A SHORT HISTORY OF THE FOURTH DIMENSION

by

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Introduction

The issue of whether space has more than three dimensions is rather like the perennial question: does God exist? Whatever the answer, how could we ever hope to find higher dimensions for ourselves? If one or more do exist, how could we know that they did if, as it seems, we cannot experience them directly? Could they be beyond human perception because the brain is programmed to process information carried only by electromagnetic signals propagating in ordinary, three-dimensional space? Are electromagnetic waves themselves the physical effect of a hidden dimension of space? Are higher dimensions undetectable merely because their scale of manifestation is too small even for scientific instruments to measure? Do ghosts, ESP and other alleged paranormal phenomena represent ephemeral intrusions into three-dimensional, brain consciousness from a four-dimensional universe? Perhaps higher dimensions are directions of extension not of matter but of some psychological 'inner space,' awareness of which might not depend upon the possession of a brain. Might they then define an after-life existence? Or the world of the personal or collective unconscious discovered by Carl Jung in his patients' dreams? Or even the states of ecstatic consciousness experienced by the religious mystic?

This article will review the philosophical, psychological and physical connotations that have been attributed to higher-dimensional space. Some thinkers have refused to differentiate between its mathematical and cognitive aspects because they saw a virtue in the subjective quality such a space gives to the universe. This can be demonstrated by the following argument: suppose that space had four dimensions but that human brains were programmed to generate awareness of only one of its four possible three-dimensional cross-sections. Humans with differently programmed brains would perceive different three-dimensional realities even though their experiences refer only to different subspaces of the same, objective, four-dimensional world. Whilst their four-dimensional brains were temporarily programmed in different modalities, humans would not even recognize one another as such, although they would observe the 'shadows' that others cast in their own realities through sharing two of the four dimensions. These shadows might induce them to believe that they had encountered a ghost or an alien from outer space. Now suppose that one type of cerebral programming was, demographically speaking, far more common than the other three. Rather than admit that *their* universe was not unique and that *their* definition of reality was based upon nothing more fundamental than the opinion of the majority, people with this type of brain would feel more inclined to dismiss as worthless hallucinations the visions of the few capable of using on rare occasions other brain modes. Ignorant of the other worlds and their inhabitants, this majority would disbelieve persistent stories told about other realities by the minority, who would be called: 'self-deluded,' 'publicity-seeking fraudsters' or even 'mentally ill.' A false dichotomy would exist in society between, on the one hand, the 'true,' 'respectable' or 'scientific' view of the world accepted by the sensible majority and the 'pseudo-scientific' or 'occult' versions described by the non-conforming minority (psychics and mystics) and their credulous supporters.

Of course, this is only a parable about the perennial schism in society between sceptics and believers of the paranormal. However, many who have tried to reconcile their

opposing views have taken seriously its basic message by embracing the idea of the fourth dimension. This, too, has attracted much popular interest because of its potential to bridge the deep philosophical abyss separating the scientific model of reality and the worlds of the psychic and the religious mystic. After surveying the history of this idea, we shall explain why philosophies of higher dimensions ultimately failed to achieve this ambitious goal of reconciliation. Unconcerned with such issues, physicists have turned in recent years to higher-dimensional theories in order to understand the basic forces of nature — in particular, to so-called 'superstring theory,' which requires space to have nine dimensions, and to so-called 'bosonic string theory,' which requires the space-time continuum to have twenty-six dimensions. Superstring theory is based upon the mathematics of the Tree of Life, which is not only the evolutionary blueprint for humans but also the cosmic blueprint for matter itself. The basic particles of matter making up every atom in the universe are shaped according to the very same 'Image of God' as the first chapter of *Genesis* describes the creation of the human species. In other words, the very basic forms of matter are, themselves, the most rudimentary manifestation of this universal paradigm.

Early Ideas

Why space should have three dimensions is a question that goes back to the Greek philosopher Aristotle (384–322 B.C.E.), who discussed the problem in his *De Caelo* (1). From the commentary of Simplicius and Eustratius (2), the mathematician Ptolemy, who flourished about 150 C.E., is known to have written a study (now lost) of the three-dimensionality of space entitled *On Dimensionality*, in which he argued that no more than three spatial dimensions are possible. The idea that the universe is an ephemeral, shadowy illusion reflecting a higher, eternal world was proposed by Plato in his *The Republic* (c. 370 B.C.E.). According to Plato, behind the facade of reality there is an unchanging world of perfect 'Ideas' or 'Forms' that cast the moulds of all material things. This idealist philosophy became popular in the 17th century in the circle of Cambridge Platonists around Henry More (1614–1687), who was the first to use the term `fourth dimension' in his *Enchiridion Metaphysicum* of 1671, although for More it meant not a dimension of space but the location of Plato's Ideas. It was not until a hundred years later that this term was used in its mathematical sense by the great French mathematician d'Alembert, who made the first published suggestion that time is the fourth dimension in his 1754 article on the dimensions of space in the *Encyclopédie*, edited by Diderot and himself. He attributed the idea there to "un homme d'esprit de ma connaissance," who is thought to have been his fellow mathematician Lagrange, although the latter did not publish such a suggestion until 1797 in his *Théorie des fonctions analytiques*.

