Title page:

Intellectually gifted, but inherently fragile – society's view of female scientists as experienced by seismologist Inge Lehmann up to 1930.

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Abstract

Celebrated for her 1936 discovery of the Earth's inner core, seismologist Inge Lehmann (1888-1993) is often portrayed as a trailblazing female scientist with an impressive international career. She is the inspiration behind Denmark's funding program designed to strengthen gender equality in scientific research. Yet, newly discovered documents show that Lehmann's path to a career in science was not at all straightforward. In a society where women were considered mentally and physically unsuited to academic studies, let alone scientific careers, gender bias and discrimination thwarted her ambitions and limited her early career options. Lehmann's letters to Niels Bohr document the disappointment and frustration with restrictions on women at Cambridge University that prompted her to return to Denmark. Her mental breakdown in the winter of 1912 likely resulted from academic over-compensation in attempts to overcome gender bias. After obtaining a Danish degree in mathematics, she became an underpaid clerical employee at the university. Only by pragmatically changing her field from prestigious mathematics to little known seismology could she establish herself as a successful scientist.

1. Introduction

The Danish seismologist Inge Lehmann (1888-1993) is best known for her 1936 discovery of the Earth's inner core. Originally trained in mathematics, she began working as a seismologist in the mid-1920s and continued in this field for fifty years, gaining international acclaim for her meticulous seismic research. For twenty-four of those years, she headed the Seismology Department of the Danish Geodetic Institute. When her career began, it was rare for women to hold academic positions at all, let alone leadership positions. This is still true today: a 2015 governmental taskforce found that, despite constituting about half of Denmark's earned PhDs, only 18% of Danish professors were women (Anbefalinger 2015). Inspired by her trailblazing career, the Danish Ministry of Higher Education and Science initiated the Inge Lehmann Research-funding Program. To develop talent and promote more equal gender representation in academics and research, the program prioritizes female over male applicants with similar qualifications.

Critics call the Lehmann Program biased and discriminatory, Recently, claims were made that her scientific credentials were exaggerated, that she 'only' discovered the earth inner core. Further arguments suggest that her impressive academic career means that she could not have experienced gender discrimination. Hence, the Lehmann Program's rationale is based on a false narrative.

Whereas the first claim is easily dismissed based on scientific evidence, the second claim is more difficult to disprove since little is known about her career before the 1930s (although see, for example, Bolt and Hjortenberg, 1994).

This article fills this gab in our historical knowledge using newly discovered, unpublished documents from Inge Lehmann's graduate and postgraduate years. It shows the degree to which gender played a decisive role in her experiences, and suggests to what extent her experiences were shared by contemporary female academics.

Inge Lehmann bequeathed her personal archive to her colleague, Erik Hjortenberg. who donated it to the Danish National Archives in 2015. The collection consists of twenty-one boxes of notes, letters, manuscripts and references. Additional letters from the 1910s and 1920s are held in the archival collections of Niels Bohr and Niels Erik Nørlund. Newly discovered material in these collections provides key insights into her early career (see Jacobsen, 2015). Recently, letters between Inge and her family were discovered by Lotte Kaa Andersen, including correspondence with her father about continuing her studies at Cambridge. These letters reveal the prevalent social belief at that time, that academic aspirations destabilized women's fragile mental capabilities. They also shed new light on Inge Lehmann's purported sickly constitution as a young woman and her breakdown after Cambridge — precisely the opposite of characteristics attributed to her later in life (see, for example, Jack Oliver's interview, 1997). I suggest that cultural perceptions of female academics have changed over time, not Inge Lehmann's intellectual prowess and stalwart character.

Table 1, a timeline of women's rights in Denmark, and Table 2, a timeline of Danish women in academia, display the historical context of Inge Lehmann's achievements. Together, they show that women's entry in Danish academia predated landmark rights legislation. Exceptions are positions of university leadership and membership in the Royal Society, where women were slow to appear. Rather than comprehensive lists of gender equality measures in Denmark, the tables capture the female academic experience as background for the early years of Inge Lehmann's career.

Table 1: Landmarks for women's rights in Denmark

1875 Women gain university admittance (except in theology).
1899 Married women gain the same financial rights as unmarried women.
1903 Girls are permitted to attend high school on equal terms with boys.
1915 Women secure the right to vote.

1919 Legislation stipulates equal pay for equal work in civil service.
1921 Legislation insures Equal Access for Women to All Public Service and Occupations (except for clerical and military positions).
1922 Married women share legal custody of their children (but not sole guardianship).
1924 Nina Bang becomes the first female Cabinet Minister (Minister for Education)

Table 2: Firsts for women in Danish academia:

1875 Studied at a university (medicine), Nielsine Nielsen.
1889 Obtained a degree in science, (entomology) Sofie Rostrup.
1893 Earned a scientific doctorate (history), Anna Hude.
1909 Earned a scientific doctorate in science (physics), Kristine Meyer.
1915 Gained an academic university position (calculator), Julie Marie Vinter Hansen.
1922 Founded the Danish Association of University Women.
1946 Becomes a university professor (history), Astrid Friis.
1958 Becomes a science professor (organic chemistry), Bodil Jerslev.
1968 Elected to the Danish Royal Academy of Science and Letters, Eli Fischer-Jørgensen (linguistics).

