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The trailblazing career of **WILLIE HOBBS MOORE**

Ronald E. Mickens

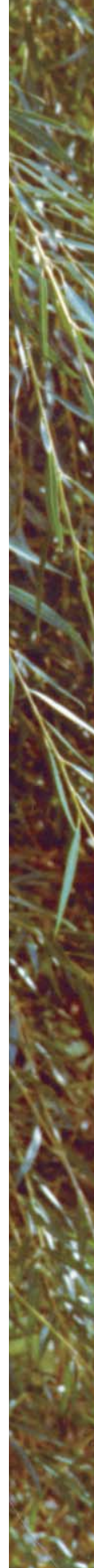
**The first African American woman to
earn a PhD in physics remains little known.
But her legacy is enormous.**

There was a time when I believed that Shirley Ann Jackson, who received her PhD in physics from MIT in 1973, was the first African American woman to attain that degree. I realized that view was incorrect around 1984, when I learned that Willie Hobbs Moore (1934–94) finished her PhD in physics at the University of Michigan in 1972. At that time, for more than a decade I had been collecting data on African Americans with advanced degrees in physics—and had even published a list of Black physicists. Needless to say, learning about Moore came as a welcome surprise for me.

The fact that Moore received her degree from Michigan was of additional interest to me because of the long-standing connection between its physics department and that of Fisk University in Nashville, Tennessee. While I was at Fisk, first as an undergraduate student in 1960–64 and later as a professor, the physics department had several faculty members who obtained their doctorates from Michigan, including Nelson Fuson in 1938,

James Lawson in 1939, and Herbert Jones in 1959. Moreover, Elmer Imes, who received his BA and MA from Fisk in 1903 and 1915, respectively, became the second African American to earn his PhD in physics, from Michigan in 1918 (see my article in *PHYSICS TODAY*, October 2018, page 28).

For some unexplained reason, Moore and I never ended up at a conference or workshop together. We never met! By the time I gained a better



Willie Hobbs Moore (left) with her daughter, Dorian, in the 1980s. (Courtesy of the Ronald E. Mickens Collection on African-American Physicists, AIP Niels Bohr Library and Archives.)



understanding of who she was, her research, her career in industrial research and management, her role as a mentor, and her community involvement, she had died of cancer. One of my greatest personal and professional regrets is that I didn't have the opportunity to meet her in person. I am certain that the two of us would have had much to discuss.

Over the past several decades, however, I have been in contact with several individuals who knew Moore (shown in figure 1), including family members, former students and mentees, and her PhD adviser. All of them provided a consistent narrative about her personality and how she dealt with others: They found her to be highly intelligent, witty, and quick to verbally respond to what we would now call microaggressions. They characterized her as being even-tempered, empathetic, kindhearted, and curious. They said she was an excellent teacher. Many of them recalled her large glasses, her fast-talking nature, and her mild, yet distinct, New Jersey accent.

My interests in the history of science have led me to write about many African American physicists. So when I found out that Moore was the first Black woman to receive a PhD in physics, I was curious about her family life and scientific accomplishments. Certainly, a knowledge of her life would be of importance to understanding the many roles that Blacks have assumed in helping to create the general collective culture of the US.

The year 2022 marks the 50th anniversary of Hobbs's PhD, so I can think of no better time to introduce Moore's impressive life and career to the readers of *PHYSICS TODAY*. She is an example of an African American woman physicist who succeeded as a researcher and administrator while simultaneously providing leadership and guidance to her family and community.

Early life

Willie Hobbs was born on 23 May 1934 in Atlantic City, New Jersey. Her father, William, was a plumber and small businessman, and her mother, Bessie, was a housewife and worker in a local hotel. Hobbs had two younger sisters, Alice and Thelma.

In high school, Hobbs was a straight-A student who was especially strong in mathematics and science. It was thus no surprise that her guidance counselor suggested that she continue her education in engineering. Although no one in Hobbs's extended family had ever received a college degree, she chose to attend the University of Michigan. Later, Hobbs credited her many successes to her close-knit and supportive family, stating that she and her two sisters were "raised with the expectation that they would always do their best."¹

Hobbs arrived at Michigan in 1954, the same year that the US Supreme Court struck down legalized school segregation in the landmark *Brown v. Board of Education* case.² Entering the College of Engineering, she successfully completed the requirements to earn two degrees in electrical engineering: a BS in 1958 and an MS in 1961.

