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Magnetism in Renaissance Science

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Abstract

The study of magnetism was an important field of Renaissance natural philosophy and the practical sciences. Scholars examined the powers of the magnet (i.e., the lodestone or loadstone) by experiments and observed the magnetic properties of the Earth, for example, the direction and declination of the compass needle, by means of instruments and long-term observations. In 1600, William Gilbert published the first extensive study on magnetism (*De magnete*) and claimed the Earth was a giant magnet. While most philosophers rooted in medieval Scholasticism and Galenism deemed it impossible to analyze the physical causes of magnetic phenomena, several Renaissance philosophers attempted to explain the powers of the magnet within a range of different philosophical frameworks. Philosophers such as Pierre Gassendi and René Descartes imagined particles being emitted by a magnet, while others attributed animal-like behavior to it. Aside from this type of investigation, magnetism also figured as an explanatory principle or as an analogy in various contexts. The very term *magnetismus*, for example, was coined by Andreas Libavius in a 1597 work on alchemy. During the seventeenth century, a controversy emerged around Gilbert's "magnetic philosophy," which accounted for the diurnal rotation of the Earth by its magnetic power. Johannes Kepler even considered certain planetary movements as caused by the magnetism of the sun.

Synonyms

Loadstone; Lodestone; Magnet; Magnetic attraction; Magnetite

Heritage and Rupture with the Tradition

The majority of Latin sources from Antiquity up to the Renaissance refer to the magnet or lodestone (which is a naturally magnetized piece of the mineral magnetite) by the Latin word "lapis magnes" (from the Greek word "λίθος μάγνης"). The Latin expression *magnetismus* however was coined only in the late sixteenth century and did at first not refer specifically to the magnet or to its power of attracting iron, but to attractive forces in general. The word "magnes" was also occasionally used to refer to particular minerals which were not magnetic in the modern sense, such as manganese. Moreover, scholars spoke of minerals such as the "theamedes" which they described as having the magnetic power of repulsion (in the modern sense) (Sander 2017). Despite

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this complicated terminological situation, for the sake of simplicity, the words "magnet" and "magnetism" will throughout this article denote the mineral magnetite and its physical powers.

Sixteenth-century scholarship inherited much of its knowledge about magnetism from earlier periods. While Aristotle hardly mentioned the magnet, Pliny the Elder's *Natural History* provided a brief account of ancient mineralogical knowledge about the magnet (Radl 1988). Philosophers such as Alexander of Aphrodisias, Lucretius, Galen, and many others discussed the question of how magnetic powers are to be explained. The thirteenth-century scholar Petrus Peregrinus wrote the first surviving study in Western science (*Epistola de magnete*) describing magnetic powers systematically and on the basis of experiments. It included the first detailed account of a magnetic compass (Smith 1992; Petrus Peregrinus 1995).

Renaissance authors showed increasing interest in the study of magnetism. In particular, the English physician William Gilbert claimed in *De magnete* (1600) to have established a novel "magnetic science" (*magnetica disciplina*) that was purely based on experiments and solid reasons. This claim was explicitly directed against traditional Aristotelian natural philosophy, matter theory and cosmology, and against their supposedly "bookish" approach.

Innovative and Original Aspects

Overall, the original aspects of the Renaissance study of magnetism can be divided into three, partly interconnected research programs: (1) the observation of magnetism: What are the magnet's powers and properties and how can they be discovered? (2) the explanation of magnetism: How can we account for magnetic phenomena (e.g., attracting iron) in terms of natural philosophy? and (3) the comparison with other phenomena: What other (e.g., medical or astronomical) phenomena can be compared to, or even be explained by, magnetism? Of course, several authors contributed to more than one of these research programs, for example, by using experiments to arrive at conclusions about the causes of magnetic phenomena. Gilbert intertwined all three programs to building his "magnetic philosophy." However, the majority of sources focused on one of these three programs.

Observing Magnetism: Experiments, Discoveries, and Research

The historical knowledge of magnetic phenomena can be inferred from four types of sources: (1) Important sixteenth-century publications on the magnet (monographic studies or book chapters) include Peregrinus's *Epistola* (Lullus 1520; Petrus Peregrinus 1558; Taisnier 1562), Gerolamo Cardano's *De subtilitate* (Cardano 2004 [1550]), Robert Norman's *The new attractive* (Norman 1581), and Giambattista Della Porta's *Magia naturalis* (Porta 1589). The most important extensive (printed) study on the magnet is William Gilbert's *De magnete* (Gilbert 1600), which were in due time followed by two monographs by Jesuit authors, Niccolò Cabeo's *Philosophia magnetica* and Athanasius Kircher's *Magnes* (Cabeo 1629; Kircher 1641). (2) A particularly important manuscript on magnetism (*Tratatti della calamita*) was written by the Jesuit Leonardo Garzoni around 1580 (Garzoni 2005; Sander 2016). His work was partly incorporated into Della Porta's *Magia*, was known to Fra Paolo Sarpi and was reworked by Cabeo. (3) Several authors, including Johannes Kepler, Marin Mersenne, and Galileo Galilei, discussed the topic of magnetism frequently in their respective correspondence with often less known contemporary scholars. These sources often report recent discoveries but remained mostly unpublished. (4) Few surviving scientific objects, such as the so-called armed magnets (see below) and magnetic instruments (like nautical compasses or sundials with magnetic needles), also bear witness to their makers' knowledge of magnetic phenomena. Maps or globes furthermore bear witness to the acquaintance with geomagnetic phenomena, for example, by locating magnetic poles on the earth.