2. Childhood and schooldays

Inge Lehmann was the elder of two sisters who grew up in Copenhagen in an intellectual family. Their mother, Ida ne Tørsleff (1866-1935), came from a family of booksellers. Several female Tørsleff family members were part of the Women Rights Movement and significant public figures. Inge's cousins served as head of the Danish Girl Scouts, chair of the Danish Women's Society, and the Minister of Trade. Famously, her younger sister Signe, a single mother, became a school superintendent.

Inge's father, Alfred Lehmann (1858-1921), held a Masters Degree in Applied Science from Copenhagen Polytechnic. He established psychology as an independent research subject in Denmark after he set up a private Psychophysics Laboratory for experimental psychological research in 1886 (Moustgaard and Petersen, 1986). When the University of Copenhagen took over the laboratory in 1890, Alfred Lehmann was appointed interim 'docent' (a teaching post ranked just below professor). Financial constraints meant that he had to take on additional paid work until

1911, as a censor at a teachers' college, a librarian at the Royal Veterinary and Agricultural University, and a technical drawing teacher. Not until 1910 was he appointed ‘ekstraordinær professor’ (professor without chair). Nine years later he was elevated to a professorship with chair. Alfred Lehmann's substantial number of scholarly publications on experimental and applied topics range from how emotions influence blood circulation, and the existence of occult phenomena (of which he was skeptical), to studies of the maximum yield of physical and intellectual work (for detailed descriptions of Alfred Lehmann's work, see Funch, 1986; and Pind, 2019).

Inge's parents had progressive views on education. In 1894 they enrolled her, and later her sister Harriet, at Hanna Adlers Fællesskole, the first co-educational school in Copenhagen where girls and boys were taught the same subjects together. This was highly unusual – most schools had separate academic tracks for boys and girls. For intellectually inclined girls, gender-segregation policies went even further. Exposing girls to intellectual exhaustion and stress during puberty was considered harmful. Hence, girls under seventeen years old were prohibited from taking the high school entrance exam, whereas boys, who were considered better suited biologically for such activities, could take the exam and enter upper-secondary school (high school) at age fifteen (Larsen, 2010). This policy persisted until 1903.

The school was found by Hanna Adlers and build upon her own experiences from academia. In 1892, seventeen years after the University of Copenhagen admitted its first women students, Adler (1859-1947) and Kirstine Meyer (1861-1941) were the first two women to earn Master’s Degrees in Physics. Meyer was also the first woman to gain a habilitation in Physics, the traditional prerequisite for a professorship. Inspired by advanced pedagogy in the USA, Adler opened her school a year after completing her degree. As teachers, she hired several of her female co-graduates who were excluded from many of the jobs open to their male counterparts. At that time, women could not get university positions and, although their degrees qualified them to teach at the upper-secondary school (high school) level, most female college graduates found work as primary (elementary) schoolteachers. A trailblazing female academic, Hanna Adler firmly believed in gender equality. She was also the aunt of physicist and Nobel laureate, Niels Bohr, and a frequent guest in the Bohr household.

In autobiographical notes, Inge Lehmann described her schooldays as happy, marked by serious study without differential treatment of boys and girls (RA: Lehmann autobiographical note, [ca 1970]: W84-258078). Inge showed considerable talent in mathematics and physics, and her father was keen for her to pursue a degree in science. Kirstine Meyer taught her physics, and Thyra Eibe

(1886-1955), known for her expert translation of Euclid's *Elementes,* taught mathematics. These female scientists were uniquely qualified to support Inge's academic ambitions. With such role models, it is not surprising that the girl developed a strong sense of intellectual entitlement and belief in gender equality.

Figure 1: Inge Lehmann (to the right) with fellow High School graduates, 1906 – the first-year women graduated on equal terms with the men (Anon [1918] Frk. H. Adlers Fællesskole 1893-1918 . Kbh.).

After passing her upper-secondary school graduation exams in 1906, Inge Lehmann worked as a private tutor before beginning studies in mathematics in the Faculty of Sciences at the University of Copenhagen in autumn, 1907

Between 1875 and 1925, 369 women sat for final examination at the University. Of that total, 326 did so after 1900, when the overall number of students also increased from between 2,100-2,300 at the turn of the century to approximately 4,500 in 1925. In the Faculty of Mathematical Sciences, the first precise student count dates from 1912, at which point 146 students were enrolled, 22 of them

women (for details on early female students at Copenhagen University, see Grane and Hørby, 1993; Rosenbech, 2014; Phil, 1983). Thus, when Inge Lehmann started at the Faculty, female students were no longer rare, but neither were they numerous.

