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Frederick Lindemann and the renaissance of physics in Oxford

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Abstract. Frederick Lindemann was the most controversial of all leaders in the history of physics at the University of Oxford. This paper reviews his development as a physicist and his ascent to an Oxford Chair and through his friendship with Winston Churchill, his role as an influential operator in Westminster. It is argued that although Lindemann was a widely unpopular figure - and had undeniable weakness and character flaws - his achievements have been under-rated.

Frederick Lindemann (figure 1 - left) was famously disliked and derided by many of his physicist peers. Yet he did much to improve the quality of physics at the University of Oxford and might even be said to have effected a renaissance of the Department of Physics partly by welcoming émigré physicists.

No other leader of Oxford's Department of Physics has been discussed more than Lindemann. There are at least five biographies of him as well as mountains of mostly disobliging comment about his place in national life following C.P. Snow's entertaining but tendentious book about Lindemann's relationship with his nemesis, the much-admired Henry Tizard. Shortly after Lindemann died, Air Chief Marshal Philip Joubert de la Ferté wrote that it was always helpful to know where Lindemann stood on any matter because he was always wrong. Most of the top brass in the military agreed, as did most of the leading academic physicists who worked for the Government during World War II. Yet too many of Lindemann's detractors underestimate his contribution to the development of Oxford physics after World War I, especially in the 1930s.

Lindemann was appointed to the Dr Lee's Professorship of Physics in 1919 when he was aged 33 on the understanding that he would strive to put Oxford physics on the map. The modern discipline of physics had taken shape about a century before. Previously the branches of learning deemed to be physics were regarded as aspects of natural philosophy. Michael Faraday, for example, regarded himself not as physicist but as an experimental philosopher, while James Clerk Maxwell described himself as a mathematical philosopher, never as a theoretical physicist.

In the nineteenth century the national status of the constellation of subjects now described as comprising 'physics' increased sharply. Its findings had undeniably proved to be extremely useful for governments looking to develop their imperial ambitions and for industrial leaders seeking reliable theoretical underpinning for profitable ventures. Two classic examples are the development of heat engines and the burgeoning of the communications industry, followed closely by Maxwell. Some physicists today seem to think that he was thinking only about discovering fundamental laws of nature, but he had much wider interests. He was much involved in improving standards of measurements and in developing the potential of new technologies. It is too often forgotten that he ended his days as head of a physics laboratory and liked nothing more than to talk about philosophy, poetry and metaphysics.

Internationally admired, Maxwell was one of the UK's leading natural philosophers at a time when most of the key advances were made by his peers on the continent, especially in the region that

comprised the nation-state Germany after its formation in 1866. Maxwell carefully followed the work of several physicists in that part of Europe, notably Hermann von Helmholtz and Rudolf Clausius. It was support from the government and industry and from its adapting educational institutions that made German physics so outstanding. Theoretical physics was born there as an autonomous discipline and it first became a profession in the early 1860s when Max Planck became the first full-time theoretical physicist. It is no coincidence that the two foundational theories of 20th century physics - quantum theory and relativity – were largely forged by either Germans, German speakers or physicists trained in Germany.

Compared with most leading European universities, the Department of Physics at Oxford was regarded internationally as weak for much of the nineteenth century and was not well placed to run with the radical new ideas of quantum theory. The University authorities expected Lindemann to drag the Department into what was then the modern era of physics albeit with limited resources. With the wisdom of hindsight, Lindemann was fortunate to have been born to a German father who emigrated to the United Kingdom. Frederick was born with a silver spoon in his mouth and he was educated, no doubt thanks to his parents' guidance, in Germany where he was inculcated in this thriving culture of science. He studied for his PhD at the University of Berlin, supervised by physicist Walther Nernst, a leading expert in thermodynamics. Lindemann was well placed to benefit from modern thinking about theoretical physics, although his correspondence indicates that he was unenthusiastic about pursuing truly radical developments in the subject. He was nonetheless quick and able.

Although half of his family tree was German, Lindemann always regarded himself as purely British and often pointed out that he had never owned a German passport. As a young physicist he worked at the aviation development laboratory in Farnborough where he stood out as a capable scientist and it was from there that he had the luxury of taking up the position in Oxford at the old Clarendon Laboratory. Lindemann's predecessor Robert Bellamy Clifton, appointed in 1865, was in post for almost half a century. His colleagues noted sotto voce that during those five decades he wrote one good paper. Although he had helped set up the UK's first purpose-built physics department in 1872, he left the Department in a poor state. Towards the end of his tenure during World War I the Oxford authorities began to look for an energetic successor - someone able to bring new energy to physics at the University. Lindemann appeared well qualified for the post.

