Chapter 6.

Mapping light.

> The idea that all the colours of the visible world could be subsumed under the three primaries, red, yellow, and blue, was …derived from the painterly experience of mixing material pigments, rather than from an analysis of the prismatic spectrum, and all these notions allowed Turner to resist the conclusion that colour, even as it is perceived, is simply a function of the action of light on surfaces. [1]
>
> John Gage, 1999. *Colour and Meaning – Art, Science and Symbolism*.

In this chapter I discuss the processes by which art and science reveal the night sky. Paradoxically this space is accessible to us all yet almost completely inaccessible. It can only be accessed through observational and imaging technologies that extend our vision. It is a form of reality taken on trust and from which we create our own realities.Turner's intuition to 'resist the conclusion that colour, even as it is perceived, is simply a function of light on surfaces,' [2] harks back to the beginning of this exegesis where I refer to the problems involved in the representation of nature and our orientation within it. The natural world is continually being remade on the basis of new understandings in art and science. I reiterate the observation in the context of my own work that, unlike scientists, artists are not accountable to demonstrate proof. As the art historian and scientist Kemp suggests:

> [w]hat the artist presents as a final product is an open but not unstructured field for the exercise of the spectators' faculties, blatantly exploiting the subjective impulses that are apparently wrung out of the dry exposition of science.[3]

Our understandings and representations of cosmic space and the relationship between the observer and the observed, have been changed by .the study of light and colour. This has happened in conjunction with discoveries in classical mechanics, and the eventual emergence of the new physics, as well as technologies and phenomena such as electricity, magnetism, and then photography. In both direct and indirect ways these

---

[1] John Gage, *Colour and Meaning – Art, Science and Symbolism*, (London: Thames and Hudson, 1999), p. 165,167.
[2] Ibid.
[3] Kemp, *Visualizations,* p. 6.

technologies have been employed in the making of my work. Scientists today are searching for ways in which to visually represent complex problems and data. Artists however, have always responded to the problems of the representation of complex abstract information in time and space, producing over time diverse visual languages.

The physicalization of celestial space – the secularization of light.

With the rise in the belief of scientific inquiry and the physicalization of celestial space, European culture underwent a scientific revolution that saw its eventual secularization. There was a seminal shift in the orientation of the cosmos with the Copernican revolution, which together with the telescope transformed conceptions of space. Cosgrove observes that:

> [t]he Copernican revolution was secured through the circulation of cosmographic images that challenged ways of imagining and experiencing not only planetary arrangement and movement but the entire cosmic arrangement in which human existence was created and performed. [4]

At the beginning of the modern age the seventeenth century French philosopher, René Descartes, proposed a mathematical, rational and mechanical universe. In this universe the body steps back and separates itself from the cosmos. The motions of matter become the source of knowledge of the external world of phenomena. Kemp notes that Descartes:

> exhibited a particular genius for the demonstration of invisible phenomena in terms of mechanical contrivances… The phenomena and its mechanical visualization were analogous systems of the three prime properties of mechanical systems – magnitude, figure and motion – through which causes and effects were to be analysed. [5]

These phenomena produced sensations over which a totalizing vision of spatial order had to be imposed. One of Descartes' explanatory illustrations, (see figure. 69), is the *Study of the Formation of a Rainbow*, 1637, explaining the formation of the rainbow's colour spectrum. This diagram demonstrates his ability to combine the observation of natural phenomena with the geometry of a 'magnified' raindrop – the water filled glass sphere. Descartes was interested in the operation of the senses, especially sight, as

[4] Cosgrove, *Apollo's Eye*, p. 6.
[5] Kemp, *Visualizations*, p. 39.

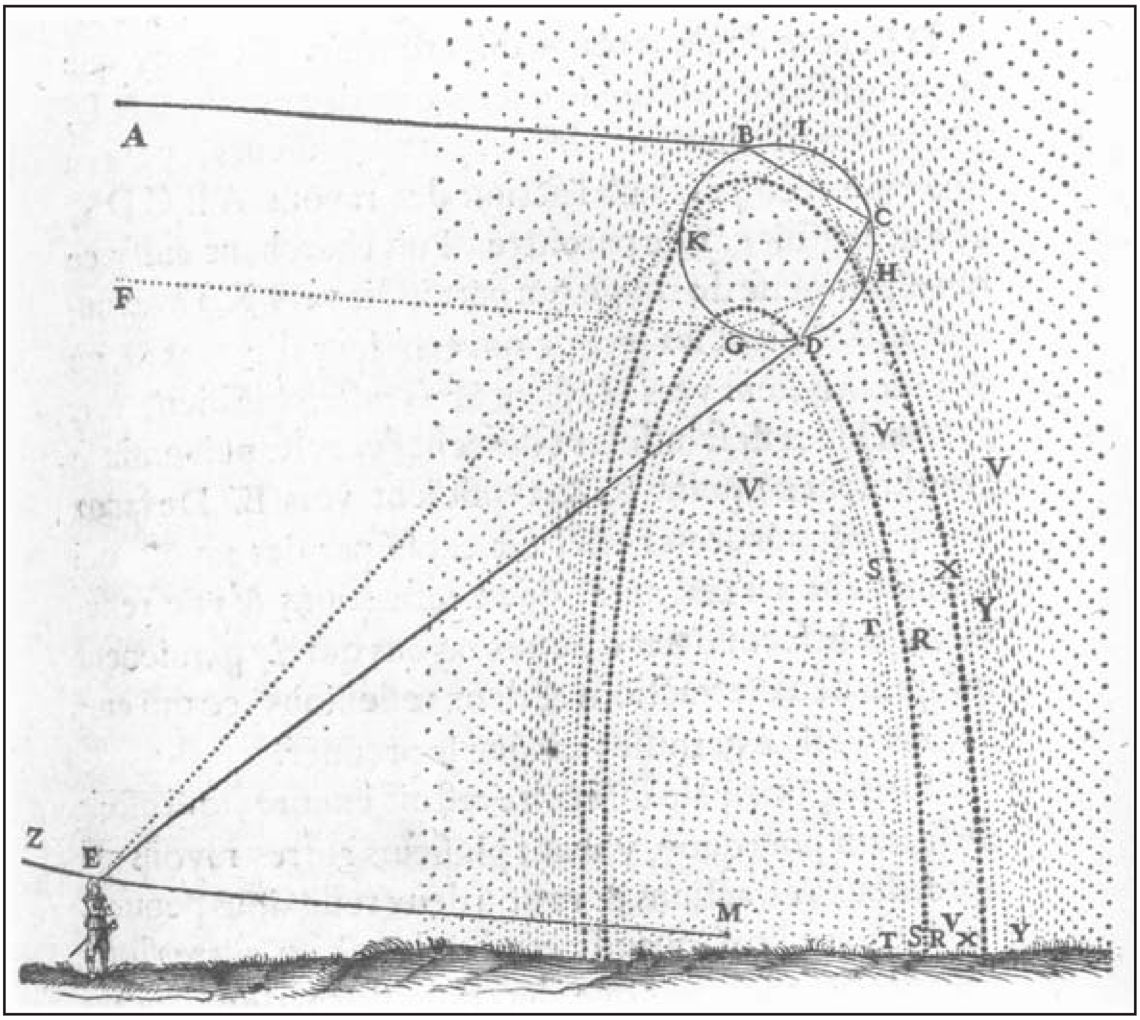

Fig. 69 Rene Descartes, *Study of the Formation of a Rainbow*, 1637, in 'Discours sur la Method', Special Collections Division, University of California Research Library.

the privileged source of direct information about the world, dependent on a coherent spatial frame. Like the measured and ordered graticule beginning to appear on maps at the time, this frame was defined by the Cartesian grid. [6]

Descartes' method of radical doubt however implied that it was possible to throw the whole of our sense experience into doubt. He suggested that we can only be sure of our own existence because it is the 'I' who is doing the doubting. In other words, 'I think therefore I exist.' The influence of this radical and sceptical idea of truth separated the thinking mind from the physical body. Such dualism divided the world into observer and observed, the 'in here' from the 'out there.' It paved the way for the increasing and dominating influence of a rigid scientific determinism. Merleau-Ponty observes that:

> for Descartes … perception is no more than the confused beginnings of scientific knowledge. The relationship between perception and scientific knowledge is one of appearance to reality. It befits our human dignity to entrust ourselves to the intellect, which alone can reveal to us the reality of the world. [7]

Ideas about free will, the role of intuition and the senses were reduced through rational thought to the logic of reason, cause and effect. In this climate there was little room for poets and mystics, for intuition or feeling to temper reason. In contemporary art however an engagement with these aspects of human thinking serves to critique the imposition of scientific determinism.

Using classical mechanics to investigate 'objective' reality, nature was eventually reduced to mathematical relationships by the seminal Enlightenment mathematician and scientist Sir Isaac Newton. Schlain observes:

---

6 Our knowledge of the conceptual foundations of mapping histories in other cultures has been filtered through European eyes. The European emphasis on verisimilitude through sophisticated geometrical and optical knowledge in order to accurately 'represent' space, is very different from the spatial visualizations in non – Western cultures where space is ordered, divided or inhabited in more abstract ways that blur the distance between the observer and the observed. Japanese, Indian and Chinese aesthetics traditionally avoid the kind of scientific representation reflected in the rigidity of the Cartesian perspectival grid. These cultures prefer a spatial order that is based on a subtle network of relationships connecting intervals between objects, and mirrored in psychological life in a more holistic way. Mapping cannot be isolated from its embeddedness in these systems of meaning of which the products and techniques are the manifestations.

7 Merleau-Ponty, *The World of Perception*, p. 42.

> [s]pace and time were a tight intersecting grid where the events of science took place. The investigator (like God) usually sat motionless and observed the external world. …Western European art had also been concerned with the concrete objects of the external world. Perspective distinctly separated the 'I' from the 'it.' Just as perspective was a framework that allowed painters to carry out what the nineteenth century English painter John Constable later called "experiments with nature", so Newton's system was to be a map that made possible an exploration to the edge and beyond. [8]

Newton determined that physical laws were universal laws applying both to the Earth and the heavens. He was able to demonstrate that the 'law of gravity' the single force of gravity, explains how we keep our feet on the earth, the moon revolving around the earth and the planets in an elliptic around the sun, the sun around the centre of the galaxy and the galaxy on its as yet unknown path in the universe. Conceiving the idea of universal gravitation, calculated by the motion of the moon around the earth, Bronowski explains Newton's reasoning:

> [t]he moon was a powerful symbol for him. If she follows her orbit because the earth attracts her, he reasoned, then the moon is like a ball (or an apple) that has been thrown very hard: she is falling towards earth, but is going so fast that she constantly misses it – she keeps on going round because the earth is round. How great must the force of attraction be? [9]

Motivated largely by the desire to improve the telescope, Newton experimented with a camera obscura and a glass prism. He noticed that when sunlight shines through a very small hole through a prism on to a surface in a darkened room, the colours produced separate and fan out into an elongated spectrum as the light is bent or refracted through the glass. Developing the experiment further by re-directing the light through another prism, he realized that the spectrum is not the product of the glass but of the sunlight. He demonstrated that colour is inherent in what appeared to be the white light of sunlight, and is composed of individual colours which he called the colours of the spectrum.