Although Hobbs had no difficulties in her academic studies and was generally held in high regard by her professors, she faced the same type of discrimination that generations of Black students had faced at US universities, including Michigan (see



FIGURE 1. WILLIE HOBBS MOORE, circa 1978. (Courtesy of the Ronald E. Mickens Collection on African-American Physicists, AIP Niels Bohr Library and Archives.)

box 1), during the 20th century. About a year before graduation, for example, she encountered the chairman of another engineering college department. In response to her greeting, he stated, "You don't belong here. Even if you manage to finish, there is no place for you in the professional world you seek."³ That comment vividly illustrates how even Black individuals who possessed advanced degrees were not guaranteed either academic or professional employment.

Family, finances, and employment

Hobbs's first job after finishing her master's degree was at the Bendix Aerospace Systems Division in Ann Arbor, Michigan. As a junior engineer in 1961–62, her duties included calculating the radiation from various types of plasmas and writing pro-

"She had the ability to be taken seriously yet have fun; be firm yet flexible; stress accountability while reinforcing team ethics. As a manager, Dr. Moore accepted no excuses for incompetence and laziness."

posals. She followed that up in 1962–63 with a year at the Barnes Engineering Company in Stamford, Connecticut, where she worked on approximating the IR radiation from the wakes of space reentry vehicles.

On 17 August 1963, Hobbs married Sidney Moore, with whom she eventually had two children, Dorian and Christo-

pher. Sidney had received a BS in mathematics from Jackson State University in Mississippi and an MS in educational psychology from the University of Michigan. He was a faculty member at Michigan's Neuropsychiatric Institute for 38 years before he retired in 1997. Dorian completed her bachelor's degree and MD at Michigan; Christopher received his undergraduate degree from Michigan State University.

The same year that she married Sidney, Moore returned to Ann Arbor to accept a job as a system analyst at Sensor Dynamics, where she was responsible for the theoretical analysis of stress-optical delay devices and reported to the vice president. She also made formal and informal presentations to company executives and visitors.

In 1965 Moore returned to the University of Michigan as a research associate at the Institute of Science and Technology, where she modeled optical hypersonic wakes and verified existing flow-field models. She also consulted with fellow employees to aid them in using existing techniques with which they were not familiar.

Moore's next move, in 1967, was to KMS Industries in Ann Arbor, where, as a system analyst, she was responsible for supporting the optics design staff and establishing computer requirements for the optics division. Only two years later, she left KMS to take a senior analyst position at the Datamax Corp in Ann Arbor. There, she headed the company's analytic group and evaluated the performance of company products. She was also involved in long-range planning with respect to library requirements, computer needs, and projected employee requirements.

One reason why Moore changed jobs so frequently during the 1960s and early 1970s was due in large part to the financial needs she faced in helping support a growing family. Another factor was her 1966 decision to return to the University of Michigan to begin working on a PhD in physics. She financed her education by working part-time at the university, KMS, and Datamax.

Graduate studies and later career

One year into her doctoral work, in 1967, Moore began studying under the renowned spectroscopist Samuel Krimm (see figure 2). Her PhD work centered on a theoretical study of the secondary chlorides in polyvinylchloride (PVC) polymers, which are the world's third-most produced synthetic plastic polymers. PVCs have a broad range of applications and are used, for example, in pipes, plastic bottles, packaging, plumbing, and phonographic records and as insulation for electrical cables.

In her dissertation,⁴ Moore calculated the vibrational modes of several nonlinear organic molecules containing secondary chlorine atoms (see box 2). If a molecule contains N atoms, then there are $3N - 6$ vibrational modes and associated frequencies, each of which corresponds to a separate degree of freedom, which generally represents either a bond length or a bond angle. The molecule oscillates about the equilibrium values of those bond lengths or angles. Those generalized coordinates

and their time derivatives can be denoted, respectively, by q_i and dq_i/dt , where $i = 1, 2, \dots, N$. In the harmonic oscillator approximation, the kinetic energy T and potential energy V can be expressed as sums of quadratic terms in those variables. From those two expressions, the Lagrangian can be constructed as $L = T - V$, from which the equations of motion can be directly calculated.