So far, no sources have been found that describe Lehmann's university experiences in Copenhagen. She is not mentioned in records linked with other leadings students at the faculty, such as Niels Erik Nørlund in mathematics or Niels Bohr in physics. Nor was she in the interdisciplinary study group, *Ekliptika*, which had several women participants (Pind, 2014). Lehman lived at home, evidently focusing entirely on her studies. She earned fine grades on the first part of her degree examination in summer, 1910 (RA: Københavns Universitet, Karakterprotokol Matematik, [1908]: 2. del).

2.1 Studies at Newham College, Cambridge University

After graduation, Inge Lehmann was eager to study abroad. In the spring of 1911 she entered Newnham College, one of two women's colleges at Cambridge University, UK. Cambridge was renowned for excellence in mathematics. A form of examination unique to the university was notorious for its scope and difficulty. The Mathematical Tripos covered theoretical and applied mathematics, plus subjects in astronomy and physics. The exam was so challenging that preparation traditionally involved equal parts theoretical study and physical activity – training both body and mind in order to strengthen the intellect. Even after modification in 1909 to counter falling enrollment and accommodate students' needs to specialize within a single subject, the Mathematical Tripos remained equally prestigious and exceedingly demanding (Warwick, 2003). By choosing to read mathematics at Cambridge, Lehmann revealed the depth of her ambition, but the English university setting proved quite different from what she had known in Copenhagen.

Women had been eligible to sit for the Tripos since 1881. Yet, although women could attend lectures, they could not matriculate, attain full university membership, or be appointed to academic posts. Only in 1948 were women admitted to Cambridge on equal terms with men. Un-matriculated female students were denied access to laboratories and libraries. Since individual tutoring at Cambridge often occurred in conjunction with lab work, female students were, in effect, prohibited from taking part in practical, hands-on experimentation, and could not be tutored by male lectures (for further details on the experiences of female academics at Cambridge University, see, e.g., Evans, 2010; Richmond, 1997).

At Cambridge, the regular system of tutors, grants and student clubs was the prerogative of men. This further marginalized female students. During the 1880s and 1890s, therefore, a parallel system

of laboratories, libraries and tutors exclusively for female students gradually built up around the two women-only colleges, Girton and Newham.

While Inge Lehmann knew about similar parallel systems in Denmark – the Women's Reading Society (Kvindelig Læseforening), for example – she had not experienced the degree of gender segregation that prevailed in Cambridge. Even though Cambridge reformed its examination system in 1909, making a number of vital resources available to female students via their colleges, it was still difficult for women to study freely. In particular, restrictions imposed on socializing between students of different sexes were far more onerous in Cambridge than in Copenhagen, and posed a real obstacle to knowledge sharing. This was alien territory for Inge, who expressed frustration about her experiences in her correspondence with Niels Bohr, who was also coming to Cambridge.

Figure 2: Newham College (Inge Lehmann Collection, The Danish National Archives)

Niels Bohr completed his doctoral dissertation – *Studies on the Electron Theory of Metals* (*Studier over Metallernes Elektronteori)* – in the spring of 1911 and planned to spend time at Cavendish Laboratory in order to follow the experimental work of J. J. Thomson, the physicist.

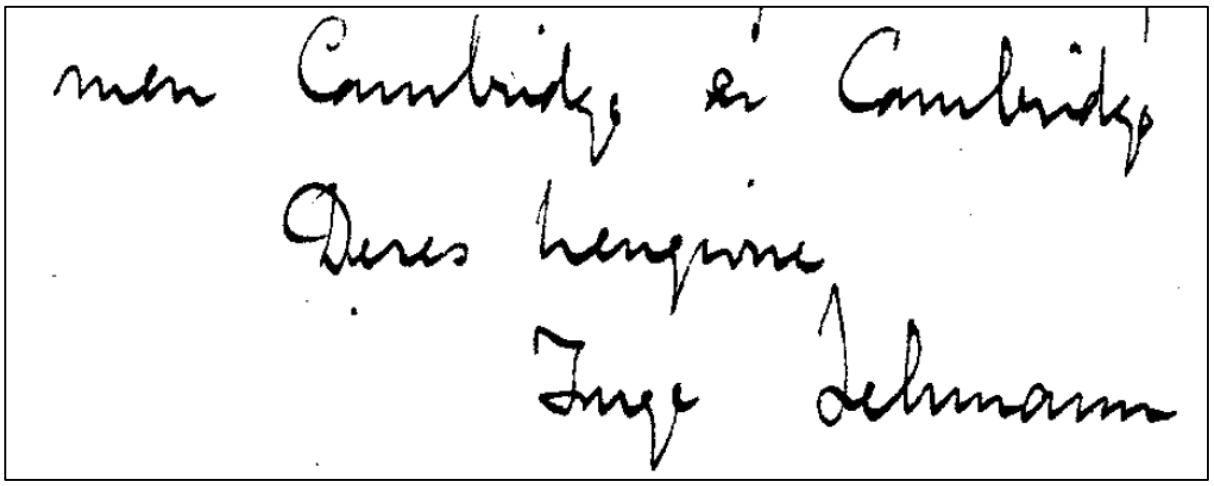
Bohr's interaction with Lehmann in Cambridge is detailed by Aaserud and Heibron (2013). In May 1911, he wrote asking for her help in finding out which physics lectures would be relevant to his areas of interest, laid out in the enclosed copy of his doctoral dissertation. After reading the manuscript, Lehmann briefly outlined the lectures he might find useful, ending her letter by expressing hope that they could meet up when he came to Cambridge (NBA: I. Lehmann letter, 2. Mai 1911). This proved considerably harder than she had envisaged.