Refutation of Euclid

Perhaps the one event in the history of mathematics that led people to question whether space really possessed the properties they had always assumed it to have was the independent discovery by the Russian Nicòlai Lobachevsky (1793–1856) and the Hungarian Janos Bolyai that the geometry of Euclid was not unique. In his famous *Elements* Euclid (330–275 B.C.E.) had assembled a system of geometrical axioms which everyone believed during the next two thousand years was completely logical and absolutely true. However, Euclid himself had recognized that his so-called 'fifth postulate' was merely an assumption that he had never managed to prove. It stated that, given any straight line and a point not on the line, there is only one other straight line passing through the point, which is parallel to that line. Many attempts had been

made over the centuries to prove the fifth postulate rigorously, but none were successful. Lobachevsky and Bolyai challenged the logical necessity of this postulate by constructing between 1826 and 1829 a self-consistent system of geometry in 'hyperbolic space,' which permits an infinite number of straight lines to pass through a point parallel to a given line. This refutation of Euclid — and, by implication, the logical necessity of the existence of a space in which his axioms were true — led the great mathematician Georg Friedrich Bernhard Riemann (1826–1866), in his famous lecture on June 10, 1854 before the philosophy faculty of the University of Göttingen in West Germany, to propose a new kind of differential geometry of spaces with any number of dimensions and curvature. On this revolutionary branch of mathematics, Albert Einstein later based his General Theory of Relativity (1916), which explained the force of gravity in terms of the acceleration felt by objects moving freely in a four-dimensional space-time whose geometry is distorted by gravitating bodies.

Geometry as Convention

The second half of the 19th century saw no rush by mathematicians to consider the geometries of n-dimensional spaces. Some did introduce spaces of higher dimensions, but only to solve particular types of problems in their own work. No one actually thought they might be relevant to the real world. Although the mathematician Möbius had discovered in 1827 that it is possible to turn a three-dimensional object into its mirror image by an appropriate rotation through four-dimensional space (3), only gradually did mathematicians become more interested in the physical properties of four-dimensional figures and space. The reason for this was not the intellectual difficulty of the subject but the widespread debate, raised by the revolutionary discovery of Lobachevsky and Bolyai, over the issue of whether Euclid's axioms were true *a priori*. This argument gave mathematicians and physicists no motivation to explore higher-dimensional geometries.

The idealist philosopher Immanuel Kant (1724–1804) had claimed a century earlier that Euclid's geometry must be true because time and three-dimensional space were not empirical facts but necessary preconditions for the functioning of the human mind: space was 'a pure form of sensuous intuition.' However, the positivist scientist Hermann von Helmholtz argued that Euclidean axioms were valid only in an empirical sense, and he seized upon new non-Euclidean and higher-dimensional geometries as proof of the falsity of Kantian idealism. He even proposed that tests should be made to see whether space has a non-Euclidean geometry, although the great mathematician Carl Friedrich Gauss (1777–1855) and Lobachevsky himself had performed such tests many years earlier — with negative results. Supporters of Kant argued that non-Euclidean geometry was not 'intuitive.' But in his *On the Origin and Significance of Geometrical Axioms*, first given as a speech in Heidelberg in 1870 and later incorporated in the second volume of his *Popular Lectures on Scientific Subjects* (4), Helmholtz used the 'pseudosphere,' an example of non-Euclidean geometry proposed by the Italian mathematician Beltrami in 1868, to prove that such geometries could be intuited, thus refuting the arguments of Kant's supporters. He did not believe, however, it was possible to imagine four-dimensional space. Nevertheless, Helmholtz's example of an intuitive non-Euclidean geometry failed to convince the neo-Kantians, who argued that Beltrami's model provided no real intuition of pseudo-spherical space.

The distinguished French mathematician Henri Poincaré (1854–1912) joined the debate by declaring in 1887 that the axioms of geometry are neither empirical nor true *a priori* but are, instead, *conventions* whose truth it is meaningless to question. He formulated in 1891 his famous illustration (5) of the impossibility of proving the truth or falsity of the hypothesis that space is Euclidean. He argued that, if we measure the angles between

the lines joining three stars and find their sum is not 180º (the Euclidean value), we could either give up Euclidean geometry or assume that light travels in curved instead of straight lines. He believed the latter possibility could neither be proved nor disproved but would be more convenient to adopt than giving up Euclidean geometry. This opinion of the most famous scientist of his day came to be widely accepted until physics began in the modern era of post-Einsteinian cosmology to measure the extent to which terrestrial and astronomical space is curved.