If the values of q_i are selected properly, then the solutions to the equations of motion can be represented as sums of the periodic trigonometric functions whose arguments contain the vibrational frequencies and their associated phases. The coefficients

“Dr. Moore emphasized the importance of understanding the cultural and political environment of working for a Fortune 500 company. . . . After every meeting with senior leadership [she] would ask us to summarize not the meeting but rather provide our perceptions of the participants. . . . We realized that once we understood the political undercurrents, we were able to navigate much easier.”

of the kinetic energy terms can be directly calculated, but it is more difficult to determine the coefficients of the quadratic expressions for the potential energy. That information is generally derived from experimental data, which can be accomplished by fitting the theoretical values of the frequencies using a technique such as the method of least squares. That methodology requires both accurate data and expertise in various aspects of computational and mathematical sciences.

In her investigation, Moore aimed to obtain a complete potential field that could be used in normal coordinate analyses to predict the vibrational modes of all secondary chlorides. After she determined that potential field, she used vibrational spectroscopy to ascertain the structure of PVCs. With that data, she obtained and verified a force field for secondary chlorides and used it to calculate the vibrational frequencies of crystalline PVC.



FIGURE 2. THE SPECTROSCOPIST SAMUEL KRIMM WAS

Moore's doctoral adviser at the University of Michigan. He and Moore coauthored several papers on secondary chlorides. (Courtesy of Samuel Krimm and the AIP Emilio Segrè Visual Archives.)

Box 1. Michigan's legacy of discrimination

Willie Hobbs Moore was only one of many Black students to face discrimination at the University of Michigan. (And in that regard, Michigan was far from unique.) An illustrative example is the situation that confronted John Franklin, who studied chemical engineering at Michigan in the late 1940s and early 1950s. In a 2016 letter to Michigan's dean of engineering, the African American aerospace engineer Alec Gallimore, Franklin recalled how the discrimination he had faced at the university led him to change careers:

I have never told this story to anyone before but I will tell you. I was standing outside and I heard this professor telling to another one "black students

are inferior and have no place in this school." I turned to him and said "you do not know what the hell you are talking about." I did not know that he would be my thermodynamics professor. He gave me a D+ which I knew I didn't deserve. Thanks to the Dean and the faculty, they voted not to have me repeat the course because of my high grade average.

Other students, with lower grade averages, were invited to join the honor society but not me.

I could not get a job as an engineer, so I went to medical school.⁸

Upon completing her PhD in 1972, Moore stayed at Michigan in a postdoctoral position in the department of physics and the Macromolecular Research Center from 1972 to 1977. During that period, she, Krimm, and several other collaborators published more than 13 papers on their research. When I corresponded with Krimm in 1999, he recalled Moore as "an intelligent and creative person [who] always had a positive attitude and showed it in her approach to problems that arose in research, moving purposefully to solve them." He believed that if not for "financial considerations she would undoubtedly have progressed in the academic area."

In 1977 Moore accepted a position as an engineer with the Ford Motor Company. After a series of promotions, she advanced to the executive level. A highlight of her career was the significant role she played in extending the use of Japanese-style manufacturing and engineering methods at Ford in the 1980s. That effort was codified in a 1985 book she wrote jointly with Yuen Wu, titled *Quality Engineering Products and Process Design Optimization*, which explains the application of the "robust design" methods of Japanese engineer Genichi Taguchi.⁵

Moore, the person

Although I never had the opportunity to meet or communicate with Moore, I have discussed her life and career with several individuals who knew her as a friend or colleague. All of them gave similar evaluations and recollections of their experiences with Moore. Carla Traci Preston, for example, first met Moore as an 18-year-old engineering student intern at Ford. She went on to hold a range of managerial positions at the company and was employed there for 15 years. In a 2004 email, she stated that Moore was "one of the most significant and influential people in my life." (The pull quotes throughout this article are from Preston's reminiscences of Moore.)

Moore also left a mark on Donnell Walton. Currently a director at Corning Inc, Walton got to know Moore through her tutoring work while he was a graduate student in applied physics at Michigan. He and Moore quickly forged a wonderful friendship. The two often had lunch with other Michigan graduate students in science and engineering. As he ex-

plained to me in a 1999 letter, those lunches often included "countless debates on the design of experiments and the education of engineering and graduate students." It came as a major shock to Walton when Moore died not long after they first met.

