Picton, T. W. (2013) *Creature and Creator: Intersections between Science and Religion* (pp. 91-110)

And Yet It Moves

(i) Nature's Book

Any evaluation of the relations between science and religion must consider Galileo Galilei.[1] In 1633, Galileo was forced by the Inquisition to abjure his belief that the earth moves round the sun, an idea contrary to the Holy Scriptures. Legend has it that he muttered *Eppur si muove* (And yet it moves) after his recantation. This is probably not true. Legend also has it that the Catholic Church finally saw the error of its ways and rehabilitated Galileo. This is also probably not true.

At the time of Galileo, truth was determined by the Holy Scriptures, as revealed by God and interpreted by his church. Unfortunately, the holy words can be interpreted in different ways, just as scientific observations can be explained by different theories.

Much of the Protestant Reformation was based on interpretations of scripture at odds with those of the Roman Catholic Church. In order to prevent the spread of such heresies, the Council of Trent (1545-1563) set up an index of books that were not to be read. The council further decreed that

> in matters of faith and morals pertaining to the edification of Christian doctrine, no one, relying on his own judgment and distorting the Sacred Scriptures according to his own conceptions, shall dare to interpret them contrary to that sense which Holy Mother Church, to whom it belongs to judge their true sense and meaning, has held and does hold.[2]

Did "matters of faith and morals" include science? The early church had fought vigorously against heresies concerning the nature of the trinity and the reality of the resurrection, but had tended to stay clear of natural philosophy, as science was then known.

St. Augustine had proposed that the book of nature provided as much evidence for the glory of God as the sacred writings: "The scripture is a book that must

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[1] Drake, S. (1978). *Galileo at work: His scientific biography*. Chicago: University of Chicago Press; Heilbron, J. L. (2010). *Galileo*. Oxford: Oxford University Press; Wootton, D. (2010). *Galileo: Watcher of the skies*. New Haven: Yale University Press.

[2] Decree of the Council of Trent Session IV, 1546, April 8, as translated by Blackwell, R. J. (1991). *Galileo, Bellarmine, and the Bible:* Notre Dame, IN: University of Notre Dame Press (p. 183).

be heard; the universe a book that must be observed."[3] Augustine had been a Manichaean before he converted to Christianity. Manichaeism was a Gnostic religion that believed in a universe where the good of the spirit was in continual conflict with the evil of the world. By describing the beauty of the world, Augustine hoped to convince the Manichaeans that the world created by God was basically good rather than evil.

In 1543, Nicolaus Copernicus published *The Revolutions of the Heavenly Spheres*.[4] This proposed that the earth and planets circled around the sun (heliocentrism) rather than the sun and planets revolving around the earth (geocentrism), which had been the accepted theory since Claudius Ptolemy (90-168 CE). The systems are compared in Figure II.1. Realizing that philosophers trained in the theories of Aristotle and Ptolemy would be displeased, Copernicus did not publish his findings until he was close to death. His book was read and the philosophers were offended. However, the church did not list it on the Index.

The Jesuit Roberto Bellarmine (1542-1621) was much concerned with how to interpret scripture, and how to distinguish heretical belief from hypothetical supposition. His *Disputations on the Controversies over Christian Faith against the Heretics of the Day* (1586-1593) proposed that the scriptures could be understood both literally and spiritually. For example, the literal meaning of the Exodus is that God rescued the Jews from Egypt and led them to Canaan, whereas the spiritual meaning is that God will save the faithful and bring them to heaven. However, interpretation remained a sensitive issue and the first volume of Bellarmine's *Disputations* was temporarily placed on the Index because he also claimed that the temporal rulers of the world should govern by the consent of their subjects, and not because the church had anointed them as emperors or kings. Nevertheless, by 1599 his books were no longer prohibited, and Bellarmine had become a cardinal.[5]

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[3]. Augustine (5th century CE) *Enarrationes in Psalmos* 45, 7 Available at http://www.documentacatholicaomnia.eu/04z/z_0354-430_Augustinus_Enarrationes_in_Psalmos_LT.doc.html)

[4] Copernicus, N. (1543*). De Revolutionibus Orbium Coelestium*. translation available at http://www.webexhibits.org/calendars/year-text-Copernicus.html

[5] Blackwell, R. J. (1991). *Galileo, Bellarmine, and the Bible: Including a translation of Foscarini's Letter on the motion of the earth*. Notre Dame, IN: University of Notre Dame Press.