Lindemann requested references from the distinguished physicists Robert Millikan, Albert Michelson, Lord Raleigh and most importantly, Lord Rutherford, who had recently become Director of the Cavendish Laboratory in Cambridge. Rutherford wrote of Lindemann's considerable potential, strongly endorsing his application for the Chair. Lindemann later wrote to Rutherford in a letter that was often quoted at the Cavendish, saying how he looked forward to a close and fruitful collaboration between the Clarendon and the Cavendish Laboratories. In 1919 'the Prof,' as he later became known, moved to Oxford to take up his position and he was billeted initially in the Randolph Hotel. He soon saw that the Department of Physics he was so proud to lead was actually in a terrible state. The laboratories did not even have a mains supply of electricity, nor was the standard of students remotely as high as he had expected. There were only two research students and five undergraduates studying for Physics Finals. It survived a near-death experience in 1922 only because of a grant from the University Grants Committee of £30,000, an enormous amount of money at the time. A similar crisis occurred the following year and the Committee realised that government funding was needed to keep the University of Oxford and other universities afloat. Lindemann was distressed by the lack of progress he made in increasing the status of physics at Oxford and made clear his resentment to dons in other subjects. Some of the Prof's challenges arose within the Department: the arrival of another Professor of Physics, John Sealy Townsend, saw the beginning of turf wars that lasted years.

One way to understand what Lindemann did at Oxford is to investigate Walther Nernst – shown in figure 1 (right). Nernst in fact called himself a chemist, but in the way that physicists always appropriate the best science to their own subject, one might call him an honorary physicist. He was very well known in Berlin and attended chemistry and physics seminars, where he was regarded as scientific royalty. He must qualify as a physicist because he discovered a fundamental law of nature, the third law of

thermodynamics: the entropy of a perfect crystal at the absolute zero of temperature is zero. After Planck's discovery of quantum theory, low temperature physics emerged as one of its primary testing grounds. Nernst seized this opportunity and turned his laboratories into a world-class centre for cryogenics – the study of matter at extremely low temperatures.

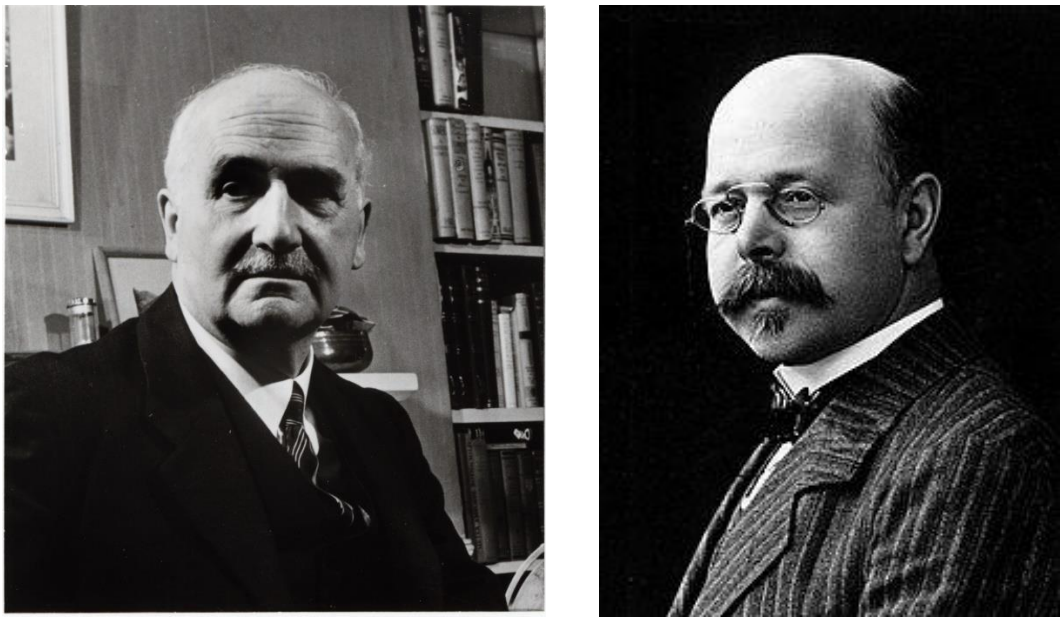

Figure 1. Frederick Lindemann (left) and Walther Nernst (right).