Bohr arrived in Cambridge at the end of September 1911. By early October, he had found an apartment with help from Lehmann and her network of friends. Over the next few months, Niels Bohr and Inge Lehmann visited one another numerous times, although arranging these visits was troublesome: according to university regulations, Inge had to be chaperoned when spending time in the company of a man.

On one occasion, shortly after Niels arrived in Cambridge, he was invited to Peile Hall, where Inge lived at Newnham College. Their meeting was possible because Newnham's Vice-Principal, Miss Strachey, had agreed beforehand to be present (NBA: Lehmann letter, n.d. [1911]. Another visit was cancelled because Inge couldn't find a suitable chaperone on a Sunday (NBA: I. Lehmann letter, 13. October 1911).

A dinner party in early December 1911 proved particularly challenging. Inge was traveling to Copenhagen to spend Christmas with her family, so Niels invited her, along with two male mathematicians, to a farewell-dinner at his lodging. Before she could accept his invitation, Inge had to ask him for the name of her chaperone. With that information, she could ask the principal of Newnham Hall for permission to attend. She regretted the trouble, but wrote with resignation: "… but Cambridge is Cambridge" (NBA: I. Lehmann letter, 5. December 1911b). Wise from experience, Bohr had already arranged for a friend to attend the dinner party with his sister. Unfortunately, Lehmann informed him, that sister was also a student at Newnham College, and her presence would not fulfil the requirements of effective supervision (NBA: I. Lehmann letter, 5. December 1911a). Eventually, the list of dinner guests grew so long that Bohr was afraid there would be no room for them in his small apartment, or so he ironically wrote to Margrethe Nørlund, his fiancée.

Figur 3: Inge Lehmanns resigned note about the archaic idiosyncrasy of Cambridge. (Niels Bohr Archive)



This correspondence illustrates how the restrictive social conventions at Cambridge obstructed interactions between students of different genders – including the exchange of knowledge. Inge Lehmann unquestionably felt the restrictions most acutely, but Niels Bohr also grumbled about the University's strict code of conduct, which he found quite absurd. Although Bohr was likely influenced by his free-thinking aunt, Hanna Adler, there can be no doubt that social conventions between students of different sexes were far less cumbersome at the University of Copenhagen, where no formalized system of gender segregation ever existed and teaching and practicums were co-educational.

Lehmann went home for Christmas in 1911, expecting to return to Cambridge at the start of spring semester. In March 1912, Bohr decided he had nothing more to gain from staying in Cambridge and moved on to Professor Ernst Rutherford's laboratory in Manchester, where he spent the next six months developing his pioneering atomic theory.

It was during Christmas break that Lehmann decided not to return to Cambridge for the next semester. She was profoundly overworked. She had spent 1911 preparing for the Mathematical Tripos, and intended to sit for the exam in the spring of 1912. It has generally been assumed that Lehmann abandoned her studies altogether because her recovery from utter exhaustion was so slow. She was literally unable to resume her university studies for a long time (e.g. Bolt, 1997).

In reality, she was exhausted, but also keen to return to Cambridge. Recently discovered correspondence shows that Alfred Lehmann put a stop to her plans by refusing to fund them. Instead, he urged her to seek employment in Denmark and make a living outside academia. In a

letter to Inge written in March 1912, her father explained his reasoning at length. Practically speaking, the rising cost of living made it impossible for him to finance her studies any longer. Alfred's economic concerns seem genuine, given his precarious employment at the University and his younger daughter Harriet's recent enrollment at the Danish Royal Theatre's acting school. Yet, Inge's health was of primary importance. To protect his daughter, he could no longer in good conscience support academic aspirations that were ruining her heath. To Alfred and many of his peers, it was a proven fact that, whereas women might be as intellectual gifted as men, they lack the rigorous constitution necessary for academic pursuits. College was better suited to the male disposition.