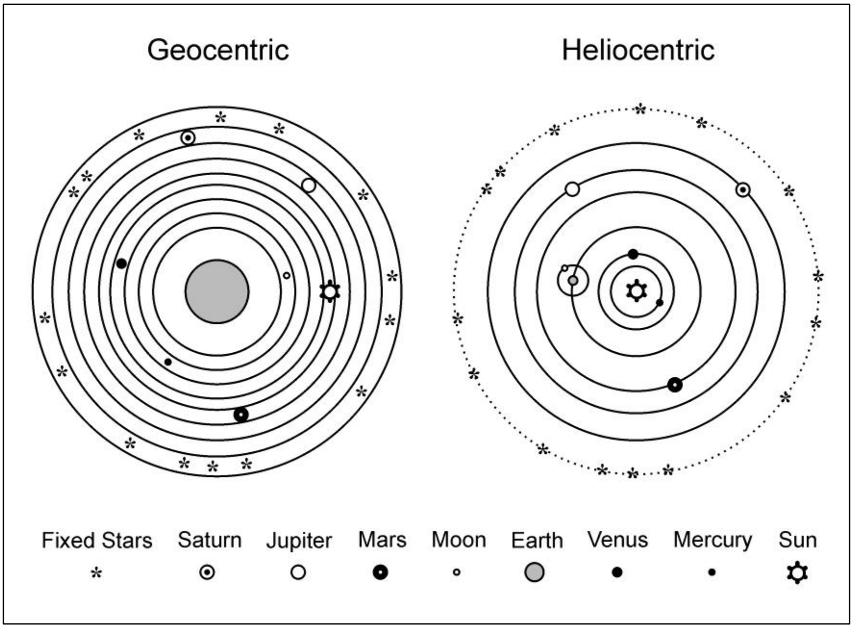

Figure II.1 Astronomical Systems of the 16th Century. On the left is the geocentric system as published in the *Cosmographia* of Peter Apian and Gemma Frisius (1564).[6] In this system the planets move in crystalline spheres. On the right is the heliocentric system as proposed by Copernicus in 1543. In this system the planets circle through space around the sun.

One difficulty with interpretation is to determine when something is meant metaphorically rather than literally. The Christian Eucharist derives from the last supper wherein Jesus shared bread and wine with his disciples:

> For I have received of the Lord that which also I delivered unto you, that the Lord Jesus the same night in which he was betrayed took bread:
> And when he had given thanks, he brake it, and said, Take, eat: this is my body, which is broken for you: this do in remembrance of me.
> After the same manner also he took the cup, when he had supped, saying, this cup is the new testament in my blood: this do ye, as oft as ye drink it, in remembrance of me.[7]

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[6] Available at http://archive.org/details/cosmographiaapia00apia

[7] I Corinthians 11:23-25

The term "Eucharist," (thanksgiving) derives from the thanks given before breaking the bread. In the 13th century CE, the Roman Catholic Church proposed a doctrine of transubstantiation: that the substance of the bread and the wine were changed during the Eucharist into the actual body and blood of Christ. Thomas Aquinas explained the process using Aristotle's metaphysics. Objects have both a "substance" (which defines what they are) and "accidents" or "appearances" (which determines how we perceive them). In the Eucharist, the substances of the bread and wine are changed even though they appear the same.

This interpretation was rejected by the Protestants, who considered the presence of Christ in the communion to be spiritual rather than actual.[8] The Council of Trent, however, affirmed the doctrine of transubstantiation. Not to believe this interpretation of the Eucharist was considered anathema. God is not served by compromise.

At the end of the 16th century, the Roman Catholic Church also began to consider whether the heliocentric hypothesis of Copernicus contradicted scripture. The Bible actually does not provide a cosmology, being far more concerned with salvation than with physics. However scholars found a key quotation in Ecclesiastes

> One generation passeth away, and another generation cometh: but the earth abideth for ever.
>
> The sun also ariseth, and the sun goeth down, and hasteth to his place where he arose.[9]

The word translated as "abideth" is the Hebrew word for "stand." As in English, this can mean to be erect, to remain, or to endure. Although it has the main sense of being immovable, in some contexts the word is more related to persistence in time than to stability in space. The first verse quoted from Ecclesiastes compares the transience of man to the eternity of the universe, and is not directly applicable to the immobility of the earth. Nevertheless, the second verse clearly describes the movement of the sun. The proposal of Copernicus that the sun stood still at the center of the orbiting planets could thus be considered as contradicting the word of God.

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[8] Most Protestant denominations assert a spiritual rather than physical presence, for example: Church of England. (1562). *Articles of Religion* (Article 28). However Lutheran Churches believe that the body and blood of Christ are present in addition to rather than instead of the bread and wine ("consubstantiation").

[9] Ecclesiastes 1:4-5.

(ii) Physics and Poetry

Giordano Bruno (1548-1600) was a Dominican priest, poet and itinerant philosopher.[10] He agreed with Copernicus that the earth moved around the sun. He further conceived the universe to be limitless, with an infinite number of worlds circling around an infinite number of suns, a view that has some resonance with the parallel universes of modern physics.[11]

For Bruno, everything was infused with God.[12] However, Bruno's writings were more poetic speculation than scientific theory. The epigram *Se non è vero, è molto ben trovato* (If it is not true, it is very well invented) is often attributed to him, though he was probably quoting an earlier proverb.[13] Even if the attribution is not true, it is appropriate.

Physics has often been suspicious of poetry. In Göttingen in 1927, on finding out that his friend J. Robert Oppenheimer was writing poetry, Paul Dirac joked that

> In science, you want to say something nobody knew before, in words everyone can understand. In poetry, you are bound to say something that everybody knows already in words that nobody can understand.[14]

Bruno returned to Italy in 1592. He was soon arrested for heresy by the Inquisition, imprisoned for seven years and finally brought to trial in Rome in 1600. Due to his expertise in the evaluation of heresy, Roberto Bellarmine was appointed one of the judges presiding at the trial. Although Bruno had proposed a heliocentric cosmology, this was not itself then considered heresy. Bruno's main heresy was his claim that bread could not be transubstantiated into flesh. His belief in an infinite universe and his refusal to believe in the divinity of Christ were probably among his other heresies. Bruno refused to

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[10] Rowland, I. D. (2008). *Giordano Bruno: Philosopher/heretic*. New York: Farrar, Straus & Giroux.

[11] Tegmark, M. (2003). Parallel universes. In J. D. Barrow, P. C. W. Davies, & C. L. Harper (Eds.) *Science and Ultimate Reality: From Quantum to Cosmos*. (pp. 459-491). Cambridge, UK: Cambridge University Press.