As well as discrediting Kant's argument that space must be Euclidean, Poincaré declared that space need not even be three-dimensional. In an article in *Nature*, December, 1869, Sylvester had spoken of Gauss, Cayley, Riemann, Clifford, Kronecker and other fellow mathematicians as having "an inner assurance of the reality of transcendental space" (6) — a reference to four-dimensional space. Similarly for Poincaré, four-dimensional space was not a geometrical space but a perceptual 'inner space.' In his *The Foundations of Science*, he remarked that "experience does not prove to us that space has three dimensions; it only proves to us that it is convenient to attribute three to it" (7). He also speculated: "A person who should devote his existence to it might perhaps attain to a realization of the fourth dimension" (8). In his *Science and Method* (1908) he wrote: "So the characteristic property of space, that of having three dimensions, is only a property of our table of distribution, an *internal*[*] property of human intelligence, so to speak. It would suffice to destroy certain of these connections, that is to say, of the association of ideas to give a different table of distribution, and that might be enough for space to acquire a fourth dimension." Poincaré was in effect proposing that the three dimensions of space are an illusory property of normal brain consciousness — that the dimensionality of space was a *subjective* property. Regarded by the philosopher Bertrand Russell as the greatest Frenchman of his day (9), Poincaré was an influential popularizer of science and his three major books: *Science and Hypothesis* (1902), The Value of Science (1904) and *Science and Method* were widely read in France during the early years of the 20th century. His contention that our experience of the three-dimensional world was only the product of mental conditioning, destruction of which might lead to perception of a four-dimensional world, would have fascinated radical thinkers and artists in France seeking in their work to overthrow bourgeois notions of reality. Indeed, Poincaré's sympathetic attitude to the fourth dimension influenced members of the Cubist art movement to depict figures seen from several perspectives simultaneously, as if viewed from a fourth dimension of space (10).

Henri Poincaré

Four-dimensional Ghosts?

Fascination with the fourth dimension first emerged in England during the 1870s.

[*] Author's italics.

Johann Carl Friederich Zöllner (1834–1882), professor of astronomy at Leipzig University, visited England in 1875 and met Sir William Crookes, the famous chemist and inventor of the cathode ray tube, who was conducting experiments with the American Spiritualist medium, Henry Slade. Two years later, Zöllner carried out experiments with Slade in which the latter allegedly tied knots in a cord without ever touching it, despite its ends being joined together by a glob of sealing wax impressed with Zöllner's own seal. Leather rings also mysteriously appeared around the column supporting a table whose tripod legs were too wide to thread through them. The scientist taught at the same university where in 1827 the mathematician August Möbius had made the discovery that it would be possible to turn a three-dimensional object into its mirror image by means of a rotation in four-dimensional space. Zöllner was aware of this fact and conducted séances without success in which he hoped that snail shells with a clockwise or anticlockwise twist would be turned into their mirror image by the spirits. Although the results of his experiments were not entirely as he had anticipated, what did happen during his séances was sufficiently remarkable to convince Zöllner that the spirits responsible for these feats must have four-dimensional bodies, so that a fourth dimension of space exists for the soul to inhabit. Predictably, his account (11) of his investigations with Slade failed to convince most scientists. However, Zöllner's views were read by a public that was fascinated by sensational reports of the latest Spiritualist phenomena, and they stimulated wide interest in the fourth dimension. At the same time, however, the increasing association of this idea with the occult cast a certain lack of scientific respectability on the subject, although this only made it all the more attractive to those who had rejected what they saw as the God-less, purposeless universe described by the materialistic science of their day.

Johann Zöllner

Hinton's 'Tesseract'

Another populariser was E.A. Abbott (1838–1926), a Victorian schoolmaster and clergyman who published in 1884 his famous novel *Flatland*. Ostensibly a story about two-dimensional creatures ('Flatlanders') who dare to imagine life in a three-dimensional universe called 'Spaceland' and even a four-dimensional world called 'Thoughtland,' it is really a satire on the class-ridden, male chauvinistic values of Victorian society, as well as being a veiled explanation of mystical experience in terms of journeys to worlds of higher dimensions. Abbott was influenced by the English mathematician Clifford's translation of Riemann's 1854 lecture in the scientific journal *Nature* (1873) and by Charles L. Dodgson, a mathematics lecturer at Oxford University who is better known as Lewis Carroll, author of *Alice in Wonderland* and *Alice Through the Looking Glass*, in which he poked fun at the concept of the fourth dimension and its fascination for the contemporary English reading public.

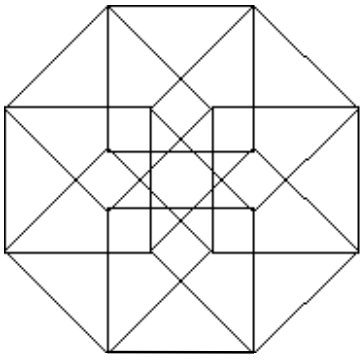

Figure 1. The tesseract, or 4-d hypercube, has 16 corners, 32 edges, 24 square faces and 8 cubic faces, or 'cells.'

