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FRANCES GERTRUDE WICK (1875-1941)

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BIOGRAPHY

Frances Gertrude Wick was born on October 2, 1875, in Butler County, Pennsylvania, to Alfred and Sarah Ann (Mechling) Wick. Her origins went back at least two generations in Pennsylvania. Her father, Alfred Wick (1837-1904), was the eldest son of Andrew and Sarah (Shryock) Wick. He clerked in his father's store in West Sunbury, Butler County, before starting his own business as an innkeeper. In 1884 he started a successful career as one of the county's leading oil producers. He married her mother on September 15, 1859. The Wick family also included Alice (born ca. 1862), Harry (deceased by 1894), Mary (1865-1945), Stella A. (born ca. 1868), Sarah Blanche (1873-1960), and George B. (1879-1934).

In 1893 Frances Wick and her older sister, Sarah Blanche, entered Wilson College in Chambersburg, Pennsylvania. Frances Wick received an A.B. degree. in 1897 with honors, although the degree was not in physics (Davison 1941). She then returned home and commenced teaching at Butler High School for $45 a month. At the end of one school year her assignment for the next year included physics, in which she had no previous training. To help remedy this situation, she took a summer course at Chautauqua and studied late into the night, trying to keep ahead of her class. Evidently these labors aroused her curiosity and intellect, and she determined to become a physicist. She was not dissuaded from this, even though to her peers, forsaking a well-paying job for an uncertain and unconventional future seemed "rash and foolish." Her family did not echo these sentiments but, rather, reinforced her own resolution with encouragement and understanding (Lloyd 1931).

Wick began her formal study of physics at Cornell in the fall of 1904, earning a second A.B. degree by 1905, an A.M. degree the next year, and a Ph.D. degree in 1908. She received a Graduate Scholarship in Physics in 1906-7 and a Graduate Fellowship in 1907–8 (Lloyd 1931). At the time, research at Cornell's Physical Laboratory was unique in the United States for its primary focus on experimental investigations of luminescence and fluorescence. Edward Leamington Nichols, chair of the Cornell physics department and cofounder of the *Physical Review*, had shifted to this topic from his research on electricity. The discoveries of Wilhelm Roentgen (Nobel laureate, 1901) and A. Henri Becquerel (Nobel laureate, 1903), in which fluorescence had been pivotal, also revived a general interest in these variant and baffling phenomena.

Cornell's emphasis upon experimentation suited Wick's internal drive to learn by trying, again and again, to elucidate a puzzle. The colorful glow of luminescent minerals excited her aesthetic delight; this together with the enthusiasm at Cornell for these phenomena combined to foster her lifelong commitment to the study of luminescence. It was probably Nichols himself who played the greatest role in Wick's rapid development as an experimental physicist.

Nichols "was her ideal, and the relation of teacher and student merged grad- ually into that of collaborator and friend" (McDowell 1942). Nichols broadened her experience in some ways but may have limited it in others. He recommended that she diversify her background by pursuing a doctoral thesis in another field (McDowell 1942), but her professional goals may have been adversely affected by his use of her data to support his theories. Especially in the first decade and a half of her research, many of the experiments she undertook were the direct suggestions of Nichols and Ernest G. Merritt; her publications always concluded with liberal expressions of gratitude to them for providing both guidance and the equipment needed to conduct the work.

While at that time most physicists could not accept the possibility of women making professional contributions to physics, Nichols appears to have been an exception. As president of the APS, he encouraged women to attend the society's banquets, whose traditional after-dinner smoking had long been interpreted as an overt message that women were not to attend (Whiting 1912). A photo from that era includes four women among 24 physics students seated beneath a tree ("Ithaca Summer Group"). One of the other women was Louise S. McDowell,* who had also left a high school teaching position to become a physicist.

Wick and McDowell formed a lasting friendship that continued to flourish during the many subsequent summers they spent together performing experiments at Cornell. Apparently they had an open, long-standing invitation to pursue research at the Cornell Physical Laboratory each summer. Most years they took advantage of this offer. The two women coauthored two papers, one in each of their fields (Wick and McDowell 1916, 1918). Their close friendship was well known at Cornell. Recalling Wick's ebullience as a Cornell student, McDowell wrote in her memorial of Wick:

I can see her now almost running down the basement corridor on her way to shop or supply room to get something to carry out her latest idea, so eagerly intent on her work that she had no time to waste. Her heart was in her research. She was never so happy as in the laboratory... taking careful measurements which to many would have seemed monotonous drudgery. (McDowell 1942)

From 1908 until 1910, after her graduation from Cornell, Wick was a physics instructor at the recently founded Simmons College in Boston. Although Sim- mons was not a research institution, Wick found an unoccupied dark space under a basement staircase and set up her spectrometer there (McDowell 1942).