Nernst was a prime mover in setting up the first Solvay physics meeting, which was by invitation only, and he brought along Lindemann as his secretary. Lindemann loved hob-knobbing with leading physicists, including Albert Einstein who was in his second year as a brilliant newcomer to the subject's front line. Lindemann even became something of a friend to Einstein. At the meeting Lindemann sat at the top table of physics and made the most of the excellent company. Although he was present primarily to take notes, it was nonetheless clear that Lindemann was a promising physicist – although not a gifted researcher, he occasionally made impressive insights to discussions and had a gift for simplifying a complex topic and identifying its essential features.

Lindemann's first attempt to generate a Nernstian centre of physics did not end well. He acquired from Nernst a hydrogen liquefier, but was unable to get it to work. This disheartened him and from 1924 he concentrated entirely on trying to set up a successful physics department and published no further original research. Most of the appointments that he made were individualists who worked at home and as a result, his Oxford department had little of the vibrancy and creativity he was seeking. Lindemann sought collaborations with local firms and industry with only modest success.

Lindemann spent much of his time cultivating his reputation amongst the British aristocracy and influential Conservative politicians. A joke about Lindemann at the time began '*Why is he like a channel steamer?*', the answer being that '*he runs from peer to peer*'. Even more than he wanted Oxford physics to flourish, he yearned to be accepted as part of the English elite. It was at one of their select garden party gatherings, organised by the Duke of Westminster, that Lindemann met the man who was to become his hero: Winston Churchill.

At first Churchill and Lindemann did not click, perhaps because their characters were so different. Churchill was generous-spirited, loved good food and fine wines, sought the limelight and was much keener on the arts than on the sciences. Lindemann, on the other hand, was a strict vegetarian, almost teetotal, disdainful of the arts and an Olympian grudge bearer, always ready with a sneering comment about each of his numerous enemies. Churchill's friend Violet Bonham Carter said that Lindemann was

stone blind in areas outside physics. Many of Lindemann's fellow dons regarded him as a philistine and disliked the rudeness and condescension he showed the many colleagues he regarded as beneath his station.

Churchill was nonetheless happy to be Lindemann's friend because the Professor was loyal as a guard dog and knew a lot about the science that was important for the military. Lindemann had quickly become a confidant of Churchill, always at his beck and call. The Prof became the most frequent visitor to Churchill's house and arranged for Einstein to visit him there in the spring of 1933. Lindemann's greatest gift was his ability as a science writer, able to write clearly about complicated topics and to understand how to interest people who knew little physics. He ghosted about thirty articles for Churchill, many of them in the News of the World, a Sunday paper read by four million people.

A notable befriender of multi-millionaires, Lindemann became close to Alfred Mond. Otherwise known as Lord Melchett, Mond was a veteran of World War I and a would-be poet. As Director and part-owner of Imperial Chemical Industries (ICI) he paid Lindemann as a consultant, making the Prof a conspicuously wealthy academic. He frequented Mond's soirées, including one in the spring of 1933 at which Churchill chaired a presentation by Lindemann about the much-publicised advances made the previous year by his competitors at Rutherford's Cavendish Laboratory, including James Chadwick's discovery of the neutron and the first splitting of the atom carried out by John Cockcroft and Ernest Walton.

Lindemann had been at Oxford for over ten years. Having achieved only modest success in establishing the Department of Physics on the international stage, he returned to his vision of setting up a top tier cryogenics laboratory. He consulted with Nernst and Nernst's students. In 1930 Lindemann had visited Berlin, where he met Kurt Mendelssohn, who was not only a promising young experimenter but also flexible and a good communicator. Mendelssohn accepted Lindemann's invitation to join the Oxford department and soon became its most outstanding researcher. Shortly after Christmas 1932 he became the first person to liquefy helium in the UK, ahead of his brilliant competitor in Cambridge, Rutherford's favourite protegé, Pyotr Kapitza. Lindemann was delighted: at last his department had one up on its Cambridge counterparts.