A mathematician by the name of W.I. Stringham published in 1880 in the *American Journal of Mathematics* (12) an article containing one of the earliest known sets of

Howard Hinton

illustrations of the projections on a plane of the six regular polyhedroids, or polytopes — the four-dimensional counterparts of the five regular polyhedra: tetrahedron, octahedron, cube, icosahedron and dodecahedron. Figure 1 shows his depiction of the four-dimensional cube, or 'tesseract.' It contains 16 corners, 32 edges, 24 square faces and 8 three-dimensional cells. The mathematician Victor Schlegel went further by producing in 1884 actual models of the polytopes' projections onto three-dimensional space. Many popularisers of 'the fourth dimension' adopted Stringham's depiction of the tesseract. The most influential of these was Charles Howard Hinton (1853–1907). The son of James Hinton, a noted English surgeon and liberal thinker, Hinton obtained his B.A. from Oxford University in 1877 and married Mary Boole, daughter of George Boole, the inventor of the branch of mathematics known as Boolean algebra. Influenced by his father, who championed sexual freedom in marriage, the young Hinton was arrested in 1885 for bigamy and lost his teaching post as science master at the Uppingham School. After serving a token jail sentence of three days, he fled the country with his wife and children for a teaching post at a middle school in Yokohama, Japan. Hinton later taught mathematics at the University of Princeton from 1893 to 1897 and at the University of Minnesota from 1897 to 1900, then worked at the United States Patent Office in Washington, D.C. until his death in April, 1907.

Rather than supporting scientists like Helmholtz who believed that the non-Euclidean geometries of Lobachevsky and Bolyai had discredited Kant's contention that Euclidean geometry is true *a priori*, Hinton gave the philosopher credit for identifying space as the necessary means by which human beings cognise the world. However, instead of accepting the three-dimensionality of perception as an unalterable fact of life, Hinton proposed in his books *A New Era of Thought* (1888) and The Fourth Dimension (1904) that it was merely a temporary feature of man's evolution. He agreed with Kant that the three-dimensionality of space is a necessary condition of man's consciousness. However, it is necessary only to normal awareness. Altered states of consciousness such as those experienced by mystics and psychics acquired four-dimensional perspectives. Four-dimensional space had a mystical significance for Hinton. If not the Unknowable One that mystics spoke of, it was the closest level of this ineffable Reality that the rational mind could approach. He claimed that four-dimensional mental vision could be acquired with sufficient effort — just as Poincaré had speculated earlier. For this purpose, he developed a complex system of mental exercises to visualize the four-dimensional hypercube or tesseract, using multi-coloured cubes as sections of the hypercube. He regarded time as an illusion created by movement in the fourth dimension, and he claimed his method produced a time-ordered vision of the tesseract made up of successive observations of its coloured, three-dimensional cross-sections. However, it is unlikely that readers who purchased his cubes from the publishers of his books ever managed to achieve the experience of four-dimensional vision that he claimed his cubes had given him.

Believing that matter had a very small extension in the fourth dimension, Hinton generalized the famous English physicist Lord Kelvin's theory of atoms as vortex rings in the aether by suggesting that electrically charged particles are four-dimensional vortices in the aether. This brilliant idea of attributing electric charge to the effect of a

fourth dimension of matter was given rigorous, mathematical expression thirty-one years later by the physicist Theodor Kaluza, who tried to incorporate Maxwell's theory of electromagnetism into Einstein's theory of gravitation, as will be discussed later in this chapter. Indeed, it is possible, though unlikely, that Hinton may have *influenced* the young scientist, because his books were published in Russia in 1915 — four years before Kaluza sent his paper on five-dimensional space-time to Einstein. Hinton argued that four-dimensional vision was possible in principle, if difficult to achieve in practice, because the small bits of matter that encode human thought can form four-dimensional patterns. For Hinton the fourth dimension was not merely a mathematical abstraction. It was, instead, a mode of perception at present dormant in human consciousness yet attainable now if one knew how to develop one's mind in the direction of this next stage of human evolution.

The mystical theme running through Hinton's hyperspace philosophy — in particular his view that four-dimensional consciousness was the mental component of mystical experience — attracted the attention of the great American psychologist William James, whose book *The Varieties of Religious Experience* was published in 1902, two years before Hinton's *The Fourth Dimension* appeared. They became friends, corresponding with each other from 1892 to about 1906. In 1904, *The Fourth Dimension* was published simultaneously in London and in New York, where there was already strong interest in the subject, particularly in *avant-garde* circles on the East coast of America. During the 1880s and 1890s, nearly all American articles on the fourth dimension had appeared in scientific periodicals such as *The Popular Science Monthly*, *Science* and *The New Science Review*. After 1900, however, articles began to appear regularly in popular magazines such as *Harper's Monthly Magazine*, *Harper's Weekly*, *Current* Literature and *The Forum*, reflecting a fascination in the occult and mystical aspects of the subject.