Of interest to me however is Newton's observation that colour is a matter of perception. He wrote, '[i]ndeed (light) rays, properly expressed, are not coloured. There is nothing else in them but a certain power… to produce in

[8] Schlain*, Art and Physics*, p. 70.
[9] Bronowski, *Ascent of Man*, p. 222.

us that sensation of this or that colour.' [10] Schlain explains how our eye and brain process light. In doing so he touches on the recurring dialectic between the idealist and the materialist, the intellect and the senses, the mind and the body. He describes how:

> [t]he retinas of our eyes contain cells called cones that fire upon being stimulated by light of certain wavelengths. The electro-chemical signals from the cones then travel to the rear of our brains to illuminate in technicolour a magical screen on the opposite side of the head from the eyes called the visual cortex. Thus our perception of the colour red and its assignment to the wavelength spectrum of 7,000 angstroms represent two complementary aspects of a truth about colour that unifies the idealists and the materialists. .. Colour is after all light, and though it exists in a specific location within the electromagnetic spectrum, it demands a cone-eyed conscious mind if its chromatic energy is to be known. [11]

In 1987, the contemporary British team of optical engineer Michael Wenyon and the artist Susan Gamble, were exploring light to visualize mental phenomena. Their interest was in the history of astronomy and the way in which we obtain knowledge and collect it. While conducting research for a residency at the National Maritime Museum at Greenwich in the U.K. they looked for material through artistic linkages with the Museum. They produced a work titled *Newton's Rings*, a three colour image of the light formations that Newton observed through his optical experiments. This took the form of a hologram, a mid-twentieth century device that grew out of the study of light. It was mounted on a traditional easel and placed in front of black and white photographic projections of fragments of shelves of books in the Observatory's library. In the exhibition *Space Odyssey* in Japan in 2001 their work, *The Fringes of the Shadows of the Knives, 1987,* (see fig. 70), reproduced another experiment in Newtons *Optics*, and in other works they used archival photographic plates from the Royal Observatory in Edinburgh that revealed the colour and temperature of various stars.

It had been Newton's belief that light was a stream of particles based on the fact that light can be observed to travel in straight lines. At the beginning of the nineteenth century the English physician Thomas Young established that colours correspond to light of differing wave lengths. He performed what has been described as the classic 'two slit' experiment which showed that light

[10] Ben Bova, *The Story of Light,* (Illinois: Sourcebooks Inc., 2001), p. 141.
[11] Schlain, *Art and Physics*, p. 170.

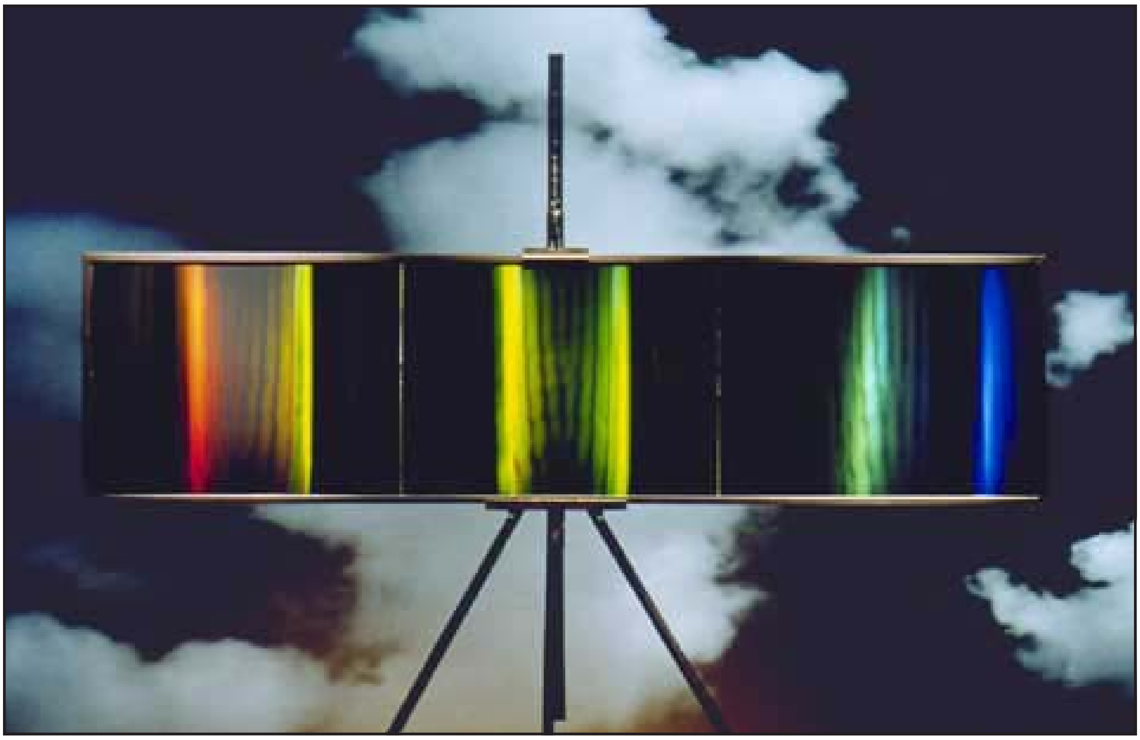

Fig. 70 Wenyon and Gamble, *The Fringes of the Shadows of the Knives*, 1987, hologram, easel, in *Space Odyssey*, Japan.

creates interference patterns like ripples in a pool of water. This established that light must be a form of wave motion. [12]

Concurrently the German astronomer William Herschel found, when passing a thermometer across a spectrum emitted from a glass prism, that the highest temperature came from a zone beyond the red where no coloured light was visible. This zone is now called ‘infra-red’, an invisible form of radiant heat coming from the sun, the discovery of which resulted in a new understanding of the properties of light. It also enabled an exploration of colour and its relationship to the mechanisms of perception, the effects rather than the causes. These reflections stimulated a developing interest by artists and writers in the formation of colour theories. Emphasizing the subjective phenomena associated with colour, in 1810, the German poet Goethe developed *Farbenlehr*’, (theory of colours). This was an artistic and historical reference in which he outlined the history of colour in painting, and refuted Newton’s theory that colour is a function of light alone. Gage suggests that:

> [t]he extraordinary vitality and tension of much nineteenth century colouristic painting derives precisely from the struggle with the intractable ideas and sensations of colour. The Newtonian solution to the problem of an antithesis between ‘apparent’ and ‘material’ colours had thrown the scientific emphasis entirely on to the study of light, and decisively separated the procedures of the laboratory from those of the painter’s studio. [13]

Evidence that the process of perception had become the primary concern of vision was in fact, by the 1840’s, reflected in the work of Goethe, Ruskin and J.M.W. Turner. Turner is recognized as a master painter of the romantic evocation of nature through light and colour. Kemp suggests however that, ’[f]or Turner, scientific awe and such sentiments as poetic melancholy coexisted within a single mental spectrum.’ [14] The camera obscura, as a model for the condition of an observer was collapsing. Natural phenomena as described in classical mechanics were being displaced by new theories. As Crary observes:

[12] For a more detailed description and an image of Turner’s work refer to H. Robin, *The Scientific Image*, New York: Harry. N. Abrams,1992, p. 207.
[13] John Gage, *Colour and Meaning- Art, Science and Symbolism,* (London: Thames and Hudson, 2000), p. 47.
[14] Kemp, *Visualizations*, p. 57.

> Turner's direct confrontation with the sun… dissolves the very possibility of representation that the camera obscura was meant to ensure. His solar preoccupations were "visionary" in that he made central to his work the retinal processes of vision: and it was the carnal embodiment of sight that the camera obscura denied or repressed. [15]

Light and dust.

Turner's floating visions of space, light and colour suggest what he describes as the 'infinitude' of space, as Kemp quotes him, 'the wide concave of the circumambient air.' He continues:

> [th]is phrase should be understood in the context of his intuition that the building of 'Nature' was 'too colossal for the intellectual capacity, its height to measure or its depth to fathom – the Universe and Infinitude.' [16]

Challenging in a paradoxical way Turner's romantic intuition however was Herschel's monumental new sky survey. In the creation of my work *Deep Field* I had the sense of this paradoxical layering of art and science. Underlying this map of floating visions in the depth of the night sky is the emanation of light revealing the measured rationalism of science.

Through his innovative telescopes Herschel's sky survey studied and measured the distribution of stars through space. He counted hundreds and thousands of stars sectioned into minute fields of view and made many detailed, intricate and evocative drawings of various nebulae. On closer observation these were seen to be myriad stars, grouped into huge disc formations as represented in this *Diagram of the Milky Way Galaxy*, 1785. (See fig. 71). Through these investigations and the identification of new planets he was able to demonstrate that the heavens had a depth and scale well beyond that already imagined. Herschel realized that to map the universe in three dimensions it was necessary to work on the principle that stellar distances and stellar magnitude depend on distance from the earth.
Whitfield explains:

> Herschel proposed that the Milky Way held the key to the structure of the Universe, that the universe was a disc shaped mass of stars which we see edge on as the Milky Way. When we look at right angles to the Milky Way

[15] Jonathan Crary, 'Visionary Abstractions,' in *Olafur Eliasson – Surroundings Surrounded*, p. 128.

[16] Kemp, *Visualizations*, 136. For an image of Turner's work see Gage, *Colour and Meaning*, p. 177.

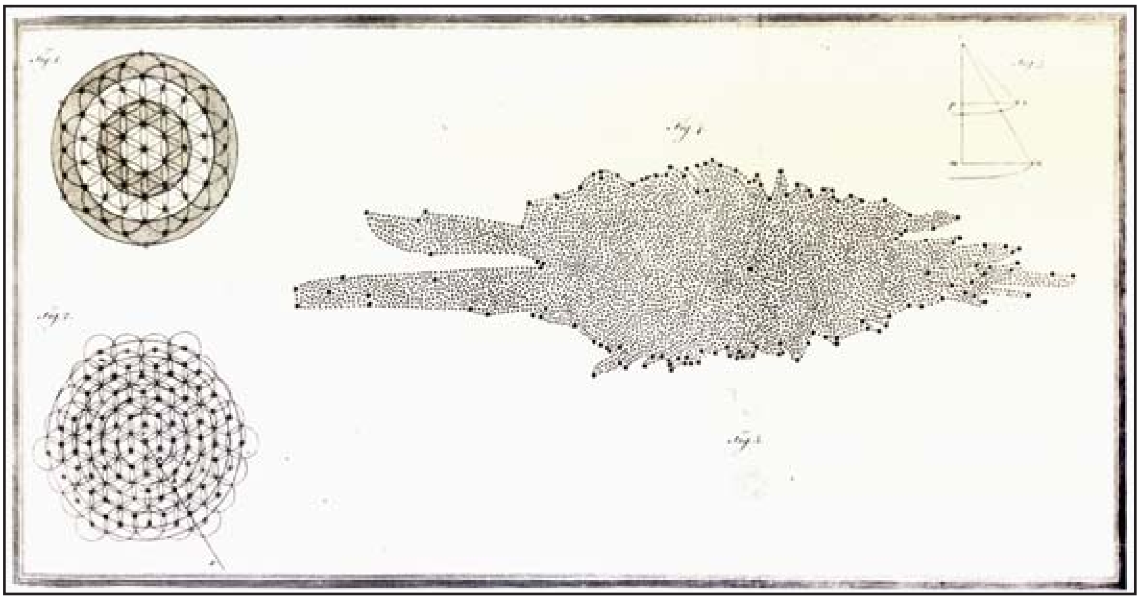

Fig. 71 William Herschel, *Diagram of the Milky Way Galaxy*, 1785, The British Library.

> we are seeing through the thinning edges of the disc towards empty space. [Later however] he perceived that certain of the nebulae, the clouds resembling luminous dust that were far removed from the plane of the Milky Way, were resolvable into myriads of innumerable stars; on his disc model there should be no high star concentrations at those places. [17]

Herschel's belief remained however, that the heavens were contained in a spherical shell at fixed points from earth. It was the astronomer Edmund Halley who challenged the idea of fixed stars when he observed small movements of the stars. This was later found to be the motion of the solar system in conjunction with the stars moving independently.

John Herschel's studies of light, optics and chemistry were crucial to the development of photography. In 1839, Henry Fox Talbot presented his first paper on the subject of photography. He acknowledged his collaboration with Herschel and the contribution that Herschel made to Fox Talbot's understanding of the technology. Humphries notes that:

> [t]he balance between artist and scientist, creator and researcher seems to be integrated in the collaborative research between these romantics/rationalists. It is clear that Talbot and Herschel shared a common interest in surmounting the many technical problems inherent in developing the new medium, and that in order to do this they drew on an eclectic range of skills and understanding. If it is arguable that the mechanical image's role as evidence or fact lends it a veracity which is a fundamental shift from manual image making, then digital imaging, with its facility for photo-realist fantasies and virtual worlds engages the viewer in an indeterminate struggle between what to believe and what to doubt. [18]

I have worked with a range of image making processes through painting, printmaking and photography in a milieu where reproduction technologies and the instant dissemination of information are commonplace. In doing so I look at the inter-relationships between media to both engage with and critique what is meant by reality. Mapping the remote space of the night sky through such technologies is in fact mapping a simulated reality.