[12] Bruno, G. (1585, translated by R. de Lucca and R. J. Blackwell, 1998). *Cause, principle, and unity. Essays on Magic*. Cambridge, UK: Cambridge University Press.(especially Dialogue 2)

[13] Bruno, G. (1585, translated by Memmo, P. E. ,1965). *Giordano Bruno's The heroic frenzies*. Chapel Hill: University of North Carolina Press (II:3).

[14] Farmelo, G. (2009). *The Strangest Man: The Hidden Life of Paul Dirac*, Quantum Genius. London: Faber and Faber (p. 121)

recant and was sentenced to be burned at the stake in the Campo dei Fiori.[15] For Bellarmine, what had previously been ideas for discourse and debate now became matters of fire and flesh.

Although Bruno is considered a marginal figure in the history of science, his martyrdom cast a huge shadow over what happened in the ensuing years. Galileo took great pains not to be like Bruno. Yet he was ultimately arraigned in the same rooms where Bruno had been tried and sentenced.

On the 400th anniversary of Bruno's death, the Roman Catholic Church expressed regret about the execution. Nevertheless, the church confirmed that he had been justly condemned for views contrary to Christian doctrine, and that his Inquisitors had acted compassionately and had attempted to save his life.[16] These comments miss the point. Human beings reject the idea that a man might be executed solely for his beliefs.

Heather McHugh published a poem about these matters in 1993.[17] It is a complex and multilayered poem about the experiences of a group of American poets in Italy. At the end of their visit they are taken by the "most politic and least poetic" of their hosts to dinner in the Campo dei Fiori where a statue of Bruno had been erected in 1889. Their host tells them

> The statue represents Giordano Bruno,
> brought to be burned in the public square
> because of his offence against
> authority, which is to say
> the Church. His crime was his belief
> the universe does not revolve around
> the human being: God is no
> fixed point or central government but rather is
> poured in waves, through all things. All things
> move. "If God is not the soul itself, He is
> the soul of the soul of the world." Such was
> his heresy.

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[15] Singer, D. W. (1950). *Giordano Bruno: His life and thought, with annotated translation of his work On the infinite universe and worlds.* New York: Schuman

[16] Soldano, A. (2000, February 17.). Letter concerning the Conference on Giordano Bruno. (http://www.vatican.va/roman_curia/secretariat_state/documents/rc_seg-st_doc_20000217_sodano-letter_it.html)

[17] McHugh, H. (1994). *Hinge & Sign: Poems, 1968-1993*. Hanover, NH: Wesleyan University Press. (*What he thought*, p. 4)

(iii) Music of the Spheres

Copernicus' heliocentric theory of the universe provided a more efficient way of tracking the stars than the geocentric theory. To our current thinking, this is obvious. However, we understand much more now than we did then. The history of science is best considered from the viewpoint of the scientists alive when it happened. To think now as they did then, we

> must have in mind … a series of spheres, one inside another, and at the heart of the whole system lies the motionless earth. The realm of what we should call ordinary matter is confined to the earth and its neighbourhood – the region below the moon; and this matter, the stuff that we can hold between our fingers and which our modern physical sciences set out to study, is humble and unstable, being subject to change and decay … The skies and the heavenly bodies – the rotating spheres and the stars and planets that are attached to them – are made of a very tangible kind of matter too, though it is more subtle in quality and it is not subject to change and corruption.[18]

The medieval understanding of the heavens was part of a more extensive theory of physics. Matter was composed of four elements: earth, water, air and fire. Earth and water are subject to gravity and tend to fall, whereas air and fire are characterized by levity and tend to rise. If the elements did not mix we would have four concentric spheres: a solid earth at the center covered by an ocean of water, an atmosphere of air and finally a region of enduring fire. However, during the creation some of the earth had been drawn out of the waters to form the land. The elements that had been thus mixed together then tried to return to their proper spheres.

The heavens were made of a fifth element (quintessence) that was incorruptible. The moon, the sun, the planets and the stars were fixed in spheres that rotate around the earth. These spheres were made of a subtle crystalline material so that the higher spheres could be observed through the lower. And in the tenth sphere God could observe his creation and focus on the world of man.

However, observed planetary motions did not fit the pure circles presumed by the rotating spheres. Predicting the positions of these "wandering stars" required additional movements called epicycles. The planets thus circled around a point that circled around the world.

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[18] Butterfield, H. (1949, updated 1957). *The origins of modern science: 1300-1800*. London: Bell (p. 17).

Copernicus' system was simpler. However, it still needed epicycles to make the theory exactly fit the data, because the actual planetary orbits around the sun are elliptical rather than circular. The idea that these orbits were not circular was slowly becoming known through the work of Tycho Brahe and Johannes Kepler. However, it was not until Isaac Newton that these planetary orbits could be understood. Aristotelian physics postulated that things composed of earth seek their proper sphere. Gravity was thus only related to the earth. The idea of gravity as a universal force of attraction between objects was not formulated until Isaac Newton.

(iv) Mutability of Heaven

Part of the accepted view of the universe in the 16th century was that imperfection and change only occurred in sublunar regions. The heavens were perfect and, though they moved, they did not otherwise change. As astronomers searched the heavens, however, they found evidence that the heavens might change. In 1572 Tycho Brahe discovered a transient new star (*nova*) out among the fixed stars, and in 1577 he showed that a comet was moving beyond the moon in a path that could not be fit with the rotating spheres of classical astronomy.