In 1910 Wick was offered an instructorship by Vassar, where she taught for the next 30 years. She became an assistant professor in 1915, associate in 1919, professor of physics in 1922, and department chair in 1939.

During World War I Cornell's physics department was devoted to the war effort. Wick joined the effort there, under the U.S. Signal Corps. She was assigned to develop gun sights and lightweight radio equipment for airplanes. Vassar granted Wick leave to remain at Cornell for that academic year (Lloyd 1931). Wick's importance to the U.S. government impressed the Vassar admin- istration, and she was promoted to associate professor upon her return.

After the November 1918 armistice, when affairs at Cornell reverted to normal, Wick remained there, teaching and conducting research. The results of the studies on the fluorescence of uranium compounds were incorporated by Nichols into the text of a Carnegie Institution book (Wick, Nichols, et al. 1919). Wick also retained an affiliation with the U.S. government for some years after the war by serving on the Luminescence Committee of the NRC.

Wick spent the summer of 1920 at the General Electric (G.E.) Research Laboratory in Schenectady, New York. There she determined the crystal structure of two rare earth halogen salts with Wheeler P. Davey (Wick and Davey 1921). While at G.E., she may have first met technician

Mabel K. Slattery (later Vincent). Slattery went on to Cornell to pursue graduate studies in physics, as did several of Wick's other students (Hartman 1984). Wick and Slattery (Vincent) collaborated on several occasions, both while Slattery was at Cornell (Wick and Slattery 1928) and again in 1940 after Slattery-Vincent returned to Vassar. They published the first observation of luminescence in minerals excited by neutrons (Wick and Vincent 1940). The latter study was sponsored by an APhilS grant. In 1922 Wick used the award of a $1,000 Sarah Berliner Fellowship and a Subvention for Research from Vassar to take a year's leave. By spending the first semester at Harvard's Jefferson Physical Laboratory under Percy W. Bridgman (Nobel laureate, 1946) and the second at the Cavendish Laboratory in Cambridge, England, under Joseph J. Thomson (Nobel laureate, 1906), Wick gained access to experimental facilities and to an interchange of ideas that Vassar could not provide. At Harvard, using apparatus designed by Bridgman, she was the first to observe color changes in solutions subjected to pressures of up to 3,500 atmospheres (Wick 1923).

Wick traveled to Europe three times: in the summer of 1927 to work at the University of Berlin, in 1930 as part of a trip around the world, and in 1936 to the Radium Institute of Vienna, where she had spent three months of the previous trip. Wick always carried specimens of fluorescent minerals and synthetic ma- terials in her suitcase during these travels. When she first arrived at the Radium Institute in 1930, she proposed that the radium (to which she had no access in the United States) be used to excite fluorescence in her samples. Stefan Meyer and Karl Przibram invited her to stay to perform the experiments herself; these were later presented to the Academy of Science in Vienna and published in English and German (Wick 1930, 1931). The hospitality and cooperation of this research community impressed her; it became the source of friendships that were renewed during her final visit in 1936. She reciprocated this generosity by sending her copies of American physical journals to the Radium Institute as long as Austria remained free (McDowell 1942).

Although Wick was active in alumni activities of both alma maters, her primary involvement was with Wilson College. In 1931 Wilson College awarded her an honorary D.Sc. degree. Shortly after Nichols's 1937 death, the Cornell physics department voted unanimously to honor Wick by formally giving her unrestricted access to Nichols's collection of luminescent minerals for use in her research. Wick never married. Like her parents, she was affiliated with both the Re- publican Party and the Presbyterian Church. Wick lived on the Vassar campus until 1926, when she bought a house near the college and was joined there by her sister, Sarah Blanche. The two sisters lived together until Frances Wick died on June 15, 1941, at the age of 65, after an illness of several months.

