

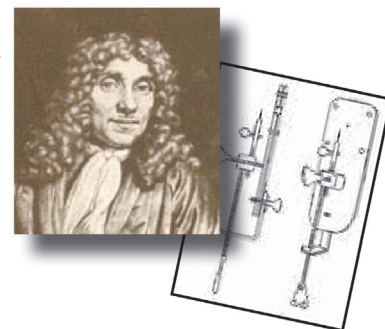
MicroscopyPioneers

Pioneers in Optics: Johann Wilhelm Ritter and Ernest Rutherford

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Johann Wilhelm Ritter (1776–1810)

Johann Wilhelm Ritter was a somewhat controversial scientist best known for his discovery of ultraviolet radiation. He was born on December 16, 1776, in Samitz, Germany, an area that is now part of Poland. Apprenticed to an apothecary in Leignitz at the age of fourteen, Ritter developed an acute interest in chemistry that carried over into other scientific fields. When he inherited a sum of money five years later, he was able to leave his position and decided to enroll at the University of Jena. There he studied medicine, staying on in a teaching position after his graduation, until the duke of Saxe-Gotha became his patron in 1802.

Ritter's numerous scientific experiments were diverse, but many of them were concerned with electricity or electrochemistry. One of his earliest studies focused on the manner in which muscle tissue reacts to electrical charges, research that helped lead him to develop a general theory of nature. Later, in 1800, Ritter duplicated chemist William Nicholson's feat of using electrolysis to decompose water into hydrogen and oxygen, but he took the experiment a step further by collecting the gases discretely. The work led to his invention of the process of electroplating, which is used in modern times to plate gold, silver, and other metals. Additional inventions soon followed, most notably the dry-cell battery in 1802 and an electrical storage battery in 1803.

Ritter's greatest accomplishment, however, is considered his discovery in 1801 of a previously unknown region of the solar spectrum. A year before, William Herschel had announced the existence of the infrared region, which extends past the red region of visible light. Ritter, who believed in the polarity of nature, hypothesized that there must also be invisible radiation beyond the violet end of the spectrum and commenced experiments to confirm his speculation. He began working with silver chloride, a substance decomposed by light, measuring the speed at which different colors of light broke it down. As a result, Ritter confirmed the common belief that violet light was more effective than red (in decomposing silver nitrate) and, he also demonstrated that the fastest rate of decomposition occurred with radiation that could not be seen but that existed in a region



beyond the violet. Ritter initially referred to the new type of radiation as chemical rays, but the title of ultraviolet radiation eventually became the preferred term.

Despite his significant scientific achievements and his acceptance into the Bavarian Academy of Sciences, Ritter was not well received by his contemporaries. His writing was considered oblique and confusing, and he often delayed explaining his experiments in detail. Some believed Ritter made claims that he could not support and deemed him an unreliable source of information. His interest and studies of occult phenomena further damaged his reputation as a serious scientist. Jaded by his lack of credit and plagued by financial difficulties, Ritter suffered a premature death at the age of thirty-three and did not receive proper recognition for his scientific exploits until more than a century later.

Ernest Rutherford (1871–1937)

Distinguished experimental physicist and Nobel Prize laureate Ernest Rutherford was born in Spring Grove, New Zealand, on August 30, 1871. He was one of twelve children, but his early educational success set him apart. He was chosen to enroll at the Nelson Collegiate School, which was followed by an academic award to attend Canterbury College in Christchurch, New Zealand, in 1889. There he majored in mathematics and physics, graduating in 1893, though remaining for another year of research. Based on his work, which employed the magnetic properties of iron to detect radio waves, Rutherford received a scholarship provided from the profits of the 1851 Exhibition and decided to attend England's Trinity College at Cambridge University.