Galileo was the first to use a telescope to observe the stars. He published his results in 1610 in the book *The Starry Messenger*.[19] Viewed in his telescope, the moon's surface was not perfectly smooth but showed mountains and craters (Figure II.2).

Even more intriguingly, the telescope revealed smaller stars in the vicinity of Jupiter that moved in ways that could only be interpreted as orbits around Jupiter. Such movements could not be understood in the Ptolemaic system. Small stars near Jupiter should have been embedded in the crystalline sphere that moved Jupiter. The importance of the finding was that if moons revolved around Jupiter, perhaps the planets revolved around the sun. Galileo named Jupiter's moons after Cosimo II de' Medici, Grand Duke of Tuscany. By dint of this, he obtained a position in the court in Florence.

Galileo's research began to attract attention and criticism from those who followed traditional views. One of the scriptural contradictions often discussed

[19] Galileo (1610) *The Starry Messenger.* In Drake, S. (1957). *Discoveries and opinions of Galileo*. Garden City, NY: Doubleday (Anchor Books).

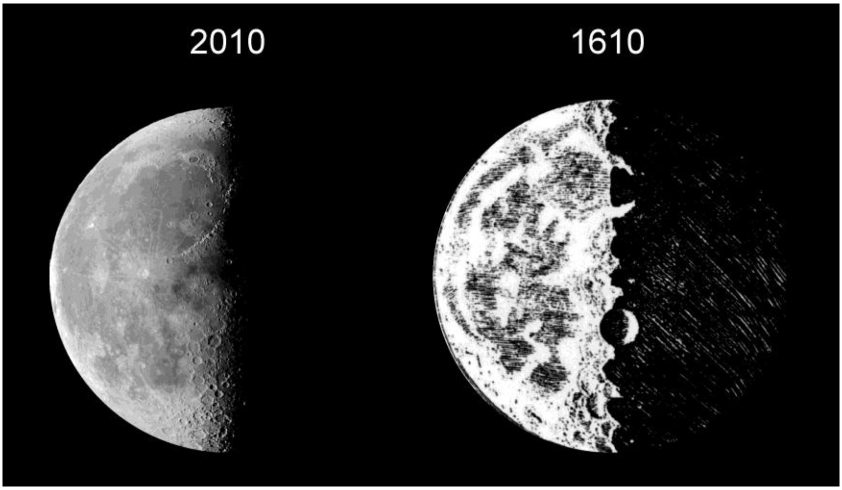

Figure II.2. The Moon. The image on the right is the moon as illustrated in Galileo's *Starry Messenger*, and the photo on the left is the moon as seen through a modern telescope (copyright 2010 by Fred Espenak, www.MrEclipse.com).

was the fact that God had stopped the sun when Joshua had defeated the Amorite kings in the battle of Gibeon.[20] Why should the sun be commanded to stand still if the sun were already motionless? The scripture cried out for a figurative interpretation, but the church understood only a miracle.

In a 1615 letter to the Grand Duchess Christina, mother of Cosimo, Galileo justified his work. He pointed out that Joshua's stopping of the sun is no more explicable in the Ptolemaic system than in the Copernican. He quoted Augustine:

> If anyone shall set the authority of Holy Writ against clear and manifest reason, he who does this knows not what he has undertaken; for he opposes to the truth not the meaning of the Bible, which is beyond his comprehension, but rather his own interpretation; not what is in the Bible, but what he has found in himself and imagines to be there.[21]

[20] Joshua 10:13

[21] Galilileo (1615) *Letter to the Grand Duchess Christina* In Drake, S. (1957). *Discoveries and opinions of Galileo*. Garden City, NY: Doubleday (Anchor Books) (p 186). The quotation from Augustine is from his letter to Marcellinus (412 CE) available at http://www.newadvent. org/fathers/1102143.htm

In December 1615, Galileo travelled to Rome to discuss these matters. The Roman churchmen felt that astronomical measurements dealt with appearances rather than reality. In February, 1616, the church decreed that the heliocentric theory of Copernicus was “foolish and absurd [*stultam et absurdam*], philosophically and formally heretical, inasmuch as it expressly contradicts the doctrine of the Holy Scripture.”[22]

Shortly after the decree, Galileo met with Cardinal Bellarmine. Galileo was warned that he should abandon any Copernican beliefs. Whether or not he was also ordered to abstain from discussing the Copernican system is a matter of dispute. An unsigned memorandum in the Vatican files states that he was so instructed, whereas a letter from Bellarmine to Galileo assured him that he was simply notified that he should not believe Copernicus.

Cardinal Bellarmine died in 1621, and Cardinal Barberini was elected Pope Urban VIII in 1623. The new Pope had been a friend of Galileo in Florence. Galileo asked him if he might write a dialogue in Italian concerning the differences between the Ptolemaic and Copernican systems. The Pope agreed and the *Dialogue Concerning the Two Chief World Systems* was published in the spring of 1632 with Vatican approval.[23] The dialogue has three characters: Salviati, Sagredo and Simplicio. The first two were named after friends of Galileo, and represented science and reason. The third represented the views of Ptolemy and Aristotle. Simplicio was a fool.

The dialogue considered Galileo’s recent research. Most important was the discovery that the planet Venus went though phases just like the moon. These phases are not observable without the telescope. These changes would be impossible in the Ptolemaic system since the sun was in a sphere more distant from the earth than Venus. In such a system we could never see Venus and the Sun close together with Venus illuminated over more than half of its aspect since it could never be on the other side of the sun (Figure II.3).

