

# A Commentary on Electromagnetism and its Importance

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## Commentary

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### ABOUT THE STUDY

In physics, electromagnetism is an interaction that occurs between particles with electric charge via electromagnetic fields. The electromagnetic force is one of the four fundamental forces of nature. It is the dominant force in the interactions of atoms and molecules. Electromagnetism can be thought of as a combination of electrostatics and magnetism, two distinct but closely intertwined phenomena. Electromagnetic forces occur between any two charged particles, causing an attraction between particles with opposite charges and repulsion between particles with the same charge, while magnetism is an interaction that occurs exclusively between charged particles in relative motion. These two effects combine to create electromagnetic fields in the vicinity of charge particles, which can accelerate other charged particles via the Lorentz force. At high energy, the weak force and electromagnetic force are unified as a single electroweak force.

The electromagnetic force is responsible for many of the chemical and physical phenomena observed in daily life. The electrostatic attraction between atomic nuclei and their electrons holds atoms together. Electric forces also allow different atoms to combine into molecules, including the macromolecules such as proteins that form the basis of life. Meanwhile, magnetic interactions between the spin and angular momentum magnetic moments of electrons also play a role in chemical reactivity; such relationships are studied in spin chemistry. Electromagnetism also plays a crucial role in modern technology: electrical energy production, transformation and distribution, light, heat, and sound production and detection, fiber optic and wireless communication, sensors, computation, electrolysis, electroplating and mechanical motors and actuators.

Electromagnetism has been studied since ancient times. Many ancient civilizations, including the Greeks and the Mayans created wide-ranging theories to explain lightning, static electricity, and the attraction between magnetized pieces of iron ore. However, it wasn't until the late 18<sup>th</sup> century that scientists began to develop a mathematical basis for understanding the nature of electromagnetic interactions. In the 18<sup>th</sup> and 19<sup>th</sup> centuries, prominent

scientists and mathematicians such as Coulomb, Gauss and Faraday developed namesake laws which helped to explain the formation and interaction of electromagnetic fields. This process culminated in the 1860s with the discovery of Maxwell's equations, a set of four partial differential equations which provide a complete description of classical electromagnetic fields. Besides providing a sound mathematical basis for the relationships between electricity and magnetism that scientists had been exploring for centuries, Maxwell's equations also predicted the existence of self-sustaining electromagnetic waves. Maxwell postulated that such waves make up visible light, which was later shown to be true. Indeed, gamma-rays, x-rays, ultraviolet, visible, infrared radiation, microwaves and radio waves were all determined to be electromagnetic radiation differing only in their range of frequencies.

In the modern era, scientists have continued to refine the theorem of electromagnetism to take into account the effects of modern physics, including quantum mechanics and relativity. Indeed, the theoretical implications of electromagnetism, particularly the establishment of the speed of light based on properties of the "medium" of propagation (permeability and permittivity), helped inspire Einstein's theory of special relativity in 1905. Meanwhile, the field of Quantum Electrodynamics (QED) has modified Maxwell's equations to be consistent with the quantized nature of matter. In QED, the electromagnetic field is expressed in terms of discrete particles known as photons, which are also the physical quanta of light. Today, there exist many problems in electromagnetism that remain unsolved, such as the existence of magnetic monopoles and the mechanism by which some organisms can sense electric and magnetic fields.