Shifting focus – mapping light and the 'Carte du Ciel.'

The advent of photography in the nineteenth century re-positioned the observer and the observed. Touch was fundamental and integral to classical

[17] Whitfield, *Mapping The Heavens*, p. 114.
[18] Tristan Humphries 'From the Virtual to the Physical', in exh. cat. *Transformations Australia – Digital Imaging and the Art Object*, p. 6.

theories of vision. In the seventeenth and eighteenth centuries, there had been a concern to preserve the idea that there must be a unity of the senses involved in perception. The development of virtual viewing devices and technologies, and the priority given to ideas about pure visibility that developed in the nineteenth century meant, Crary observes, 'the unloosening of the eye from the network of referentiality incarnated in tactility and its subjective relation to perceived space.' [19] During the nineteenth century, ideas about representation and the observer's relationship to the visible shifted ground. The focus on geometrical optics moved to a focus on physiological optics. This was associated with the remaking of the subject through the exercise of social power embedded in the processes of mechanization, normalization and standardization. With this came revolutionary notions about the human mind and about time and space, Consequently, the emergence and operation of the photographic camera found the observer situated in a different and changing milieu of representations.

The development of photography during the nineteenth century revolutionized mapping processes in astronomy. As telescopes improved, more and more of the night sky became visible. This remote space was starting to be de-mystified and re-imagined through the lens of a camera as well as the telescope. It was now possible to photograph the planets and, as Whitfield notes, 'the time exposed photographic plate could detect light sources far fainter than the human eye, and it could preserve the image for later study and analysis.' [20] In 1887 in Paris, it was proposed to publish a new *Carte du Ciel*, (map of the sky), mapping the sky using light. It was an *Atlas of the Galaxies*, the first attempt at a vast international astro-photography sky-survey using not only the telescope, but photographic prints and mapping co-ordinates.

Figure 72 pictures a group of photographs of spiral galaxies from the *Atlas of Galaxies Useful for Measuring the Cosmological Distance Scale*, 1988, listed in the *New General Catalogue of Nebulae and Clusters of Stars*, or *NGC*, originally published in 1888.The top left photograph is the *Whirlpool Galaxy* (*NGC 5194/5*), described as a pair of connected galaxies *The Hunting Dogs*,

[19] Crary, *Techniques of the Observer*, p. 19.
[20] Whitfield, Mapping The Heavens, p. 120.

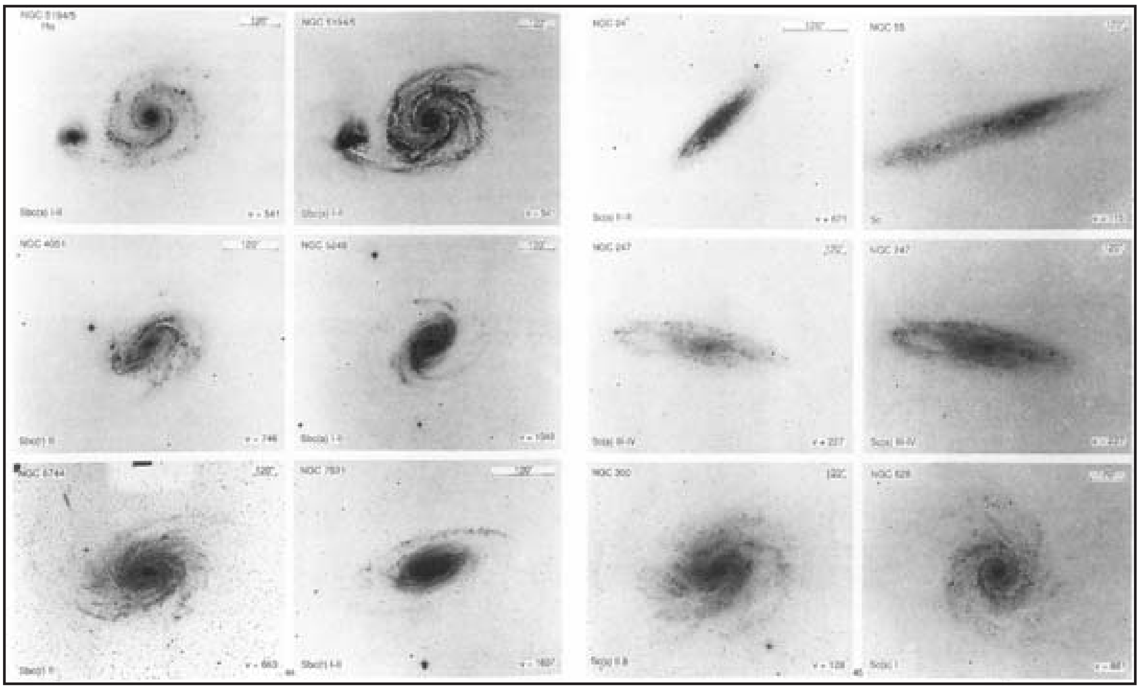

Fig. 72 Alan Sandage and John Blake, *Galaxies Useful For Measuring the Cosmological Distance Scale,* 1988, NASA SP 496, 41 by 52 cm, Library of the Paris-Meudon Observatory.

said to be painted by Vincent Van Gogh in *Starry Night*. c.1880's. As astro-photography improved the night sky extended exponentially as more stars came into view. Whitfield describes the *1954-58 National Geographic Palomar Observatory Sky Survey* that used:

> [a] series of 1,758 plates, each showing thousands of stars reaching down to magnitude 21 (which) expanded the published image of the universe by 25 times.. It carried the observer across a billion light years of space and its stars are as uncountable as those in the sky itself. [21]

Figure 73 pictures a detail of *The Palomar Sky Survey*, (November 28-28th,1951), a photograph, (actual size), taken with a ten minute exposure by a five metre telescope at the Mount Palomar Observatory in California. It covers an area of approximately six degrees. To identify specific objects astronomers use a transparent overlay indicating a catalogue number and symbols that identify the type of object.

The invention of colour printing in the late nineteenth century disseminated information about astral phenomena through maps, images and pioneering photographs. In the 1860's spectroscopy had revolutionized astrophysics and the public were beginning to be curious about the content and colour of the stars. The printer Guillemin produced astronomy images for public consumption, including the 1865 image *The Colour of the Stars,* (see fig. 74), and a highly illusionistic view of the *Night Sky over Paris*. (See fig. 75). Whitfield notes the impact of astro-photography on the public imagination:

> [p]art of the excitement of astro-photography was undoubtedly the ambiguity of some of the new features it revealed. Intense interest in the possibility of life on Mars was aroused by the interpretative drawings based on photographs by Lowell and Schiaparelli. The books of Camille Flammarion in particular, one of the great nineteenth century popularizers, are a heady mixture of science and imagination, photography and fantasy. [22]

---

[21] Whitfield, *Mapping The Heavens*, p. 121. The apparent magnitude of a star is its brightness as seen from earth which is not the same as its actual luminosity. The brighter the object visually, the lower is the designated apparent magnitude. (The absolute magnitude is the apparent magnitude that the star would have if it could be seen from a standard distance of 32.6 light years). The brightest object in the night sky, the full moon is of magnitude – 12.5 and the faintest stars normally visible to the naked eye are of magnitude +6. There are 21 first magnitude stars including Sirius – 1.4 down to Regulus +1.4. Patrick Moore, *The Atlas of the Universe* (Mitchell Beazley, 1981), p. 19, 56.

[22] Ibid., p. 125. Gustav Holst (1874-1934) subsequently composed his work *The Planets Suite for Large Orchestra* , which farewells the nineteenth century, but finds correspondences with the zeitgeist, 'fin de siecle', (*No. 1 Mars, Bringer of War*), and earlier historical trends in music.

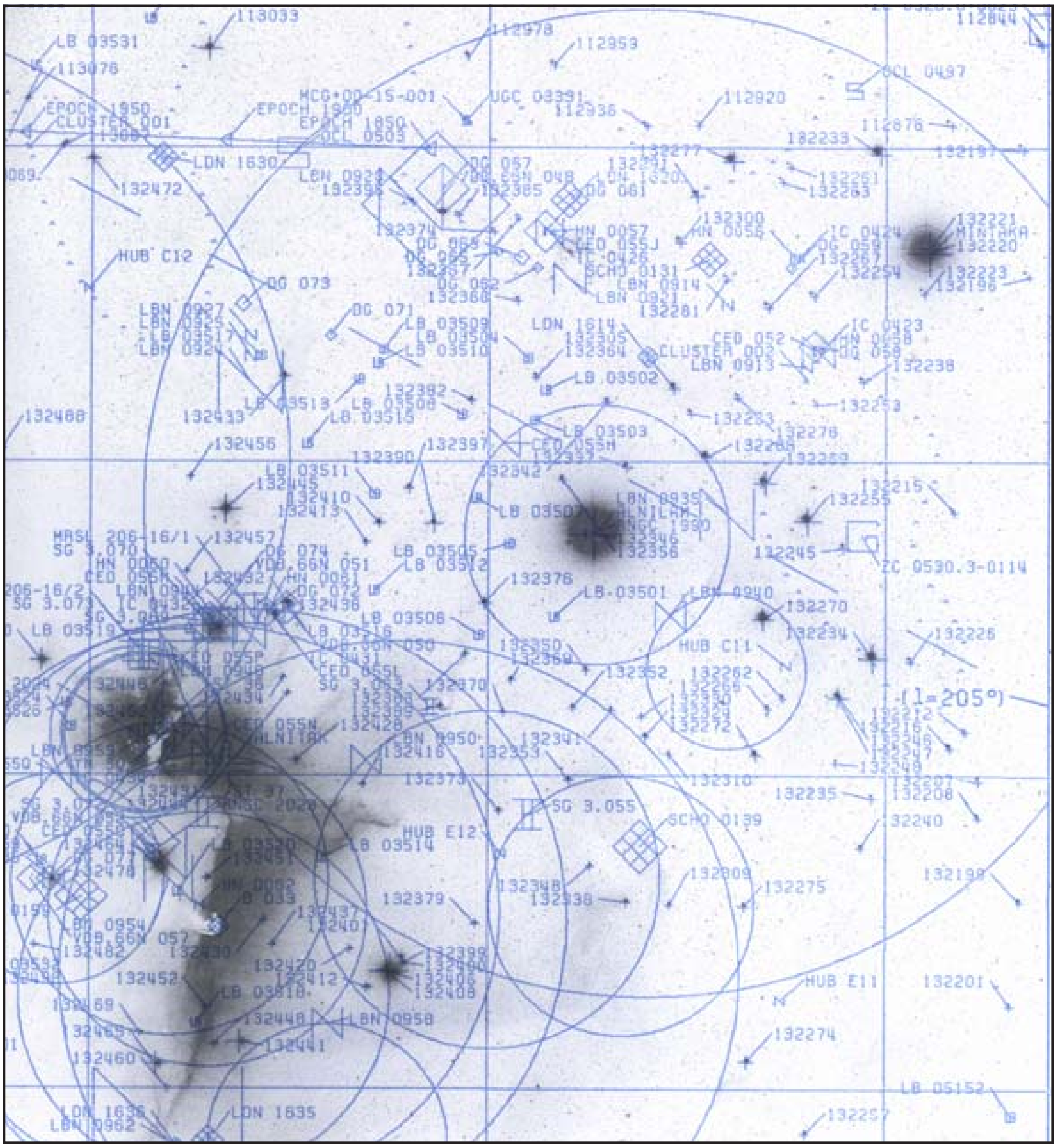

Fig. 73 *The Palomar Survey*, (detail), 1951, Library of the Paris-Meudon Observatory, Paris.

