Chapter 1

The Importance of Cosmology in Culture: Contexts and Consequences

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Additional information is available at the end of the chapter

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Abstract

Scientific cosmology is the study of the universe through astronomy and physics. However, cosmology also has a significant cultural impact. People construct anthropological cosmologies (notions about the way the world works), drawing in scientific theories in order to construct models for activities in disciplines, such as politics and psychology. In addition, the arts (literature, film and painting, for example) comment on cosmological ideas and use them to develop plot lines and content. This chapter illustrates examples of such work, arguing that scientific cosmology should be understood as a significant cultural influence.

Keywords: cosmology, culture, politics, psychology, literature, film, space travel

1. Introduction

Modern scientific cosmology is valuable in itself for what it reveals about the nature of the cosmos we inhabit [1]. It is a demonstration of the power of modern science to transform our understanding of who we are and where we came from. However, most cosmologists focus on scientific questions and are not fully aware of the impact of cosmological theories on culture, including politics and the arts. This chapter introduces this wider context on the basis that both scientists and the public should be aware of the broader importance of their work and its influence on the way we think. Cosmologists often rely on the fascination the subject brings: as Rowe observed in his textbook way back in 1968, 'In the fields of astronomy and cosmology we live in a period of excitement' [2]. Cosmology therefore both impacts culture and is described and represented by it. This chapter explores some ways in which this happens. As Muriel Rukeyser wrote, 'The universe is made of stories, not of atoms' [3]; see also Impey [4].

If we select four fundamental causes of changes in our perceptions of the world in the last century, then they would be first relativity, second quantum mechanics, third the expanding universe and fourth, the space programme. The first three date from a fairly narrow time band, if we date special relativity from 1905, general relativity from 1915, that the universe is expanding and is much bigger than previous thought from Edwin Hubble's publications from 1924 to around 1930 and quantum mechanics from Niels Bohr and Werner Heisenberg's formulation of the Copenhagen interpretation in 1925–1927 [5]. This epic revision of scientific knowledge of underlying structures of the universe was therefore concentrated into just a quarter of a century. The dramatic period of the human space programme was concentrated into just over 8 years from the first human space flight in 1961 to the Moon landing in 1969.

All have fundamentally altered the way that we think about life here on Earth. Often these changes are taken for granted. For example, mobile phone technology, dependent as it is on satellite networks, is transforming not only the social lives of teenagers in the west, but also the economic muscle of poor farmers across the third world. Meanwhile, super-fast quantum computing makes use of phenomena such as entanglement and is driving the development of artificial intelligence, and hence of robotics. The implications for society over the next few decades are potentially enormous. The most important conclusion to be drawn from this combination of revolutionary changes is the role of the observer: as the basis of differing perspectives of time and space in relativity, an influence on the world (at least, at the sub-atomic level) in quantum mechanics, and the witness for the first time, of the spherical earth, hanging in space, in photographs taken by Apollo astronauts in 1968. Such ideas and experiences have decisively underpinned modern ideas that one person's complete individual experience or perception is as equally valid as anyone else's. Einstein is held particularly responsible for these ideas [6, 7] as a result of popular equations between relativity on the one hand, and cultural relativism (the idea that no one culture is superior or inferior to another) on the other. Moral relativism (the idea that no one culture is morally superior or inferior to another) is controversial and widely rejected, but cultural relativism does have beneficial scholarly consequences. This is especially the case in the new field of cultural anthropology in which academic rigour requires that in order to better understand other cultures, researchers must abandon any idea that one culture is superior or inferior to another.

2. Defining cosmology

The term cosmology can be traced to the 1730s, although its appearance in a scientific sense dates from only after the Second World War [8]. The *logos*, which is the root of 'logy', means 'an account', so that, as a preliminary working definition, cosmology is simply 'an account of the cosmos'. The primary Latin equivalent of the Greek *Kosmos* is *Universus*, from *Unus verto*, or 'changing into one', thereby suggesting unity. We can divide the definitions of cosmology into two: the scientific and the anthropological. The scientific are perhaps the more familiar, but even here there is variation. Scientific definitions range from the narrow, such as 'the study of the universe' [9], to the broad ('the science, theory or study of the universe as an orderly system, and of the laws that govern it; in particular, a branch of astronomy that deals with the

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structure and evolution of the universe') [10]. The idea that cosmology is synonymous with astronomy is widespread [2, 11]. Yet the relationship between astronomy and cosmology is not settled, and Hawley and Holcomb [9] argue that cosmology is a separate discipline, which combines features of both astronomy and physics. There are other places where disciplines overlap. For example, astronomy has to include geophysics precisely because the Earth itself is in space [12].