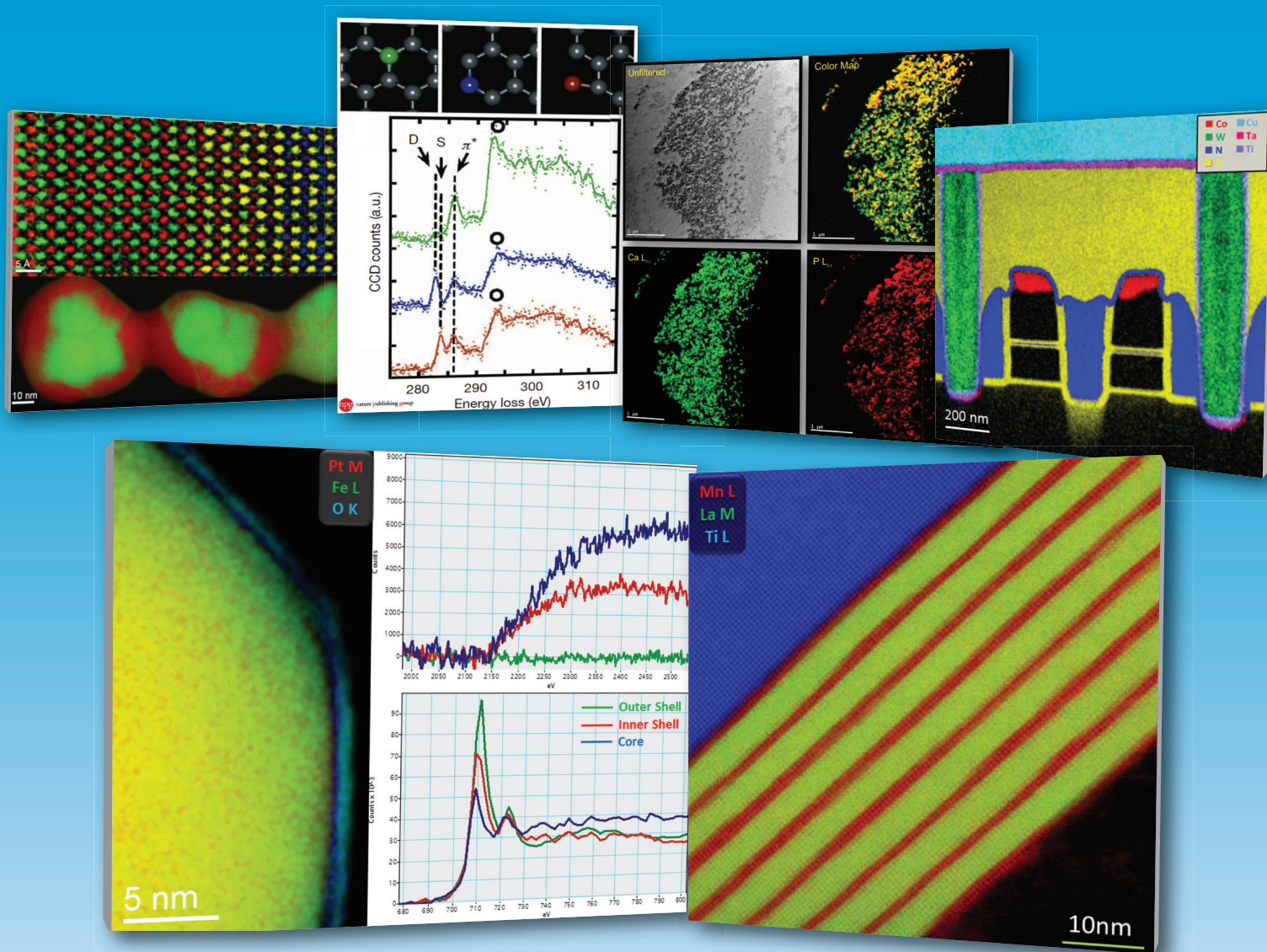
As a research student at Cambridge, Rutherford had the opportunity to work with the renowned physicist J. J. Thomson at the Cavendish Laboratory. During his three-year stay, Rutherford investigated the conductivity of gas ionized by radiation and discovered the existence of two distinct types of rays in uranium radiation. Those that were more powerful but easily absorbed, he termed alpha rays, whereas those that produced less radiation and had greater penetration ability were termed beta rays. In 1898, Rutherford accepted the physics chair at the illustrious



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Top Images, left to right:

- (Top) Colored elemental map showing Sr $L_{2,3}$ -edges (green), Ti $L_{2,3}$ -edges (red), La $M_{4,5}$ -edges (yellow), and Mn $L_{2,3}$ -edges (blue). Data captured using a Gatan Enfinium™ER. Sample courtesy of Prof. David Smith, Arizona State University.
- (Bottom) RGB composite EELS SI image of Au/Pd nanoparticle; Au $M_{4,5}$ -edges at 2206 eV in green and Pd $L_{2,3}$ -edges at 3173 eV in red. Data captured using a Gatan GIF Quantum™ER. Sample courtesy Dr. Jianfang Wang of The Chinese University of Hong Kong.
- ELNES of individual atoms in graphene. Different states of atomic coordination are illustrated at top. ELNES of carbon K (1s) spectra shown on bottom. Green, blue and red spectra correspond to the normal sp² carbon atom, a double-coordinated atom and a single coordinated atom, respectively. Data captured using a Gatan Quantum™ER Low-Voltage Special. Data courtesy of K. Suenaga and M. Koshino (AIST, Tsukuba, Japan). Figure 1 from: K. Suenaga et al. "Atom-by-Atom spectroscopy analysis at graphene edge"; Nature 468, 1088 (2010). Permission to use Figure 1 granted by K. Suenaga and Nature Publishing Group. Copyright © 2010, rights managed by Nature Publishing Group.
- Unfiltered, conventional TEM image and elemental maps of a capillary blood vessel captured using a Gatan GIF Quantum™ER. The Ca and P elemental maps were extracted from an EFTEM-SI dataset acquired using Gatan's DigitalMicrograph™ software. EFTEM-SI is capable of revealing relative concentrations below 1% as shown in the P elemental map. Sample courtesy of Dr. Wenliang Lin, Mayo Clinic.
- Color composite EELS composition map from data acquired using a GIF Quantum™ERS system on a 300 kV probe corrected STEM with 1.0 nA beam current. The EELS data was acquired at 4.1 ms/pixel with a 20 mR convergence angle and 42 mR collection angle. The 200 x 200 pixel map took under 3 minutes to acquire (164 s). The black areas are Si, which has been omitted for clarity. TEM facilities courtesy FELMI and TU Graz, Austria.