In October of 1632, Urban VIII called Galileo to Rome to appear before the Inquisition on suspicion of heresy. What had happened to the convivial relationship between scientist and pope? Someone had clearly informed the pope that there was an injunction on file forbidding Galileo to consider the

[22] de Santillana, G. (1955). *The crime of Galileo*. Chicago: University of Chicago Press. (p 121).

[23] Galilei, G. (1632, translated by S. Drake, 1953 revised 1967) *Dialogue Concerning the Two Chief World Systems*, Berkeley, CA: University of California Press.

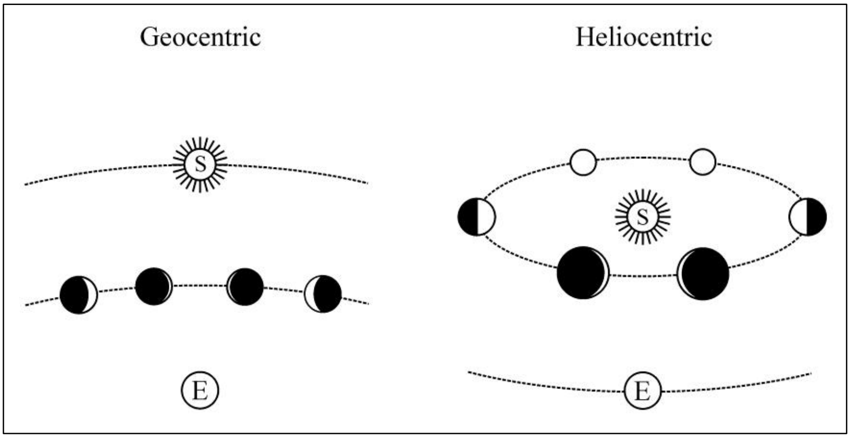

Figure II.3. The Phases of Venus. In the geocentric system represented on the left, the planet Venus is never on the far side of the sun (S) relative to the Earth (E) and therefore is never illuminated over more than half its aspect. In the heliocentric system the planet goes through phases much like those of the moon, and also increases in apparent size when in front of the sun. The change in the apparent size explains why Venus maintains an almost constant brightness during its phases.

theories of Copernicus. However, Urban VIII may have also believed that he had been played for a fool. Someone could easily have suggested that Simplicio was a papal caricature.

The trial was complex. The unsigned memorandum in the Vatican files was countered by the signed letter from Bellarmine to Galileo allowing him to consider the ideas of Copernicus, provided he did not believe them. This led to what we would today call a "plea bargain." Galileo was to confess to having inadvertently made the Copernican view too convincing in his dialogue, to ask for mercy, and to get off with another admonition.[24]

It was not to be. The judgment was that Galileo's heliocentrism was "vehement heresy." What had happened? Had those who had schemed against

[24] Blackwell, R. J. (2006). *Behind the scenes at Galileo's trial: Including the first English translation of Melchior Inchofer's Tractatus syllepticus*. Notre Dame, IN: University of Notre Dame Press; Fantoli, A. (2005). The disputed injunction and its role in the Galileo's trial. In E. McMullin (Ed.) *The Church and Galileo*. (pp. 117-149). Notre Dame, IN: University of Notre Dame Press.

Galileo led him into a trap? Was the pope more upset by the affair than had been presumed?

Perhaps Galileo supported other heresies that the court did not wish to make public. Some have proposed that Galileo's ideas on the substance of things as described in his 1623 book *The Assayer* were contrary to the church's doctrine of transubstantiation and therefore heretical.[25] However, whether these ideas contributed to the outcome of the trial remains only speculation.[26]

The tribunals of the Inquisition did not follow the same principles as courts of law: "In a theological state, man is not innocent until proved guilty. Much the reverse, he is presumed guilty and God or the authorities alone can know how much."[27] The very fact of having been arraigned before the Inquisition meant that heresy had been discovered, and all that remained was for its extent to be precisely determined.

The sentence of the court was severe. In 1633 Galileo was forced to abjure his heresies and was condemned to prison. However, this imprisonment took the form of house arrest. Although Galileo's dialogue was placed on the Index of prohibited books, it was smuggled out of Italy, translated into Latin and published in Holland in 1638.

(v) Creating Theory

How did this revolution in the way we conceive the heavens occur? When did the accepted way of looking at things no longer work? Where did the new theories come from? Scientists collect new data, but they have often no clear way to discern what they mean.

> The progress of Science is generally regarded as a kind of clean, rational advance along a straight ascending line; in fact it has followed a zigzag course at times almost more bewildering than the evolution of political thought. The history of cosmic theories in particular, may without exaggeration be called a history of collective obsessions and controlled

[25] Redondi, P. (1983, translated R. Rosenthal, 1987). *Galileo heretic*. Princeton, NJ: Princeton University Press; White, M. (2007). *Galileo antichrist: A biography*. London: Weidenfeld & Nicolson.

[26] Ferrone, V., & Firpo, M. (1986). From inquisitors to microhistorians: a critique of Pietro Redondi's Galileo eretico. *Journal of Modern History, 58,* 485–524.

[27] de Santillana, G. (1955). *The crime of Galileo*. Chicago: University of Chicago Press. (p 227-228).

