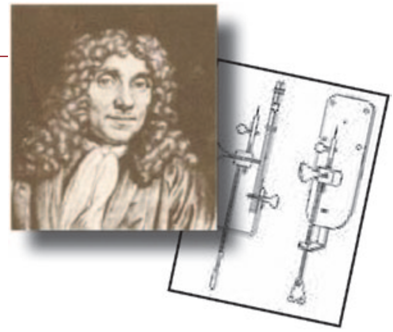
Pioneers in Optics: Marvin Lee Minsky and Lord Rayleigh (John William Strutt)



Michael W. Davidson

National High Magnetic Field Laboratory, Florida State University, Tallahassee, FL 32306

davidson@magnet.fsu.edu

Marvin Lee Minsky
(1927–Present)

On August 9, 1927, in New York City, Marvin Lee Minsky was born to Dr. Henry Minsky, an eye surgeon, and Fannie Resier, an active participant in the Zionist movement. At an early age he developed an interest in science, a characteristic that was encouraged at the private schools he attended as a child. Nevertheless, after high school he joined the United States Navy. Following his two years of service, Minsky entered Harvard University, where he pursued a variety of subjects, including psychology, physics, neurophysiology, and mathematics. After graduation in 1950, he transferred to Princeton University to pursue his doctorate in mathematics, and during his first year there he constructed the first neural network simulator. Subsequent to receiving his PhD in 1954, he revisited Harvard, but this time as part of the renowned group of scholars known as the Society of Fellows.

Minsky's new status at Harvard University provided him with an increased opportunity to engage in his own research, and it was at this time that he made his primary contribution to the field of optics. Extremely interested in the inner workings of the mind and at odds with many dominant psychological theories regarding the matter, Minsky desired to examine images of neural networks in unstained samples of live brains. However, contemporary microscopes were not well equipped to handle such a project, spurring Minsky to invent his own instrument to meet his research needs. The result was the confocal scanning microscope, which he first produced in 1955.

The basic premise of the confocal approach is the use of spatial filtering to eliminate out-of-focus light in specimens that are thicker than the plane of focus. In his original design, Minsky used a pinhole placed in front of a zirconium arc source as the point source of light. The light was focused by a microscope objective at the preferred focal plane in the specimen, and light that passed through was focused by a second objective lens at a second pinhole confocal to (having the same focus as) the first pinhole. Any light that traveled through the second pinhole struck a low-noise photomultiplier, which produced a signal that correlated to the intensity of the light from the specimen. The second pinhole barred light originating from above or below the plane of focus in the specimen from arriving at the photomultiplier. To build an image, the focused spot of light was scanned across the specimen. However, a real image was not formed in Minsky's original configuration, but instead the output from the photomultiplier was translated into an image on the screen of a military surplus long persistence oscilloscope.

Despite the theoretical benefits of the confocal approach for biological purposes, Minsky's microscope originally generated little interest. In hindsight it has become apparent that the technology of the period limited Minsky's demonstration of the potential of the confocal approach. Still, years later, with the advent of such applicable devices as lasers, sensitive low-noise photodetectors, and fast microcomputers with image processing capabilities, Minsky's microscopy method has generated a significant amount of use. Modern confocal scanning microscopes are, however, based on a reflected light version of the instrument that used a single objective lens and a dichromatic mirror assembly that Minsky described in his writings, although it was not the basis of his original instrument design.

Following his three-year stint at Harvard, Minsky embarked on a long career at the Massachusetts Institute of Technology (MIT). There he co-founded the Artificial Intelligence Laboratory in 1959 and quickly developed into one of the world leaders in the emerging field. For his efforts, he was made Donner Professor of Science in 1974 followed in 1990 by his acceptance of the Toshiba Professorship of Media Arts and Sciences. Minsky has written several works, including the popular, but highly controversial The Society of Mind (1987), and received a great number of prestigious awards, including the Turing Award from the Association for Computing Machinery (1970), the Japan Prize (1990), the Rank Prize from the Royal Society of Medicine (1995), and the R.W. Wood Prize from the Optical Society of America (2001). He continues to hold a professorship at MIT, though he has apparently spent an increasing amount of time carrying out independent research and further developing his own theories of the human mind.