Bottom Images, left to right:

- (Left) Colored elemental map based on Pt M-edge (red), Fe L-edge (green), and O K-edge (blue) intensities. Data captured using a Gatan GIF Quantum™ERS and 300 kV probe corrected STEM with 180 pA beam and 5 ms exposure.
- (Right) Extracted Pt $M_{4,5}$ edges (upper) and Fe $L_{2,3}$ edges (lower) from the thin outer shell (green), low density inner shell (red) and core (blue). Despite the sub-nm proximity of the outer shell to the core, no Pt is detected. The Fe-L2/L3 ratio and peak position vary significantly with the Fe chemistry of the layer. Sample and TEM facilities courtesy McMaster University, Canada.
- Colorized 1k x 1k elemental map of LaMnO₃ / SrMnO₃ superlattices grown on SrTiO₃ (Mn - Red, La-green, Ti L-blue). Data was acquired on an Enfinium™ (UHV special) coupled to a 100 kV NION UltraSTEM. Image courtesy Mundy, Adamo, Schlom & Muller, Cornell University. (Results published in Monkman & Adamo, et al, Nature Materials, vol 11, 2012).



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McGill University in Canada, ending his work with Thomson. However, the knowledge and confidence he gained during those years would carry him through a long and prestigious career.

At McGill he continued his research on radioactivity, demonstrating in 1902 with the help of Frederick Soddy that radioactive elements can spontaneously shed protons and neutrons (in the form of smaller atoms), transfiguring them into different elements. Although many scientists were skeptical of the findings, which seemed reminiscent of medieval alchemy, the Royal Society soon elected Rutherford a fellow and awarded him the Rumford Medal in 1904. That same year he published the book *Radio-Activity*, making his ideas familiar to a wider audience. Although he turned down various other appointment offers as he became more famous in the scientific world, in 1907 he accepted a position at the University of Manchester. Once again in England, Rutherford developed a center dedicated to radiation studies and received the Nobel Prize in Chemistry in 1908 for his work in that field.

In 1911, however, Rutherford completed what would be his most lasting contribution to science. Based on studies of alpha particles passing through thin plates of mica and gold, Rutherford came to the conclusion that the intense electric field required to cause the large deflections that were occurring could be explained only if all the positive charge in the atom were concentrated on a very small central nucleus. He further postulated that the positive charge on the nucleus must be balanced by an equal charge on all the electrons distributed around the nucleus. Rutherford's atomic model paved the way for the modern understanding of the atom. It was also the foundation of the important developments

regarding the structure of atoms made by Niels Bohr, who was once his protégé.

The Rutherford experiment. This classic scattering experiment, which examined the scattering of alpha particles (helium nuclei containing two positive charges) by a thin foil made of gold metal, was conducted in 1911 by Hans Geiger and Ernest Marsden at the suggestion of Ernest Rutherford. Geiger and Marsden expected to find that most of the alpha particles travel straight through the foil with little deviation, with the remainder being deviated by a percent or two. This thinking was based on the theory that positive and negative charges were spread evenly within the atom and that only weak electric forces would be exerted on the alpha particles that were passing through the thin foil at high energy.

What they found, to great surprise, was that while most of the alpha particles passed straight through the foil, a small percentage of them were deflected at very large angles and some were even backscattered. Because alpha particles have about 8,000 times the mass of an electron and impacted the foil at very high velocities, it was clear that very strong forces were necessary to deflect and backscatter these particles. Rutherford explained this phenomenon with a revised model of the atom in which most of the mass was concentrated into a compact nucleus (holding all of the positive charge), with electrons occupying the bulk of the atom's space and orbiting the nucleus at a distance. With the atom being composed largely of empty space, it was then very easy to construct a scenario where most of the alpha particles passed through the foil, and only the ones that encountered a direct collision with a gold nucleus were deflected or scattered backward.

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Lynwood Swanson to Receive Pittcon Heritage Award

The Chemical Heritage Foundation (CHF) will present the 2014 Pittcon Heritage Award to Lynwood Swanson, co-founder and former chairman, CEO, and chief scientist of FEI Company. Swanson will receive the award in recognition of his establishment and leadership of one of the world's largest instrument companies, as well as his landmark development of liquid metal ion sources. This 13th annual award will be presented at Pittcon 2014 in Chicago. The award will be presented at the opening plenary session on Sunday, March 2.

“The company Lynwood Swanson founded creates devices that helped to make Moore's Law a reality,” said Carsten Reinhardt, president and CEO of CHF. “His company made focused ion beam sources that allowed the number of transistors on a microchip to grow from tens to millions. He combines research, innovation, and entrepreneurship in the best tradition of Pittcon Heritage Award winners.”

Swanson stepped down as CEO of FEI in 1998, and in 2002 he relinquished the position of Chairman. He continues to conduct research and create patents with FEI.

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