> schizophrenias; and the manner in which some of the most important individual discoveries were arrived at reminds one more of a sleepwalker's performance than an electronic brain's.[28]

New concepts are created by melting down the frozen structure of accepted theory so that some new fusion of ideas can take place. Arthur Koestler was particularly taken by analogies between the process of scientific discovery and the attainment of mystic vision:

> Every creative act – in science, art or religion – involves a regression to a more primitive level, a new innocence of perception liberated from the cataract of accepted beliefs. It is a process of *reculer pour mieux sauter,* of disintegration preceding the new synthesis, comparable to the dark night of the soul through which the mystic must pass.[29]

Many of the cosmologists of the 16th century tended to mysticism. Copernicus derived his ideas more from love of geometry than attention to data. He proposed that the universe was spherical because the sphere was the perfect geometric shape.[30]

Johannes Kepler was even more in thrall to geometry. In his *Mysterium Cosmographicum* of 1596 he interpreted the orbital distances of the planets from the sun in terms of the five Platonic solids. These are solid shapes with faces that are congruent regular polygons. Thus the cube has six equal square faces, and the dodecahedron has twelve pentagonal faces. Kepler proposed that the spheres in which the planets revolved around the sun were separated from each other by an interposed Platonic solids. The shapes did not actually exist in space. However, the relative distances between the orbits could not be explained in any other way. The orbital ratios formed the signature of God on his creation. The model was as beautiful as it was meaningless, as irrelevant to science as his later work on the elliptical nature of the planetary orbits was essential.

Once a theory was proposed, how was it accepted or rejected? A theory must not only fit the data from which it was derived, but must also be compatible with other areas of belief. Here was the great sticking point for the heliocentric

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[28] Koestler, A., (1959, later reprint with new preface, 1968). *The sleepwalkers: A history of man's changing vision of the universe*. Harmondsworth, Middlesex: Penguin Books. (p.11). *Reculer pour mieux sauter* means "stepping back to take a better leap."

[29] ibid., p 529

[30] Copernicus, N. (1543). *De Revolutionibus Orbium Coelestium*. translation available at http://www.webexhibits.org/calendars/year-text-Copernicus.html

theory of planetary motion. The Holy Scriptures were accepted as the word of God and they appeared to contradict Copernicus. In 1615, when Bellarmine reviewed the work of Copernicus, he wrote

> For there is no danger in saying that, by assuming the Earth moves and the sun stands still, one saves all of the appearances better than by postulating eccentrics and epicycles; and that is sufficient for the mathematician. However, it is different to want to affirm that in reality the sun is at the center of the world and only turns on itself, without moving from east to west, and the earth is in the third heaven and revolves with great speed around the sun; this is a very dangerous thing, likely not only to irritate all scholastic philosophers and theologians, but also to harm the Holy Faith by rendering Holy Scripture false.[31]

Galileo's astronomical findings were based on telescopic observations. The mountains and craters on the earth's moon, the movements of Jupiter's moons, and the changing phases of the planet Venus are not visible to the naked eye. Learning to look through a telescope takes time. All perception requires learning and experience. Many of Galileo's contemporaries were unable to see the phenomena that he described, even when they looked though the same telescope.[32]

Even if we saw what Galileo saw, we would still have had to believe that the telescope provided a veridical view of the heavens. The argument that Galileo's telescope distorted reality becomes apparent when his pictures of the moon are compared to modern photographs (as in Figure II.2). Galileo's pictures are not topographically correct. The mountains and the craters he sketched are exaggerated impressions rather than exact representations.[33] Nevertheless, proving that the moon was not perfect did not require an accurate mapping of its imperfections.

Some of the discussions at the time of Galileo's trial concerned issues surprisingly similar to our modern concerns about underdeterminism in science. Today we worry that multiple theories might explain the same set of

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[31] Bellarmine, R. (1615/1989). Letter to Father Paolo Foscarini. In M. Finocchiaro (Ed.) *The Galileo Affair. A Documentary History*. (pp, 67-69). Berkeley, CA: University of California Press.

[32] Feyerabend, P. (1975, revised 1988). *Against method*. London: Verso (Chapter 9).

[33] Gingerich, O., & Van Helden, A. (2003). From occhiale to printed page: the making of Galileo's Sidereus Nuncius, *Journal for the History of Astronomy*, 34, 251-267

data; in the days of Galileo, these ideas were expressed in terms of God's ability to make the world in whatever way he pleased.[34]

Insightful though he was, Galileo could sometimes be mistaken. Galileo's dialogue attributed the tides to the motion of the earth around the sun. On this point he was completely wrong: tides are caused by the gravitational attraction between the oceans and the moon.

Galileo's research also highlights the problem of handling contradictory evidence. If the earth moves round the sun, the relative positions of the stars should change, a phenomenon called "stellar parallax." Galileo tried to demonstrate this but failed.[35] The stars were further away than he thought, and the parallax he was seeking was beyond the resolution of his telescope. However, Galileo did not know this. Should the absence of stellar parallax have disproved his theory? Scientists tend to hold to theories despite negative evidence. Provided a theory is supported by the weight of the evidence, we wait to see if we can find an explanation for the discrepancy before we abandon the theory.

(vi) Play of Science

Bertolt Brecht wrote three versions of his play *The Life of Galileo*.[36] The first was written in 1938 in during the time of the Nazi Party in Germany. The second version, written in English in collaboration with the actor Charles Laughton, was produced in Los Angeles in 1947. The context for this production was the recent dropping of the atomic bombs on Japan. A final German version of the play was produced in Cologne in 1955. The context for this final version was the security hearings for J. Robert Oppenheimer in 1954.

The play is generally faithful to the science and the history although it changes the sequence and setting of the events to make for better theater. As Eric Bentley says in his introduction to the 1947 version,

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[34] de Santillana, G. (1955). *The crime of Galileo*. Chicago: University of Chicago Press. (p 222).