Vassar honored Wick at a memorial service on January 21, 1942. McDowell, then chair of the Wellesley physics department, President Henry N. MacCracken of Vassar, and physics major Louise Grosvenor '43, each gave memorial ad- dresses. Her colleagues recorded their sentiments at an earlier faculty meeting: "She will live as a remarkable example of contagious happiness and constant devotion to her chosen work" (Eldridge 1944).

Throughout most of her time at Vassar, Wick was involved in the instruction of one or more of the general introductory courses in physics. Her teaching style, which expressively conveyed both a dramatic sense of physics and its relation to everyday life, may have been grounded in her earlier teaching experiences at Butler and Simmons. At Vassar's memorial for Wick, a student recalled her impression after Wick's first lecture one term: "The class lasted only one hour. Yet at the end, we realized that Miss Wick had introduced us to a new and exciting world. She was able to translate simply and directly this new language of physics into our own terms" *(Vassar Miscellany News* 1942).

Wick's master's thesis (Wick 1906) was published as a pair of articles in *Physical Review* and translated into German for *Physikalische Zeitschrift* (Wick 1907), which was considered a great honor for the work of a graduate student. Later these were excerpted to form the second chapter of Nichols and Merritt's 1912 book *Studies in Luminescence.* In part of this study, Wick found that the absorption of light by resorufin solutions increased when the samples were stimulated to fluoresce; the same wavelengths emitted by fluorescence were absorbed (Wick 1907, 407). This effect, termed fluorescent absorption by Nichols and Merritt in a 1904 article, was disputed by Robert W. Wood, who in 1908 was unable to replicate it by a different method. Although Wick's work had been regarded by Nichols and Merritt as a “definitive and positive" confirmation for their theory, they later examined the spectrophotometer and found a source of systematic error in the instrument; the intensity of light transmitted by the slit did not increase linearly with slit width at the narrowest openings. This prompted them to conclude that "the supposed increase in absorption due to fluorescence either does not in reality exist or is too small to be detected by these methods' (Nichols and Merritt 1912).

Wick's doctoral dissertation, "Some Electrical Properties of Silicon" (Wick 1908), was published as a set of four articles in the *Physical Review* (Nov. 1907; July, Aug., and Oct. 1908). In undertaking these studies of silicon, she had followed Nichols's advice to broaden her experience by working outside the field of luminescence. She measured the electromotive force, thermal electro-motive force, electrical resistance, and Hall effect in 95 percent pure rods fab- ricated at G.E. from silicon stock prepared by the Carborundum Company. The brittleness of silicon posed a considerable challenge; thin specimens repeatedly broke upon removal from a mold. Electrical contact between silicon and other materials was difficult to establish; copper-plating worked occasionally, while soldering proved impossible. Differences in the rods' purity and condition were evident in all measurements. Wick published once more in this area, testing the response of a silicon detector receiver for use with short waves, in collaboration with her close friend, McDowell (Wick and McDowell 1916).

From 1914 to 1919 Wick contributed to a systematic survey of the fluorescence of uranium compounds compiled by Nichols in a 1919 Carnegie Institution publication (Wick, Nichols, et al. 1919). This research, conducted both at Vassar and Cornell, and also published separately in the *Physical Review* (Wick 1915, 1918), provided her with a thorough grounding in the techniques of spectroscopy practiced at the time.

Disciplined consistency and a keen eye were essential to the task of measuring relative intensities and positions of crests in the fluorescence spectra of about 20 uranyl salts. Nearly all Wick's research was conducted by visual observations with eyes adapted to the dark; photomultipliers were not available until a decade or more after Wick's death. The observations of triboluminescence, which com- prise Wick's later work, were all made visually; as material was crushed, its light illumined a direct-vision spectroscope (Wick 1937, 1939).

On a few occasions Wick employed equipment not normally available to her to record fluorescent emission by nonvisual techniques. In a 1924 *Physical Review* paper (Wick 1924), a microphotometer was used to measure the optical density of fluorescent spectra of fluorite recorded on photographic plates. In a 1931 paper produced at the Institute for Radium Research in Vienna, Wick observed the thermoluminescence of minerals irradiated by radium by manually recording the deflection of an electrometer indicator connected to a photoelectric cell. The beats of a metronome, simultaneously noted, served as a clock. During her fellowship leave at Harvard's Jefferson Physical Laboratory, Wick photo- graphed the transmission spectra of neodymium solutions subjected to 2,000 atmospheres (Wick 1923).

