Contributions of galileo galilei to modern astronomy religion essay

Galileo’s Early Life and Career

Galileo was born in Pisa, Italy. He was the oldest son of Vincenzo Galilei, a musician who made important contributions to the theory and practice of music. In the early 1570s, the family moved to Florence where they had lived for generations. In his middle teenager years, Galileo attended the monastery school at Vallombrosa, near Florence, and then in 1581 matriculated at the University of Pisa, where he was to study medicine but he decided to study mathematics instead.[3] In 1585, Galileo left the university without having obtained a degree and for several years he gave private lessons in the mathematics in Florence and Siena. During this period he designed a new form of hydrostatic balance for weighing small quantities.[3] He also began his studies on motion for the next two decades. Galileo discovered some ingenious theorems on gravity which brought him recognition among mathematicians, which resulted in him obtaining the chair of mathematics at the University of Pisa in 1589. It was here where he was reported to have shown his students the error of Aristotle’s belief that speed of fall is proportional to weight, by dropping two objects of different weight simultaneously from the Leaning Tower of Pisa.[4] His contract was not renewed in 1592, probably because he contradicted Aristotelian professors.[4] The same year he was appointed to the chair of mathematics at the University of Padua, where he taught geometry, mechanics and astronomy until 1610. It was during this period that Galileo made significant discoveries in both pure fundamental science and practical applied science. It was because of these discoveries that Galileo has been called the “ father of modern observational astronomy", the " father of modern physics", the " father of science", and " the Father of Modern Science."[5]

Galileo's Work and Contributions to Modern Astronomy

At Padua, Galileo invented a calculating " compass" for solving mathematical problems.[6] He discovered the law of falling bodies and of the parabolic path of projectiles. He also studied the motions of pendulums and investigated mechanics and the strength of materials.[7] In 1595, Galileo began to support the Copernican theory of the Earth revolving around the Sun (Heliocentric model) rather than the Aristotelian and Ptolemaic theory of the Earth at the centre of the universe (Geocentric model). The Copernican model had supported Galileo's tide theory which was based on the motions of the Earth.[5]

In the spring of 1609, Galileo heard that a spyglass had been invented in Holland. By trial and error, he quickly figured out the secret of the invention and made his own three-powered spyglass from lenses for sale in spectacle makers' shops.[5] Others had done the same, but what set Galileo apart was that he quickly figured out how to improve the instrument, having taught himself the art of lens grinding, and thus, produced increasingly powerful telescopes.

galileostele. jpg

A Photo of The Original Galileo Telescope[8]

By December 1609, Galileo had built a telescope of 20 times magnification and began observing the heavens. He discovered that the moon was not smooth, as had been thought by Aristotle and in fact, there were mountains and craters present on it making it rough and uneven.[9]

Moon1. jpg

Picture Showing Craters on the Moon[10]

In January 1610, Galileo discovered four moons revolving around Jupiter thus proving that not all objects orbit the Earth (which was thought by Aristotle and Ptolemy).[11] These moons are now referred to as Galilean Moons.

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Galilean Moons of Jupiter[12]

These discoveries were tremendous and Galileo described them in a small book called “ The Sidereal Messenger” which he dedicated to Cosimo II de Medici, the grand duke of his native Tuscany. He had also named the moons of Jupiter after the Medici family referring to them as the Sidera Medicea or Medicean Stars.[3] As a reward, Galileo was appointed as mathematician and philosopher of the grand duke of Tuscany.

In Florence of that same year, he observed that Venus exhibited a full set of phases similar to that of the moon, which proved that it must orbit the Sun and not the Earth.[1] This observation was among the most important in human history, for it provided the first conclusive observational proof that was consistent with the Copernican system but not the Ptolemaic system. According to Nicholas Copernicus’ heliocentric model of the solar system, the Sun is at the centre of the solar system with the Earth being just another planet orbiting the Sun. The orbit of Venus around the sun would allow all the phases of Venus to be visible from the Earth. On the other hand, Claudius Ptolemy's geocentric model, with Earth at the centre and Venus orbiting Earth, only the crescent and new moon phases of Venus would be observed.

venus_orbit. png

Ptolemaic View versus Copernican View of Venus[11]

Galileo's telescopic observations of the crescent, gibbous and full phases of Venus provided empirical and conclusive evidence that the Ptolemaic's model was incorrect. Galileo was now confirmed in his belief, that the Sun is the centre of the universe and that the Earth is a planet, as Copernicus had previously argued. Galileo's conversion to Copernicanism was a key turning point in the scientific revolution.

In 1613, Galileo also observed the Sun through his telescope and saw that there were dark patches present on it, (now referred to as sunspots,) which were considered to be " imperfections" at the time.[13]

sunspots. gif

Sunspots on the Sun as Observed by Galileo through his Telescope[14]

This was contrary to what Aristotle had proposed in that, the heavenly spheres and bodies were made from a divine, unchanging, perfect substance which he said was the fifth element called aether.[15] (The four elements were earth, fire, air and water.) Aristotle held that this perfect substance, had by nature to execute perfect (uniform, circular) motion.[16] Galileo observed the motion of these sunspots which indicated that the Sun was rotating on an axis which made it possible that the Earth might be rotating on an axis as well, as required by the Copernican model. Thus, if the heavens were in fact not perfect, then the idea of elliptical orbits (according to Kepler) was not so objectionable.[11] These new facts were both unknown to Aristotle and Ptolemy.

