The Unification of Torah and Science:
Basic Principles and a Case Study on Electromagnetism

Part 8--History of Electro-Magnetism

From Amber to Ampère

The first discoveries of the fundamental electric and magnetic forces were made by philosophers of ancient Greece. They observed that when amber is rubbed with animal fur, it acquires the ability to attract small bits of reed or feathers. This effect was the first observation of nature's allusion to electricity[1] just as magnetite (lodestone) bears the natural property of magnetism.

One of the primary revolutionaries in the fight to combat and overcome superstition was the British physician to Queen Elizabeth I, William Gilbert. He zealously devoted his life to uprooting superstitions through scientific observation. He made the preliminary scientific discovery concerning magnetism in the year 1600.

Although navigational compasses had already been in use for some centuries, Gilbert's was the first scientific inquiry into the nature of a compass. By observing the effects of magnets on a model earth that he constructed, Gilbert discovered that the whole planet is in fact a gigantic magnet. The magnetic field induced by the world's magnetic power is that which makes the compass point north

1 The Greek word for amber, "electron," is the origin of the word "electricity."

(although this is not geographically north, which explains why the direction changes somewhat as one travels around the face of the earth).

The next major breakthrough that played a crucial role in understanding electromagnetism came two centuries later, in 1820, when Ørsted, one of the leading scientists of the nineteenth century, discovered that a compass needle deflects from magnetic north when an electric current is switched on or off in a nearby wire. This showed that electricity and magnetism were related phenomena, a finding that laid the foundation for the theory of electromagnetism and for the research that later created such technologies as radio, television and fiber optics. Through his experimentation, Ørsted established firmly that static electricity can be converted into an electric current (something which was tentatively discovered 20 years earlier by Volta, who is hailed as the inventor of the battery.) Between Gilbert and Ørsted came a number of scientists who postulated that static electricity and magnetism are two different forces of nature, however, since they were proven incorrect, we will not include their theories here.

Following Ørsted we come to Ampère, who, as in the famous Chassidic parable, "stood on the shoulders" of those who preceded him, reaching even greater heights through his own revelations to their discoveries. Through his

experimentation, Ampère discovered that two wires with parallel currents attract one another, while two wires with currents running in opposite directions repel one another. The force involved in this phenomenon is a magnetic force, thus forming the totally new revelation that electricity induces magnetism.

From Faraday to Zeeman

A few years after Ampère's discovery came the discoveries of Michael Faraday. Faraday was a religious non-Jew who was brought up in a poor family and had no formal education. He worked as apprentice to a bookbinder and as such had access to many books. The religious sect to which Faraday belonged believed in a direct relationship with God, with no intermediaries. Because of his religious inclinations, he was relatively free of preconceptions and he hated superstitions and as such was able to make breakthroughs in science by intuiting a totally different outlook on things.

Faraday discovered the concept of field theory. Although the idea of electrons was as yet unknown, he was the first to observe that iron filings produced a form of circles around a magnet. He was also the first to discover that only a moving (implying a time factor) field produces electricity. His law of induction states that a magnetic field changing in time creates a proportional electromotive force. Thus he was the first to introduce time into the equations. All motors and generators

are based on the discoveries of Faraday which serve as the basis of all modern technology.

Faraday was an excellent experimentalist who conveyed his ideas in clear and simple language. However, his mathematical abilities did not extend far enough to form the necessary mathematical equations. It was Maxwell, his younger contemporary, who took the work of Faraday, and others, and consolidated it with a set of equations, now collectively known as Maxwell's equations, that lie at the base of all modern theories of electromagnetic phenomena.

Maxwell discovered perhaps the most astounding discovery of all, the discovery that light is a wave that transverses an electromagnetic field, proving that light is an electromagnetic phenomenon. He showed that his equations predict the existence of waves of oscillating electric and magnetic fields that travel through empty space at a speed that could be predicted from simple electrical experiments. Using the data available at the time, he reached a close approximation of the speed of light.

Hertz further developed Maxwell's discoveries when, through experimentation, he proved that transverse free space electromagnetic waves can travel over some distance. With his apparatus configuration, the electric and magnetic fields would radiate away from the wires as traverse waves. Hertz

measured Maxwell's waves and demonstrated that the velocity of radio waves was equal to the velocity of light. While experimenting, Hertz "fell upon" the fact that he produced some type of invisible radiation, which we now know to be radio waves.

Hertz's discovery led to the discovery of other invisible radiation – radio waves have the longest wavelength, being the weakest of the different forms of electromagnetic radiation. The next strongest waves are microwaves, followed by infrared waves, visible light, ultraviolet light, x-rays and lastly, gamma rays. Zeeman followed Hertz, discovering that in the presence of a magnetic field a spectral line is split into several components, an effect that is called the Zeeman Effect. Zeeman's discovery developed to become the beginning of understanding astrophysical magnetic fields surrounding stars and galaxies, which affect the energy that is radiated to the earth from outer space, ultimately affecting the entire universe.

From Einstein to Mashiach

In 1905, Einstein presented his Special Theory of Relativity together with his most famous equation of $E=mc^2$, eliminating the necessity of a luminiferous ether from Maxwell's equations. Discarding a previous scientific theory is uprooting a superstition, thus Einstein did away with the ether superstition in which scientists

believed until his day. Superstitions, however, have a tendency to return, as we see with the current theory of black matter and others.

Einstein also reinforced Maxwell's theory that the electric and magnetic fields are one. Yet Einstein's most important discovery was the existence of the massless elementary particle of electromagnetic radiation, the photon, proving that light is not merely a wave phenomenon, but also has some of the properties associated with particles.

The final theory to date is the theory of Quantum Electrodynamics (QED), the most well-founded theory of 20th century physics or science. Feynman, a key developer of QED, combined Heisenberg's uncertainty principle, together with the dual property of light and his knowledge of probability, to produce the most unified theory of science available today. However, the Grand Unified Theory of all of the forces of nature and what is beyond will ultimately be revealed to us by Mashiach.