To argue his case Alfred Lehmann quoted several male professors of his acquaintance who strongly believed that women did not have the mental stamina to meet the 'by no means unreasonable requirements' for an MA in Copenhagen, let alone the more challenging studies in Cambridge. He went on to relate "…a series of sad examples of how it went with intellectually gifted women who wanted something more…". Their studies made them so ill that they were forever in and out of nerve clinics, if not half insane. Not wanting the same fate for Inge, who already had shown signs of fatigue, her father felt it would be irresponsible of him to let her continue with her studies. Instead, he urged his daughter to seek practical clerical employment where she could undoubtedly rise to a valuable and responsible administrative position in due time. Thus, there was no need for her to complete her final exam (Private: A. Lehmann letter, 11. March 1912).

The biological argument that women were not equipped with enough energy and fortitude for scientific studies likely originated in the rise of scientific medicine in the 19th century and, by extension, the study of biological gender. From 1890 to the late 1910s, Doctor Leopold Meyer published a series of influential medical texts in Denmark that problematized menstruation in relation to physical and intellectual work: due to their female physiology, too much exertion of the brain and nervous system would make women ill (Rosenbeck, 2014). Since Inge's father studied the body's reaction to physical and intellectual work, he was most likely familiar with Meyer's ideas and, therefore, concerned about his daughter's future in her chosen field.

Inge must have protested because Alfred – somewhat mollified – wrote again two weeks later to suggest that she convalesce at home until September. Then, mindful of her health, she should resume her studies at Copenhagen University. If her strength and her exam results were satisfactory at the end of a year, he would find the necessary funds for another year at Cambridge, where she

could complete her MA-degree without sitting for the Mathematical Tripos. Ultimately, Alfred thought it ill-advised for Inge to pursue a foreign degree when a degree from Copenhagen University would better prepare her for employment in the Danish school system. To what degree Alfred's own precarious experiences in academic influenced his advice to Inge is unknown, but as a women her job opportunities would be limited in general and nearly non-existent at the university.

3. Gap years

Inge took her father's concerns to heart and did not return to Cambridge. The next six years of her life are sporadically illuminated in recently discovered autobiographical notes, written much later in hindsight. In them, she acknowledged that acute overwork and a lengthy recovery period led her to provisionally abandon her studies for the typical life of a middle-class working woman.

In the fall of 1912, a friend of her father's secured her an actuarial job at the insurance company, *Det Gjensidige Forsikringsselskab "Danmark"*. Her choice of employer was not unusual given that the insurance business attracted many female academics with mathematical backgrounds. There, they could use their statistical knowledge and calculating skills in office environments where female clerks and typists had long been a common presence (Kragh, 2008). The notes do not explain why Lehmann did not resume her studies as her father suggested. Possibly her fatigue lingered longer than she had anticipated, or her family's financial needs were more pressing. In any event, the outbreak of World War I in 1914 put an end to any thoughts of returning to Cambridge.

Inge Lehmann remained at the insurance company for a number of years but expressed little interest in the business aspects of her work (RA: Lehmann, biographical notes [u.d.]: W84-258079). When she was not promoted in step with her male colleagues, she recognized that gender was again the restricting factor. Passed over for promotion, and with the prospect of a male boss she found unacceptable, she considered relocating to Canada, but another bout of overexertion prevented her from emigrating.

Unable to secure a managerial position, Lehmann considered marriage. In February 1917, at the age of 29, she became engaged and resigned from *Danmark*, as employment was incompatible with matrimony. Only a month later she broke off the engagement in order to resume her studies and pursue an academic career (RA: I. Lehmann, biographical notes [u.d.]: W84-2580). Inge Lehmann's decision to remain unmarried to further her academic ambitions was not an unusual choice at the

time. Abstaining from marriage was common for university women until the 1920s. Thereafter, the number of married female academics increased but slowly (Rosenbeck, 2014). Lehmann embodied this trend as she remained unmarried and without children all her life.

4. Return to the University of Copenhagen

In August 1918, Inge Lehmann finally resumed her studies at the Faculty of Mathematical Sciences in Copenhagen. Two years later, she passed the second and final part of her examination with top grades, earning her MA. It is worth noting that Lehmann's lengthy period of study manifested a general tendency among female students at the Faculty. A survey of degrees completed between 1916-1920 at the Faculty of Mathematical Sciences shows that a number of female students were enrolled for considerable lengths of time, and that female students in general were enrolled longer than their male counterparts (Københavns Universitet, 1925).

Alfred Lehmann passed away in September of 1921. Among many other things, this meant that Inge needed to secure a stable income. Also that year, an act was passed giving women equal access to public sector employment, including all university positions. No longer forced to settle for public school teaching, Inge Lehmann could now pursue a university career in mathematics with concomitant salary, prestige and scholarly recognition.

