

*Interesting and important  
Extensive citations  
9.8*

**The Development of Physics  
Beyond the Western World:  
A Global Perspective**

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From Aristotle to Newton to Einstein, the big names in physics that we've covered this semester are all Western. But physical science is a human endeavor, not just a Western one. The urge to discover, to seek knowledge and to understand the world around us is an essential human trait, one that is shared by all cultures and races. It is important to recognize that over the course of human history, a number of distinct cultures have developed in parallel, each with its own contributions to our modern understanding of the world around us. By drawing from the voluminous annals of history, we can demonstrate that science is a collective human endeavor, not just a Western one. We can show that various cultures contributed to the discovery of important scientific principles and analyze the progress of research from a global perspective.

Having been raised in a Western society, we tend to exhibit ethnocentricity when considering scientific accomplishments. Living in a world in which the West is dominant in science and technology, it is easy to assume that all science and scientific discoveries originated from great minds in the West. However, it is important to recognize that historically, the West has not always been dominant. Over much of history, the West fell behind in terms of scientific development in comparison to the accomplishments of other cultures.

Though many of the scientific and technological advances that are of note today came about during a period of Western supremacy, there are many fundamental scientific developments that originated outside of the Western world. In fact, the rise of the West would not have been possible without its adoption of sciences and technologies from other parts of the world. As we'll see, many fundamental physical concepts which we take for granted today can be attributed in part or in whole to the efforts of scientists and scholars outside of the Western world.

The scientific history of mankind is far too extensive to cover in a single paper. Let us instead focus our attention on the development of several important principles of physics. We will take a holistic view of their evolution over time and see how cultures from around the world contributed to the understanding of science that we enjoy. We will look at the development of the principle of inertia, famously described in Newton's First Law of Motion. We will then look at how our understanding of light and vision has developed over time, and then of our knowledge of electromagnetism.

Let us begin with the Hellenistic origins of Western science. In the West, scientific ideas can often be traced back to the ideas put forth by the Greeks. Indeed, the Greeks, great philosophers who liked to think in terms of abstractions and generalizations, produced intuitive explanations for how the world around us works (Spielberg and Anderson 20). The Greeks based their theories and explanations on the observation of how things seemed to work, a tradition that still carries on in Western science today. Their ideas were so much in accord with common sense that they were held as the absolute truth well over a thousand years past their time, seen even in Galileo's time, during which the Church held fast to Aristotle's teachings on physical principles ("Galileo Galilei," 2009).

The Greek philosopher Aristotle was one of the most influential thinkers of the Western world ("Aristotle," 2009). One of Aristotle's most important, most intuitive, yet notably incorrect explanations of the physical nature of the world was the belief that objects in motion tend to slow down (Pollock). This is in accordance with our intuition. However, we know this to be false. Yet this theory was held to be true by the West from Aristotle's time around 370 B.C.E. up until Galileo's work two millennia later. Today, we understand that force acting on a body determines acceleration, not velocity. This is the principle that underlies Newton's First Law (Ronan 85).

Beyond the West, scholars have had a grasp of this principle since at least the third century B.C.E., well before the time of Newton. The Chinese scholar Mozi asserted in 250 B.C.E. that "The cessation of motion is due to the opposing force ... If there is no opposing force ... the motion will never stop. This is true as surely as an ox is not a horse" (Leinhard). A similar idea was stated by the Islamic scholar Ibn al-Haytham, who is also known as Alhacen. In his *Treatise on Place*, which dates back to around 1000 C.E., he states that "a body moves perpetually unless an external force stops it or changes its direction of motion" ("Alhacen," 2009).

In the West, it is not until 1613 that Galileo states that "a body moving on a level surface will continue in the same direction at constant speed unless disturbed" in his principle of inertia ("Inertia," 2009). This was adapted as Newton's First Law of Motion in his *Philosophiæ Naturalis Principia Mathematica*, which was published in 1687 ("Newton's laws of motion," 2009).

Now, let us examine the development of the understanding of light and vision. It happens that some of the same scholars who had great insight into the laws of motion also did research on the properties of light. The Western interpretation of the phenomena of light and vision can be traced back to the Greek philosopher Pythagoras, who had an explanation for sight around 530 B.C.E. In his explanation, objects are made visible when they are struck by a ray that is emitted from the eyes. He referred to these rays as "flux" (Ronan 90). This concept is known as emission theory, and was embraced by the great Greek philosopher Plato, who was active a century after Pythagoras ("History of optics," 2009).