[35] Graney, C. M. (2008) But still, it moves: tides, stellar parallax, and Galileo's commitment to the Copernican theory *Physics in Perspective*, 10, 258–268.

[36] Brecht B. (1947, English version by C. Laughton, with introduction "The science fiction of Bertolt Brecht" by E. Bentley, 1966). *Galileo.* New York: Grove Press; Brecht B. (1955, translated by J. Willett, with an introduction by J. Willett and R. Mannheim, 1980, reprinted, 2008). *Life of Galileo*. New York, NY: Penguin Books.

> History can be (or appear to be) chaotic and meaningless: drama cannot. Truth may be stranger than fiction; but it is not as orderly. Or as Pirandello stated the matter: the truth doesn't have to be plausible but fiction does.

The play stresses the sociological effects of Galileo's new ideas. The perfect order that had existed when man lived at the center of God's universe went hand-in-hand with the hierarchy of society. As the universe was arrayed from heaven to earth, so was society from king to peasant. The new idea that the earth was not the center of the universe could easily give birth to anarchy. A key scene in Brecht's play is that of the carnival balladeer who sings

> Good people, what will come to pass
> If Galileo's teachings spread?
> No altar boy will serve the mass.
> No servant girl will make the bed.

In the 1930s, the new idea was communism rather than heliocentrism. Just as the church of the 16th century was terrified by atheism, the rich of the 20th century were frightened by egalitarianism. Communism became the heresy of modern times.

The play, however, also comments more generally on the relationship between the individual and authority. Authority was exerted by the church in the time of Galileo and by the Nazi party in the time of Brecht's youth. In their introduction to the last version play, Willet and Mannheim suggest that Soviet communism was another example of authority:

> The parallels are too clear: the Catholic Church is the Communist Party, Aristotle is Marxism-Leninism with its incontrovertible scriptures, the late 'reactionary pope' is Joseph Stalin, the Inquisition the KGB.

Brecht, however, seemed blind to these comparisons, being more concerned with similarities between the Inquisition and the Committee on Un-American Activities of the US House of Representatives.

The climax of the play comes when Galileo recants. The humiliated Galileo is then rejected by his pupil Andrea who exclaims, "Unhappy the land that has no heroes." Galileo replies, "No. Unhappy the land where heroes are needed."

The next scene occurs many years later when Andrea visits Galileo. Galileo has survived. He has saved himself, and he has continued his science. He has outwitted the Inquisition and kept a hidden copy of his new book on mechanics and motion. What he lacked in courage he made up for in cunning. Andrea is given the book to smuggle out of Italy for publication. Nevertheless, Galileo broods on what he has done, and laments that scientists have become the lackeys of those in power:

> Had I stood firm the scientists could have developed something like the doctors' Hippocratic oath, a vow to use their knowledge exclusively for mankind's benefit. As things are, the best that can be hoped for is a race of inventive dwarfs, who can be hired for any purpose.

This bitter speech, which only occurs in the later versions of the play, was triggered by the invention and detonation of the atomic bomb. In his own notes about the play, Brecht considered Galileo's refusal to stand by the truth as the "original sin" of modern science. The atomic bomb was "the end-product of his contribution to science and his failure to contribute to society."[37]

(vii) Separate Magisteria

The major consequence of the trial of Galileo was the separation of science from the church. Scripture no longer played any part in the evaluation of scientific theories. Theories became accepted by how well they fit the data, how simply they did so, and how well they withstood testing. For a while, scientists tried to show how their findings were compatible with the Bible. However, instances wherein the Bible was clearly incompatible with the empirical evidence came to be interpreted metaphorically.

The church nevertheless held to its authority to interpret scripture and to create doctrine. At the same time that the Roman Catholic Church was proposing the doctrine of papal infallibility at the First Vatican Council of 1870, the American philosopher Charles S. Peirce was describing how science depended on "fallibilism."[38] Religion makes statements that are only subject to the test of faith; science makes statements that are falsifiable and subject to rejection or modification on the basis of further research. Science finds its strength in basic uncertainty rather than in absolute truth.

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[37] Brecht B. (1955, translated by J. Willett, with an introduction by J. Willett and R. Mannheim, 1980, reprinted, 2008). *Life of Galileo*. New York, NY: Penguin Books. Galileo's comments are quoted on p. 123)

[38] Blackwell, R. J. (2006). *Behind the scenes at Galileo's trial: Including the first English translation of Melchior Inchofer's Tractatus syllepticus*. Notre Dame, IN: University of Notre Dame Press; Peirce, C. S. (1897/1931). Fallibilism, continuity, and evolution. In C. Hartshorne & P. Weiss (Eds.). *The Collected papers of Charles S. Peirce. Volume 1. Principles of Philosophy* (pp. 58-72). Cambridge, MA: Harvard University Press.

Nevertheless, many have claimed that science has become hidebound and incapable of viewing the world other than through accepted theories. Koestler criticized the conservatism of modern science.[39] He gave as examples of the hubris of science: the refusal to consider the possibility of telepathy, and the inability of scientists to consider that the universe serves a purpose. In fact, science has considered telepathy, and found no evidence for it in controlled studies.[40] The problem of purpose, however, remains a major difference between science and religion. Science goes from beginning to end, and finds no evidence for causes that occur after the fact. Time does not work in reverse. Religion describes a universe that is drawn toward fulfillment.

