstein and relativity is difficult to pin down. His extensive correspondence reveals no particular interest in relativity; he was not a passionate opponent as were several others on the Nobel committee. Still, Arrhenius might well have been surprised and dismayed by Einstein's response to his letter of sympathy and solidarity sent to many German scientists in the aftermath of defeat in November 1918. Einstein expressed glee over the end of the Kaiser's Empire and declared himself to be a democrat and republican, who was deeply concerned with issues of human rights.[20] Neither Arrhenius nor his many close relationships in German science were democrats or republicans.

In the immediate aftermath of writing his report, Arrhenius could follow Weyland and Gehrcke's attack on Einstein at the rallies against relativity held at Berlin's Philharmonic Hall. Through his many contacts and the Swedish and German press's reporting, he could follow this and subsequent events, including Einstein's response to the event. In a highly-publicized and controversial essay in a liberal Berlin newspaper he called out the anti-Semitic underpinning to Weyland, Gehrcke, and Lenard's attacks on relativity[21]. Rumors circulated that Einstein was planning to leave Germany as a result of death threats.[22] Arrhenius regretted that he could not attend the Bad Nauheim national scientific conference where a show-down, at least scientifically, was expected between Einstein and Lenard. Following Einstein's accusation of anti-Semitism, Lenard launched a series of countercharges assailing Einstein for being the one who introduced the matter of race into debates over relativity.[23] Lenard provided his caustic version of what eventually transpired at Bad Nauheim in a letter to Arrhenius, surely indicating a trusted and valued relationship.[24]

Making matters difficult to gauge Arrhenius' beliefs and intentions, as an old master of maneuvering in the Academy with respect to Nobel matters, he frequently allowed strategic pragmatic considerations—political and personal—to steer his actions. Given his numerous close relationships with scientists from many nations, and given his need to negotiate with factions within the Academy, Arrhenius developed keen diplomatic skills, including the art of being two-faced. Did he understand the futility of challenging the committee majority's adamant opposition to relativity and simply provided a text to its liking? His own dependence on his colleagues' good will for obtaining desperately needed additional funding for his Nobel Institute could also have subdued any desire to make a stand against the German critiques of relativity.[25] Yet, possibly he was expressing his true belief when quoted in a far right-wing Swedish newspaper right after the Philhamonic Hall rallies that the Einstein's relativity is nothing but "pure speculation."[26]

In fact, the committee wanted from the start to award the prize for 1920 to Charles-Edouard Guillaume for his contributions to precision measurement. This choice surprised most everyone, including Guillaume. Although scarcely nominated, Guillaume had long been championed by Hasselberg, who now, gravely ill and about to retire after 20 years on the committee, received his last-wish. Guillaume no doubt also proved an attractive choice politically after the harsh accusations of Swedish pro-German bias. In fact, Einstein had heard rumors very early in the process that he could not receive a prize in 1920 for political reasons.[27] Guillaume, the Swiss leader of the France-based International Bureau of Weights and Measures, could bolster the Academy's claims of being neutral and being a supporter of international cooperation in science.[28]

4. 1921: Bias and Arrogance

In 1921, Einstein's place in physics received unambiguous nominational confirmation, including comparatively broad international support from nominators.[29] Some, such as Lorentz and Planck, portrayed Einstein's status as being that of a scientific giant, the likes of which has not been seen since Newton. Both theoretical and experimental physicists proposed Einstein, especially for his work on relativity. Some claimed that it would be difficult to consider other candidates without first seeing Einstein recognized. Einstein's mandate overshadowed all other candidates.

Gullstrand took it upon himself to write a detailed report on Einstein's relativity and gravitational theories. Gullstrand, a brilliant contributor to physiological and geometric optics, defined himself as both ophthalmologist and physicist. He is largely remembered for his path-breaking instrumental innovations for studying the eye and his complex analyses of the eye as an optical system. He received the 1911 Nobel Prize in medicine. That same year, the physics committee had also decided to award its prize to Gullstrand, in both cases based on local Swedish nominations. Gullstrand maintained that one Nobel Prize was sufficient; the medical prize was decided first, and that was the prize he accepted.[30] Gullstrand's extraordinary talents were accompanied by stubbornness and arrogance. For over 25 years, he refused to admit error after concluding that the retinal macula, responsible for color vision, was devoid of yellow coloring. Similarly, he rejected advice to abandon his personal cumbersome and confusing form of mathematical analysis when more expedient, and more readily comprehensible forms, became available. He had once compared each Nobel Prize to a Swedish flag displayed in such a way that the entire civilized world could see and admire it.[31] Like Arrhenius, his command of recent theoretical physics was limited.