Anthropological cosmologies are based on the proposition that ideas about the cosmos are integral part of human cultural and social systems. For example, the archaeologist Timothy Darvill talks of a cosmology as being, 'The world view and belief system of a community based upon their understanding of order in the universe' [13]. George Gumerman and Miranda Warburton argued that '… to truly comprehend a culture we must have some sense of its cosmology – the group's conception of themselves in relation to the heavens' [14]. And without diminishing the scientific status of modern cosmology, ideas do not come from theory and experiment alone, but can be inspired by wider cultural influences, as Holton [15] illustrates in relation to Einstein's reading and education before he formulated the theory of special relativity. Heisenberg [16] actually argued that science and art are parallel attempts to describe the world, and may both be part of a wider cultural picture. Bell [17] then talks of 'complex subsystems of cosmic exchange' which underpin mundane systems of behaviour, such as socio-economic exchange, but are designed to reinforce individual and social existence within the cosmos.

3. Defining cosmology

The philosopher Terry Eagleton concluded, '"Culture" is said to be one of the two or three most complex words in the English language' [18]. A good working definition, though, is offered by the anthropologist Clifford Geertz, who argued that culture is 'an historically transmitted pattern of meanings embodied in symbols, a system of inherited conceptions expressed in symbolic forms by means of which men communicate, perpetuate and develop their knowledge of and attitudes toward life' [19]. The influence of cosmology on culture then becomes a matter of exploring its impact on political and religious ideas, and its use in the arts, perhaps mainly in literature, painting and film. Michael Rowan-Robinson wrote that 'the intellectual horizon of the human race at any time has always been inextricably bound up with the scale of the universe… there can be little doubt that a people's perceived scale of the universe must play a fundamental role in its culture and consciousness' [20]. He could equally have said that culture and consciousness are bound up with conceptions of the universe as a whole. It was Einstein himself who made the case for the cosmologist intervening in culture. In 1936 he wrote, 'the physicist cannot simply surrender to the philosopher the critical contemplation of the theoretical foundations' of the universe, and 'the critical thinking of the physicist cannot possibly be restricted to examination of his own field. He cannot proceed without considering critically a much more difficult problem, the problem of analysing the nature of everyday thinking' [21]. Mostly the cosmologist does not intervene directly in modern culture. Instead other people interpret and represent cosmological ideas.

4. Politics

Cosmology has had a substantial impact on political theory and continues to do so. We can therefore talk about 'political cosmology' [22]. The earliest recorded societies used the stars or planets to represent their rulers or guide their actions, functions which tended to overlap with religion. The Egyptians and Inca saw their rulers embodied in the Sun, the Chinese in the Pole Star, and in Babylon the chief god, Marduk, was represented by Jupiter. On a practical level, most pre-modern cultures structured their religious sanctuaries, and sometimes their urban communities, according to their conceptions of the cosmos. Hence we may speak of 'cosmopolises' or 'cosmograms'. A 'cosmic state' is one in which the entire state is organized to embody the structure of the cosmos.

The significant step into modelling politics on the cosmos as an organised system was taken by the Greek philosopher Plato (ca. 428/7?–348/7). Plato's cosmos emanated out of a single consciousness which existed in a realm of unchanging eternity. The material world was then an imperfect representation of the world of Ideas (Plato spoke of the physical world being embedded in the world-soul) and was governed by time, the mathematically regulated, harmonious rhythms measurable by the motions of the planets. Plato's mathematical universe provides a rationale for scientific speculation to the present day [23, 24].

Plato advocated an education emphasising such subjects as music, mathematics and geometry, and a political system based on rule by philosophers, all designed to harmonise society with the cosmos, for the common good. This concept of the perfect society underpins the entire history of utopianism down to the present day. There were two main consequences of Plato's system, with consequences down to the present day. First, the perfect ruler was envisioned as the Philosopher King, whose right to rule was justified by his wisdom and understanding of cosmic principles. Second, the system tended to be authoritarian because, being founded on cosmic principle, it could brook no opposition. Plato's ideas were revived in Renaissance Europe and were to become extremely influential. The notion of human history as the progressive unfolding of the world soul towards a final, perfect condition was central to the ideas of Georg Friedrich Hegel (1770–1831). Hegel's influence on Karl Marx (1818–1883) led the twentieth century philosopher of science, Popper [25], to see Plato's thought as the foundation of modern totalitarianism: where Plato influenced Marx, via Hegel, was in the notion that history has an inescapable trajectory, founded in the structure of the cosmos itself. For revolutionary Marxists, such as Lenin, Stalin and Mao Tse-tung, it was then inconceivable that anyone could oppose their rule, for to do so was to oppose the cosmos.