Through her collaboration with the G. E. Research Laboratory, Wick gained access to the Coolidge cathode ray tube there, which was capable of achieving up to 240,000 volts. Each week Wick and Edna Carter drove to Schenectady, exposed their samples, and transported them back to Vassar in Dewar flasks of liquid air. While preserved at this temperature, energy loss by luminescence was undetectable; experiments to derive decay curves were performed later at Vassar, after the samples were heated (Wick and Carter 1929; *Vassar Miscellany News,* Nov. 19, 1930). Some of the impediments to research at a small women's college are evident in this scenario, such as the extent to which availability of equipment determines the type and style of inquiry.

Since the typical faintness of fluorescence proved an impediment to analysis, investigators sought conditions under which these emissions were enhanced. Thermoluminescence provided such an opportunity; minerals stimulated by light, cathode, or X-rays and subsequently heated emitted light at temperatures far below their incandescence. By selecting samples whose thermoluminescence was particularly intense, long lived, and chromatically stable, Wick reduced some aspects of this behavior to a more complete description. Through decay curves, she recorded the thermoluminescent response to variations in the length of exposure to cathode and X-rays, and in the sample's temperature at exposure and heating (1925, 1927, 1928). In an earlier paper coauthored with Vassar psychologist Josephine Gleason (Wick and Gleason 1924), she explored the effect of preheating minerals up to about 600°C, prior to cathode ray stimulation at room temperature.

Wick's studies of the triboluminescent light emitted while materials-often crystalline-are rubbed, fractured, or crushed continue to be cited in the liter- ature. Wick was one of the first investigators to find that prior exposure to radium or X-rays substantially enhanced the sample's triboluminescence. This assisted her in making some of the first visual observations of the bands in tribolumi- nescent spectra, and in comparing them with the thermoluminescent bands char- acteristic of the same materials (Wick 1937). Her report on the luminescence of ice and candies upon mechanical stress or sudden cooling, after subjection to an electrical spark, received some national coverage through the Associated Press *(New York Times,* 1939). All these observations led her to identify three forms of triboluminescence: an emission resembling the material's thermoluminescence upon exposure to radium or X-rays, an emission characteristic of the material (independent of sources of excitation other than mechanical crushing), and an emission resembling an electric discharge.

Despite the outpouring of interest from laboratories around the world, a sat- isfactory explanation of the complex phenomena of fluorescence required the full development of quantum theory. During her sabbatical in 1929-30, Wick visited colleagues engaged on this topic in Tokyo, Allahabad, Berlin, and Vienna.

In her paper (Wick 1939) establishing the three emissions characteristic of tri-boluminescence, Wick refers to theories of J. T. Randall (1939) and Frederick Seitz (1938), which invoke discrete electronic transitions in accounting for lu- minosity. In her proposal, the first emission is produced by “activator atoms," excited to a higher state by X-rays or radium, and prompted to drop to ground states by thermal or mechanical stimulus. Rare earth bands in the spectra of many luminous minerals, similar to lines in the spectra of the free atoms, may act as signatures, identifying the role of these “activators. "In this way Wick had begun to connect her own broad experience with the phenomena of luminescence to the emerging rudiments of quantum theory.

Wick's membership in a variety of professional and honorary societies reflects both the extent of her involvement in social contexts and the extent to which her contributions were valued by others.

She was among the young women who joined the APS as an associate member in 1907 (Whiting 1912), becoming a regular member in 1915. Wick also was a fellow of the AAAS, the OSA, the Association of College Professors, the AAPT, and the AAUW, serving on its Committee on Intellectual Cooperation. Through press reports based on presen- tations made at annual meetings of these societies, her work reached a wider, popular audience *(New York World,* 1930; *New York Times*, 1939). She was also a member of two honorary societies: Sigma Xi and Sigma Delta Epsilon. Wick's painstaking observations of a varied range of luminous phenomena were widely noted throughout the contemporary literature during her lifetime (Dake and De Ment 1941; Harvey 1957; Nichols et al. 1928; Przibram 1956). As one of the first to characterize systematically thermo- and triboluminescence, her work continues to be referenced in the current literature. The study of these phenomena no longer ranks among the topics of pivotal importance in physics. Although Wick followed a purely investigative course in her research, through her public lectures to Vassar audiences she advocated the application of flu- orescent materials for lighting and other uses. The impact of her contributions is increasingly commonplace: from the lighting over our heads to the Day-Glo designs on tee shirts.

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