The Chinese were also actively studying light around this time. Around 400 B.C.E., the Chinese scholar Mozi worked with a pinhole camera, a primitive form of the camera obscura. A pinhole camera is a closed box with a small pinhole in one of the sides. Light travelling through

the pinhole is projected onto the interior of the box, forming an inverted image. The inversion of this image led Mozi to realize that light travels in straight lines, as light from the top of the scene hits the bottom of the screen after passing through the pinhole, and vice-versa: light from the bottom of the scene hits the top of the screen (“Camera obscura,” 2009).

In the third century B.C.E., Euclid wrote his *Optics*, in which he described reflection and the travel of light in straight lines, a century after the work of Mozi. Euclid, like Pythagoras, believed in the emission theory of light. This theory would continue to persist amongst classical Western thinkers for many more centuries. Notable thinkers who believed that light was emitted by the eye included Hero of Alexandria, who studied the properties of light during the first century C.E., and Ptolemy, who wrote about optics in the second century C.E. (“History of optics,” 2009).

A fuller description of the nature of light would be provided centuries later by Ibn al-Haytham in his *Book of Optics*, which was completed in 1021. He provided a detailed description of the behavior of rays of light and of how images are formed in the eye (Ronan 94). He also worked with pinhole cameras and analyzed the workings of a camera obscura.

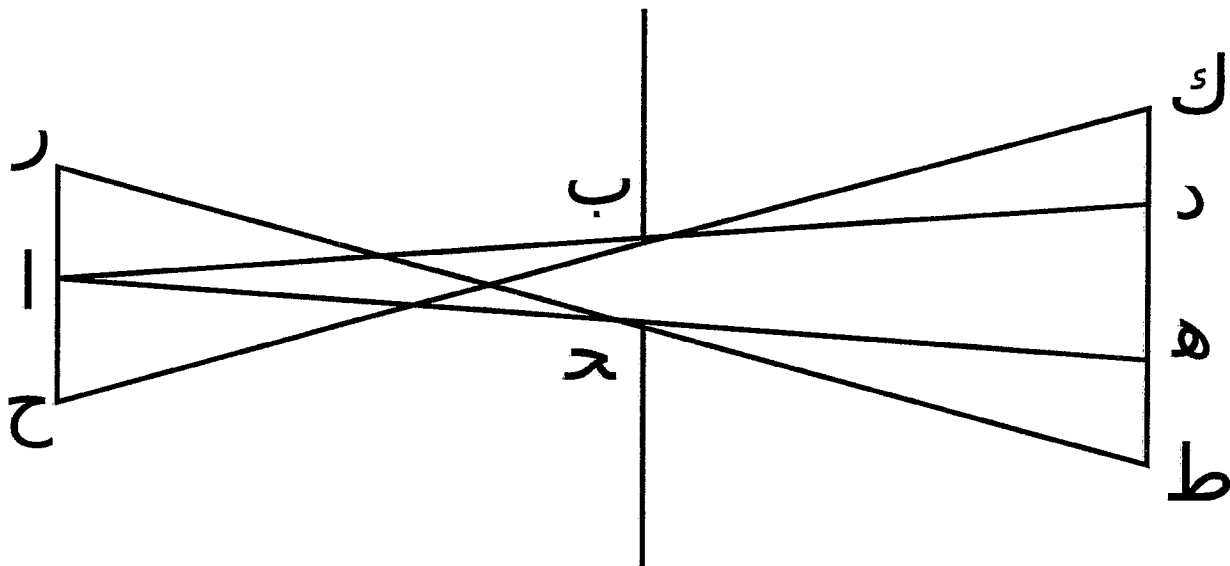


Figure 1. Ibn al-Haytham’s diagram of light passing through a pinhole.

Ibn al-Haytham refuted the emission theory of light, pointing out that distant stars are visible immediately after opening one's eyes. He also reasoned that bright lights hurting a viewer's eyes is inconsistent with the emission theory and seems to suggest that light comes from outside of the eyes, not from the eyes ("Alhacen," 2009). It is interesting to note that Ibn al-Haytham supported his theory of light with experimentation. His combination of experimentation, observation, and reasoning have led Ibn al-Haytham to be identified as the originator of the modern scientific method ("History of scientific method," 2009).

Ibn al-Haytham's work was translated into Latin and spread throughout Europe. His *Book of Optics* would go on to form the basis of the Western perception of light. In 1704, nearly seven hundred years after Ibn al-Haytham, Isaac Newton published his theories on light, in which light took the form of infinitesimally small particles called "corpuscles." Our modern understanding of the nature of light would come two centuries afterward. Max Planck wrote about the quantum nature of light in 1900. In 1905, Albert Einstein conducted his research on the wave-particle duality of photons, for which he would later receive the Nobel Prize (Ronan 93). This goes to show that the groundbreaking research of modern physics, though conducted in the most part by Western scientists at Western institutions, owe their roots to scientists from outside of the Western world.