Separate to the platonic strand in European political cosmology, the astronomical discoveries from Copernicus onwards all helped shape western politics. Copernicus' argument that the Sun, not the Earth, is the centre of the universe (or the solar system as we would now say) was attached to the ancient idea that the Sun is associated with kings. It was then used to support claims that, just as the entire universe orbits the Sun, so the whole of society orbits the king [26]. Propaganda in support of absolute monarchy then reached its height in the iconography of the French king Louis XIV. Such authoritarian ideas were directly countered by what I have called Political Newtonianism [22]. This held that, just as Newton had argued that one law

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governed the whole universe, so the same principle must apply to terrestrial affairs and one law must govern the whole of human society. In principle, then, all people were equal, and there was no justification for monarchy. Such ideas were influential among both the American revolutionaries of 1776 [27] and the French in 1789.

Newtonianism was taken one step further by Auguste Comte (1798–1857), the founder of sociology. Adding Galileo and Kepler to Newton as sources of authority, Comte [28] argued that if the entire universe was a mathematically regulated mechanism, so human society must also be governed by the same principle. If planets moved in mathematically determined patterns, Comte reasoned, so must people. By collecting and analysing data on human behaviour, Comte concluded, the same laws that controlled the wider universe should be discovered in human affairs. And in turn the state, governed by experts who were the modern equivalent of Plato's philosophers, could be managed for the good of all. This remains the foundation of twenty-first century sociology.

There have been a few attempts, for example, to identify Einsteinian relativity either as a form of political discourse, or to draw political implications from it. As far as the former is concerned, I refer to the French feminist and social theorist Luce Irigaray who has identified the theory of relativity as a political rather than scientific formula [29]. Sokal and Bricmont [28], meanwhile, noted how the notion of relativity in time and space was used by postmodern theorists in order to advocate cultural relativity on the grounds that, if the universe has no single centre, neither does culture.

The anthropologist Falzon [30] has defended multi-sited ethnography against the charge of lack of depth by arguing that it takes into account shifting perceptions of space and time. The anthropologist Marcus [31] refers to 'space-time compression', in which the essential difference between space and time contracts in light of the recognition that both are socially produced as a result of what Falzon calls 'a product of interrelations'; Marcus derived his understanding from special relativity, and so directly from his understanding of Einstein. Elsewhere, Einstein's call for humanity in general to take on the implications of the new cosmology has been used to advocate a collaborative global order in which international problems are solved thought global institutions rather than war [32].

5. Psychology

The consequences of Newtonianism (the belief that the entire universe is mathematically regulated) permeate western thought wherever there has been a search for a universal law based on supposedly hard data. Psychology is a prime example. When the word 'psychology' was coined around 1800, it was thought that, since Newtonian science explained everything that exists and occurs in the material world, there could and should be just one science explaining what exists and occurs in the psychological world. As Gilbert Ryle wrote, '"Psychology" was supposed to be the title of the empirical study of "mental phenomena"', a counterpart to Newtonian celestial mechanics [33]. Concepts such as normality and deviation have dominated some of the major schools of western psychology, their roots in Newtonian cosmology's

devotion to predictable order unrecognised and forgotten. The measurement and mathematical analysis of the human mind then became the basis of much psychiatry and academic psychology. Even the notion developed by Sigmund Freud (1856–1939), that psychic—or psychological—material can be 'repressed', as if by some kind of downward pressure, is derived from Newtonian mechanics through the influential German physicist Hermann von Helmholtz (1821–1894) [34]. The goal of Freudian psychoanalysis is for the patient to become aware of such repressed material through the so-called talking cure, the conversations which take place during sessions with the psychoanalyst, thus releasing in downward pressure.