Lord Rayleigh (John William Strutt)
(1842–1919)

Lord Rayleigh was a British physicist and mathematician who worked in many disciplines including electromagnetics,

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physical optics, and sound wave theory. The criteria he defined still act as the limits of resolution of a diffraction-limited optical instrument. Rayleigh wrote over 446 scientific papers but is perhaps best known for his discovery of the inert gas argon, which earned him a Nobel Prize.

Born John William Strutt, Rayleigh inherited his title when his father died in 1873. Although he was to become the third Baron of Rayleigh, as a young child he was slow to show eminence. He was the eldest of seven children and was almost three years old before he began speaking. Rayleigh's childhood and early education at Eton and Harrow were frequently disrupted by poor health. Hailing from a long line of landowners, Rayleigh was not raised in a scientific family, and his predilection for the field was unexpected.

At Cambridge University, however, Rayleigh exhibited strong promise in mathematics and an avocation for photography. He became the top member of his class under the tutelage of Edward Routh, a famous applied mathematician, and then a fellow at Trinity College in 1866. During his undergraduate years, Rayleigh was heavily influenced and inspired by George Stokes, who was a Lucasian professor of mathematics. After graduation, Rayleigh married the sister of the future prime minister, Lord Arthur Balfour, and together they had three sons, the eldest of whom would eventually follow his father's scientific path.

Due to his privileged background, Rayleigh's hard work was a choice rather than a necessity. Still, he was a natural history professor at the Royal Institution of Great Britain, a justice of the peace, chancellor of Cambridge University, and recipient of many honorary science and law degrees. A fellow of the Royal Society of London, Rayleigh achieved the Royal, Copley, and Rumford Medals and eventually served as president of the organization. In the London Mathematical Society, Rayleigh was also president, from 1878 to 1880 and a De Morgan Medal recipient in 1890. Many physics laws and constants bear his name, as do craters on the moon and Mars. Rayleigh's greatest honor, however, was the Nobel Prize in Physics awarded to him in 1904.

Various scientific achievements earned Rayleigh his renowned reputation. Soon after his marriage, an attack of rheumatic fever almost cost Rayleigh his life. It was on a recuperative trip to Egypt that he began his great work on the theory of sound. The first volume was released in 1877 and a second in 1878. Their discussion of vibration, resonance, and acoustics remains one of the principal accomplishments in the field. Another early undertaking was a mathematical explanation for the light scattering that gives the sky its blue appearance. The Rayleigh Scattering Law evolved from this theory and has since become a landmark in the study of wave propagation. Rayleigh also vigorously examined the precision of electrical measures and standardized the ohm.

In optics, the Rayleigh Criterion was chosen by Lord Rayleigh to define the limit of resolution of a diffraction-limited optical instrument. The criterion is defined as the condition that arises when the center of one diffraction pattern (Airy disk) is superimposed with the first minimum of another diffraction pattern produced by a point (or line) source equally as bright as the first. For a microscope under this condition, a 26.5 percent dip in brightness appears between the two maxima, giving rise to the sensation (or probability) of peak separation.

The work that was to become Rayleigh's most famous stemmed from his fastidious attention to detail. His discovery of argon was principally due to the detection of a minute inconsistency in density between atmospheric nitrogen and chemical nitrogen. Instead of trying to rid himself of the discrepancy, Rayleigh attempted to amplify it. The difference between the two substances was that one was completely derived from air, while the other partially from ammonia. He substituted oxygen for air in the chemical derivation method so that all of the resultant nitrogen would be derived from ammonia. Rayleigh observed that the nitrogen attained from the ammonia was lighter than that derived from air. He then deduced that the phenomenon transpired because there was a heavier gas than nitrogen in air. Isolating the element proved extremely difficult, however, but Rayleigh eventually succeeded. The gas was named argon, the Greek word for inactive, because it refused to combine chemically with other substances.

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