Gullstrand's unusually long, 50-page evaluative report appears at first glance to be comprehensive and to engage with details of Einstein's work.[32] Closer inspection shows an internal logic based on the premise that Einstein cannot be right. By 1921, the political and racial aspects of the German anti-Einstein campaign was well known, yet Gullstrand explicitly stated that he accepts the content and conclusion of Arrhenius' 1920 evaluation. Gullstrand aimed at defusing those aspects of Einstein's theory that called for "an overhaul of the common sense foundations of mechanics." According to Gullstrand that which remained once Einstein's errors and unproven assertions were eliminated could best be treated successfully by classical mechanics. He refers to literature written by Einstein's supporters as being subjective, delivering unsound and insufficiently proven claims from a "cult of believers." "Belief" rather than evidence-based scientific reasoning recurs several times in Gullstrand's discussions of those who accept Einstein's theories. No similar criticisms are directed toward Einstein's opponents.

Gullstrand does not explicitly refer to Gehrcke's arguments related to Einstein's treatment of the Mercury perihelion anomaly; no doubt because he presented his own critique and explanation. The British eclipse data, according to Gullstrand, are useless. Even if the minute bending of starlight actually received confirmation that would not constitute proof of Einstein's 4D spacetime. He based that conclusion on a little known Norwegian-language, semipopular scientific article by meteorologist and aether-physicist Vilhelm Bjerknes.[33] Gullstrand refers extensively to Bjerknes' effort to account for the deflection using classical physics. In the end, Gullstrand asserts that Einstein's theories are devoid of any real content and have no relationship with physical reality; they lacked "the significance for physics for which an awarding with a Nobel Prize can come into question."

The committee accepted Gullstrand's evaluation and recommended to the Academy that because no candidate was deemed worthy, the prize for 1921 should be reserved until 1922. No member of the Nobel committee accepted the British data as valid evidence. Hasselberg wrote from his sick bed, "it is highly improbable that [Alfred] Nobel considered speculations such as [Einstein's] to be the object of his prizes."[34] Granqvist had for years rejected theories that were "in conflict with the laws of physics" and that violated notions of "common sense." Carlheim-Gyllensköld, who had surprised the others in 1919 by arguing for the need to recognize Niels Bohr, agreed to reserve the prize based on his belief that further experimental evidence was required before relativity could be awarded. In a letter of protest after discussions in the committee and then in the Academy's ten-member Physics Section, he stated that he does not agree with everything that was written in Gullstrand's report.[35]

Why did not Arrhenius make any formal disagreement? By the summer of 1921, he certainly understood the nature of the antirelativity agitation. He had renewed and strengthened his close relations with the Berlin physical science community. When he visited he attended seminars and colloquia as well as social engagements. He met Einstein, if not before, then on a visit in June 1921.[36] Although Arrhenius no doubt looked unfavorably on Einstein's social-democratic ideals and, like most others, disapproved as well as envied his fame, he seems to have developed a strong liking for Einstein. He understood that among Berlin's scientific élite, Einstein enjoyed great respect and appreciation as researcher and colleague. Moreover, Arrhenius attended the Berlin physics seminar in June 1921 where von Laue took up and rebutted what Arrhenius described as Gullstrand's "attack" on Einstein.[37] Yet, there is no evidence of Arrhenius questioning or challenging Gullstrand's flawed report.

Gullstrand himself kept his political and scientific opinions close to his chest. In a banquet address at the December 1921 prize ceremony in Stockholm for Anatole France (literature) and Walter Nernst (chemistry), as reported in several Swedish newspapers, Gullstrand emphasized the intimate link between a nation's racial characteristics and the culture and science it creates. He surely grasped that the German Einstein opposition was not purely based on scientific disagreement. His close Uppsala University colleague and friend, theoretical physicist Carl Wilhelm Oseen (1879–1944) learned directly from Max Born how Einstein was badly shaken up at the Bad Nauheim meeting by reactionary, anti-Semitic attacks that left him seriously thinking of leaving Germany.[38] What Oseen and Gullstrand thought of that and similar news from Germany is not clear.