4.1 Assistant in the Faculty of Mathematical Sciences

A small scholarship allowed Lehmann to study mathematics at the University of Hamburg for a short period of time. After returning home again, she started work in March 1923 as assistant to Professor Johan Frederik Steffensen in his Actuarial Mathematics Laboratory at the University of Copenhagen. Inge's yearly income was DKK 700, plus a small bonus (RA: Københavns Universitets Forsikringsmatematiske Laboratorium, Korrespondance: Konsostorium, letter 1. March 1923). For this modest salary, she had to tutor students, assist in practicum sessions and grade assignments. Grading mathematical problems after the practicums ate up a disproportionate amount of her time, and it quickly became obvious that her income was not commensurate with the demands of her duties.

Realizing this, Professor Steffensen tried on several occasions to secure better pay and conditions for his assistant. In December 1924 he tried to get a reduction in her workload. A few months later he complained to the Minister for Education that Lehmann's pay was considerably inferior to that of other (presumably male) scientific assistants at the University and requested that it be brought up

to the same level as the others (RA: Københavns Universitets Forsikringsmatematiske Laboratorium Korrespondance: Steffensen, letter 16. February 1925). The gap between her salary and that of the others must have been pitiful, because the Ministry of Education was quick to act: in April her salary rose to almost three times its previous level! (RA: Københavns Universitets Forsikringsmatematiske Laboratorium, Korrespondance: Konsistorium, letter 30 September 1925) While working at the Laboratory of Actuarial Mathematics, Inge Lehmann had taken on part time jobs, including translation and editing for another Mathematics Faculty member: Professor Niels Erik Nørlund. In addition to his professorship, Nørlund had been appointed Director of the Danish Geodetic Service (Den Danske Gradmåling) in 1923, with a mandate to reform and merge the Service with the Topographic Division of the General Staff (Generalstabens Topografiske Afdeling).

The role of teaching assistant and occasional secretary was traditionally the end of the line for many women in academia, but Lehmann was not content in this station. Having worked as Niels Erik Nørlund's occasional secretary, in June 1925 she cautiously pointed out to him that she wanted a research job: "I believe that I would venture to undertake calculation work, if it does not involve too great a theoretical foundation in areas with which I am not familiar, whereas I am not so certain that you would be served by my assistance with correspondence, as I understood to be your plan." (RA: N.E. Nørlund, letter (I. Lehmann) 17. June 1925)

Nørlund could not employ her as research assistant at the university, but he saw another opening for her talent. He was in the process of reorganizing the Geodetic Service and needed to add seismological stations to their activities. An annual contribution from the Carlsberg Foundation made the project feasible, and for the next couple of years Inge Lehmann helped to set up the new seismological stations. In 1926 she helped establish seismic stations in Copenhagen (COP) and Ivittuut (IVI), Southwest Greenland, and in 1927 at Scoresbysund/ Ittoqqortoormiit (SCO), West Greenland (for the early history of seismology in Denmark, see Lehmann 1987; Jacobsen 2017; Dahl-Jensen, Jacobsen, Sølund, Larsen and Voss (submitted)).

Lehmann carried out the work of setting up and running the seismological stations in addition to her work at the Laboratory of Actuarial Mathematics. In January 1927, restructuring the Geodetic Service was so far advanced that she could resign from the Actuarial Laboratory and work exclusively for Niels Erik Nørlund. The plan was for Inge to learn the science of seismology so she could work in that field in the future.

As seismology in Denmark was in its infancy, Nørlund arranged for Lehmann to spend four months abroad in the autumn of 1927 to immerse herself in the science. Part of her time was spent at the precursor of the International Association of Seismology and Physics of the Earth's Interior (IASPEI), then known as the International Seismology Association of the International Union of Geodesy and Geophysics (IUGG) (for the history of IASPEI, see Rothé, 1981; Schweitzer and Lay, 2019). The IUGG bureau was located in Strasbourg; there, she spent several weeks learning to read seismograms. After attending the IUGG General Assembly in Prague, she put this skill to good use while studying with Beno Gutenberg at his home in Darmstadt, Germany. (Lehmann 1987).