Time as the Fourth Dimension

The writer H.G. Wells resurrected d'Alembert's identification of the fourth dimension as time in his science-fiction story *The Time Machine* (1895). He had first encountered the notion of the fourth dimension whilst attending the Royal College of Science from 1884 to 1887 (13), where there was interest in higher dimensions among students. In an early version of his story — in a section omitted from the final text published by *Heinemanns* — he discussed a 'Rigid Universe' with three dimensions of space and one of time. This is an example of the vein of prophetic insight running through Well's writings, for it is remarkably similar to the 'four-dimensional space-time continuum' formulated in 1908 by the Russian mathematician Hermann Minkowski, which became an integral feature of Einstein's Special Theory of Relativity. Wells used the idea of the fourth dimension as time as a means by which his time-traveller could expound Well's social theory. Other writers who used the fourth dimension in a similar fashion were Oscar Wilde in his *The Canterville Ghost* (1891), an irreverent spoof of ghost stories, Charles Dodgson's friend George Macdonald (*Lilith*, 1895) and Joseph Conrad and Ford Madox Hueffer (*The Inheritors*, 1901).

H.G. Wells

Theosophical Interpretations

Although the success of Einstein's theories finally established time as the fourth

dimension, this was always the less important of its two interpretations in the scientific and popular literature of the late 19th and early 20th centuries. For example, the American science magazine *Scientific American* organized an essay competition in 1909 for "the best popular explanation of the Fourth Dimension" (14). None of the entrants referred to time as the fourth dimension. Yet, this was four years after Einstein had published his paper on the Special Theory of Relativity. In the popular imagination, any higher dimension was one of *space*. Hinton's book *The Fourth Dimension*, which was published a year before Einstein's Special Theory, was far more influential in the first two decades of the 20th century, and all the essays in the *Scientific American* competition borrowed heavily from Hinton's work. A major reason for this was the association of the fourth dimension with the occult and the rising popularity of Theosophy during this time. It is ironic therefore that the driving force behind the Theosophical Society — Helena Petrovna Blavatsky — was unenthusiastic about the notion of higher dimensions of space — or at least the naive way it was being used to explain physical phenomena taking place at Spiritualist séances up and down the country. In 1888 — the year in which Hinton's book *A New Era of Thought* appeared — she published her *magnum opus The Secret Doctrine*. Although her work contained a scathing attack on the positivism and materialism of Victorian science, Madame Blavatsky believed the notion of the fourth dimension was irrelevant to the paranormal. She wrote: "The process of natural development which we are now considering will at once elucidate and discredit the fashion of speculating on the attributes of two, three and four or more 'dimensional Spaces;' but, in passing, it is worthwhile to point out the real significance of the *sound but incomplete*[*] intuition that has prompted — among Spiritualists and Theosophists and several great men of Science, for the matter of that — the use of the modern expression, 'the fourth dimension of Space.' To begin with, of course, the superficial absurdity of assuming that Space itself is measurable in any direction is of little consequence. The familiar phrase can only be an abbreviation of the fuller form — the '*Fourth dimension* of Matter in Space.' But even thus expanded, it is an unhappy phrase, because while it is perfectly true that the progress of evolution may be destined to introduce us to new characteristics of matter, those with which we are already familiar are really more numerous than the three dimensions.... Thus, when some bold thinkers have been thirsting for a fourth dimension to explain the passage of matter through matter, and the production of knots upon an endless cord,[†] what they were really in want of was a sixth *characteristic of matter*" (15).

H.P. Blavatsky

C.W. Leadbeater

According to Blavatsky, beyond the properties of matter revealed by the five senses was a sixth one she called 'permeability,' which was revealed by clairvoyance.

[*] Author's italics. These words suggest that Blavatsky did not deny the existence of higher dimensions of space, only their simplistic use by Zöllner, Hinton and others as explanations of mystical and psychic phenomena.

[†] A reference to Zöllner's experiments with the medium Slade.

Later Theosophical writers were less hesitant about linking higher dimensions of space with occult beliefs in heavenly worlds or planes. For example, Charles Webster Leadbeater (1847–1934), who claimed to have visited habitats of the after-life in what parapsychologists would now call 'out-of-the-body-experiences,' related the Theosophical doctrine of higher planes of consciousness to higher-dimensional space, although it is important to emphasize that nowhere in his prolific writings did he identify superphysical realms simply with higher-dimensional space. In his book *Inner Life* (1912) Leadbeater wrote:

"We find ourselves in the midst of a vast universe built of matter of varying degrees of tenuity, which exists in a space of (let us suppose) seven dimensions. But we find ourselves in possession of a consciousness which is capable of appreciating only three of those dimensions, and only matter of certain degrees of tenuity" (16).

In his *The Other Side of Death* (1903), he wrote:

"In effect, in our physical world we know only of three dimensions. It is not that only these three dimensions exist, but that they alone can be understood by the physical brain. In reality, we live in a space possessing a quantity of dimensions. The limits that are imposed on us for comprehending them in different states always exist only in our consciousness and consequently are truly subjective. We see only what we are susceptible to see, but there is much more to see" (17).