As usual, the minutes of the full Academy's Nobel meeting record only the result of the vote, and little more. Still, a number of archival sources provide some insight into the event. The Academy's discussion revealed gaps in Gullstrand's command of physics and, in an emotional outburst, also his prejudice.[39] Indeed, in spite of devoting almost a year aiming to prove Einstein wrong, his efforts to master the mathematical and theoretical details proved insufficient. While working on his report, Gullstrand occasionally had discussed his objections to Einstein's theories with Oseen, who tended to respond very quickly by pointing out Gullstrand's misunderstandings. Oseen told the younger theoretical physicist Oskar Klein about these tribulations while noting that Gullstrand was hindering a prize for Einstein. Oseen confessed to Arnold Sommerfeld that it was a misfortune Gullstrand had to evaluate theoretical work that he did not understand.[40] Oseen was one member of the Academy who could have countered Gullstrand's report and spoken on behalf of relativity. Although he had lectured favorably on relativity in 1919, he increasingly disapproved of general relativity and by 1921 opposed awarding it a prize.[41] Although Oseen distanced himself from the vociferous and at times grossly racist attacks against Einstein and relativity by a few Swedish physicists, he was long interested in racial influences in science and mathematics, and even, many years later, expressed admiration for Lenard's racist *Deutsche Physik* (19363–1937).[42] If the issue for the Academy was simply an error in Gullstrand's report, then in principle, the Academy was free to act once this was brought to light, especially in light of the extraordinary support from nominators.

A rebellion that year in the Academy against the committee was unlikely. Many if not most members of the Academy were staunchly conservative politically and scientifically. Equally important, the Academy's culture of deference to authority meant that voting against Gullstrand's conclusions would constitute a grave insult, especially when he, one of Sweden's most accomplished scientists, was so adamantly opposed to Einstein. It mattered little that leading international physicists had praised Einstein as the greatest living representative of their discipline, and had declared his accomplishments in relativity theory to be among the most significant in the history of science. Local "expertise" had spoken; the Academy guarded its own authority and its own right to assess and judge.

For 1922, Einstein again dominated the nominations. Bohr also received strong support. Gullstrand supplemented his report. He rejected suggestions of bringing in a foreign expert to assist with the evaluation. Privately he declared that Einstein must never receive a Nobel Prize.[43] He continued to adhere to Gehrcke's argument that mass suggestion created the popular mania over relativity. Gullstrand agreed that new discoveries will soon reveal Einstein's hoax; the enormous interest in relativity will then rapidly "evaporate [*fördunsta*]." Again, Gullstrand ignored the nominators' enthusiastic declarations and extraordinary praise. From his perspective, even scientists can succumb to mass suggestion. Gullstrand focused now more directly on the special theory of relativity. The many favorable books on the subject do not provide a critical examination of the underlying assumptions: "dogma ... is mistaken for facts." Gullstrand insists that "the question of the special (and with that also the general)

theory of relativity's justification is a matter of faith." As in 1921, Gullstrand declared that Einstein's theories lack the significance for physics needed to be considered for a Nobel Prize.[44] The committee accepted this judgement without any formal dissent.

5. 1922: Enter a Master of Strategy

In addition to Einstein's contributions to relativity and gravitation theory, some nominators had also been praising his many other seminal contributions as warranting a prize. These included his work with quantum theory, especially through his theories of the photoelectric effect and of specific heat of solids; others mentioned his work related to Brownian motion and kinetic theory. In both 1921 and 1922 one lone nominator, Oseen, specified Einstein's discovery of the law of the photoelectric effect. He chose his words with care.[45]

The law of the photoelectric effect emerged in connection with Einstein's 1905 paper "On a Heuristic Point of View Concerning the Production and Transformation of Light," where he suggested that light behaves at times as discrete, individual particles. Few physicists at first accepted Einstein's claim for a corpuscular nature of light. A number of scientists gradually provided experimental data that tended to confirm the law. In 1916, Robert Millikan painstakingly accumulated experimental data with which he hoped to disprove Einstein's theory, but instead he found Einstein's law beautifully confirmed. By the early 1920s, a few notable physicists had accepted Einstein's notion of light quanta, most remained uncertain or opposed. Numerous alternative physical explanations to account for the law were then in circulation. First with the reception of Arthur Compton's 1923 experiments showing X-rays acting as particles with momentum, Einstein's notion of light-quanta and theory of the photoelectric effect received widespread acceptance.[46]

When the committee met early in 1922 to assign reports, it accepted the need for greater expertise in theoretical physics. It petitioned the Academy in May to coopt Oseen for the committee as an ad hoc member. Once on the committee in June, he insisted on maintaining a clear demarcation between his own nomination of the discovery of the law and those that specified the theory of the photoelectric effect. Oseen wanted Einstein to receive a prize, but not for relativity; equally significant, he strongly supported awarding a prize to Bohr. Oseen had long supported Bohr's professional development and admired his quantum theory of the atom and its unexpected successes as something of great beauty.[47] The Nobel committee had been dismissing Bohr's candidacy on the basis that his quantum theory of the atom was in conflict with physical reality. Oseen understood the need for caution. He long despaired over the Academy and committee physicists' lack of understanding of and antagonism toward quantum theory.[48] Now, with a brilliant strategic plan, Oseen recognized how he could overcome committee resistance to both Einstein and Bohr.