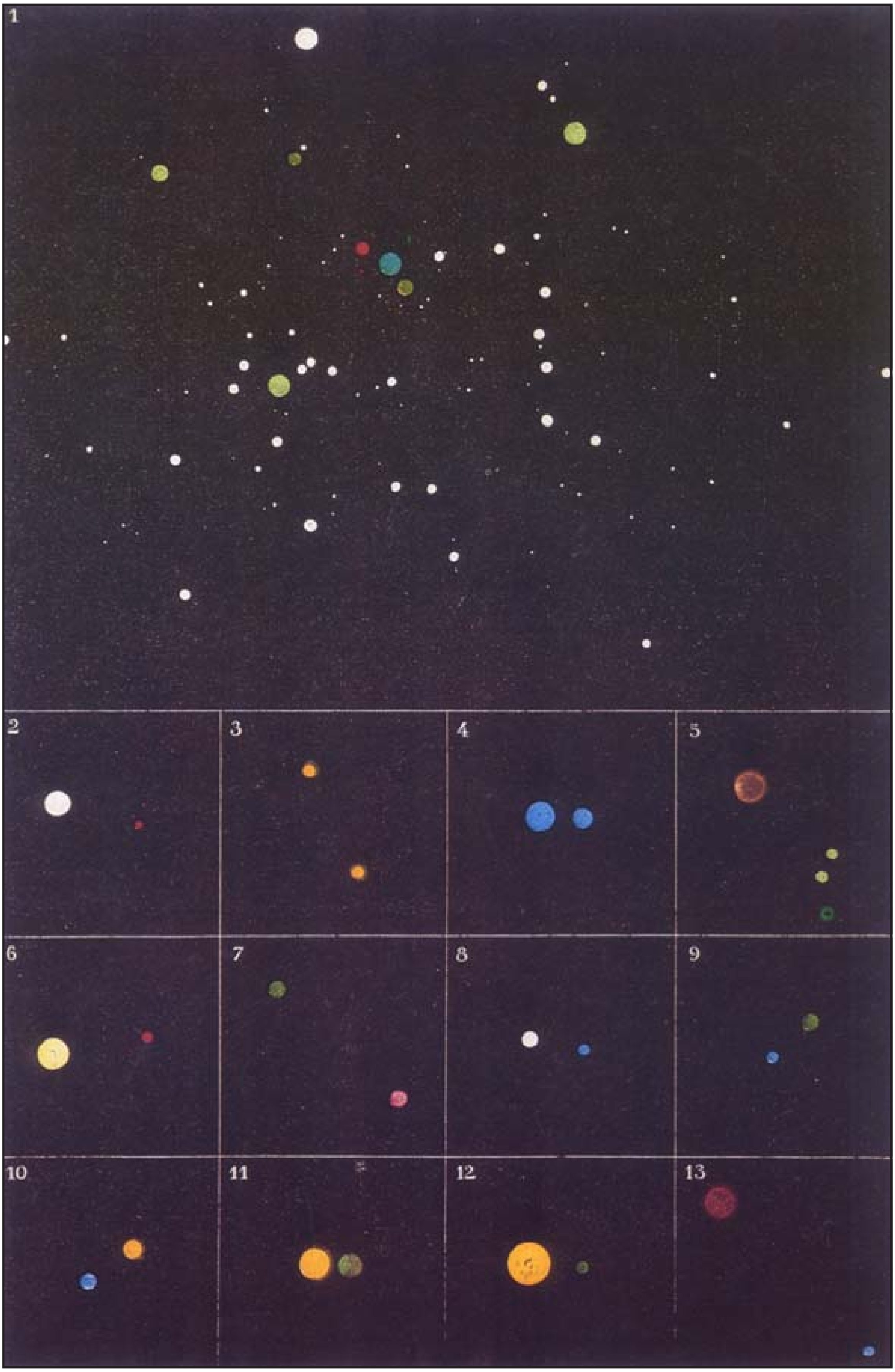

Fig. 74 Amade Guillemin, *The Colour of the Stars*, 1865, The British Library.

Fig. 75 Amade Guillemin, *The Night Sky over Paris*, 1865. The British Library.

These new revelations captured the imagination of the French painter, magician and filmmaker, George Melies, and he made a film in 1902 called *La voyage dans la lune*, (*A Trip to the Moon*). This revealed the moon as he had seen it in museum models and early photographs, overlaid with his own imaginings in science fiction. Magicians combine the skills of optics, chemistry and mechanics. He often combined his films with other props mixing the virtual and the physical to heighten the theatrical experience.. Muniz makes the observation that:

> [m]agic has always at the borderline between art and science; it teaches us how deceptive the appearances of natural phenomena can be, as well as how dependent we are on the knowledge of nature to produce something that can transcend it. [23]

Seeing beyond the seen.

The recording of phenomena and objects in space was no longer limited by conditions of visibility. The physicist James Clerk Maxwell's revolutionary work in the late nineteenth century revealed the attraction between electricity and magnetism through lines of force. His Electromagnetic Field Theory determined through mathematical analysis that light is an electromagnetic radiation phenomenon. Where there is electricity there is always magnetism and electromagnetic waves travel at the speed of light. [24] This natural radiation consists of gamma rays, x-rays, ultraviolet rays, visible light, infra-red, millimeter waves, (microwaves) and radio waves, (Heinrich Hertz's radio waves being the foundation of tele-communications). Watson explains:

> [a]rranged in order of wavelength, they form the electromagnetic spectrum. Somewhere in the middle is the radiation to which our eyes are sensitive. Its wavelength is measured in nanometers (millionths of a millimeter), and ranges from about 400 nanometres (nm) for violet light to about 700 nm for deep red. In between lies the rainbow of the visible spectrum. [25]

---

[23] Muniz, *Reflex*, p. 182.

[24] In 1881 Mitchelson and Morley's experiment to measure the speed of light heralded the beginning of the revolution in physics. In 1905 Einstein's theory of relativity showed that no particle in nature can travel faster than the speed of light . Bova explains, 'Shine a beam of light in the same direction as the earth is moving and its light (in a vacuum) is 186,000 miles per second. Shine a beam of light in the opposite direction, so that the velocity of the Earth should work against the beam of light, and the speed is still the same.' Bova, *Story of Light*, p. 156. Einstein's theories united electric and magnetic forces, greatly simplifying electromagnetic calculations.

[25] Watson, *Stargazer,* p. 2

Vision is no longer limited by the spectral capacity of the human eye, or the camera eye. It has extended to include the whole of the electromagnetic spectrum. Remote sensing technologies gather and image information without actual contact with the object or phenomena to be investigated. Not all electromagnetic radiation can penetrate the Earth's atmosphere so the gathering of information may have nothing to do with what is visible to the human eye. Figure 76, *A Protective Shroud*, gives a picture of the depth to which electromagnetic radiation can penetrate to the Earth's surface, and the various satellite observatories that are able to detect the radiation that is only available to us in this way. The eye comes into play with the imaging of information as it has to be presented to the human observer, to human consciousness, in visual form. I construct my mappings from this information.

Early in the twentieth century artists calling themselves Suprematists, suggested that everything in the world was formed through energy and movement. They became interested in the interaction of geometry as form, (a product of the mind), and colour as light or energy, (a product of the world), experienced as sensation. One of these artists, Kazimir Malevich, was influenced by Plato's theories of underlying and pre-ordained systems to construct the world. He proceeded to explore Maxwell's work in *34 Drawings* 1920, and a series of electromagnetic paintings. Railing relates:

> [a] series of drawings included in his 1920 book, SUPREMATISM.34 make visible the shape of electrical and magnetic forces. In the way that the cube is pulled into rectangular bars that repel and attract, the Suprematist drawings reveal the shape of the activity of two forces. So in looking at these drawings, one must look at the shape of the energy, the shape of the forces. The object – the geometrical plane - reveals the shape of the energy, and is not the shape of an object in space. [26]

In this way Malevich was attempting to make visible the systems underlying human invention.

Joyce Hinterding, the contemporary Australian artist, has explored these seemingly invisible phenomena and the underlying forces of nature that we might otherwise take for granted. She has worked with electromagnetic fields to expose the process in its most material form. In her work *Electrical Storms,*

[26] Patricia Railing 'Suprematism as Pure Creativity' in *White Noise*, 18. Images p.1-18..

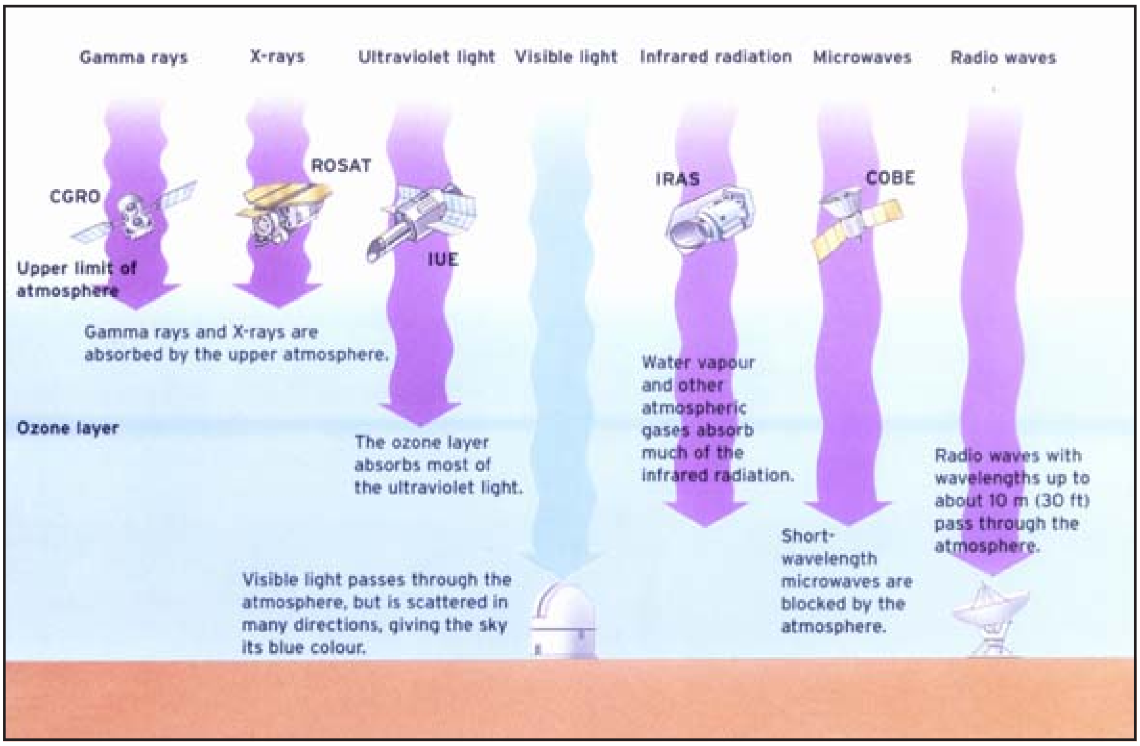

Fig. 76 *A Protective Shroud*.

1992, she placed a number of devices beneath the roof on the Bond Store in Sydney which she desribed as:

> [h]umming and whistling [an] assemblage of devices [which] is reliant on atmosphere turbulence so that activity such as the downward passage of electricity and photons on bright sunny days and the streaming upwards through shafts of verified plasma during storms is translated from the electromagnetic to the electromechanical. [27]

I share with Hinterding an interest in making the invisible visible. Not in a controlled or exploitative way which often goes with the territory of science, but in a way that maps the mystery and wonder in things beyond the visible.

Coded light.