This success emboldened Lindemann as a departmental leader, although he was still a part-timer compared with the workaholic Rutherford, who was a far superior physicist as everyone knew. Rutherford was very much an experimentalist but took an interest in the latest developments in theoretical physics. He knew that Lindemann's briefings on the meaning of quantum theory were pretentious nonsense – Lindemann was confused about the fundamentals of the theory. Rutherford regarded Lindemann as a physicist manqué. As laboratory leaders, neither Lindemann nor Rutherford were well known for advancing the careers of women physicists, but there were some notable exceptions. Among the few women physicists in the new Clarendon Laboratory was Helen Megaw, an Irish crystallographer who later became the first woman to achieve what is now called 'tenure' at the Cavendish Laboratory. At the recommendation of her supervisor, John Bernal, she spent a year working with Francis Simon at Oxford.

The climax of Lindemann's career at Oxford began in Easter 1933 just after the triumph of Mendelssohn and his colleagues at the Clarendon. Lindemann foresaw that Germany was about to collapse after Hitler had just been 'elected' Chancellor. Mendelssohn later wrote that Lindemann saw the possibility of creating at Oxford a worthwhile continuation of Nernst's school. Around Easter the Prof's valet Harvey drove him in his Rolls Royce into the heart of Germany, aiming to identify scientists who might want to move to the UK and persuade them to emigrate, ideally to Oxford. He saw the chance to do good and at the same time to do well. At about the same time the Academic Assistance Council began to enable refugees to escape the strife in Europe and move to the UK. The Council's leader, London School of Economics and Political Science (LSE) Director, William Beveridge worked with Rutherford at his side; Lindemann did not sign the Council's first declaration. Lindemann negotiated separate contracts, taking advantage of his connections with ICI and securing grants from them. In this way he enabled many refugee physicists to work at Oxford. Many of the physicists Lindemann recruited

were better rewarded than most of those under the Academic Assistance Council, which he appeared to regard as an irritant. This is perhaps the main reason why Rutherford and Lindemann fell out.

Lindemann's most eminent recruit was Francis Simon, who quickly became an 'intellectual magnet' in the Department of Physics, attracting dozens of leading academics eager to work with him. His home, near the Clarendon Laboratory, became a kind of pied-à-terre of warmth and generosity – in the coming years he and his wife offered many foreign newcomers to Oxford a place at their dinner table. To Lindemann's credit, he helped ensure that Simon secured a permanent academic post and become one of the few émigré scientists to be given tenure by a British university. Austrian-American physicist Victor Weisskopf later remarked that the UK missed a trick by not extending a much warmer welcome to many more of those refugee physicists. Most of them simply went on to settle in the United States.

Hungarian experimental physicist Nicholas Kurti was another notable refugee who happily settled in Oxford and did much to enhance the reputation of Lindemann's department. The good-humoured Kurti was multi-talented – not only an able physicist but also a skilful musician and cook. In Leiden, where he had first shone as a student of Kamerlingh Onnes, Kurt became an expert on the entropy of salts, leading him once to remark memorably that in the case of gadolinium sulphate, '*it was love at first sight*.'

Lindemann was less successful in his attempts to recruit émigré theorists. His wooing of Austrian quantum theory pioneer Erwin Schrödinger was widely regarded a triumph, however, especially after the Nobel Prize authorities awarded Schrödinger a Prize shortly after he arrived in Oxford. He never settled, however, and moved on a few years later. Lindemann was relieved to see him depart, regarding Schrödinger as a bounder, mainly because of his unconventional private life. A more successful recruit was Hungarian Leo Szilard, a friend of Einstein's and a singularly free spirit, unlikely to settle down at his time of life. Correspondence between the two men demonstrates that Lindemann gave Szilard a remarkably free rein, allowing him long periods of absence not generally granted to his colleagues. This suggests that Cambridge physicist J.J. Thompson was a little harsh when he commented that Lindemann ran the Clarendon like a '*Prussian dictator*.'

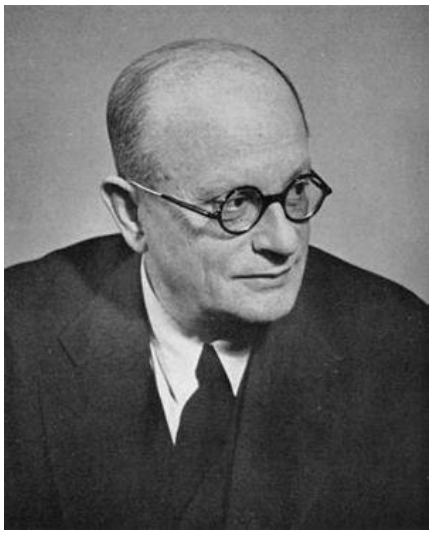

Figure 2. Francis Simon.