As odd as it might appear today, Oseen's surgical procedure of separating the law from the theory of the photoelectric effect reflected keen insight with respect to both the state of physics at the time and the Academy. His strategy entailed emphasizing that the law relating discrete absorption and emission of energy to the frequency of light is a meticulously proven "fundamental law of nature" independent of the theory from which it was derived.

Although in his report Oseen reviews Einstein's quantum derivation of the law, his nominations, his actions on the committee, and his specific motivation for a prize all specify only the law. In its petition to coopt Oseen, the committee indicated he would write a special report on Einstein's theory of the photoelectric (and on Bohr's atomic theory). Once Oseen began attending meetings, the minutes specify a report on the discovery of the law of the photoelectric effect.[49] Similarly, in a preliminary draft of the general report, written prior to Oseen's input, Arrhenius and Granqvist sketched a possible proposal entailing Einstein's quantum theory for the photoelectric effect and for the specific heat of solids. After Oseen attended an early September meeting, all of this was crossed-over and rewritten. The final committee report includes a long list of Einstein's various contributions mentioned by nominators including for "the quantum theory of the photoelectric [*ljuselektriska*] effect." At the very end, and separate from the others, it notes that from Oseen, "Einstein is proposed solely for his discovery of the law of the photoelectric effect." Although stating in its report that the discovery of this law stimulated advances in quantum theory, the committee's recommendation to the Academy specifies Einstein's services to theoretical physics, especially his discovery of the law, without any mention of quantum theory.

Oseen understood that he not only needed to be wary of the general lack of sympathy for quantum theory among Academy physicists, he also had to overcome past committee evaluations. In particular, in 1921 Arrhenius wrote a short report for the committee on the theory of the photoelectric effect. He argued that regardless of Einstein's genius-like insights, quantum theory was largely developed by others. Moreover, he concluded that it would seem odd to recognize Einstein for this considerably "less significant" accomplishment than for relativity and other work, such as related to Brownian motion. He recommended rejecting Oseen's initial 1921 nomination for the discovery of the law of the photoelectric effect.[50]

With Arrhenius's prior assessment in mind and wanting to defuse potential opposition, Oseen closed his evaluation with a discussion on the relative significance of Einstein's many accomplishments. Rejecting any universal hierarchy of importance, he suggests that each type of researcher considers its own preferred Einstein achievement as the most significant. He then provides a list, so that, for example, theoretical physicists might be drawn to Einstein's contributions to quantum theory; mathematical physicists and epistemologists would be most attracted to the general theory of relativity. And for "the measuring physicist" — the type of physical scientist most represented and admired in the Academy—no work of Einstein's can compete in significance with the discovery of a new fundamental law of nature, the law of the photoelectric effect.[51] Oseen then wrote an evaluation of Bohr's quantum model of the atom. By emphasizing the very close bond between Einstein's empirically-proven fundamental law of nature and Bohr's theory, Oseen overcame the committee's earlier charges of speculative theory in conflict with the established laws of physics. Oseen convinced his colleagues in the committee to accept his proposals for the two physics prizes to be awarded in 1922.

When the Academy took up the committee recommendations, dissent emerged over the official motivation for Einstein's prize. According to Mittag-Leffler's diary entry, a long discussion

ensued over competing suggestions for the wording.[52] Finally, a proposal from conservative Former Prime-Minister, Hjalmar Hammarsköld "won": relativity was not to be mentioned. This would indicate that further criticism of Gullstrand's evaluation must have emerged. Mittag-Leffler, for one, wished to include both relativity and the discovery of the law in the official motivation for the prize. He disapproved as "a dangerous precedent" the vague general phrase relating to Einstein's contributions to theoretical physics. After the vote, the Academy made it clear that relativity should not be mentioned on the Nobel diploma or in any other official documentation.[53]