What lies beyond the reach of our immediate vision? In 1860, two scientists Kirchhoff and Bunsen, developed the technique of spectroscopy. Through the analysis of light spectroscopy enabled the chemical and physical characters of a light source to be revealed. Mysterious dark lines had been noticed crossing the solar spectrum, and, as Fred Watson explains, these two scientists recognized the dark lines to be chemical messengers from the sun's atmosphere. They were 'absorption lines.' Their position in the solar system coincided exactly with the positions of bright 'emission lines' (light of a single wavelength) in the spectra of various terrestrial elements such as calcium or iron when they were excited by a spark or flame in the laboratory. Watson describes this as 'light with a bar-code', the basis of the science of spectroscopy, the spectroscope being a tool of astrophysics. [28] *The Spectrum*, (see fig. 77), shows the 'fingerprint' of particular elements present in a light source.

Like household lights, stars emit a spectrum of light. Just as a train whistle changes pitch as it speeds past you, getting lower as it moves away, the

---

[27] Joyce Hinterding, in exh. cat. *The Boundary Rider – 9th Biennale of Sydney*, Anthony Bond 1992-93, p. 118.

[28] A spectroscope analyses the component colours of light. The spectrum of a heated lamp bulb filament is a continuous band, a 'continuous spectrum.' When gases are made to glow via an electric current or flame they produce an 'emission line spectrum' containing only certain colours corresponding to specific wavelengths. They appear as bright lines across a dark background. The pattern of lines is different for different gases. If a hot object like the sun is viewed through gas at a lower temperature in the star's atmosphere, the continuous spectrum is crossed by dark lines that are exactly where the emission lines would appear if it were glowing. This is an 'absorption line spectrum.' Watson, *Stargazer*, p. 236-237

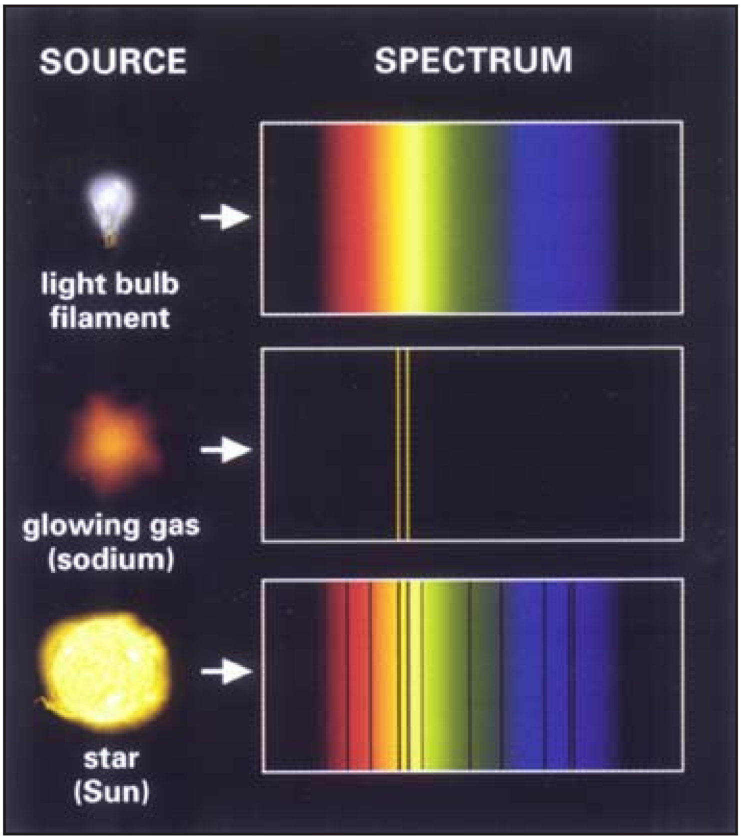

Fig. 77 Keith Soares/Bean Creative, *The Spectrum*, National Air and Space Museum, Smithsonian Institution, 2002.

pitch or frequency of a moving light will get lower when it speeds away from you. The light will appear redder than it is actually. This is called the *Doppler Effect*, after Christian Doppler the Austrian scientist. He observed that wavelengths change in a moving energy source. Levin describes how light behaves:

> [i]ts energy depends on its wavelength, shorter wavelengths corresponding to higher energy and frequency, and hotter light, pushing it to the bluer end of the spectrum. The red end of the spectrum indicates lower energy and frequency, longer wavelengths and cooler light. [29]

In 1868 the English astronomer William Huggins, using a spectroscope to analyze stellar spectra, noticed this red shift in the star Sirius. He calculated that it was speeding away from earth. This became the key to an understanding of the expanding universe. He also noticed that some of the fuzzy, misty, cloud-like stars which Herschel had described as 'planetary nebulae', had just a single bright emission line. This indicated that they were made solely of luminous gas, the composition later to be identified as mostly hydrogen and oxygen. Watson notes in Huggins own words:

> [o]ne important object of this original spectroscopic investigation of the light of the stars and other celestial bodies, namely to discover whether the same chemical elements as those of our earth are present throughout the universe, was most satisfactorily settled in the affirmative; a common chemistry, it has shown, exists through out the universe. [30]

The echoes of light - data and the senses.

Once explorers went to a remote place and mapped it. When the Apollo 11 astronauts mapped the moon the reverse was true. Preceding lunar exploration in-situ, the data required for technological cartography had already been collected by telescope, photography and remote sensing.

Mapping space and extending vision with the aid of the electromagnetic spectrum uses all the different forms of radiation that bombard the earth. It comes from sources everywhere in the universe. As seen in figure 76 much of it never reaches the surface of the planet because it is absorbed into the

[29] Levin, *How The Universe Got Its Spots*, p. 61.

[30] Fred Watson, *Stargazer,* (Sydney: Allen and Unwin, 2004), p. 238-9. The significance of these findings became clearer over time. In the 1950's systems were devised in star maps that revealed more than a star's location in the sky. Through colour and symbol, a wide variety of information drawn form spectroscopy and photography analysed the stars. This involved information about their spectral class, their magnitude or relative brilliance, and the structure of both stellar and non-stellar objects such as galaxies and nebulae, (island universes or immense star systems beyond our own).

earth's atmosphere. All of these signals are manifestations of the same underlying physical phenomena; travelling packets of oscillating electric and magnetic fields, the light coming in a range of wavelengths. The shortest are gamma rays, and the longest are radio waves. These forms of electromagnetic radiation all travel at the same speed, the speed of light, 300,000 km. per second. Different wavelengths will interact with matter in different ways. The most obvious examples are radio waves with a radio receiver, and visible light with the eye. References to the role of the electromagnetic spectrum in the process of mapping remote space can be found in my work, including fine spectral lines which traverse the digital images. (See appendix 4).

From 2006, the Australian and New Zealand artist collective *radioqualia,* (supported by the Fondation Daniel Langlois for Art, Science and Technology), has been presenting *Radio Astronomy*. This is a conceptual art project aimed at revealing the sounds that are embedded in what appears to be the silence of the night sky. [31] The project plans to intercept sounds from space and make them available to a participatory public by transmitting them via internet or radio waves. The Collective emphasizes that the data from radio observatories, (the perception of which is largely based on visual data such as graphic visualizations), is as significant for understanding the universe as visual observation. My research in the creation of a sound installation has enabled me to use material from a number of radio observatories. These sounds demonstrate that indeed space is quite noisy, each stellar object having its own sonic signature.

Searching for nature in the digital realm.

Rather than maps of the heavens, mapping now reveals images of the heavens through electronic imaging and enhancement. The light captured from space through a telescope is most commonly detected and analysed with either spectroscopy or photometry. As previously discussed spectroscopy splits light apart through a diffraction grating (a thin glass plate etched with thousands of very fine lines). This splits the different colours of

[31] The website notes that *Radio Astronomy* could also be viewed as the rehabilitation of the poetic resonance of the "music of the spheres" imagined in classical antiquity and revived during the Renaissance. www.fondationlanglois.org/html/e/page.php?NumPage=383 [accessed 8/02/2006]

light and records the individual signature of the dark or bright lines produced in the light from a star or nebula. These lines, caused by atoms absorbing or emitting light with specific colours, can reveal the temperature, pressure, density, composition and motion of celestial objects. They also reveal the chemical content of stellar atmospheres and interstellar gas clouds.[32]

Working with imaging photometry, purpose built cameras have improved the light collecting efficiency of the telescope. Often taking the place of the observer at the eyepiece of the telescope, the camera records visual information projected on to a light sensitive surface. The camera uses electronic detectors, charge coupled devices (similar to a digital camera or webcam).[33] A computer then reads the information and builds an image in false colour (using a layered three colour process to recreate colours). It reveals images and specific information often gathered at unseen wavelengths, such as the Saturn image used in my work *Bipolar 2.* (See Appendix 7). This imaging process enables considerable enhancement of the subjects, most of which represent phenomena beyond the human eye. In any event the human eye is unable to see colours when light levels are low, so light is enhanced through colour to make such phenomena visible. Such images represent both the intellectual and artistic dimension of mapping. Whitfield observes:

> [w]e now see across billions of miles of space to multi-coloured nebulae, galaxies, interstellar dust and supernovae, as an earlier generation once delighted in images of sunrise, storm-clouds and mountains. As celestial maps have become ever more austere and functional, so the art of the astro-photographer has become more lavish and kaleidoscopic; the taste for visual drama which was once satisfied by the mythology of the constellations has been transferred from maps to photographs.. [34]

---

[32] Astronomers measure temperatures using the Kelvin scale. Freezing point for this scale corresponds to - 273.16 degrees Celsius. The temperature at the surface of the sun for example is 5800 K which corresponds to 5527 degrees Celsius. When astronomers began to study the relationship between the colour of a star and its absolute brightness … they found that many stars obey a simple rule. This shows up clearly when absolute brightness of magnitude is plotted against colour in a kind of graph known as a colour-magnitude diagram known as the Hertzprung-Russell diagram… Stars at the bottom of the diagram are faint, cool and red, (3500K), while stars at the top left are bright, hot and blue-white, (25,000K). Most visible stars lie in a band running from top left to bottom right called the 'main sequence.' Gribbin*, Space*, p. 50.

[33] The charged coupled device is an electronic eye that is far more sensitive than a photographic plate, the photosensitivity being vastly superior to chemical film. It converts light rays that strike its surface into an electrical charge stored in a grid of picture elements or pixels. The amount of charge that builds up on each pixel over the length of an exposure can be read by a computer and built up into an image. Sparrow, *The Universe*, p. 181.

[34] Whitfield, *Mapping The Heavens*, p. 128.

Much of the material collected to build my works on paper, (such as photographs or mapping models), is the result of digitally manipulated analogue and digital photography. When layered and enlarged through Photoshop both the process and the content are embedded in the layered surfaces. Through these imaging technologies they reveal, in a sense, both a macro. and micro. mapping of the night sky.

The astro-photographer David Malin permitted me to use in these works some of his time lapse star trail images taken with a hand-held analogue camera. (See appendix 8). Malin has exhibited his astronomical photographs along with a number of international artists (including the work of Wenyon and Gamble), in the exhibition *Space Odyssey* held in Japan in 2001. [35] This exhibition emphasized the ties that link human beings to space. Malin observes that:

> [t]he concepts of time, space, and the origin of the elements provide an intellectual framework within which many profound and difficult ideas can be explored. These ideas touch on philosophy, religion, and the nature of time and space, and consciousness itself. This explains why astronomy is deeply cultural as well as a scientific activity. [36]

Malin has been an innovative experimenter with photographic film and his astronomical photographs are taken with a prime focus camera mounted in a cage at the Anglo-Australian Observatory. *Planetary Nebula AAT 110 NGC 6781* is an example. (See fig.78). As his website explains:

> Malin takes three black and white exposures through separate coloured filters of red, green and blue. These are then superimposed onto photographic film, resulting in images of stars with their actual colours, thus giving an indication of their age, size, temperature and evolutionary history….his allotment of precious telescope time [has been] usually 5-8 nights a year, and sometimes some of those nights are cloudy. In twenty years…he has produced fewer than 200 pictures, some of which have taken years to produce.[37]

---

35 www.arttowermito.or.jp/art/uchunotabi.html

36 David Malin, *The Invisible Universe* (New York, London: Callaway Editions, A Bulfinch Press Book, Little Brown and Company: Boston, 1999), p. 10. In this book Malin juxtaposes traditional drawings by other astronomers and prints of sky mapping, with his photographs, acknowledging earlier observations and discoveries recorded with painstaking accuracy and copious notes before sophisticated telescopes, photography and computerization were used.