Freud's student C.G. Jung opened a radically different strand of thought in modern psychology which is highly influential in many schools of psychotherapy and counselling practiced in society as a whole, although usually outside the academic system. Jung revived the Platonic theory that everything in the world is a manifestation of an original pure idea or archetype. Jung's system, known as analytical psychology, adheres to a kind of archetypal philosophy in which all psychological types correspond to an archetype, such as the eternal youth (the puer aeternus), anima (female principle) or senex (wise old man), which exist in the collective unconscious, Jung's update of the Platonic world-soul. The aim of Jung's therapeutic model is for the individual to become truly themselves by recognising the role of the archetypes in their lives and, in effect, understanding their true connections to the cosmos. The idea that one can become one who truly is also relates back to Aristotelian cosmology in which it was thought that the four elements (fire, earth, air and water) all try to find their natural place in the world. This, Aristotle thought, was why flames go up to the sky, where fire belongs, and water falls to the ground, because that is where it finds its natural home. In Aristotelian politics, kings are at the top of society and peasants at the bottom, because that is the natural state of affairs; in Aristotelian psychology every individual then has a natural way of being. Jung, though, was equally concerned with the latest science, and formed a collaboration and friendship with the quantum physicist Wolfgang Pauli (1900–1958) [35]. Together they formulated the concept of synchronicity by which meaningful events are connected because they take place at the same time, without any causal connection [36]. Newtonian psychology—the belief that all mental states can be measured—survives in university departments and psychiatry. But in the wider world, where increasing numbers of people seek counselling and psychotherapy, Einstein is taken as the inspiration for the argument that therapists and analysts must be 'less concerned with the basic nature of time and more with the human experience of it' [37].

6. Literature and film

One of the major genres of writing in western culture goes under the name 'celestial journey literature', derived from ancient texts on the soul's journey. The soul's journey was secularised in Dante's (1265–1321) 'Divine Comedy' [38]. Inspired by Plato's myth of Er, Dante is guided by the poet Virgil and his love, Beatrice, through the spheres of Hell, Purgatory and Paradise (Hell and Purgatory are structured in spheres analogous to the spheres on which the planets and stars orbit). The last great example of the celestial journey of the soul or a dream world was Johannes Kepler's 'Somnium', an account of lunar astronomy written in 1608 but published in 1634,

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and sometimes referred to as the first work of science fiction. The genre took a decisive step forward in Francis Godwin's 'Man in the Moon' [39], published in 1638. Like Dante, Godwin used his story to describe the structure of the cosmos, now, after Johannes Kepler and Galileo, rejecting the planetary spheres and challenging the Aristotelian idea that all things have their natural place. Godwin departed from the old idea of a journey of the soul or a dream world. Instead, his hero, Gonzales, flies to the Moon carried by giant geese. From Godwin onwards the celestial journey becomes physical, arriving at the Moon rocket in Jules Verne's 1865 novel, 'From the Earth to the Moon'. Verne's book was one of the inspirations for what may be the first space film, Georges Méliès' 'Le Voyage dans la Lune'—in English 'A Trip to the Moon'—after which astronomy and cosmology have a regular presence in film culture [40]. In Méliès' film, the astronomers encounter the inhabitants of the Moon, known as Selenites, in what is clearly a parable for European colonialism: the film was released midway through the so-called 'Scramble for Africa', the final face of the European take-over of Africa from the 1880s to 1914. From Méliès on, the major celestial journey novels have often been filmed. Perhaps the most famous is Stanley Kubrick's film of Arthur C. Clarke's '2001: A Space Odyssey'. Clarke's meta-physical story is vividly portrayed first through the transition from ape to human, and then, in the final scene, the transformation of the dying astronaut into the star child. Accompanied by the stirring music of Wagner's 'Also sprach Zarathustra', Kubrick created a vivid evocation of both ancient beliefs in the soul's ascent to the stars and modern ideas that human destiny may take us to realms beyond our current imagination.