When Lindemann was engineering this renaissance in Oxford physics, he spent much of his time developing his political career (despite his best efforts, he never became a Member of Parliament). Most importantly, he supported Winston Churchill in pressing the government to improve the country's air defences in response to Germany's fearsomely rapid re-armament. Churchill and Lindemann were unpopular with many colleagues but displayed commendable foresight in identifying the threat posed by Hitler's preparations for war. They made many enemies, including many of the leading physicists at the Cavendish Laboratory, notably Patrick Blackett, another scientist who detested Lindemann and was contemptuous of his judgement. During the War, Blackett pioneered the application of scientific

thinking to military matters, had no time for the work Lindemann did on this and worried about Churchill's reliance on the Prof's arguments.

By the late 1930s Oxford was one of the powerhouses of physics in Britain. Lindemann had secured the funds to build a new Clarendon Laboratory, arguing to an advisory committee that Oxford graduates were of more use to industry than Cambridge graduates. He reasoned that Oxford paid more attention than Cambridge to the practical problems faced by industry. He had a point: there is more to physics than trying to understand nature's fundamental forces and particles. In the summer of 1939 the new building was all but ready with architecture that might be described as brutally utilitarian or simply Lindemannian.

Lindemann had barely settled into his office in the new Clarendon Laboratory when the Second World War began. He immediately headed to Westminster. By May 1940 Rudolf Peierls and Otto Frisch had hit on the brilliant notion that contrary to widespread belief it was theoretically possible to build a nuclear weapon. This would require the purification of sufficient uranium-235 (a rare isotope) to engineer a collision between two sufficiently massive quantities of it, through a nuclear chain reaction, quickly leading to an explosion big enough to wipe out a city.

The favoured method in Oxford of separating uranium isotopes was gaseous diffusion - forcing uranium hexafluoride through fine membranes to separate the two isotopes. The project's mastermind was Francis Simon (see figure 2), who led a research group and briefed Lindemann on the underlying physics in Oxford most Saturday mornings. As Lindemann well knew, Simon consulted with industrial experts on the viability of building a plant that could make such a weapon in the UK. He also successfully sought help in the form of the *engineering* skills of Paul Dirac, the UK's leading theoretical physicist, not known for his interest in solving practical problems despite his undergraduate training in electrical engineering. Dirac worked at home in Cambridge on the British nuclear bomb project as an applied mathematician, occasionally attending meetings at the Clarendon Laboratory.

Lindemann, now ennobled as Lord Cherwell, spent the War advising Churchill on science and technology. It is unclear whether the Prof's judgment was as terrible as enemies and detractors sometimes claimed. He certainly made serious errors (notably in dismissing the threat of V-1 bombs) but also supplied Churchill with immaculate briefings on aspects of nuclear physics and a host of other topics. There is much for scholars to do before they can give a definitive answer on this. After the War Cherwell returned to his post in Oxford exhausted but ready to resume his duties. In 1951 the 76-year-old Churchill was re-elected Prime Minister '*gloriously unfit for office*,' in the words of his biographer Roy Jenkins. Cherwell relented and returned to work for his hero.

After he returned to national politics, Cherwell had several successes. He persuaded Churchill not to drop completely the British nuclear weapon programme because such a move would probably render the UK a satellite state of America. Cherwell also successfully encouraged Churchill to develop the British nuclear power industry and an independent British nuclear deterrent. Finally, it was on Churchill's watch with Cherwell at his side that Britain signed up to the international particle physics laboratory later known as CERN. By that time he was desperate to give up the Directorship of the Clarendon and he successfully engineered the appointment of his friend Francis Simon as his successor. Simon took up the post on 1st October 1956 but tragically died within a month – a terrible loss for Oxford physics and to Lindemann.

Frederick Lindemann was always a controversial figure. His many enemies have amply attested to his shortcomings as a scientist and adviser, and to his many unpleasant personal characteristics. However, it is hard to deny his achievements, especially in leading the renaissance of physics at Oxford beginning in the 1930s. Air Chief Marshal Philip de Joubert la Ferté may have had good reason to discount Lindemann's judgment, especially in military matters. The Prof was wrong much more often than he liked to admit, but he was right about some matters, several of them of national importance. The Department of Physics at Oxford today is a monument to the best of him.