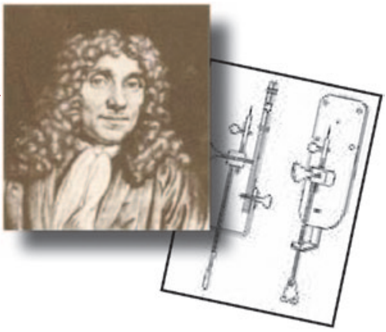

# Pioneers in Optics: Marie Alfred Cornu and John Frederick William Herschel

**Michael W. Davidson**
National High Magnetic Field Laboratory, Florida State University, Tallahassee, FL 32306

davidson@magnet.fsu.edu

## Marie Alfred Cornu
### (1841–1902)

Marie Alfred Cornu was born in Orleans, France, on March 6, 1841, and was educated at the École Polytechnique and the École des Mines. He became employed as a physics professor at the École Polytechnique in 1867, a position he maintained for the rest of his life. Cornu made a wide variety of contributions to the fields of optics and spectroscopy but is most noted for significantly increasing the accuracy of contemporary calculations of the speed of light.

In 1878, Cornu made adjustments to an earlier method of measuring the velocity of light developed by Armand Fizeau in the 1840s. The changes and improved equipment resulted in the most accurate measurement taken up to that time: 299, 990 km per second. For the achievement he was awarded membership into the French Academy of Sciences, along with the prix Lacaze and the Rumford Medal of the Royal Society of England.

Other significant accomplishments of Cornu include a photographic study of ultraviolet radiation and the establishment of a graphical approach, known as the Cornu spiral, for calculating light intensities in Fresnel diffraction. A proponent of the wave theory of light, Cornu was also interested in the relationship between electricity and optics and the understanding of weather phenomena. He played a considerable part in the creation of the Observatory of Nice and in 1886 became associated with the Office of Longitudes. He received several honors during his lifetime, including an honorary doctorate from Cambridge University awarded three years before his death in April of 1902.

**Measuring the Speed of Light.** Starting with Ole Roemer's 1676 breakthrough endeavors, the speed of light has been measured at least 163 times by more than 100 investigators using a wide variety of different techniques. Finally in 1983, more than 300 years after the first serious measurement attempt, the speed of light was defined as being 299,792.458 kilometers per second by the Seventeenth General Congress on Weights and Measures. Thus, the meter is defined as the distance light travels through a vacuum during a time interval of 1/299,792,458 seconds. In general, however, (even in many scientific calculations) the speed of light is rounded to 300,000 kilometers (or 186,000 miles) per second.

## John Frederick William Herschel
### (1792–1871)

John Herschel was born in Slough, England on March 7, 1792, the only child of renowned scientist and astronomer William Herschel. He received an excellent education and, while studying for his undergraduate degree in mathematics, instituted the Analytical Society of Cambridge in conjunction with George Peacock and Charles Babbage. The group introduced Leibniz notation into English mathematics to supplant the unwieldy Newtonian symbols. When Herschel graduated from Cambridge in 1813, he was at the top of his class.

Herschel began to study in London for a career in law in 1814 but changed his mind within a year. He then returned to Cambridge for a brief stint as a teacher of mathematics but left in 1816 to assist in the astronomical research of his aging father. The years they spent working together served as the groundwork from which the younger Herschel would build the rest of his career. In 1820, Herschel was one of the founding members of the Royal Astronomical Society, and when his father died in 1822 he carried on his work, making a detailed study of double stars. In collaboration with James South, he compiled a catalog of observations that was published in 1824. The work garnered the pair the Gold Medal from the Royal Astronomical Society and the Lalande Prize from the Paris Academy of Sciences. Herschel was also knighted 1831.

In 1833, Herschel decided to temporarily relocate with his family to Cape Colony, South Africa, to observe the skies not visible in England. Herschel's research was carried out at a brisk rate, and by the time they ventured home four years later, he had amassed an amazing amount of data. He had made catalogs of nebulae and double stars; had described

 doi:10.1017/S1551929512000223 


Defining a
New Class of SEM
InTouchScope™
• Portable, affordable, research SEM
• Exceptional value
• High resolution imaging in HV/LV/SE/BSE
• Chemical analysis with integrated EDS
• Multi-touch screen control and wireless operation
• Fast navigation
• Simply fun to use!
First in a new class of SEMs from JEOL. Experience it for yourself - send us your samples or schedule a demo. jeolusa.com/intouch
JEOL
Another Extreme Imaging Solution
Global Solutions Provider for Advanced Technology
www.jeolusa.com • salesinfo@jeol.com
978-535-5900
Find us on Facebook and Twitter @jeolusa
Portable • Affordable • Research SEM

the Magellanic clouds, which are only visible in the southern hemisphere; and had made a study of the intensity of solar radiation using an actinometer, a device he invented in 1825.