These remarks show Hinton's influence on Leadbeater. In fact, *The Other Side of Death*, translated and published in Paris during 1911, provided a quite complete account of Hinton's thought. Leadbeater regarded Hinton's system of exercises for developing four-dimensional sight as a potential aid for Theosophists seeking to develop 'astral vision' — the clairvoyant faculty to perceive things existing in what Theosophists call the 'astral plane,' viz., the after-life. He said: "In physical life we can normally conceive only three, though by careful special training the brain may be educated into grasping some of the simpler fourth-dimensional forms." According to Leadbeater: "The astral consciousness has the power of grasping four of these dimensions," and in his *The Astral Plane* (1895) he remarked:

"... with the assistance of the astral senses, even purely physical objects present quite a different appearance. As has already been mentioned, one whose eyes are fully opened sees them, not as usual from one point of view, but from all sides at once. ... Looked at on the astral plane, for example, the sides of a glass cube would all appear equal, as they really are, while on the physical plane we see the further side in perspective — that is, it appears smaller than the nearer side, which is a mere illusion. It is this characteristic of astral vision which has led some writers to describe it as sight in the fourth dimension — a suggestive and expressive phrase."

Leadbeater claimed (19) that he developed astral sight after spending 42 days of intense, strenuous training in a form of yoga called 'kundalini yoga.' Unlike Hinton, he did not believe that matter was confined to four spatial dimensions. On the basis of the Theosophical doctrine of the seven planes of nature, he speculated that there are seven dimensions of space, the superphysical counterparts of matter existing in the fourth, fifth, sixth and seventh dimensions (20). Nor, for Leadbeater, was astral sight necessarily four-dimensional vision, for it could still be restricted like normal sight to a three-dimensional perspective unless it was developed. On the other hand, his clairvoyant observations made him certain that four-dimensional vision was an awareness of the astral plane because its quintessential quality of experiencing simultaneously all possible perspectives of a three-dimensional object was precisely

one of the characteristics of astral sight that he claimed to have experienced for himself.

Claude Bragdon

Another popularizer of the fourth dimension was the American architect Claude Bragdon (1866–1946). Originally a Theosophist, he was introduced to the idea of the fourth dimension by the writings of Hinton and by his friend Gelett Burgess, art essayist and humorist. He became interested in the philosophical and religious implications of the possible existence of a fourth dimension of space, developing even more mystical views than Hinton's. Under the pseudonym "Tesseract" (the name of the four-dimensional cube), Bragdon entered the 1909 Scientific American essay competition mentioned earlier. He had been impressed by Zöllner's investigations with the American medium Slade, and his entry, "Space and Hyperspace," relied much on Zöllner's ideas. This is undoubtedly a reason why his entry failed to win first prize, for Zöllner's espousal of Spiritualism discredited him in the eyes of most scientists. Bragdon's *Man the Square*: A *Higher Space Parable*, published in 1912, was a religious parable in which humans were likened to living in a two-dimensional world at odds with one another because they were unaware of their higher, Christ-like, existence as cubes. His most important work on the subject of the fourth dimension is *A Primer of Higher Space (The Fourth Dimension)*. Published in 1913, this work contained thirty plates drawn and lettered by Bragdon himself and illustrating most of the popular ideas about the fourth dimension that had emerged from the 19th century. The Theosophist Bragdon mixed Hinton's mystical interpretations with the view expressed by Theosophical writers like Annie Besant that evolution is as much a process of expanding consciousness as it is a bodily survival of the fittest. He remarked: "The whole evolutionary process consists in the conquest, dimension by dimension, of our successive space worlds." Here Bragdon took literally what for Leadbeater was only an association, viz. the idea that the planes of higher consciousness to which man is evolving are *merely* higher-dimensional worlds, each higher plane containing one more dimension.

Claude Bragdon

In August 1914, Bragdon published an article entitled "Learning to Think in Terms of Spaces" in the American magazine *The Forum*. It contained a statement of his belief that consciousness is evolving towards perception of higher spatial dimensions and (echoing Hinton) that time is merely a temporary outward sign of the fourth dimension of space (21). This article was included in his last major book on the fourth dimension, *Four-Dimensional Vistas*, in which he referred (without naming Einstein) to a "Theory of Relativity." His last article on the subject: "New Concepts of Time and Space," published in 1920 in the *avant-garde* periodical *The Dial*, contained a discussion of both the Special and General Theories of Relativity propounded by Einstein in, respectively, 1905 and 1916.