6. Historigraphical Remarks

At the Nobel ceremony in December 1922, a tendency began of clouding the record of how the committee and Academy processed Einstein's strongly supported candidacy (Einstein, who was away in Japan, did not attend). Of course the statutes required secrecy, yet when Arrhenius delivered introductory comments about Einstein's prize, he felt compelled to explain why the ever-so-prominent theory of relativity was not being recognized. Although such ceremonial presentations are normally dubious sources for the history of discovery and of committee's actions, Arrhenius's presentation is especially problematic. He presented a misleading narrative.[54] He explained the omission of relativity as it "... pertains essentially to epistemology and has therefore been the subject of lively debate in philosophical circles. It will be no secret that the famous philosopher [Henri] Bergson in Paris has challenged this theory, while other philosophers have acclaimed it wholeheartedly." The message here being that relativity belongs to philosophy and not physics. True, Gullstrand and earlier Arrhenius claimed relativity lacked relevant content for physics. Regardless, if special and general relativity were at best philosophical exercises, why then did so many prominent physicists nominate Einstein for a Nobel physics prize for his work on relativity? Why, for example, did the Italians award their Medaglia Matteucci physics prize in 1921 to Einstein for relativity?[55]

Arrhenius's comments subsequently stimulated research and speculation on the role of Swedish philosophers' attitudes to relativity and their relevance for the outcome in the Academy. Einstein's differences with Bergson has even been declared to be the reason why relativity was denied a prize.[56] Although Swedish philosophers debated relativity, no evidence exists that they had any influence on committee evaluations or Academy decisions. They did not enjoy any privileged position in the Academy; nor is there any evidence that committee members considered the philosophical debates about relativity relevant for their assessments and opinions. Moreover, Bergson is not mentioned in any of the committee deliberations, nor in any publication or private communication of those involved with evaluating Einstein's candidacy. At the time of the Parisian debate between Einstein and Bergson in April 1922, relativity had already been eliminated for consideration for a Nobel Prize. If anything, Gullstrand's analyses of relativity theories borrow (largely unacknowledged) inspiration and substance from Gercke, Lenard, and Stark's critiques.

In August 1981, the first detailed analysis of the Einstein prize, including the preliminary recognition of the critical roles of Gullstrand and Oseen, was presented at a Nobel Symposium and in Nature. An alternative and less controversial narrative was written the following year by Einstein biographer Abraham Pais with the help of the secretary of the Nobel Committee for Physics, Bengt Nagel. Here is the origin of the mistaken claim that Einstein received a prize for the theory of the photoelectric effect as well as the simplified notion that Gullstrand merely made a mistake in his evaluation as the reason for the lack of recognition of relativity.[57] For the 100th anniversary of Einstein's "miraculous year" in 2005, the Nobel Museum's exhibition repeated Pais's widely-cited version of history.[58] This paper takes another look at the episode in time for the 100th anniversary of the prize. Questions still remain, but clearly that which the historical record shows invites reflection and critical thought. Einstein's legacy asks nothing less of us.

Acknowledgements

The author remains indebted to the National Science Foundation (USA) for Grant Nos. 8218589, 8512431, and 9511708 that made possible his earlier research on the Nobel Prizes in physics and chemistry. More recently, support from the Max Planck Institute for History of Science, Berlin, enabled further research into Einstein's prize. For discussions about the anti-Einstein campaign in Germany, the author would like to thank Jürgen Renn, David Rowe, and Tilman Sauer. He is greatly indebted to Tilman Sauer for his interest and insightful assistance while preparing this text and to Jürgen Renn for generous hospitality and stimulation on his stays at the Max Planck Institute for History of Science, Berlin. The author also wishes to thank the Centre of History of Science that manages the archival collections of the Royal Swedish Academy of Sciences for its generous assistance over several decades.

Conflict of Interest

The author declares no conflict of interest.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Keywords

Arrhenius, Einstein, Gullstrand, Nobel Prizes, Oseen

Received: July 4, 2022
Revised: July 12, 2022
Published online:

[1] Among Albert Einstein's most famous and classic contributions to theoretical physics are: "*Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt* [On a heuristic point of view concerning the production and transformation of light]" *Annalen der Physik* (ser. 4), 17 (1905), 132-148; *Über die von der molekularkinetischen Theorie der Wärme geforderte Bewegung von in ruhenden Flüssigkeiten suspendierten Teilchen* [On the movement of small particles suspended in stationary liquids required by the molecular-kinetic theory of heat]," *Annalen der Physik* (ser. 4), 17 (1905), 549-560; «*Zur Elektrodynamik bewegter Körper* [On the electrodynamics of moving bodies]," *Annalen der Physik* (Ser. 4), 17 (1905),

891-921; "Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig? [Does the inertia of a body depend upon its energy content?]," *Annalen der Physik* (Ser.4), 18 (1905), 639-641; as well as his 1916 review paper of the general theory of general relativity: "Die Grundlage der allgemeinen Relativitaetstheorie [The Foundation of the General Theory of Relativity]," *Annalen der Physik* 49 (1916), 769–822.