Galileo's trial was not formally reconsidered by the Roman Catholic Church until 1980, when Pope John-Paul II set up a commission to evaluate the actions of the Inquisition. The council held many meetings and deliberations, but could not come to any conclusion.[41] A key issue was the idea that at the time of the Inquisition there was no way to determine whether Galileo's scientific theories or the Church's interpretation of the scriptures was correct. Later findings favored Galileo. However, given the state of knowledge in 1632 and the sociological context, the Church had a "right to make mistakes."[42] The commission concluded that, "Galileo had not succeeded in proving irrefutably the double motion of the earth – its annual orbit round the sun and its daily rotation on its polar axis."[43] The commission had failed completely to understand the way science works: nothing is ever irrefutable.

In an address to the Pontifical Academy of Sciences in 1990, John Paul II terminated the commission and summarized the *Lessons of the Galileo Case*.[44]

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[39] Koestler, A., (1959, later reprint with new preface, 1968). *The sleepwalkers: A history of man's changing vision of the universe*. Harmondsworth, Middlesex: Penguin Books (Epilogue).

[40] Shermer, M. (2002). *The Skeptic encyclopedia of pseudoscience*. Santa Barbara, Calif: ABC-CLIO

[41] Drake, S. (1983). Galileo and the church. *Rivista di Studi Italiani, 1*, 82-97; Coyne, G. V. (2005). The church's most recent attempt to dispel the Galileo myth. In McMullin, E (ed.) *The Church and Galileo*. (pp. 340-359).Notre Dame, IN: University of Notre Dame Press; Finocchiaro, M. A. (2005). *Retrying Galileo, 1633-1992*. Berkeley: University of California Press.

[42] Finocchiaro, M. A. (2005). *Retrying Galileo, 1633-1992*. (p. 348).

[43] Poupard, P. (1990). Galileo: report on papal commission findings. *Origins,* 22, 374-375.

[44] John-Paul II (1990). Lessons of the Galileo Case. *Origins,* 22, 370-374.

He agreed with Galileo's interpretation of the scriptures and faulted the theologians who had opposed him. He deplored the trial's effects:

> From the beginning of the Age of Enlightenment down to our own day, the Galileo case has been a sort of "myth," in which the image fabricated out of the events was quite far removed from reality. In this perspective, the Galileo case was the symbol of the Church's supposed rejection of scientific progress, or of "dogmatic" obscurantism opposed to the free search for truth. This myth has played a considerable cultural role. It has helped to anchor a number of scientists of good faith in the idea that there was an incompatibility between the spirit of science and its rules of research on the one hand and the Christian faith on the other. A tragic mutual incomprehension has been interpreted as the reflection of a fundamental opposition between science and faith. The clarifications furnished by recent historical studies enable us to state that this sad misunderstanding now belongs to the past.

He noted that Galileo was correct in his interpretation of the universe and hoped that the religion and science might work together:

> There exist two realms of knowledge, one which has its source in Revelation and one which reason can discover by its own power. To the latter belong especially the experimental sciences and philosophy.

The pope thus paved the way for a Christian dialogue with science. Indeed, in modern times the Roman Catholic Church has been far more amenable to science than fundamentalist Protestant churches who believe that the earth was created in six days some six thousand years ago.

Using ideas that derive from the pope's "two realms of knowledge," Stephen Jay Gould proposed his concept of "non-overlapping magisteria" (NOMA).

> [T]he net, or magisterium, of science covers the empirical realm: what is the universe made of (fact) and why does it work this way (theory). The magisterium of religion extends over questions of ultimate meaning and moral value. These two magisteria do not overlap, nor do they encompass all inquiry (consider, for example the magisterium of art and the meaning of beauty). To cite the old clichés, science gets the age of rocks, and religion the rock of ages; science studies how the heavens go, religion how to go to heaven.[45]

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[45] Gould, S. J. (1999) *Rocks of ages. Science and religion in the fullness of life*. New York: Ballantine Books. A magisterium is a domain of authority.

The last epigram goes back to before the time of Galileo, who actually quoted it in his letter to the Grand Duchess Christina: "The intention of the Holy Ghost is to teach us how one goes to heaven, not how heaven goes."[46]

More recent developments, however, have not been so insightful. Cardinal Joseph Ratzinger, later to become Pope Benedict XV, considered different interpretations of the Galileo trial, and described the limitations of scientific enquiry, pointing out that, according to relativity, heliocentrism is no more correct than geocentrism.[47] Ratzinger quoted Paul Feyerabend, an agnostic and scientific anarchist:

> The church at the time of Galileo was much more faithful to reason than Galileo himself, and also took into consideration the ethical and social consequences of Galileo's doctrine. Its verdict against Galileo was rational and just.[48]

Ratzinger thus absolved the Inquisition because geocentrism was (and still is) a justifiable position, and because Galileo's findings could have severely disrupted society. These arguments from relativity (in physical science and in sociological context) sound incongruous in the speech of a professed absolutist.

The church could indeed have judged Galileo's theory as unproven, and decided to maintain the traditional view so as not to disrupt the social order. Yet the Inquisition's judgment did not mention the ethical and social consequences of the new theory. It simply stated that Galileo was wrong and prohibited his book from further consideration.

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[46] Drake, S. (1957). *Discoveries and opinions of Galileo*. Garden City, NY: Doubleday (Anchor Books). (p.186).

[47] Ratzinger, J. (1994). *A turning point for Europe? The church in the modern world: assessment and forecast.* San Francisco: Ignatius Press. (pp. 95-100).

[48] Feyerabend, P. (1975, revised 1988). *Against method*. London: Verso; McMullin, E. (2008). Quoting Feyerabend on Galileo. *Irish Theological Quarterly*, 73, 164-173.