The Greeks rejected the Heliocentric model partly because they could not detect stellar parallax, which was the apparent shifts in stellar positions when observed from two separate points over the course of the year. Galileo observed with his telescope that the Milky Way resolved into countless individual stars, which helped him argue that the stars were far more numerous and more distant than the Greeks had believed. With this in mind, Galileo was able to conclude that stars were so far away that stellar parallax were undetectable, thus further supporting the Heliocentric model.[11]

In 1616, Galileo also discovered the planet Saturn which had seen as a three-body system, which was later found out to be the rings of Saturn but, he was unable to see this because his telescope was not powerful enough, showing them as extensions on either side of the planet.

DSC08891-Saturn. jpgPic26-ears. jpg

Galileo's Sketch of Saturn[17] View of Saturn through Galileo's Telescope in 1616[17]

Galileo also conducted experiments using rolling balls to demonstrate that a moving object remains in motion unless a force acts to stop it (now codified as Newton's First Law of Motion). This explained why objects such as birds, falling stones and clouds, which share Earth's motion in space, should stay with Earth rather than fall behind as Aristotle had argued.[11]

Thus, it was Galileo who had laid the final groundwork in modern astronomy (originally started by Copernicus and continued with Brahe and Kepler) which was used to overthrow the views of Aristotle and Ptolemaic model. It was then the work of Issac Newton who put all the pieces together and demonstrated that the laws that governed the heavens were the same laws that governed motion on Earth.

Galileo's Writings and Publications In Astronomy

Many philosophy professors had scorned Galileo's discoveries because they had strongly believed in Aristotle's views of perfectly spherical bodies existing in the heavens. In 1610, " Sidereus Nuncius" (The Starry/Sidereal Messenger) was the first scientific paper to be published based on Galileo's telescopic observations which reported about the Galilean Moons, the craters and mountains on the Moon's surface, the Milky Way and the numerous stars which it contains and the appearances of planets and fixed stars.[18] In 1613 he published work on the sunspots he discovered called the " Letters on Sunspots". This publication also included the full set of phases of Venus as well as the puzzling appearance of the three-body system of Saturn.

In 1614 a Florentine priest denounced Galileo from the pulpit because a Pisan professor (in Galileo's absence) told the Medici that belief in a moving earth was unorthodox. Galileo wrote a letter on the irrelevance of biblical passages in scientific arguments, stating that the Bible should be adapted to increased knowledge and that no scientific person should be made a critique of the Roman Catholic faith.[3] In early 1616, Copernican books were subjected to censorship by law and that Galileo must no longer hold or defend the concept that the earth moves. Galileo remained silent on the subject for some years until 1623 when he published “ The Assayer”. This book set forth his views on the mathematical formulation of scientific reasoning as well as experiments he conducted in determining longitudes at sea by using his predictions of Jupiter’s satellites. This book was successful and got support among the higher levels of Christian Churches. In 1624, Galileo went to Rome where he had a few interviews with the Pope (Urban VIII at that time), whom he told about his theory on tides that he developed in 1616. Galileo put forward proof of the annual and diurnal motions of the Earth, whereby he was granted the permission to write a book about the theories of the universe, but was warned to treat Copernican theory only hypothetically.[18] In 1630, the book titled the “ Dialogue on the Two Chief World Systems” was allowed to print by the Roman Catholic sensors at Rome, but they altered the title, excluding the words “ Ptolemaic and Copernican” (at the end of the above title). The book was finally published at Florence in 1632. However, in 1633 Galileo was summoned by the Roman Inquisition to stand trial for “ suspicion of heresy”, on the grounds that he had been personally ordered in 1616 not to discuss Copernicanism either orally or in writing and was sentenced to life imprisonment which was commuted to house arrest.[18] The Dialogue was ordered to be burned.

galilei_image01. jpg

Painting depicts Galileo standing trial in Rome for his belief in Copernicanism[19]

In 1638 at Leiden, Galileo’s final book was published entitled the “ Discourses Concerning Two New Sciences”, which reviewed and refined his earlier studies of motion and mechanics. This book led Newton to the law of gravitation that linked Kepler’s laws with Galileo’s physics.

Conclusion

Galileo became blind before his last book was published. He died at his home in Arcetri, near Florence on January 8th 1642. It was not until 1979 an investigation into Galileo’s condemnation called for a reversal by Pope John Paul II and in October 1992, a papal commission acknowledged the Church’s error. Fifty years after his death the city of Florence erected a monument in Galileo’s honour in Santa Croce.

800px-Tomb_of_Galileo_Galilei. jpg

Tomb of Galileo in Santa Croce[20]

In December 2008, during the events to mark the 400th anniversary of Galileo’s telescopic observations, Pope Benedict XVI praised his contributions to astronomy. Galileo still remains one of the most important scientists of his time and even though he had a difficult lifetime and personally suffered because of his ideas, he is greatly appreciated today.