[2] Robert Marc Friedman, "Nobel physics prize in perspective," Nature, 292 (1981), 793-98; Elisabeth Crawford and Friedman, "The prizes in physics and chemistry in the context of Swedish science". Science, Technology and Society in the Time of Alfred Nobel. Eds., C.-G. Bernhard, Elisabeth Crawford and Per Sörbom. Oxford: Pergamon for the Nobel Foundation, 1982. 311-331; Friedman, "Text, context, and quicksand: Method and understanding in studying the Nobel science prizes," Historical Studies in the Physical and Biological Sciences, 20 (1989), 63-78; Friedman, The Politics of Excellence: Behind the Nobel Prize in Science (New York: Freeman/Times Books, 2001), Chapter 7 "*Einstein must never get a Nobel Prize*"; Aant Elzinga, Einstein's Nobel Prize: A Glimpse Behind Closed Doors. Sagamore Beach: Science History Publications, 2006.

[3] Abraham Pais, 'Subtle is the Lord....': The Science and Life of Albert Einstein (Oxford: Oxford University Press, 1982), Chapter 10; Pais, "How Einstein got the Nobel Prize...," American Scientist, 70 (1982), No. 4, 358-365; Anders Barany, Fredrik Skog, Anna Stenkula. Albert Einstein "for his discovery of...". Exhibition guide, Nobel Museum Gamla Stan (May 13, 2005-April 16, 2006). Stockholm: Nobelmuseet, 2005. 80 pp.

[4] Crawford, The Beginnings of the Nobel Institution: The Science Prizes, 1901-1915. Cambridge: Cambridge Univ. Press, 1984; Friedman, The Politics of Excellence.

[5] Friedman, "Text, context, and quicksand."

[6] Daniel Kennefick, No Shadow of a Doubt: The 1919 Eclipse that Confirmed Einstein's Theory of Relativity (Princeton: Princeton Univ. Press, 2019); Jeffrey Crelinsten, Einstein's Jury: The Race to Test Relativity (Princeton: Princeton Univ. Press, 2013).

[7] The introductory essays accompanying relevant volumes of The Collected Papers of Albert Einstein [CPAE] (Princeton University Press) provide valuable detailed overviews of Einstein's life and work. See, in particular, CPAE, Vol 7 "The Berlin Years: Writings 1918-1921" (2002), Edited by Michael Janssen, Robert Schulmann, József Illy, Chrstoph Lehner, and Diana Kormos Buchwald; CPAE, Vol 10 "The Berlin Years: Correspondence, May – December 1920....." (2006), Edited by Diana Kormos Buchwald, Tilman Sauer, Ze'ev Rosenkranz, Jósef Illy, and Virigina Iris Holmes; CPAE, Vol 12 "The Berlin Years: Correspondence, January-December 1921," Edited by Diana K. Buchwald, Ze'ev Rosenkranz, Tilman Sauer, József Illy, and Virginia Iris Holmes (2009); CPAE, Vol 13 "The Berlin Years: Writings and Correspondence, January 1922-March 1923," Edited by Diana K. Buchwald, József Illy, Ze'ev Rosenkranz, Tilman Sauer (2013); " Jürgen Renn, ed., Albert Einstein, Chief Engineer of the Universe...(Berlin: Wiley-VCH, 1905) offers a comprehensive illustrated overview. David E. Rowe and Robert Schulman, Einstein on Politics.... (Princeton & Oxford: Princeton Univ. Press, 2007), Chapter 2, "Science meets politics: The Relativity Revolution, 1918-1923."

[8] Lists of nominators and nominees see, Nomination archive - NobelPrize.org and Crawford, The Nobel Propulation, 1901-1950. A Census of the Nominators and Nominees for the Prizes in Physics and Chemistry (Tokyo: Universal Academy Press, 2002).

[9] Einstein received 8 of 34 nomination votes. The actual numbers being smaller as several entailed multiple signatories.

[10] Politics of Excellence, pp.109-111.

[11] [Editorial staff], "Einstein's encounter with German anti-relativists," CPAE, 7, pp. 101-113; Hubert Goenner, "The reaction to relativity theory I: The Anti-Einstein campaign in Germany in 1920," Science in Context, 6, 1 (1993), 107-133; Rowe, "Einstein's Allies and Enemies: Debating Relativity in Germany, 1916-1920," in Interactions: Mathematics, Physics and Philosophy, 1860-1930, Boston Studies in the Philosophy of Science, vol. 251, Vincent F. Hendricks, et al., eds., (Dordrecht: Springer, 2006), pp. 231-280; Rowe, «Einstein and relativity: What price fame?," Science in Context, 25 (2012), pp. 225-231; Milena Wazeck, Einstein's Opponents: The Public Controversy about the Theory of Relativity in the 1920s (Cambridge: CUP, 2014).