Upon his return to England, Herschel began analyzing the data he had compiled in Africa, but he also experimented in photography, a field he had made advances in previously. A skilled chemist, Herschel had discovered in 1819 the solvent power of sodium hyposulfite on otherwise insoluble silver salts, which was the prelude to it being used as a fixing agent in photography. In 1839, he developed a technique for creating photographs on sensitized paper, independently of William Fox Talbot, but did not attempt to commercialize the process. However, Herschel published several papers on photographic processes and was the first to use the terms positive and negative in reference to photography.

During the following decade, Herschel carried on a number of different projects. Expanding on the work of his father, he researched infrared light, discovering in 1840 the existence of Fraunhofer lines within that spectral region. He also wrote a popular laymen's guide to astronomy, which was published in 1849, and released a volume entitled *Results of Astronomical Observations, Made During the Years 1834–38 at the Cape of Good Hope* in 1847.

Particularly important to the future of science, in 1845 Herschel reported the first observation of the fluorescence of a quinine solution in sunlight. The following is an excerpt of his findings as presented to the Royal Society of London:

> The sulphate of quinine is well known to be of extremely sparing solubility in water. It is however easily and copiously soluble in tartaric acid. Equal weights of the sulphate and of crystallized tartaric acid, rubbed together with addition of a very little water, dissolve entirely and immediately. It is this solution, largely diluted, which exhibits the optical phenomenon in question. Though perfectly transparent and colorless when held between the eye and the light, or a white object, it yet exhibits in certain aspects, and under certain incidences of the light, an extremely vivid and beautiful celestial blue colour, which, from the circumstances of its occurrence, would seem to originate in those strata which the light first penetrates in entering the liquid, and which, if not strictly superficial, at least exert their peculiar power of analyzing the incident rays and dispersing those which compose the tint in question, only through a very small depth within the medium.
>
> To see the colour in question to advantage, all that is requisite to dissolve the two ingredients above mentioned in equal proportions, in about a hundred times their joint weight of water, and having filtered the solution, pour it into a tall narrow cylindrical glass vessel or test tube, which is to be set upright on a dark colored substance before an open window exposed to strong daylight or sunshine, but with no cross lights, or any strong reflected light from behind. If we look down perpendicularly into the vessel so that the visual ray shall graze the internal surface of the glass through a great part of its depth, the whole of that surface of the liquid on which the first light strikes will appear of a lively blue.
>
> . . . If the liquid be poured into another vessel, the descending stream gleams internally from all its undulating inequalities, with the same lively yet delicate blue colour, . . . thus clearly demonstrating that contact with a denser medium has no share in producing this singular phenomenon.
>
> The thinnest film of the liquid seems quite as effective in producing this superficial colour as a considerable thickness. For instance, if in pouring it from one glass into another, . . . the end of the funnel be made to touch the internal surface of the vessel well moistened, so as to spread the descending stream over an extensive surface, the intensity of the colour is such that it is almost impossible to avoid supposing that we have a highly colored liquid under our view.

In a footnote to the report, Herschel points out that he was writing from memory, having carried out the experiment more than twenty years before. Nevertheless, his reminiscence was enough to spark further exploration, eventually resulting in the modern understanding of fluorescence. In fact, even today, quinine is one of the most commonly used fluorophores for spectroscopy, enjoyed by many for the strange, but beautiful, fluorescence that was first observed, but unable to be explained, by Herschel.

In 1850, Herschel's scientific work was put on hold when he was appointed Master of the Mint. Apparently unhappy in his new line of work, he suffered a nervous breakdown in 1854 and resigned from the position two years later. Herschel returned to his love of astronomy during his remaining years and continued to add to his catalogs of stars. When he died on May 11, 1871, he was appropriately buried in Westminster Abbey amid other distinguished scientists.

MT





https://doi.org/10.1017/S1551929512000223 Published online by Cambridge University Press https://doi.org/10.1017/S1551929512000223 Published online by Cambridge University Press