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Our third example comes in the form of electromagnetism. Magnetic iron from meteorites had been discovered in China by 3000 B.C.E. (Mattis 1). By 580 B.C.E., the Greeks were also aware of magnetic iron, which came in the form of loadstones discovered in the region of Magnesia. The region lent its name to the term "magnet." In 83 C.E., Chinese essayist Wang Chong's *Discourses Weighed in the Balance* contains the first description of a compass in which a needle is attracted by a magnet. However, the first extant record that contains indisputable

evidence of a magnetic direction finder is not created until 1040, when a manual entitled *Collection of the Most Important Military Techniques* is published in China. The manual describes a compass that points south, for use “when troops encountered gloomy weather or dark nights” (“Compass,” 2009).

In the West, the first recorded use of a magnetic compass comes from Alexander Neckam, an English scholar, in 1189. In his book *De utensilibus*, Neckam describes the use of a revolving needle placed above a magnet on ships (“Alexander Neckam,” 2009). The compass appears in the records of the Islamic world by 1232, in a Persian book containing a reference to an iron fish floating in water. In the fourteenth century, the Syrian astronomer Ibn al-Shatir invented the compass dial, a device that combines a compass with a sundial. Also during that century, Arab navigators produced a 32-point compass rose (“Compass,” 2009).

This development and propagation of the compass would lead towards the common acceptance of the device and investigation into its workings. In 1600, William Gilbert published *De Magnete*, a paper on magnetism and the uses of magnetite (Bellis). In this paper, Gilbert also remarked on the static electricity produced by amber. He referred to static electricity as “electricius,” based on the Greek word for amber, “elektron.” This is the origin of the modern English word “electricity” (“De Magnete,” 2009). Interestingly, Gilbert considered the subject of static electricity “too trivial for serious study” (Ronan 96). Although mention was made of both electricity and magnetism in Gilbert’s paper, it wasn’t until 1820 that the connection between these two phenomena was made. Hans Christian Ørsted accidentally discovered that an electric current produces a magnetic field when he placed a wire near a compass while preparing for a scientific demonstration. Ørsted published his findings that same year (“Ørsted,” 2009). This

work established the study of electromagnetism and set the stage for the great advances that would occur in that field.

We've seen that some of the major advances in physics made in the West were influenced by research in other parts of the world. Now let's look at the broader picture. How do these advancements tie into the context of history, and what trends do they reflect?

In contrast to today's interconnected world, the societies of the ancient world were isolated from each other by long, difficult to cross distances. Inventions, discoveries, and technological developments could take up to centuries to be transmitted between various parts of the world. Many times, these discoveries were made independently and separately of each other. In recent centuries, particularly from the scientific revolution up to the present, the Western world, mostly Europe and America, dominated scientific development. A look through many timelines and textbooks about the history of science reveal only the names of Western scientists.

This Western dominance was rooted in the paradigm shift that occurred in the Western world during the period of the European Renaissance. The growing acceptance of science and the great ideas in physics that emerged during this period of enlightenment spurred development in a number of other fields. This produced a self-sustaining reaction in which discoveries built upon discoveries, snowballing into the unprecedented technological golden age that spurred on the ascension of the West ("History of Science," 2009).

Unfortunately, this came at a cost to the other cultures of the world. Advancements in science lead to advancements in technology, which in turn allowed Western nations to pursue an imperialistic agenda. Western imperialism ravaged the cultures that it touched. As Daniel Headrick asserts, the Western world held "a belief that technological superiority demonstrates religious, cultural, and even biological superiority over non-white peoples" (5). Meanwhile,

other cultures which had been dominant in the past were on the decline. This also resulted in a decline in their contributions to science. Not only do great ideas in physics have implications on other fields, but great ideas – and sometimes not-so-great ideas – in other fields can have implications for physics.

After World War II, with the decline of imperialism and the rise of globalization, the West no longer holds a near-monopoly in scientific research, though it remains a top player. Today, science is conducted by teams of dedicated researchers, in contrast to the brilliant individuals to whom great discoveries were attributed to in the past. This may be due to the widespread acceptance of the value of science around the world today, in the West as well as other cultures.

Today, we see scientists from around the world making discoveries and contributions. This is quite visible in the diversity of people who are found on university campuses across the world, as well as the diverse names of the authors of published scientific papers. Once again, physics and related sciences are being actively pursued and advanced outside of the West.

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