[12] Quoted in Jeroen van Dongen, "Reactionaries and Einstein's Fame: 'German Scientists for the Preservation of Pure Science', relativity, and the Bad Nauheim meeting," Physics in Perspective, 9 (2007), p. 217.

[13] Protocol, Nobel Committee for Physics, 22 Sept 1920, Appendix 1.

[14] Wazeck, Einstein's Opponents, pp. 273-277; Rowe, "What price fame," pp. 216-218.

[15] Wazeck, Einstein's Opponents, on these and other less well-known anti-Einstein authors.

[16] Paul Weyland to Svante Arrhenius, 23 July 1920, Arrhenius papers, Royal Swedish Academy of Sciences archives.

[17] Philipp Lenard to Arrhenius, 4 August 1920, Arrhenius papers.

[18] Philipp Lenard, Über Relativitätsprinzip, Äther, Gravitation (Leipzig: S. Hirzel, 1918).

[19] Johannes Stark to Arrhenius, [no date, after 8 Nov 1919], Arrhenius papers.

[20] Albert Einstein to Arrhenius, 14 November 1918, Arrhenius papers; also published in CPAE8, Doc. 654.

[21] Einstein, "Meine Antwort. Ueber die anti-relavitätstheoretische G.m.b.H.," Berliner Tageblatt (August 27, 1920, Morning Edition); reprinted in CPAE, Vol. 7, Doc. 45, pp. 345–347.

[22] Correspondence especially with wife Maja when traveling and with Maja's brother-in-law in Berlin, physical chemist Ernst Riesenfeld. Arrhenius papers, Stockholm.

[23] Dongen, "Reactionaries and Einstein's Fame," 212-230. Arrhenius to [Ernst and Hanna Risenfeld], 1 October 1920, Arrhenius papers.

[24] Lenard to Arrhenius, 26 October 1920.

[25] Protocol, KVA Nobel Matters, 14 Sept 1921 on Arrhenius receiving an extra appropriation for his department.

[26] *Nya Dagligt Allehanda*, 25 Sept 1920.

[27] Einstein to Heinrich Zangger, [15 or 22] Dec 1919, in CPAE, 9, Document 217.

[28] Politics of Excellence, p. 128-129. Hasselberg's request in App. G to Protocol, Nobel Committee for Physics, 8 Sept 1920.

[29] 14 of 35 nominations for Einstein.

[30] C.W. Oseen, «Allvar Gullstrand. Minnesteckning....», K. Svenska Vetenskapakademiens Levnadsteckningar, Bd. 6 (1933), 480-513; J. W. Nordenson, «Allvar Gullstrand (1862-1930),» Documenta Ophthamologica, 16 (1962), 283-337.

[31] Les Prix Nobel en 1911 (Stockholm, 1912), 51-52.

[32] Protocol, Nobel Committee for Physics, 7 Sept 1921, App. A (report dated 12 May 1921). Politics of Excellence, pp. 130-135.

[33] Bjerknes, «Det nye optiske fænomen og Einsteins relativitetsteori,» Naturen (1920), 161-186. Oseen, who was in contact with Bjerknes, probably brought this article to Gullstrand's attention.

[34] Bernhard Hasselberg to H. H. Hildebrandsson, 9 Sept 1921, HHH papers, Uppsala Univ. Library.

[35] Carlheim-Gyllensköld to Vetenskapsakademiens tredje klass, 29 Oct 1921, App. B to Protocol, KVA, III Section, 29.10.21.

[36] Arrhenius to Jacques Loeb, 30 June 1921, Loeb papers, Library of Congress, Washington, D.C. and in letters to wife, Maja Arrhenius.

[37] Arrhenius to Maja [Arrhenius], 7 June 1921, Arrhenius papers. Von Laue presumably criticizing Allvar Gullstrand, «Allgemeine Lösning des Statischen Einkörperproblems in der Einsteinschen Gravitationstheorie,» Akriv för Matematik, Astronomi och Fysik, 6, No. 8 (1921), which was included in Gullstrand's evaluation of relativity.