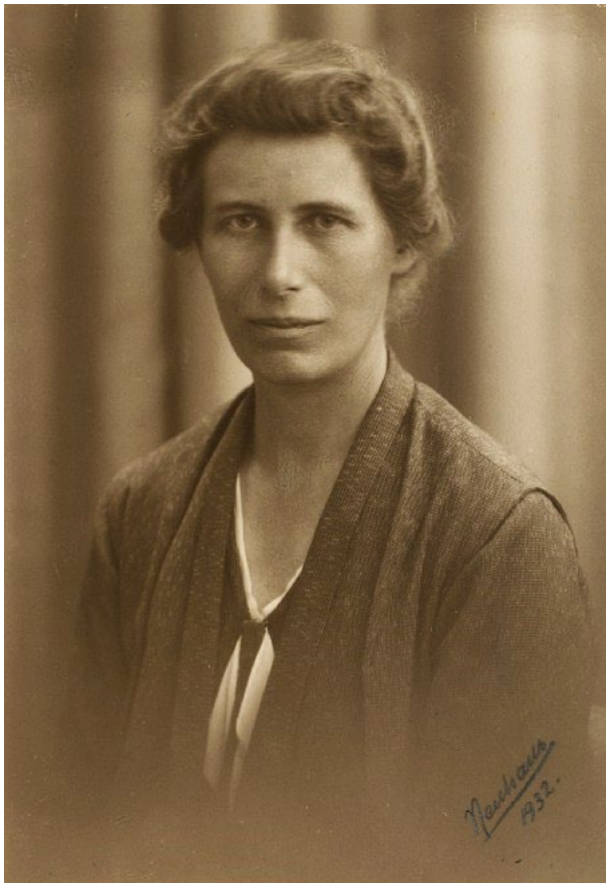
5. Director of the Seismology Department at the Danish Geodetic Institute

In April 1928, Niels Erik Nørlund was appointed director of the newly formed Danish Geodetic Institute (Geodætisk Institut). In May, Inge Lehmann was the second person in the country to sit for the 'magisterkonferens' (equivalent to an MSc) in geodesy at the University of Copenhagen, a new subject recently introduced at Nørlund's behest.

Her short apprenticeship abroad and her own studies were her only preparation for the examination, which was tailored to her future job. In the written exam, she gave an 'Account of the key methods for the determination of the epicenter of a seismic activity' (*Redegørelse for de vigtigste Metoder til Bestemmelse af Epicentret for en seismisk Bevægelse*). Her final lecture considered cartographic projection methods (Københavns Universitet, 1929), another essential area in the work of the Danish Geodetic Institute.

By summer, Inge Lehmann was Director of the new Seismology Department at the Geodetic Institute. She was responsible for running Denmark's seismological stations, along with a couple of technical assistants. Although the job was mainly administrative and involved very little research, it was a permanent position with the title and salary of a department head.

Figure 3: Inge Lehman, Director of the Seismological Department of the Geodetic Institute, 1932 (Royal Danish Library)



In a letter to Niels Erik Nørlund written that year, she expressed her pleasure and gratitude: "I do not think I thanked you properly for my appointment […] I could not have wished for anything better. I have earlier been concerned that I was asking too much when refusing to be satisfied with working in order to earn money, but sought a job in which I could really take an interest. In my work here, I have […] found more than I could ever have hoped. In return, I shall do my utmost. It is no small thing to have the opportunity and permission to use all one's strengths." (RA: N.E. Nørlund, letter (I. Lehmann) November 1928)

Until she retired in 1953, Inge Lehmann was the only academic working at the Department of Seismology. Due to her administrative duties, most of her research was performed in her spare time. Overseeing stations in Denmark and Greenland gave her access to seismograms from several locations and a range of instruments. As department head, she kept in contact with an international network of colleagues. Her expertise in reading seismograms and vigorous correspondence with leading seismologists paved the way for her discovery of the Earth's inner core in 1936, which earned her lasting international renown as one of the most influential seismologists of the 20th century (Hjortenberg 2009).

6. Discussion

As an early female scientist in Denmark, Inge Lehmann is virtually unsurpassed in the level of employment she achieved and in the scientific recognition she received later in life. However, her graduate and postgraduate experiences reflect common features shared by female academics of the time.

In her study of Danish female academics from c.1875 to c.1925, Rosenbeck (2014) identified four commonalities. These women mostly came from affluent families or academic families. Female students had higher average grades than their male counterparts, even though this gendered difference diminished as the number of female students increased around 1900. Female students also started their coursework far later than male students, although average age difference also fell over subsequent generations. Finally, the vast majority of women academics remained unmarried. Of the eight women mentioned in table 2, only three was married. Sofie Rostrup and Bodil Jerslev both had children while working as academics, while Anna Hude left her position at the Danish National Archive to marry late in life. Inge Lehmann's background and experience precisely fit in Rosenbeck's (2014) generalization of female academics of the period: she came from an intellectual family, her grades were above average, she took longer to finish her studies than the male students, and remained unmarried.