37 *David Malin.- The Man Who Colours The Stars*, http://hoa.aavso.org/postermalin.htm p.1-2, [accessed 25/08/2006].

Fig. 78 David Malin, *Planetary Nebula AAT110 NGC 6781*. astro-photograph, Anglo Australian Observatory, 2004.

Others included in *Space Odyssey* and of interest to me were Jiro Hirano and the German photographer Thomas Ruff. Hirano's installation, *100 Light Years*, 1999, used a ceiling projector to cast cosmic images on to the tables and floor. Like memories they mapped astronomical data events and sounds of each cosmic era activated by turning a dial. Ruff exhibited his *Star Series* of giant prints made from negatives supplied by the European Southern Observatory (ESO) (an international research centre situated in the Atacama Desert In Chile).

With the advent of electronic sensing equipment what has become evident is a completely illusory world presented to the sense organs via the computer. Darren Tofts discusses the cultural impact of the processes of electromagnetism. These require new organizations of the senses to understand communications, and our mutual co-existence in a world of differences. He refers to media theorist Donald Theall's, 'ecology of sense,' and synaesthesia, (broadly defined as the deferral of stimulation from one sense to another), describing it as:

> a poetic process, akin to displacement within dream-work…..an innovative organization of the senses. Within a multi-media environment, a particular sense impression can produce unexpected sensations of different types, for instance, seeing a piece of music. This is the world view of the semiotically excessed where links and associations are made between complex networks of information, amalgamating transverse codes within sign systems. [38]

Referencing these technologies I have attempted to evoke in my digital prints, screen and sound pieces, this synaesthetic language. The intention was to reveal links and associations from a diverse range of data and information that generate a broader, and deeper viewing experience.

The development of theatrically-based psychedelic multimedia light shows in the 1960's working with electronics, optics and architecture, explored this phenomenon creating immersive audio-visual environments In 1959 the abstract film maker and painter Jordan Belson and the composer Henry Jacobs organized a series of multimedia events called *Vortex* in the San

[38] Darren Tofts, 'Fuzzy Semiotics', in 21.C. *Scanning The Future,* #25, ed/pub. Ashley Crawford, p. 35.

Francisco Planetarium. They used complex sound systems and projectors and included found material from abstract film imagery and avant - garde electronic music. Albert Frankenstein reviewed *Vortex IV* describing how:

> Belson turns the entire sky into a cosmic merry-go-round: he uses some of the planetarium's normal equipment to shoot meteors across the music or fill it full of stars: most remarkable of all is the vertiginously speedy shower of huge, flaky blips in which the whole universe shakes down at the conclusion of the program. [39]

Capturing light with virtual eyes.

To observe certain sections of the electromagnetic spectrum, such as x-rays or gamma rays, telescopes need to be above the Earth's atmosphere, attached to space craft. For radio, infra-red and visible light, ground based optical telescopes are used. Ordinary stars emit most of their energy in visible light and earth based telescopes use enormous and complex reflective mirrors to collect it. As the technology improves so these extended virtual eyes penetrate further into the universe to seek out fainter objects. As the mirrors get bigger so the detail becomes finer. [40]

It is atmospheric turbulence, the same phenomenon that makes a star twinkle, that disrupts the rays of light and the information coming through the atmosphere. Consequently earth based observatories, which also require night time viewing, are situated in remote parts of the Earth. In these places there are clear skies, no artificial light or undue wind turbulence. They are often on mountain tops higher than 3,500 meters and in the middle latitudes. Radio telescopes are able to map the sky at non-optical wavelengths. These 'virtual eyes' are increasingly being revitalized by innovative instrumentation that can augment their capabilities.

---

[39] Cindy Keefer in *White Noise*, p. 32.

[40] Watson explains, 'Like all dimensions in the sky resolution is measured as an angle. It is expressed in arc seconds, microscopic units that are to angles what nanometers are to length. Geometry tells us that an arc second is1/3600th of a degree …imagine a person 5 kilometers away holding a coin. To your eye, the coin's diameter at that distance is one arc second – and you would need a sizeable telescope to be able to see it. …a one meter diameter telescope mirror is theoretically capable of showing detail on a scale of a little more than 0.1 arc seconds – the coin at 50 kilometers. But a 4 meter mirror could resolve detail of one quarter of the size – 0.03 arcseconds. That is fine enough to detect surface markings on the 'planet' Pluto, or the disc of the giant star Betelgeuse."' Watson. *Stargazer*, p. 4.

But what is it like to look into the night sky through a telescope from our own place on Earth? In the DVD I have titled *Turbulence,* which has become part of the body of my work, I reveal such a view. [41] No matter where we live or the season, we will be viewing the stars through some atmospheric turbulence. The atmosphere is constantly moving and it bends light through diffraction. This movement causes the stars to twinkle. This will interrupt the clarity of the view, but also it will reflect unusual movements and fluctuations of light and colour in the body being viewed. These may in fact not exist at all. Looking through this turbulence makes us aware of the invisible phenomena between 'back here' and 'out there', and the way that our vision is manipulated by such things. These images, seen through the virtual eye of the telescope hover between nature and culture, mystery and desire.

In recent times it has been observed that nature itself is capable of creating another exceptional 'telescope.' In the 1980's astronomers noticed two objects with identical spectral signatures seeming like a double image of the same object. They had also noticed arcs of faint light near giant clusters of galaxies. Watson explains that:

> Einstein had suggested that if a massive object such as a galaxy – or a cluster of galaxies - lies exactly between ourselves and a much more distant object, then it will behave like a gigantic lens, focusing an image of the far-off object into a ring of light. It does this because gravity itself bends light rays – a consequence of Einstein's Theory of Relativity of 1915, which had been verified four years later by observing a total eclipse of the sun. Such a phenomenon is known as a gravitational lens, and the image it forms is called an Einstein Ring. [42]

These rings and faint arcs of light are the amplified light from distant galaxy clusters that would normally be invisible. By measuring their spectra, information can be deciphered about their genesis and the properties of dark matter and dark energy. This matter and energy is thought to exist but is as yet undetected.

The most effective way to see the sky is from above the atmosphere. Extending visibility deeper into the universe, numerous and increasingly

---

[41] This DVD which focuses on the planet Mars, was made using a modified web-cam through a 12" aperture Schmidt Cassegrain telescope, with an effective focal length of 7.5 metres. It was captured by the amateur astronomer Zane Hammond at the Magellan Observatory in New South Wales, where I spent time with him in 2006.

[42] Watson, *Stargazer*, p. 280-81.

complex satellite telescopes now act as orbiting astronomical observatories. These space-borne observatories, using complex reflecting telescopes and electronic cameras, are sent into orbit by organizations such as the *European Space Agency and America's N.A.S.A. (National Aeronautics and Space Administration).* The most well known is the *Hubble Space Telescope*, (launched in1990 for ultra-violet and visible-light observations), the *Chandra X-ray Observatory* (launched 1999) and the *Spitzer Space Telescope* (launched 2003 for Infrared Observations). More have followed.

The *Hubble Space Telescope* has given us a glimpse of the universe that is more compelling than anything Earth–based telescopes have been able to produce. Figure 79 *Hubble's Deep Field* image is a 'needle eye' view of the observable limit of the universe, the number of galaxies in this tiny area is thought to be typical of the distribution of galaxies across the sky as a whole. This space-based telescope has been able to demonstrate what was once mere speculation, that the deeper you go into space, the further back in time you go. It is a reflecting telescope with a light gathering mirror that is 240 centimeters in diameter. It is controlled by radio commands relayed from *NASA's Goddard Space Flight Centre*. Computer driven instruments aboard the telescope record observations and transmit data to astronomers on the ground. Electronic cameras, (charge coupled devices), convert the electronic signals from light and a spectrograph analyzes the light. A spectrograph, like a prism, spreads light into its component colours, much as water droplets spread sunlight. As previously discussed, the resulting band is called the spectrum.

Hubble's Optical Telescope is designed so that two aspheric mirrors form focused images over the largest possible field of view. Hubble has a number of cameras including the *Wide Field and Planetary Camera 2.* These train on four neighbouring regions of the sky and are aimed so that each image slightly overlaps its neighbouring images. Image processing software compares and 'cleans up' the overlapping images as it stitches the four images together rather like a four paned-window. One of its four cameras records a magnified view. This is then scaled down to be in proportion to the other three images. The image falling on the planetary camera is magnified and views a region of the sky four times smaller than those seen by the wide

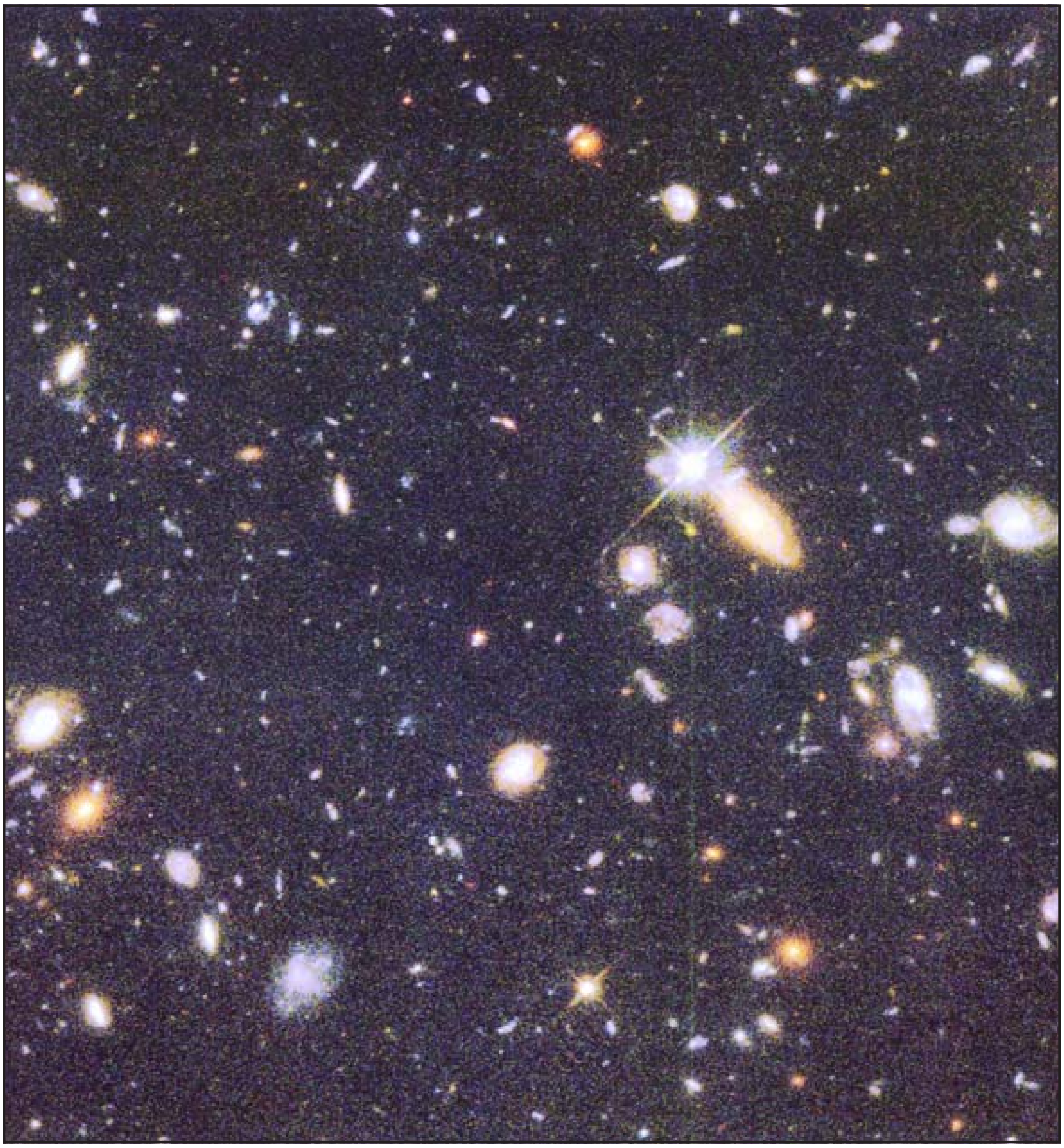

Fig. 79 *The Hubble Deep Field*, (detail), courtesy NASA.

field cameras. It records four times as much detail in that smaller region. This process, which produces a finer grid size in the detailed image and helps astronomers 'zoom in' on a particular section of the object being observed, is referenced in the vertical sequences of my digital work *Deep Field.*

Rather than using colour film, Hubble's cameras record light from the universe with electronic detectors that produce images in shades of black and white. Light from astronomical objects comes in a wide range of colours, each corresponding to a particular kind of electromagnetic wave. Hubble can detect all the visible wavelengths, plus the non-visible such as ultraviolet and infrared light. These astronomical objects often look different at different wavelengths of light. To record what an object looks like at a certain wavelength, Hubble uses special filters that allow only a certain range of light wavelengths through. Once the unwanted light has been filtered out, the remaining light is recorded.