While celestial journey films can be enjoyed as simple adventures, they often contain deeper meanings. The 1951 movie 'The Day the Earth Stood Still' exploited the current public interest in Flying Saucers. Released at a time when the Cold War was reaching its height with the conflict in Korea, the story featured a wise alien who arrived from space in order to reveal to humanity the error of its ways. The rejection of the alien's words of wisdom presented a gloomy view of humanity as incapable of solving its problems. Cosmology, through film, then becomes a means of commenting on societal change. 'Star Trek', the biggest celestial journey TV franchise of them all, was launched in 1966. 'Star Trek' was altogether more sophisticated than 'Lost in Space' and was entirely more optimistic. It is set in a utopian future in which there is one world government, collaborating with other worlds through United Federation of Planets, and money has been abolished. In the crew's adventures, the European voyages of the fifteenth and sixteenth centuries are replayed in a universe of an infinite number of galaxies, except that now alien cultures are to be respected and preserved rather than conquered and destroyed. The values espoused by the Federation were American: freedom from tyranny, freedom of expression and respect for minorities. Compared to 'Star Trek', the blockbuster film franchise, 'Star Wars', launched in 1976 and still going strong forty years later, projects into space a simpler version of the endless struggle for freedom against an evil empire, very much an update of anti-Nazi war films. In all such cases the cosmos is seen as a blank slate, a tabula rasa, on which human concerns are imposed.

There is a constant strand of literary comment on cosmology in the nineteenth century. Edgar Allan Poe (1809–1849), often known as the author of the first detective novel, wrote a remarkable work which he called 'Eureka' [41], deliberately suggesting an imaginative breakthrough in the understanding of the cosmos. Poe realised that in a Newtonian universe the stars are

likely to collapse in on each other, and that therefore the universe must be evolving [42]. Thomas Hardy (1840–1928) was as fascinated by cosmology as Poe, but unlike him lived to see the publication of Darwin's 'Origin of Species' in 1959 (when he was just 19). For Hardy evolution was a reality. He combined his encyclopaedic knowledge of myth, astronomy and cosmology into a 'moral astrophysics' [43] which provided the background for the individual conflicts and tragedies in novels such as 'Far from the Madding Crowd' (1874) and 'Tess of the d'Urbervilles' (1891/1892). Virginia Woolf (1882–1941) used Edwin Hubble's discovery of the expanding universe in the 1920s as a metaphor for personal and political insecurity in the 1930s. In Woolf's view, as we all live together on the same delicate, vulnerable planet in a vastness of space, it is incumbent upon us to live together rather than fight [44]. The Marxist playwright Bertolt Brecht (1898–1956) looked back to an earlier cosmology but equally wanted to illustrate a modern point in his 1938 play, 'Galileo'. His portrayal of Galileo as the heroic intellectual defending Copernicus, struggling against an obscurantist Inquisition (inaccurate because many in the senior Catholic hierarchy were Copernicans), was an allegory of the revolutionary struggles of the 1930s.

One of the other familiar tropes derived from modern cosmology is time travel, a topic rarely dealt with in 'Star Trek', in spite of the regular use of faster-than-light travel. There is now a considerable literature which draws on Gerald Feinberg's 1967 paper 'Possibility of faster-than-light particles', which proposed the existence of the tachyon [45]. This hypothetical particle, the tachyon, might as Martin Rees [46], says alter the order of events, if a signal from a tachyon arrived before it was sent. The genre's earliest notable example was Wells' novel 'The Time Machine' (1895) [47]. Wells coined the phrase time machine to describe a time-travelling vehicle which moved because the fourth dimension was of time rather than space. Wells was a utopian socialist and his main preoccupation was to explore varieties of human society, considering whether progress inevitably resulted in human improvement: it's clear that he didn't think that this was the case, and that ignorance and superstition could easily flourish in the future. Neither does 'Dr Who', the most successful TV time travel franchise, explain how it is possible to travel to the distant past or future. The time machine, the TARDIS (short for Time and Relative Dimensions in Space), is bigger inside than outside and references Einstein by referencing relativity in its name. The Doctor himself is increasingly represented as a lonely figure, destined to exist in perpetual sadness caused by the death or departure of his companions.

The concept of alienation is developed by Alan Lightman in his 'Einstein's Dreams' [48], a journal set in 1905—the 'annus mirabilis' when Einstein developed the theory of Special Relativity. Lightman's character experiences the alienation of a world in which any particular point in space-time is delicate, temporary and liable to vanish, an 'exile in time' [48]. In a later entry, Lightman's diarist writes 'There is a place where time stands still. Raindrops hang motionless in air. Pendulums of clocks float mid-swing' [49]. At the centre of space-time nothing moves. The concept that all time exists simultaneously actually has a long lineage. It is central to Plato's cosmology, occurs in the Bible (Ecclesiastes 3.15), and was elaborated by St. Augustine (V.9) in the fifth century [50]. He described a universal paradox whereby even if a future event in our individual lives already exists, it depends on an act of our free-will in order to take place. T.S. Elliot, impressed by Einstein, combined the lessons of relativity with

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Plato, Ecclesiastes and Augustine. Following Einstein's English visit in 1921, the year he won the Nobel Prize, Elliot wrote, 'Einstein the Great has visited England (and) has taken his place in the newspapers with the comet, the sunspots, the poisonous xxx-jellyfish and octopus at Margate, and other natural phenomena' [51].