It can be inferred from these sources that sixteenth-century authors discovered many

magnetic phenomena that had been unknown before. This increase of knowledge partly derived from the fact that the use of the magnetic compass became much more important, especially for intercontinental voyages of discovery. Moreover, it can be observed that the experimental approach to magnetism, which is already found in some medieval works on the topic, gained momentum in the Renaissance, mirroring a novel understanding of nature and a new methodological approach in natural philosophy.

Peregrinus and his late-medieval contemporaries had already known that a magnetic iron needle pivoted in a compass points north. Sundials with magnetic needles fabricated around 1450 testify to their makers' knowledge that the needle's southward direction deviated from the true astronomical south (which was called "magnetic declination" or "variation") (Hellmann 1897; Balmer 1956; Jonkers 2003). Navigators of the late fifteenth century were moreover aware of the fact that this declination changed with geographical longitude, giving rise to the hope of finding longitude positions by means of specific patterns of magnetic declination. In 1544, Georg Hartmann first described how a magnetic needle aligns itself vertically ("magnetic inclination" or "magnetic dip") (Hellmann 1898, 65–66). Robert Norman assumed that the angle of inclination varied according to geographical position. In 1634, the Englishman Henry Gellibrand pointed out that local variation also changed at a given place over time ("secular variation") (Pumfrey 1989). Most of these geomagnetic discoveries and research studies were conducted by instrument makers or scholars from the nautical or geographical sciences.

Scholars also examined the properties and powers of the magnet itself, for example, its two poles, the ways these poles can be found, and how a magnet is able to communicate its powers to a piece of iron. Peregrinus and Gilbert experimented with spherical magnets or magnets floating on wooden vessels on water. Other scholars attempted to measure the strength of the magnetic attractive power and tried to find out how this power could be increased or decreased by means of chemical experiments, for example, by putting a magnet in garlic juice, quicksilver, iron fillings, or fire. Gilbert invented the so-called "armed magnet," a magnet capped with iron plates to enlarge its power to lift a piece of iron.

Explaining Magnetism: Causal Theories in Natural Philosophy

The magnet's power of attracting and repelling iron and its power of aligning along a north-south axis posed serious explanatory difficulties to theories seeking a causal explanation of these phenomena. While ancient natural philosophers only dealt with explanations of magnetic attraction, medieval authors were aware of the directive force of a compass needle and reasoned about the celestial cause of this alignment to the north (Weill-Parot 2013). Renaissance authors developed a variety of causal theories for both phenomena – attraction/repulsion and north-pointing – which often followed ancient or medieval ideas, but were elaborated in much greater detail (Daujat 1945).

Natural philosophers influenced by Galenic medicine and Aristotelian medieval scholasticism considered it impossible to explain the magnet's powers by its elementary qualities, such as "heat" or "dryness." They therefore assumed an unperceivable "occult power" that causes the magnet to attract iron or point north (Weill-Parot 2013, 27–136). Many Renaissance philosophers were unsatisfied with this assumption, feeling that "occult qualities" or "powers" provided no satisfying explanation at all. Instead, they proposed various alternative accounts, such as the following:

(1) Gerolamo Fracastoro and others assumed the emission of immaterial yet substantial "species" to account for magnetic phenomena, which they took to be an instance of natural "sympathy" (Fracastoro 2008, 29–39). (2) Cardano and others held that a magnet sought iron as an animal seeks food (Cardano 2004, 664–77). Thereby, magnets were considered to be endowed with basic animal faculties and even a soul. (3) Aristotelian philosophers such as Garzoni and Cabeo used and modified Aristotelian principles (hylemorphism) to

account for magnetic phenomena by assuming a particular "magnetic quality." (4) Corpuscularian philosophers such as Isaac Beeckman or Pierre Gassendi imagined that tiny particles were emitted from a magnet, travelled through the air, and entered the iron. René Descartes even hypothesized in his *Principia philosophiae* (1644) that magnetic particles possessed screw shape and that all magnetic bodies had fitting threads that allowed these specific particles to enter them (Descartes 1964, VIII: 275–311).