The finished colour images are actually combinations of two or more black and white exposures to which colour has been added during image processing. These colours are not always what we would see if we were able to visit the actual object in space. Colour is often used as a tool to enhance an object's detail or visualize what the human eye cannot ordinarily see. This simulated colour system can recreate what we might see from a space craft. It can create representative colour which visualizes what might otherwise be invisible (perhaps in infrared light for example). As well it can create enhanced colour which brings out the objects subtle structural detail. As Dineman notes:

> Hubble's images have now become the material for all kinds of manipulated visual material. This enables people to visualize the more dramatic and also fictionally imaginative aspects of the nature of the universe. [43]

When modern instruments look into the universe now, 14 billion light years into space, what is seen is the received light which left its source that many billion years ago. It is like looking at a cross section of time which also represents a history of space and the universe. It takes light more than four

[43] Taylor Dinerman 'The Hubble Telescope, Artists' Muse', *The Wall Street Journal*, (March 25, 2004).

years to reach the nearest star to Earth, Alpha Centauri. The Milky Way is one hundred thousand light years across and our solar system is thirty thousand light years from its centre. Ironically, because we live inside the Milky Way we know more about the shapes of distant galaxies than we know about our own. What we do know is that the Milky Way is a vast disc consisting of 100 billion stars and gas and dust, and because it is flat the map is long and narrow. It is now possible to access through the Astrophysics Data Facility multi-wavelength all-sky images. Each image of these *Multi-Wavelength All-Sky Images,* (see fig. 80), shows the entire sky in an oval projection, aligned so the galactic plane of the Milky Way runs horizontally across the centre. A section from one of these mappings of the Milky Way Galaxy is incorporated into the layers of my work *Deep Field.* (See appendix 9).

Out There, Back Here And In Between.

The search for astral bodies has been described as analogous to mapping a forest from the inside, by working out the distances and relative positions of the trees in all different directions. [44] What has been revealed in the process is an endless and chaotic complexity from which we hope to extract order. According to Einstein's Theory of General Relativity space is expanding like a balloon skin. As this space itself expands it takes the galaxies with it like an ever expanding bang from a small initial spark. Stephen Hawking relates how Edwin Hubble, '[b]y analyzing the light from other galaxies discovered in the 1920's that nearly all galaxies are moving away from us, the farther away from us the faster they are moving away.' [45]

So every galaxy is moving away from every other galaxy as the universe expands. This was determined by the cosmological red shift. Hubble, using the measure of stars called Cepheid Variables contained in the Andromeda

[44] In measuring astronomical distances a parsec is used which is equal to 3.26 light years. The word is a combination of 'parallactic shift' and 'second of arc.' Astronomers use the parallactic shift of a star against the background of fainter stars to measure the star's distance. If a star showed a parallactic shift of one second of arc (1/3600th of a degree), its distance would be 3.26 light years away. This is approximately the angular size that a 25-cent piece would show at a distance of three miles. A parsec is just over 30 million million kilometres. Light travels at just under 300,000 km. per second and so covers 9.46 million million km in a year, a distance known as a light year. 3.4 parsecs is 11 light years from us. There are no known stars as close to our solar system as one parsec. Bova, *Story of Light*, p. 418, Gribbin *Space,* p *16.*

[45] Stephen Hawking, *The Universe In A Nutshell* (London: Bantam Press, 2001), p. 77.

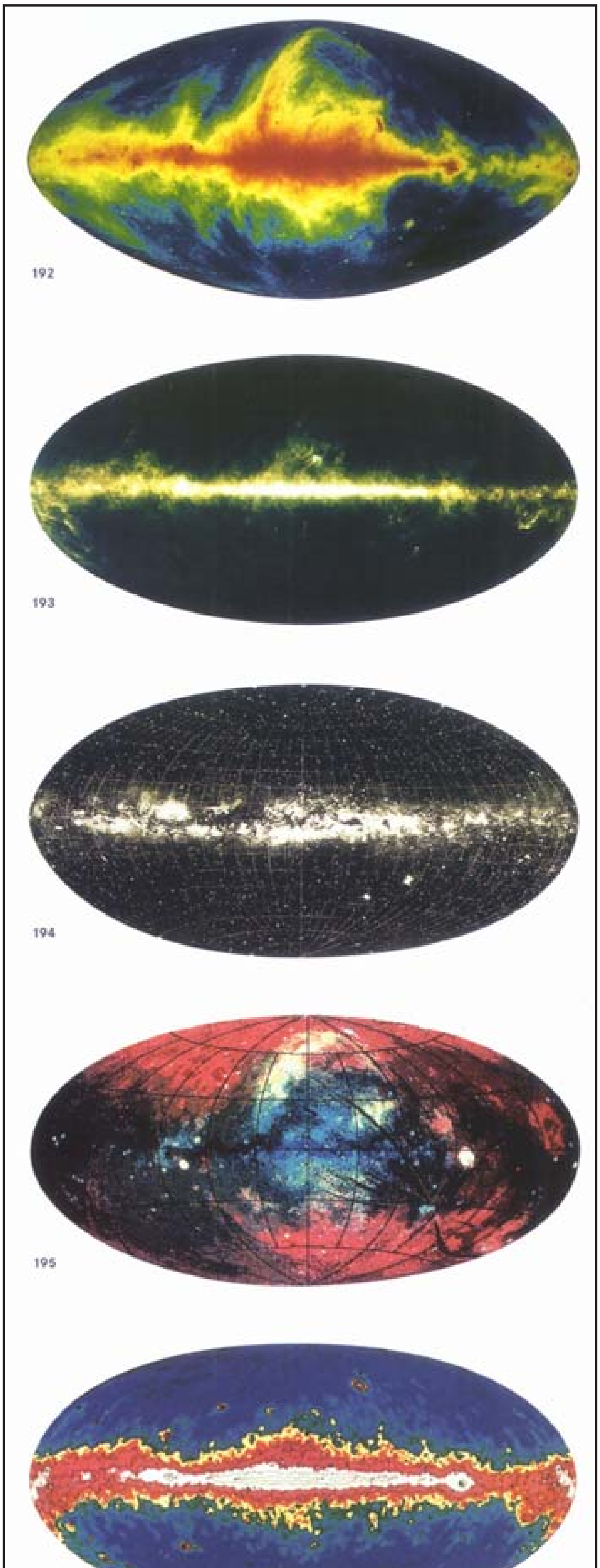

Fig. 80 *Multi-wavelength All-Sky Images, (detail), courtesy NASA*.

Spiral M.31, was able to determine that the galaxies are external systems, and not contained within the Milky Way. [46] The result of these findings was the 'Big Bang' hypothesis, proposed by George Lemaitre in 1927 and developed by Steven Weinberg, Roger Penrose and Stephen Hawking in the 1960's. This suggested that the universe began in a fireball 18 million years ago. Schlain explains:

> [t]he physicists proposal was that there was a moment before "time," a void devoid of "space," and the emergence in a single instant of light, space, time, energy and matter from a single, point-like fiery crucible ranks as one of the most profound discoveries of any age, along with the intellectual conceptual revolutions of Copernicus, Darwin, Freud and Einstein. [47]

Cosmic wallpaper - the oldest light in the universe.

This *Schematic Representation of the Hertzsprung-Russell Colour Magnitude Diagram*, (see fig. 81), represents a map of cosmic space-time which effectively shows the life history of stars. Of equal significance is the almost iconic ovoid projection, (see appendix 1 and the Bipolar prints), representing a soft-edge mosaic of the cosmic microwave radiation background. It has been described as the map of the echoes of the beginnings of the universe. [48] The light reaching us has stretched out as the universe has stretched and the most distant light is reaching us in the form of micro-waves and radio waves. In 1992 *N.A.S.A.'s Cosmic Background Explorer Satellite*, C.O.B.E., collected data which showed temperature fluctuations in cosmic radiation. These mapped the cooler cosmic background radiation – the afterglow of the 'Big Bang', and what is also believed to be the evolution of matter. The more

---

[46] Cepheid Variables are stars with fluctuating illumination. Those in the Small Magellanic Cloud were examined by Henrietta Leavitt in 1912 who found that the stars with the longer periods of intense illumination (which can range from 3 to over 60 days), were always brighter than those with shorter periods. Assuming all stars in the Cloud were equally distant from us, it followed that the longer period stars were actually more luminous. This led to the discovery of the period-luminosity law. There is a definite link which can be established between period and absolute magnitude so that the luminosity of a Cepheid can be found merely by observing the way in which it fluctuates. Once the luminosity is known, the distance of the star can be calculated without difficulty. Moore, *The Atlas Of the Universe*, p. 198.

[47] Schlain, *Art and Physics*, p. 251-52

[48] In 1963 the radio astronomers Penzias and Wilson using a special radio telescope that minimized extraneous noise that might enter it and a state-of-the-art receiver, were puzzled when they heard far more background noise than they expected. Having eliminated all causes, (including pigeons nesting in the horn), the excess noise remained the same wherever they pointed the telescope and it came equally from all parts of the sky. Finally they realized that their observations agreed exactly with predictions that the universe would be filled with radiation left over from the 'Big Bang.'