In two poems composed in the 1930s, and published in 1941–1942, Elliot considered the conundrum of time for the human condition. In 'Burnt Norton' he wrote that 'All time is unredeemable', for if the past exists in the future and the future exists in the past, all possibilities are eternally present, and in 'East Coker' he wrote the famous line 'In my beginning is my end' [52]. Elliot's speculations on time were shared by Priestly in such metaphysical plays as 'Time and the Conways' (1937) and, perhaps his most famous work, 'An Inspector Calls' (1947), in which a detective from the future extracts confessions of guilt for a poor girl's suicide from a comfortable middle class family. Priestley's immediate inspiration was Dunne's [53] work on time, which drew on Einstein (a cautiously supportive note was included by Arthur Eddington in the appendix to the third edition) in order to explain why the future could be predicted by precognition.

The popular end of such speculation is best represented by the collected works of Philip K. Dick (1928–1982). Like Elliot, Dick was inspired by ancient philosophy and modern science, especially the conclusions of quantum mechanics as expressed in Heisenberg's uncertainty principle and Erwin Schrȍdinger's famous thought-experiment with the cat (1935), ideas responsible for modern multi-verse theory. If one cannot tell both where a particle is and where it is travelling to, whether it is even a particle at all (or a wave), and how far the act of observing it has altered its state, how can one ever trust what appears to be real. For example, in the 'The Cosmic Puppets' (1957), an ordinary suburban couple return to their hometown after a gap of several years to find that everyone and everything has changed, and nobody recognises them. The novel then shifts into a traditional religious mode, located in the Zoroastrian (Persian) struggle between the good god Ormazd and his evil rival Ahriman. Eventually Ormazd triumphs, the illusory world created by Ahriman is removed, and reality returns. In Dick's award-winning counter-factual history, 'The Man in the High Castle' (1962), the ability of the observer to act on—and change—the material world is described via the lead characters' use of the Chinese oracle, the I Ching, to alter the future.

Dick's intensity is absent from the most whimsical of recent cosmological fiction, that of Italo Calvino (1923–1985). Calvino took cosmological ideas and exaggerated them until they were absurd. His short story, 'The Form of Space' (2002), points out that if one fell in curved space, one would logically fall for ever, while 'the Distance of the Moon' imagines a time in the distant past when the Moon was closer to the Earth, close enough for people to jump up to it and gather such delicacies as Moon-milk.

7. The visual arts

Representations of the sky, stars or cosmos in visual form date back to the Stone Age and are familiar throughout the ancient world. They may be symbolic, as in Egyptian

astronomical-ceilings, or take on human form, as in Roman images of planetary deities. Later they might be decorative, as in Renaissance star maps, or attempt accuracy, as in modern star maps, or be entirely abstract, as in twentieth century surrealism. The Sun and Moon make regular appearances in western painting, as one would expect. The cosmological statements, though, are often simple. Often the Sun and Moon are poetic additions, symbolising time or heaven in medieval and Renaissance art, casting light or embodying the power of nature, and even serve as political satire in the nineteenth century [54]. Cosmological changes encouraged the new spirit: the philosopher Berlin [55] argued that the astronomical revolution's abandonment of the old crystalline planetary spheres in favour of a universe without boundaries encouraged the emergence of the chaos and adventurism of Romantic art. Painting began the shift towards the abstract with the extraordinary work of Joseph Turner, who drew on both esoteric wisdom and the latest science in his portrayal of light [56, 57]. Perhaps the most famous example of nineteenth century astronomical art is van Gogh's 1889 masterpiece 'The Starry Night', a painting partly inspired by the pre-dawn rising of Venus, but easily interpreted as representing the swirling chaos of van Gogh's inner world.