By this date, Einstein's work, in which time assumes the role of the fourth dimension, was being popularised sufficiently to undermine Bragdon's campaign for scientific recognition of a fourth spatial dimension. It never occurred to him to add a fifth, purely spatial, coordinate to Einstein's four-dimensional space-time continuum, as Kaluza had done the previous year. The latter's work, which was destined to be largely ignored by physicists for over fifty years, would have been too mathematical for Bragdon to understand even in the unlikely event that it had been brought to his attention. Despite the fact that time displaced space eventually as the fourth dimension in the public mind,

Bragdon never discarded his belief in a world with four spatial dimensions because it was linked to a spiritual outlook on life that he simply could not forsake. Bourgeois views about consensus reality and their representation in classical art had given way to ferment of radical ideas in the art movements of his time. Artists like Kandisky, Kupka and Piet Mondrian had interests in Theosophy and were exploring the fourth dimension by representing the Platonic forms behind everyday things. Cubists were breaking down the barriers of conventional perspective by painting objects seen simultaneously from several angles in order to express their complete reality. Indeed, the fourth dimension became synonymous with Cubism, as the 1913 International Exhibition of Modern Art in New York bore witness (22). According to Bragdon, artists were developing the "fourth form of consciousness." The American avant-garde avidly read his books, finding in them an eclectic philosophy that suited the cultural *Zeitgeist* because it joined together the general interest in Eastern mysticism that Theosophy was stimulating, the new art movements seeking to express the subjective and spiritual elements of consciousness and widespread interests in the occult interpretation of the fourth dimension.

P.D. Ouspensky

Unlike Bragdon, the Russian P.D. Ouspensky (1878–1947) did not become interested in the philosophical issues raised by the existence of a fourth dimension of space through reading Hinton's books because they were not published in Russia until 1915, four years after his first work on the subject appeared in print. He did, however, read Bragdon's *Man: the Square* before he fled Russia in 1917 (23). Before the Revolution, non-Euclidean geometry rather than n-dimensional geometry, occupied the attention of Russian mathematicians. Zöllner's Spiritualistic experiments, however, had been accepted unreservedly by A.M. Butlerov, the noted Russian chemist, who was an advocate of Spiritualism. As a result, they created popular interest in Russia in the fourth dimension. Ouspensky's interest in the subject stemmed probably from his father, for he recalled in an autobiographical note that his father "had a particular interest in the problem of the Fourth Dimension to which he gave much of his spare time" (24). Like Bragdon, Ouspensky developed an interest in the occult, initially through reading Theosophical literature in 1907. Meeting the philosopher-mystic G.I. Gurdjieff in Moscow in 1915, he collaborated with him periodically for the next nine years, finally dissociating himself from Gurdjieff in 1924. Because he supported the Czarist monarchy, he left Petrograd for the Caucasus a week before the revolution began in the autumn of 1917. In 1921, he settled in London, where, apart from six years spent in New York during World War 2, he lived until his death in 1947.

P.D. Ouspensky

Ouspensky's first book *The Fourth Dimension* (1909) contained no new ideas or original material, being essentially a history of 19th century contributions to the subject. It rejected the mathematician's approach to higher dimensions in terms of extra Cartesian coordinates that supplement the X, Y and Z coordinates of a point in three-dimensional, Euclidean space, arguing that, however elaborate it might be, a purely mathematical understanding of higher-dimensional space could never provide any insight into how it could be experienced in altered states of consciousness. Like Hinton, Ouspensky emphasized the need to develop higher consciousness and regarded the fourth dimension as a spatial one. However, as his own understanding developed, he grew dissatisfied with naive approaches like Hinton's, which attempted to deduce features of

four-dimensional awareness by using lower-dimensional analogies but which never enabled anyone to experience directly for himself this higher state of consciousness. According to his major work *Tertium Organum* (1911) (25), what was needed was the overthrow of dualistic logic itself. This allowed the mind to order three-dimensional experiences and to arrange them neatly into categories, but it blocked access to a transcendental order of reality in which mutually exclusive, logical opposites ceased to exist separately but, instead, were experienced as aspects of an undivided unity. He felt that the fourth dimension was connected not with an unsensed extension of physical matter (as Hinton and others believed) but with the subjective 'inner space' of the psyche. It was also connected with time. Like Hinton, Ouspensky believed that time is a movement in the fourth dimension, declaring, "Time is the fourth dimension of space." The three-dimensional, phenomenal world was a cross-section of the four-dimensional, noumenal world. Whereas physicists, following Minkowski and Einstein, regarded time as a dimension that is perpendicular to the three dimensions of space, hyperspace philosophers like Ouspensky chose still to see this dimension as one of space. He regarded art, not science, as the means to understand the noumenal world behind that revealed by the senses. He declared: "The artist must be a clairvoyant: he must see that which others do not see; he must be a magician: must possess the power to make others see that which they do not themselves see, but which he does" (26). He claimed that mystical experience, or 'cosmic consciousness' (a term which he borrowed from the writings of Edward Carpenter and R. M. Bucke), could be acquired through the activity of art: "Art in its highest manifestations is a path to cosmic consciousness" (27). The noumenal world revealed by cosmic consciousness was a four-dimensional one in which time existed spatially. Timelessness, a characteristic of mystical consciousness, was simply a lack of the mystic's movement along the fourth dimension of space. Tertium Organum (lit. 'third instrument') was the new system of higher logic that reason needs to understand the noumenal world. Named after Aristotle's *Organum* [Instrument (of thought)] and Francis Bacon's *Novum Organum* [New Instrument (of thought)], this logic was inexpressible in ordinary dualistic language. However, its principal axiom was best formulated by the statement: "A is both A and Not A." According to Ouspensky, reality is an undivided unity that splits into duality when consciousness reflects on itself and employs the artificial dichotomies of language. Echoing the Hindu doctrine of *maya*, he declared, as Bragdon had done, that matter, time and the three-dimensional world were illusions.