Different hypotheses were also formulated to explain the north-pointing of the magnetic needle. Most medieval authors assumed a celestial cause, for example, the astral influence of the pole star. In the sixteenth century, Fracastoro and Gerhard Mercator thought that a magnetic needle pointed to magnetic mountains located on the Earth. The foundation of a geomagnetic theory was laid by Gilbert who argued that the Earth itself was a giant magnet (Roller 1959; Pumfrey 1987). Gilbert tried to demonstrate this theory by experiments with spherical magnets he called "little earth" (*terrella*) which he presumed to possess the same magnetic properties and powers as the Earth itself. In Gilbert's view, the irregularities of the Earth's crust are the cause of the local magnetic variation (see section "Observing Magnetism: Experiments, Discoveries and Research"). As for the cause of this earthly magnetic power, Gilbert thought that the Earth was endowed with a soul (Henry 2001).

These debates on the causes of magnetic phenomena reflect the broader development of natural philosophy in the early-modern period, particularly the polemics against Aristotelian natural philosophy and the emergence of a mechanical, corpuscularian philosophy.

Comparisons: Magnetic Power as Analogy or Explanatory Principle

In Renaissance philosophy and science, magnetism was also used as an analogue or explanatory principle in order to account for a range of natural phenomena. The most important disciplines, topics, or research contexts in which magnetism played a pivotal role include (1) cosmology, (2) medicine, and (3) alchemy – leaving aside its frequent use in theology, astrology, and natural magic.

1. Because of the supposed similarity between a spherical magnet and the celestial sphere, already Peregrinus had claimed that a spherical magnet would rotate around its own axis in keeping with the movement of the heavens. Gilbert, whose starting point was his geomagnetic hypothesis combined with an idiosyncratic theory of matter (Freudenthal 1983), argued that the rotation of a spherical magnet, when it aligns itself with the poles of the Earth, resembles the latter's diurnal rotation. He thereby tried to account for the geodynamic hypothesis proposed by Nicolaus Copernicus in 1543. Johannes Kepler adopted Gilbert's idea of magnetic powers of the Earth and developed a full-fledged magnetic cosmology, with the sun being a giant magnet that caused and directed the movements of the planets (Krafft 2010). Both Gilbert's and Kepler's magnetic cosmologies were harshly criticized, especially by Catholic authors who were fighting against physical Copernicanism (Baldwin 1985) and proposed their own geostatic magnetic cosmology (Grandami 1645).
2. Magnetic attraction was already used as an analogue in ancient and medieval medicine. The attractive power of some organs (e.g., the liver), faculties (e.g., nutrition), or purgative drugs (e.g., rhubarb) seemed to resemble the magnet's attraction of iron. In the early-modern period, this kind of analogy was further fleshed out. The philosopher and physician Paracelsus described the curative power of some drugs as magnetic (Rutschow 1965). He also believed that man himself was a magnet attracting healthful or harmful influences from his environment. This idea led to the invention of an obscure cadaveric substance called "mumia" that was considered to magnetically retrieve harmful substances or "influences" of a sick person. In the early seventeenth century, these ideas merged with the so-called "weapon salve," an unguent that was to be applied to

the weapon instead of the wound which it had inflicted (Poma 2009). Rudolph Goclenius (jr.), Jan Baptist van Helmont, and Robert Fludd argued that this healing process at a distance worked by magnetism.

3. In 1597, Andreas Libavius coined the Latin expression *magnetismus* in his handbook of alchemy (Libavius 1597, 86). He did not apply this expression to the powers of the magnet in particular but more generally to the attractive powers of specific mineral or chemical substances. This generalizing notion led to the idea that attractive powers could also be transferred (from one body to another, such as when iron was magnetized). In the alchemical works ascribed to Basilius Valentinus or those by Michael Sendivogius, the expression "magnet" denotes various substances that show a particular chemical affinity to other substances or are attractive in one way or another (e.g., Basilius Valentinus 1603, 85–86; Sędziwój 1604, 64).

   The most comprehensive account of the various "magnetisms" of nature can be found in Athanasius Kircher's *Magnes* (Kircher 1641; Baldwin 1987). Kircher discusses the magnetic faculties of plants, elements, animals, the Earth, and many other things. He also synthesized and extended the use of the magnet in tricks and gadgets of natural magic such as a magnet-driven sunflower clock. He inclined to the view that magnetism is a principal and irreducible power governing various aspects of nature.

Cross-References

- ▶ Copernicanism
- ▶ Giambattista Della Porta
- ▶ Leonardo Garzoni
- ▶ Occult Quality
- ▶ Weapon Salve
- ▶ William Gilbert

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