American historian of science, Margaret Rossiter, in her cardinal work *Women Scientists in America* (1984) points out that many women turned to the "Madame Curie strategy": instead of addressing imbedded inequality in the workplace, women often internalized their struggle. Wanting to prove their right to practice science, they tried to surpass male scientists' achievements. As a result, some women drove themselves to exhaustion or nervous breakdowns in their quest for academic excellence. Margaret Rossiter's studies were based on the condition of women in the US, but many of the patterns she observed can reasonably be applied to the situations of Danish female academics. Evidently, Inge Lehmann experienced a stressed-related breakdown in 1911 due to overexertion, a pattern of behavior analogous to Margaret Rossiter's observations about women's self-inflicted overcompensation. It is worth noting that the new material presented in this article calls into question the severity of Inge Lehmann's breakdown, and suggests that it's allegedly devastating impact on her psyche more likely reflected society's self-fulfilling prophesy about the fragility of the female intellect. Not surprisingly, intellectual insecurity was a common among contemporary female scientists. In 1890, Anna Hude left her position as the National Archive's first

female historian after only a year due to nerves. She was rehired the following year. When German physicist Lise Meitner lectured at Niels Bohr´s Institute for Theoretical Physics in 1922 she confided to Bohr´s wife that she was enormously reassured to know that he valued her work, for it helped her overcome the insecurity that sometimes afflicted her (Sime 1997). At that time, Lise Meitner had published over forty papers and discovered protactinium.

Despite the fact that women were making their way in science by the 1920s, women academics did not participate on equal terms with men. A number of societal and institutional factors in the natural sciences contributed to women's continued difficulty in making a career (Kragh, 2008). The 1921 law giving women access to public sector employment was crucial for opening academic appointments to college educated women – although in pay and prestige, women still lagged behind men. As a rule, women found employment in positions with a high turnover in male personnel, or in newly established jobs. A good example of the latter is entomologist Sofie Rostrup (Table 2), who first found work at a private experimental facility for plant pathology – a new discipline at the time. Margaret Rossiter also observed that the prospects for promotion of women scientists were considerably inferior to those of their male colleagues. In the private industrial sector, women scientists were few and far between. There, a second strategy of cynical versatility and conformity developed in the 1930s. Taking advantage of prevailing stereotypes, women deliberately sought jobs considered more suitable to their gender, but close in proximity to their academic disciplines. In fact, of the eight trailblazing women in Table 2 only the youngest four (Julie Marie Vinter Hansen, Astrid Friis, Bodil Jerslev, and Eli Fischer-Jørgensen) obtained university positions. The others were employed in positions related to their disciplines. In fact, Inge Lehmann never held a senior position at a Danish university: in 1952, she was passed over for the new position of Professor in Geophysics at Copenhagen University.

Lehmann’s appointment as Director of the Department of Seismology can also be interpreted from a gendered perspective similar to the cynical versatility Rossiter observed among female scientists in US industry. Niels Erik Nørlund’s selection of Lehmann to manage the seismological stations was likely due to several factors in addition to her scientific qualifications. Firstly, there was no tradition of seismological research in Denmark, so this research area was not prestigious. Secondly, due to seismology's obscurity, there were no male candidates. Career prospects were limited in a country where earthquakes are extremely rare. Thirdly, the job's responsibilities were mainly administrative and the Department's research was not connected to the University of Copenhagen.

Nevertheless, some of the above mechanisms worked in Inge Lehmann's favor. By switching from mathematics to seismology and accepting a job outside the University, she secured a permanent appointment and realized her ambition of holding a senior scientific post at a time when faculty positions for women were extremely rare.

To a 21st-century audience, Inge Lehmann experiences illustrate how gendered perceptions of science, however well-meaning or seemly rooted in fact, become self-fulfilling prophesies. If we want to learn from exceptional individuals, we need to look at their failures as well as successes, and at the social mechanisms surrounding science. The long-term impact of the Inge Lehmann Program on gender composition in Danish research is yet unknown, but it is one way of pushing past such social mechanisms.

7. Conclusion

Among seismologists, Inge Lehmann is remembered for her uncompromising, sometimes undiplomatic ways and as the recipient of many honors (Bolt and Hjortenberg, 1994). Despite her successful international career, a close study of Lehmann's experiences before she became a seismologist reveals that she also faced limitations. Gender bias, employment restrictions and society's perception of female biology effectively limited her career options.

During her stay at Cambridge University in 1911, she first experienced institutionalized gender-based restrictions. Her mental breakdown in the winter of 1912 can be construed as an attempt to rectify gender bias via academic overcompensation. It is plausible that the severity of her breakdown was exaggerated on her father's insistence. As a physiologist, Alfred Lehmann's own work indicated that women like his daughter, Inge, were biologically unfit for academic studies despite their substantial intellectual gifts.

In her work as an actuary and as a research assistant, Inge Lehmann found herself in a disagreeably inferior position compared to her male colleagues. When she changed her field from mathematics to seismology, she displayed a pragmatism that found hope in what was possible. By performing well within narrow parameters, she made the best of things in order to move up the career ladder.

Inge Lehmann had a career in science because at decisive moments she conformed to social and professional agendas – and because she was an exceptional talented scientist.

Disclaimer

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