Topic Page: Kirchhoff, Gustav (1824 - 1887)

Image from: **Basic components of a prism spectrometer. Light...** in *The Cambridge Dictionary of Scientists*

Summary Article: **Kirchhoff, Gustav Robert (1824-1887)**
From *The Hutchinson Dictionary of Scientific Biography*

Place: Germany

Subject: biography, physics

German physicist who founded the science of spectroscopy. He also discovered laws that govern the flow of electricity in electrical networks and the absorption and emission of radiation in material bodies.

Kirchhoff was born in Königsberg, Germany (now Kaliningrad) on 12 March 1824. He studied at the University of Königsberg, graduating in 1847. In the following year, he became a lecturer at Berlin and in 1850 was appointed extraordinary professor of physics at Breslau. Robert Bunsen went to Breslau the following year and began a fruitful collaboration with Kirchhoff. In 1852 Bunsen moved to Heidelberg and Kirchhoff followed him in 1854, becoming ordinary professor of physics there. Kirchhoff stayed at Heidelberg until 1875, when he moved to Berlin as professor of mathematical physics. Illness forced him to retire in 1886 and he died in Berlin on 17 October 1887.

Kirchhoff made his first important contribution to physics while still a student. In 1845 and 1846 he extended Ohm's law to networks of conductors and derived the laws known as Kirchhoff's laws that determine the value of the current and potential at any point in a network. He went on to consider electrostatic charge and in 1849 showed that electrostatic potential is identical to tension, thus unifying static and current electricity. Kirchhoff made another fundamental discovery in electricity in 1857 by showing theoretically that an oscillating current is propagated in a conductor of zero resistance at the velocity of light. This was important in the development in the 1860s of the electromagnetic theory of light by James Clerk Maxwell and Ludwig Lorenz.

In the 1850s Bunsen developed his famous gas burner, which gave a colourless flame, and used it to investigate the distinctive colours that metals and their salts produce in a flame. Bunsen used coloured solutions and glass filters to distinguish the colours in a partly successful attempt to identify the substances by the colours they produced. Kirchhoff pointed out to Bunsen that sure identification could be achieved by using a prism to produce spectra of the coloured flames. They developed the spectroscope, and in 1860 discovered that the elements present in the substances each give a characteristic set of spectral lines and set about classifying elements by spectral analysis. In this way, Bunsen discovered two new elements - caesium in 1860 and rubidium in 1861.

Kirchhoff also made another important discovery in 1859 while investigating spectroscopy as an analytical tool. He noticed that certain dark lines in the Sun's spectrum, which had been discovered by Joseph von Fraunhofer, were intensified if the sunlight passed through a sodium flame. This observation had in fact been made by Léon Foucault ten years earlier, but he had not followed it up. Kirchhoff immediately came to the correct conclusion that the sodium flame was absorbing light from the sunlight of the same colour that it emitted, and explained that the Fraunhofer lines are due to the absorption of light by sodium and other elements present in the Sun's atmosphere.

Kirchhoff went on to identify other elements in the Sun's spectrum in this way, and also developed the

theoretical aspects of this work. In 1859 he announced another important law which states that the ratio of the emission and absorption powers of all material bodies is the same at a given temperature and a given wavelength of radiation produced. From this, Kirchhoff went on in 1862 to derive the concept of a perfect black body - one that would absorb and emit radiation at all wavelengths. Balfour Stewart (1828-1887) had reached similar conclusions in 1858 by a consideration of the theory of heat exchanges discovered by Pierre Prévost, but Kirchhoff presented the discovery much more cogently.

Kirchhoff's contributions to physics had far-reaching practical and theoretical consequences. The discovery of spectroscopy led to several new elements and to methods of determining the composition of stars and the structure of the atom. The study of black-body radiation led directly to the quantum theory and a radical new view of the nature of matter.

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