Writers on the fourth dimension, like Hinton, Bragdon and Ouspensky, converted this mathematical concept into a spiritual philosophy by means of which psychic and mystical experiences could be given what might pass to their readers and followers as rational, quasi-scientific explanations of phenomena beyond the pale of science. But the truth of the matter is that the existence of a four-dimensional universe was for them always an article of faith, unproved by science and unsupported by any evidence other than that of clairvoyants like Leadbeater and psychic researchers like Crookes and Zöllner, who embraced the spiritistic interpretation of paranormal phenomena — kinds of evidence which most scientists regard as inadmissible. A basic weakness of all these speculative attempts to bridge Heaven and Earth was that no well-established theory of matter was then available as something that might be deduced from grandiose, metaphysical schemes such as that devised by Ouspensky. Put simply: how can one understand where Heaven begins if one does not know where Earth (matter) ends? Physics was in a state of crisis at the beginning of the 20th century. All contemporary theories of atoms predicted that they would radiate energy and collapse — a problem that was not solved until 1913 when the Danish physicist Niels Bohr proposed his now

famous model of atoms incorporating principles of the young quantum theory. Although physicists knew that most of the mass of an atom is concentrated in its central nucleus, they knew nothing about its structure other than it contained positively charged particles called 'protons.' It is hardly surprising that scientists regarded the fourth dimension of space then as an unwanted complication to add to their uncertainties. Despite Kaluza's premature attempt (28) to develop this idea, it quickly lost its scientific appeal as physicists' attention turned towards the emerging quantum theory. By the end of the 1920s, the temporal fourth dimension of Einstein's Relativity Theory had largely displaced the traditional spatial connotation in the public mind, although Surrealist artists continued to use the latter as a motif to undermine and subvert bourgeois notions of consensus reality based upon the Newtonian physics of absolute space and time, which they knew Einstein's theories had discredited.

But theories of higher dimensions that seek to go beyond their narrow, mathematical meaning can be little better than the science fiction which originally inspired them if they do not come to grips with the notorious mind-body problem. The work of the early writers only pretended to do this. They were naive, *ad hoc* attempts to reduce to n-dimensional geometry the mystical states of transpersonal psychology and parapsychological phenomena like clairvoyance. Even more recent writers on this topic, like Rudy Rucker (*The Fourth Dimension*, Penguin Books, 1985), continue in the same vein to explore merely its mathematical, scientific and science-fiction aspects and fail to confront the epistemological problems raised by the existence of one or more hidden dimensions of the space-time continuum. Turning God into an infinite-dimensional Hilbert space, as Rucker does in a final speculation, is merely repeating, albeit on a more sophisticated level, Hinton's naive error of reducing the mystics' ineffable One to the properties of four-dimensional space.

In view of the fact that the subject of higher dimensions of space was once discussed only by popular philosophers, writers, occultists and artists, it is ironic that the past few decades has witnessed the concept being taken seriously again by physicists. However, the exciting difference between now and the period 70–100 years ago when it was in vogue is that it is no longer the kind of *ad hoc* hypothesis that it was then. Physicists have shown in a variety of ways that the quantum theory of extended objects called 'strings' *predicts* that space must have either six or twenty-two extra dimensions in order that it can predict sensible (i.e. finite and positive) probabilities for quantum processes obeying the so-called 'conservation laws' of classical physics, which demand that properties like energy and electric charge remain constant during these processes. For the former class of strings (called 'superstrings') space-time must have ten dimensions; for the latter class ('bosonic strings') it must have twenty-six dimensions. Before theories of these two types of strings emerged, physicists had assumed that the basic subatomic particles occupied single points in a space-time of four dimensions. However, this led to mathematical problems that persisted even when this assumption was generalized to space-times of larger dimensionality. As non-point-like objects, strings provide the way out of this theoretical impasse.

Does, therefore, the fourth dimension exist? Yes, according to higher-dimensional theories of gravity and strings. But it exists only on a microscopic scale as one of six (or twenty-two) curled-up dimensions of space. Leadbeater actually described the former (without realising that he was referring to higher spatial dimensions) when he described the *six* higher orders of spirillae making up each 1st-order spirillae in the "ultimate physical atom," or UPA, which is identified here as the subquark state of the $E_8 \times E_8$ heterotic superstring. These six, progressively smaller orders of circular spirillae are the winding of a closed, string-like curve around the circular dimensions of a six-

dimensional, compact space known to mathematicians as the "6-torus" (think of a ring doughnut where every point on a circle wrapped around it lies on another, smaller ring, or torus). The 1st-order spirillae wind 1680 times in a closed, helix, each turn being composed of seven 2nd-order spirilla that wind around a dimension of space that is a circle. *That* is the fourth dimension.

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