[38] Max Born to C. W. Oseen, 26 October 1921, Oseen papers, Regional Archive, Lund.
[39] Diary, Gösta Mittag-Leffler dagböcker, 9 Nov 1921, Royal Library, Stockholm.
[40] Correspondence between Gullstrand and Oseen, especially in March and May 1921, in Gullstrand papers, Uppsala Univ. Library and C. W. Oseen papers, Regional Archives, Lund and in Royal Swedish Academy of Sciences. Oskar Klein to Niels Bohr, 9 March 1921, Niels Bohr Archives, Copenhagen; Oseen to Arnold Sommerfeld, 1 Sept 1921, Sommerfeld papers, Deutsches Museum, Munich.
[41] Oseen to Vilhelm Bjerknes, 14 December 1920, Bjerknes papers, National Library, Oslo; Oseen to Carl Benedicks, 20 September 1920, Carl Benedicks papers, Royal Library, Stockholm.
[42] Oseen ruminates explicitely on the differences between German and Jewish mathematics one of his later historical essays, "En svensk lärdomshistoriker från romantikens tid," Lychnos (1937), p. 77. He expresses his great like for then ardent Nazi-supporter Lenard's book and his belief that it could be a textbook for students in a letter to historian of ideas Johan Nordström, [...] Dec 1937, reproduced in Ann Boström, et. al., "Bödeln från Uppsala. Edition av brevväxling mellan Johan Nordström och C. W. Oseen 1934-1943,» B-uppsats i idé- och lärdomshistoria (1984), Uppsala universitet.
[43] Mittag-Leffler to Gullstrand, 4 Jan 1922 and Gullstrand to Mittag-Leffler, 5 Jan 1922, Gullstrand papers. Gullstrand's opinions stated in a conversation with Mittag-Leffler, Mittag-Leffler Diaries, 27 July 1922.
[44] Protocol, Nobel Committee for Physics, 6 Sept 1922, App. 1.
[45] "Nobel physics prize in perspective", pp. 793-798; "Text, context, and quicksand," pp. 66-67. Politics of Excellence, 133-138 and in subsequent chapters covering the physics prizes during the next two decades when Oseen dominated the committee. On Oseen's physics, Karl Grandin, *Ett Slags Modernism i Vetenskapen: Teoretisk fysik i Sverige under 1920-talet*, Institutionen för idé- och lärdomshistoria, Uppsala universitet, Skrifter, No. 22 (1999), 19–99.
[46] Roger Stuewer, The Compton Effect (New York: Science History, 1975); Bruce Wheaton, The Tiger and the Shark: Empirical Roots of Wave-Particle Dualism (Cambridge, Cambridge Univ Press, 1983); Robert H. Kargon, The Rise of Robert Millikan, (Ithaca, NY: Cornell Univ Press, 1982), 70-81; Stephen G. Brush, "How ideas become knowledge: The light-quantum hypothesis 1905-1935," Historical Studies in the Physical and Biological Sciences, 37 (2007), 2, 205-246.
[47] Oseen, Atomistiska Föreställingar i Nutidens Fysik. Tid, Rum och Materia: Femton Föreläsningar (Stockholm: A. Bonniers, 1919), 105-136. Oseen had been corresponding with Bohr for over a decade.
[48] Oseen to Benedicks, 19 Sept 1913, Benedicks papers; Oseen to Niels Bohr, 17 May 1918, Bohr archive, Copenhagen.
[49] Compare, Protocol, Nobel Committee for Physics, 30 May and 6 Sept 1922 (Academy granted permission officially on 7 June 1922).
[50] Committee Report, Nobel Committee for Physics, 1921, App. B.
[51] Committee Report, Nobel Committee for Physics, 1922, App. B.
[52] Mittag-Leffler diary, 9 Nov 1922. Protocol, Nobel Committee for Physics, 7 Sept 1921, App. 2 to App. H.
[53] Oseen to Arrhenius, 20 Nov 1922, Arrhenius papers.
[54] Nobel Prize in Physics 1921 - Presentation Speech
[55] R. E. Egdell, Francesco Offi, Giancarlo Panaccione, "Moseley and the Matteucci Medal," in For Science, King & Country: The Life and Legacy of Henry Moseley, eds., Roy MacLeod, R. G. Egdell, Eizabeth Bruton (London: Unicorn Press, 2018), 166-168.
[56] Jimena Canales, The Physicist and the Philosopher: Einstein, Bergson, and the Debate that Changed Our Understanding of Time (Princeton: Princeton Univ Press, 2015) and in a number of subsequent popular articles; "This philosopher helped ensure there was no Nobel for relativity: Henri Bergson's debate with Albert Einstein reached and swayed the 1921 Nobel committee," Nautilus (18 April 2016), This Philosopher Helped Ensure There Was No Nobel for Relativity - Nautilus | Science Connected.
[57] See note 3. In his publications, Pais acknowledges Nagel's assistance; this is also noted in their correspondence (Pais papers, Rockefeller Archive Center, Tarrytown, NY).
[58] Barany, et. al., Albert Einstein "for his discovery of...", pp. 66–67.