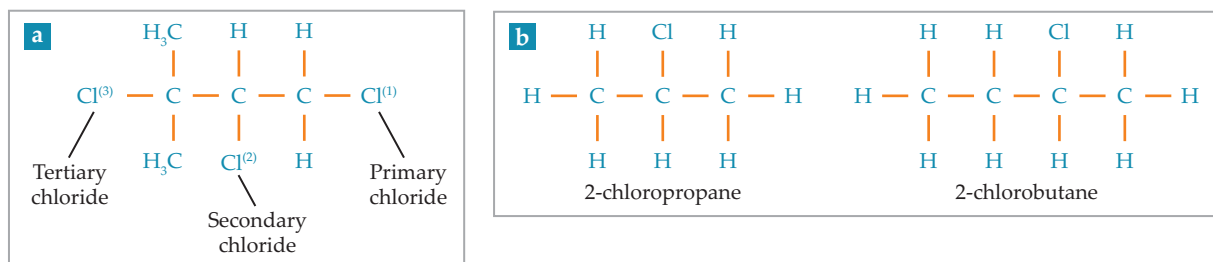
Moore's personal mantra was "You've got to be excellent."⁶ She and her husband, Sidney, taught their children (seen in figure 3) to not use their "blackness as an excuse not to excel. No excuses. But sometimes when you teach that without balancing it with the unfairness of the real world, we do our chil-



FIGURE 3. MOORE (front row, right) with her husband, Sidney (front row, left); her children, Dorian (second row, middle) and Christopher (second row, left, with flower); and two family friends. (Courtesy of the Ronald E. Mickens Collection on African-American Physicists, AIP Niels Bohr Library and Archives.)

Box 2. Secondary chlorides

A complex organic molecule containing a chlorine atom chemically bonded to a carbon atom is termed primary, secondary, or tertiary, depending on how many other carbon atoms are bonded to that carbon atom. In the molecule depicted in panel a, for example, $\text{Cl}^{(1)}$ is bonded to a carbon atom that is bonded to only one other carbon atom, which means that $\text{Cl}^{(1)}$ is a primary chloride. $\text{Cl}^{(2)}$ is bonded to a carbon atom that is bonded to two other carbon atoms, so $\text{Cl}^{(2)}$ is a secondary chloride. Because $\text{Cl}^{(3)}$ is bonded to a carbon atom that is bonded to three other carbon atoms, it is a tertiary chloride. Panel b illustrates two of the secondary chloride compounds investigated in Moore's research, 2-chloropropane ($\text{C}_3\text{H}_7\text{Cl}$) and 2-chlorobutane ($\text{C}_4\text{H}_9\text{Cl}$).



dren a disservice."⁷ She always insisted, however, that failure was not an option.

Moore was active in several community clubs and organizations in Ann Arbor, particularly those concerned with the education of Black youth. She contributed many of her efforts to tutoring and teaching at the Saturday Academy for African American Students, a community-run program that provided science and mathematics instruction for children in primary and secondary schools.

Moore was also an active member of several national organizations founded by college-educated Black women and dedicated to public service. They included the Delta Sigma Theta sorority, the Links, and Jack and Jill of America. All three groups support programs that assist the African American community. A person of faith, Moore was a member of Ann Arbor's Bethel African Methodist Episcopal Church. After a long fight with cancer, Willie Hobbs Moore died on Monday, 14 March 1994, in her Ann Arbor home.

Legacy

Moore's legacy is impressive. First and foremost, she was an extremely productive and creative scientist. Second, her personal skills helped her effectively manage a broad range of projects at several corporations. Finally, she was active in numerous community-based programs that helped enhance the educational, social, financial, and political status of African Americans in Ann Arbor.

Her accomplishments were widely recognized. In 1991 *Ebony* magazine named her one of the 100 most promising Black women in corporate America. And in 1995 she was posthumously given the inaugural Edward Bouchet Pioneer Award by the National Conference of Black Physics Students.

On 17 March 2004, a symposium was held at the University of Michigan in honor of two prominent Black physics alumni: Elmer Imes and Moore. The keynote address was given by John Marburger III, science adviser to then-president George W.

Bush. Michigan's president, Mary Sue Coleman, also gave remarks. During the symposium, Krimm gave a talk about the joint research he and Moore carried out in the 1970s, and I presented a summary of Imes's research, career, and family.

"Dr. Moore also taught us that if we plan for the long term, expect the unexpected and prepare to modify/revise the plan as needed. Always have a goal in mind and once you achieve it, celebrate the accomplishment, but move on to the next goal."

In 2018 Michigan's electrical and computer engineering department established an alumni lecture in honor of Moore. The lecture recognizes graduates from traditionally underrepresented groups who are leaders in their field and serve as role models for the engineering community because of their leadership, impact on society, and service.

This essay is adapted and expanded from my article "Willie Hobbs Moore (1934–1994)," in Notable Black American Women, Book III, J. C. Smith, S. Phelps, eds., Gale (2003), p. 443.

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