The relationship between modern art movements and science is complicated by many artists' multiple affiliations. For example, many notable early twentieth century painters were followers of Theosophy, a spiritual teaching highly indebted to Plato, Renaissance alchemy and Freudian psychoanalysis, all of which could deal with unseen realities and the interdependence of all things in the cosmos. It is therefore not easy to distinguish scientific influences on twentieth art from mystical or magic ones and it is up to art historians to interpret [58]. However, it is clear that the new physics encouraged the move towards radical, abstract forms of expression. Heisenberg's uncertainty principle appears to have supported the playful, apparently chaotic, practices of Dada, in which nothing is quite as it seems. When Marcel Duchamp (1887–1968) displayed a urinal in 1917 he was making a radical statement that, if art is not what one imagines it is, neither is anything else.

André Breton (1896–1966), the poet and author of the Surrealist Manifesto, singled out Einstein (along with Freud) as significant in 1922. J.W. Dunne's adaptation of Einstein to precognition and psychology was popular with the surrealists, as it as with Priestley. That the observer stands at the centre of time and space, as popular conceptions of relativity and quantum mechanics assume, underpins the playful juxtaposition of images and ideas, sense and nonsense, which runs through the entire history of modern abstract and conceptual art. When Joan Miro paints a picture such as 'Dog barking at the Moon' (1926), he is alluding to ideas that the Moon makes one mad— lunatic—as well as departing significantly from naturalism, but also raising a smile.

A separate strand of painting drew on mathematical conceptions of the universe, as did Duchamp's earlier painting 'Nude Descending a Staircase' (1912), or Man Ray's (1890–1976) geometrical models, such as 'Polyèdres' (1934–1936). The distinctive angular lines of Picasso's painting were also decisively influenced by the idea of multi-dimensional mathematics as explained by Miller [59]. By contrast, the whirling lines in Max Ernst's '…sur le plan de la Physique' (1943) evoke the spinning of atoms. And for Klee [60], writing in 1920, movement in painting was essential because everything in the universe is characterised by motion.

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Perhaps the most famous portrayals of the new physics are Salvador Dali's (1904–1989) paintings of bent clocks as representations of distorted space-time, as in 'The Persistence of the Disintegration of Memory' (1952).

8. Space flight

It is well understood that the photographs of the whole Earth taken by the Apollo astronauts encouraged concepts of the global village, a world devoid of racial divisions, religious schism and political boundaries [61, 62]. The first major use of the Apollo photographs was on the cover of the first Whole Earth Catalogue in 1968, placed there by the editor, political activist Stewart Brand. Subsequently, the photographs became an inspiration for the emerging environmental movement.

Since 1968/1969 we have been able to look down on our sky from space. The euphoric consequences of this experience, still enjoyed by a few hundred people, was named the 'Overview Effect' by Frank White in 1987 [63]. Interviewed on BBC Radio 4's iPM programme on 25 May 2013, the astronaut Geoff Hoffman described his own experience of the effect [64]. He recalled the strange sensation of looking down at the Earth, watching the terrestrial sky from above instead of from below, witnessing the flash of lightning storms and streaks of light as meteors plunged into the atmosphere. He saw the world as one, drawing salutary ecological lessons from the visible deforestation of tropical areas. Inspired by the ethereal nature of the Earth's halo, Hoffman hesitated to use the word 'spiritual', put to him by his interviewer in a leading question, but was happy to describe the condition he experienced on his mission as being a 'state of grace', words which he said had been suggested to him by a Jesuit priest. Shamans, Pharaohs and Platonic souls may have seen the Earth in their imaginations, but astronauts experience it physically.

The 'Overview Effect' has been institutionalised in the Overview Institute, whose purpose is to utilise the Effect for the common good. The Institute's apocalyptic and utopian agenda draws a direct connection between the experience of space travel and the need to save the Earth: 'We live at a critical moment in human history. The challenges of climate change, food, water and energy shortages as well as the increasing disparity between the developed and developing nations are testing our will to unite, while differences in religions, cultures, and politics continue to keep us apart. The creation of a 'global village' through satellite TV and the Internet is still struggling to connect the world into one community. At this critical moment, our greatest need is for a global vision of planetary unity and purpose for humanity as a whole' [65]. In this sense, the institute completes the earlier visions of Virginia Woolf and Stewart Brand.

9. Conclusion

Modern scientific cosmology needs to be valued not just for what it tells us about the universe, but for how what it tells us informs the ways that people think and behave in wider culture. A

number of themes emerge, including the vastness of space as a metaphor for loneliness and insecurity, and the new physics as a source of freedom and adventure. Scientific cosmology's wider significance needs to be more widely acknowledged, for modern society still benefits from 'complex subsystems of cosmic exchange' between scientists —cosmologists—and the general public.

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