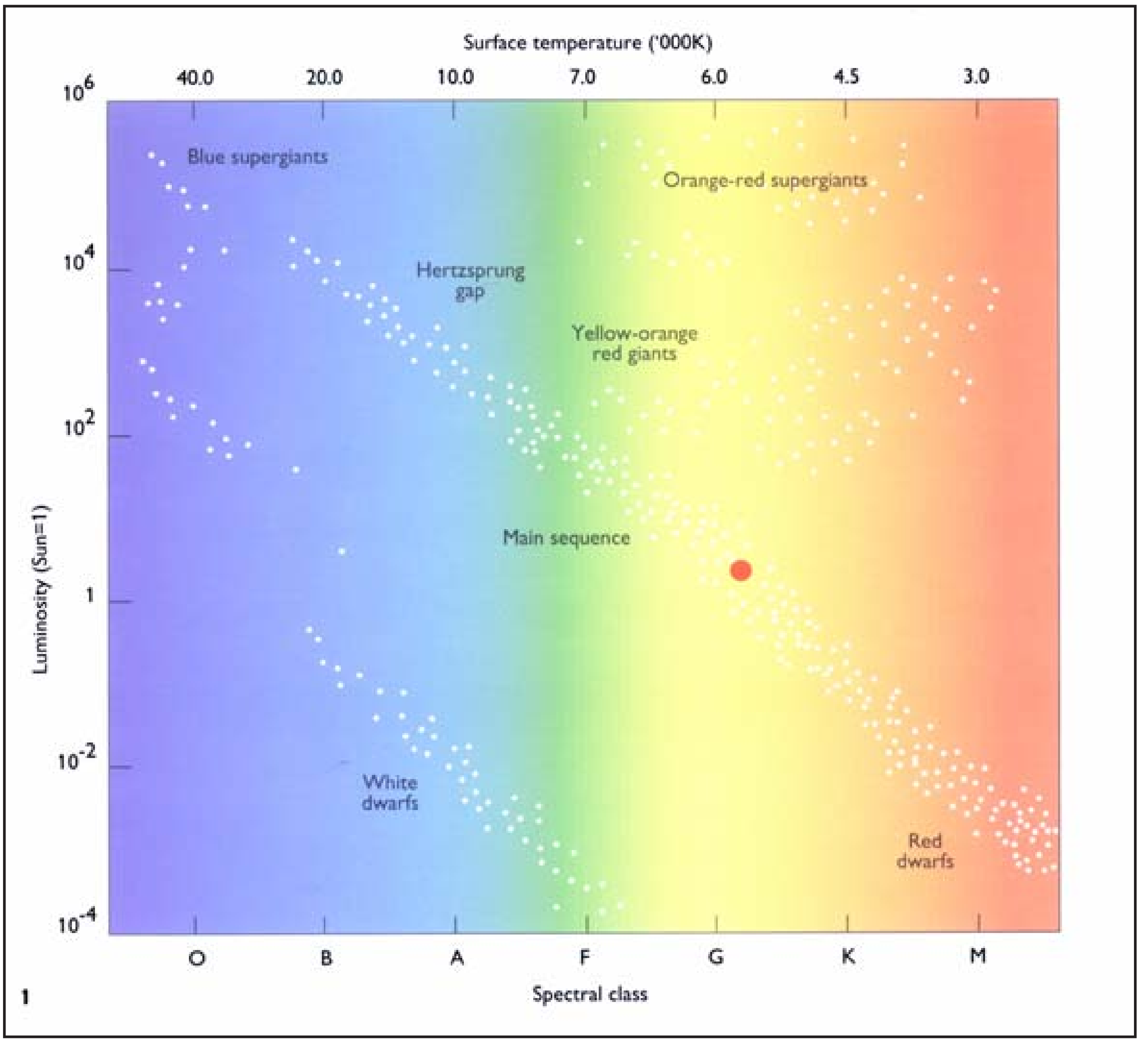

Fig. 81 *A Schematic Representation of the Hetzsprung-Russell Colour Magnitude Diagram.*

recent *Wilkinson Microwave Anisotropy Probe* has made *W.M.A.P. The First Detailed Full-Sky Map of the Oldest Light in the Universe.* [49] (See fig. 82). It appears as an oval shaped projection showing the whole sky, red indicating warmer and blue indicating cooler spots. Whitfield explains that '[t]his is claimed to relate to the uneven distribution of matter in the universe, and to be comparable to physical ripples or echoes of the Big Bang with which the universe began.' [50]

Janna Levin notes that satellite observations of the cosmic microwave sky, (background), may seem random at first pass 'but these maps tell us that there are patterns buried here, patterns that can be drawn out by locating the ghost images in the sea of hot and cold spots.' [51] Johnson suggests that mapping the universe with light might only be part of the story. He notes that:

> [w]hat we took for creation – the star and galaxies we see and imagine around us – might only be a froth on a wave made of mysterious dark matter, an essence that can be inferred by logic, but, at best, only obliquely detected. We and the universe we know might be no more than a bit of static, noise in the cosmic signal, as central to the universe scheme as the pigeons Penzias and Wilson expelled from their microwave antenna. [52]

There seem to be chaotic patterns in the distribution of stars and galaxies Using computers, mathematicians have demonstrated that there appear to be underlying patterns that are far more intricate than previously assumed. Mark Buchanan notes that, 'systems tend to self organize into 'critical states' where fluctuation and extreme instability is the norm.' [53] They seem to be deterministic but at the same time unpredictable. It is these patterns, revealed through light, that I engage with to reference the different ways in which the sky is mapped and understood at both macro and micro scales.

---

[49] Colours indicate warmer (red) and cooler (blue) spots. The oval shape is a projection to show the whole sky. The microwave light captured in the picture is from 379,000 years after the Big Bang, over 13,000,000 years ago. In 1992 NASA's COBE mission first detected tiny temperature fluctuations (shown as colour variations) in the infant universe. The WMAP image gives a sharper focus. These patterns are tiny temperature differences within an evenly spaced light bathing the Universe. http://map.gsfc.nasa.gov/m_mm.html [accessed 19/11/03].

[50] Whitfield, *Mapping The Heavens*, p. 129.

[51] Janna Levin, *How The Universe Got Its Spots*, p. 200.

[52] George Johnson, 'The Height of the Sky', in *Fire in the Mind, and the Search for Order* (Knopf 1995, Vintage, 2006), Chap. 3, in http://santafe.edu/-johnson/fire.ch3.html p.13 [accessed 04/07/03].

[53] Mark Buchanan, 'Edge of Chaos', in *The Science Book*, ed. Peter Tallack, (London: Weidenfeld and Nicolson, 2001), p. 490.

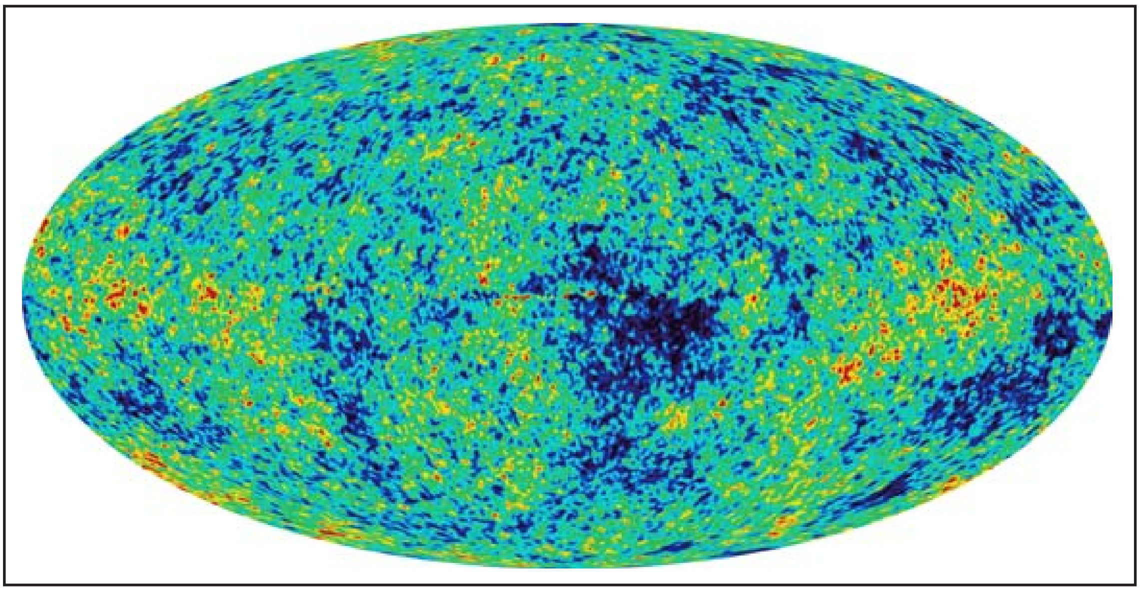

Fig. 82 *WMAP The First Detailed Full Sky Picture of the Oldest Light in the Universe*.

Cosmic architecture – charting time and chaotic order.

Working with these ideas, Benoit Mandelbrot developed a computer graphics program called *Fractal Geometry* in 1970's ('fractal' meaning broken). This described the fragmented and irregular nature of his computer generated geometric landscapes. Fractals are generated by a set of mathematical rules or algorithms which generate a sequence of numbers, each one fed back into the algorithm to generate the next. They are self-similar at varying scales – a small part of the structure looks very much like the whole, seen in the structure of plants, the formation of clouds, the fluctuations of stock markets, the distribution of galaxy clusters and coastlines. It is best described by Richard Mankiewicz using the analogy of a zoom lens:

> [a] map of the coastline looks fairly crooked and crinkly. If we could repeatedly zoom in we could see it in more detail, but at each magnification the nature of the crinkliness remains the same and is a fundamental part of the coastlines geometry. [54]

I mention Mandelbrot here because of the analogy his findings have to unfolding maps of the universe, rather like the way in which artists work with fragmentation to expose complexity. The further the telescope sees into the universe the more matter is revealed in various states of birth or death. They appear in repetitive clumps and scattered patterns at the macro and micro level. The telescope has been able to zoom in as it were, and reveal more and more detail and repetition in the universe in all directions. What astronomers are seeing are galaxies as they existed then, not now, by observing the light from billions of years ago.

In the 1980's two Harvard astronomers, Geller and Huchra, discovered the largest structure yet observed in the visible universe. By estimating the distance of galaxies with higher red shifts lying further out in space they created a three dimensional map of deep space.[55] Using earlier maps as a guide they observed more than 11,000 galaxies in a wedge of the northern

[54] Ibid., Richard Mankiewicz, "Fractals,' p. 446.

[55] In this map is evidence of the mature forms of structures that began as clumps in the WMAP image, fig. 82. Gravity, dark matter and dark energy all play a role in sculpting the hollows and clumps of galaxies found at such scales.

celestial hemisphere. To produce a graphic representation of their distribution through this wedge of the sky, a colleague, de Lapparent, fed the distances and positions of 1000 galaxies into a computer. The astronomers were stunned by what they saw in this map of galaxies and galaxy clusters. An unimagined structure emerged, which apart from local concentrations, found the galaxy distributed roughly uniformly throughout space. (Within this distribution a child's stick figure drawing was identified. This led to discussion of the 'Anthropic Principle' as a possible model of our perception of the universe).[56] On this map of *The Distribution of Galaxies,* (see fig. 83), celestial longitude is shown around the edge of a wedge of a latitudinal cross section using a North polar projection, (like the classical star charts, as if seen from above). The galaxies radiate out over 600,000 light years. It is called *The Great Wall.* Wilford describes the enormity of this structure and our place within it:

> [o]n the completed map, issued in 1989, the Great Wall of inter-connected galaxies stretched at least 500 million light years long, 200 million light years wide, and 15 million light years thick. In order to incorporate so much space, of course, the map and subsequent ones were drawn on a scale rendering Mars and Earth invisible; at this scale Earth is smaller than an elementary particle and whole galaxies are like tiny islands of dim light, enormous clumps of them surrounded by veritable seas of empty space. [57]

Increasingly ambitious mapping of the skies is being attempted as technologies become more refined. *The Sloan Digital Sky Survey Project* is one of these and I have referenced it in my work *Deep Field*. [58] (See appendix 10). This is enabling astronomers to further investigate these large scale patterns. *The Sloan Digital Sky Survey 3D Universe Map*, (see fig. 84), reaches from the Milky Way at the lower vertex to a distance of two billion light years at the upper curved boundary. Within this wedge or slice of the

---

[56] The twentieth century understanding of the vastness and complexity of the universe has re-awakened a sense of metaphysical mystery but perhaps also a sense of dislocation. The 'anthropic principle,' 'the fact that the universe is at any level comprehensible to the human intellect is thought to indicate a special affinity between man and the cosmos. … that the purpose of the universe is somehow connected with man, that without man's perception of it it would have no objective reality. This sets up unmistakable echoes of the eighteenth century empirical dictum *esse est precipe* – to be is to be perceived. There is an intriguing circularity about this emergence of a man centred universe, four centuries after the Copernican revolution broke up the enclosed relationship between, man, the cosmos and the creator.' Whitfield, *Mapping The Heavens,* p. 130.

[57] Wilford, *The Mapmakers*, p. 464-65.

[58] The SDSS is being conducted in cooperation with the United States, Japan and Germany, using a new wide-field telescope in New Mexico. This survey extends the breadth and depth of our view into the sky using complex telescopes situated around the world. It may help to explain various theories about the evolution of the universe.

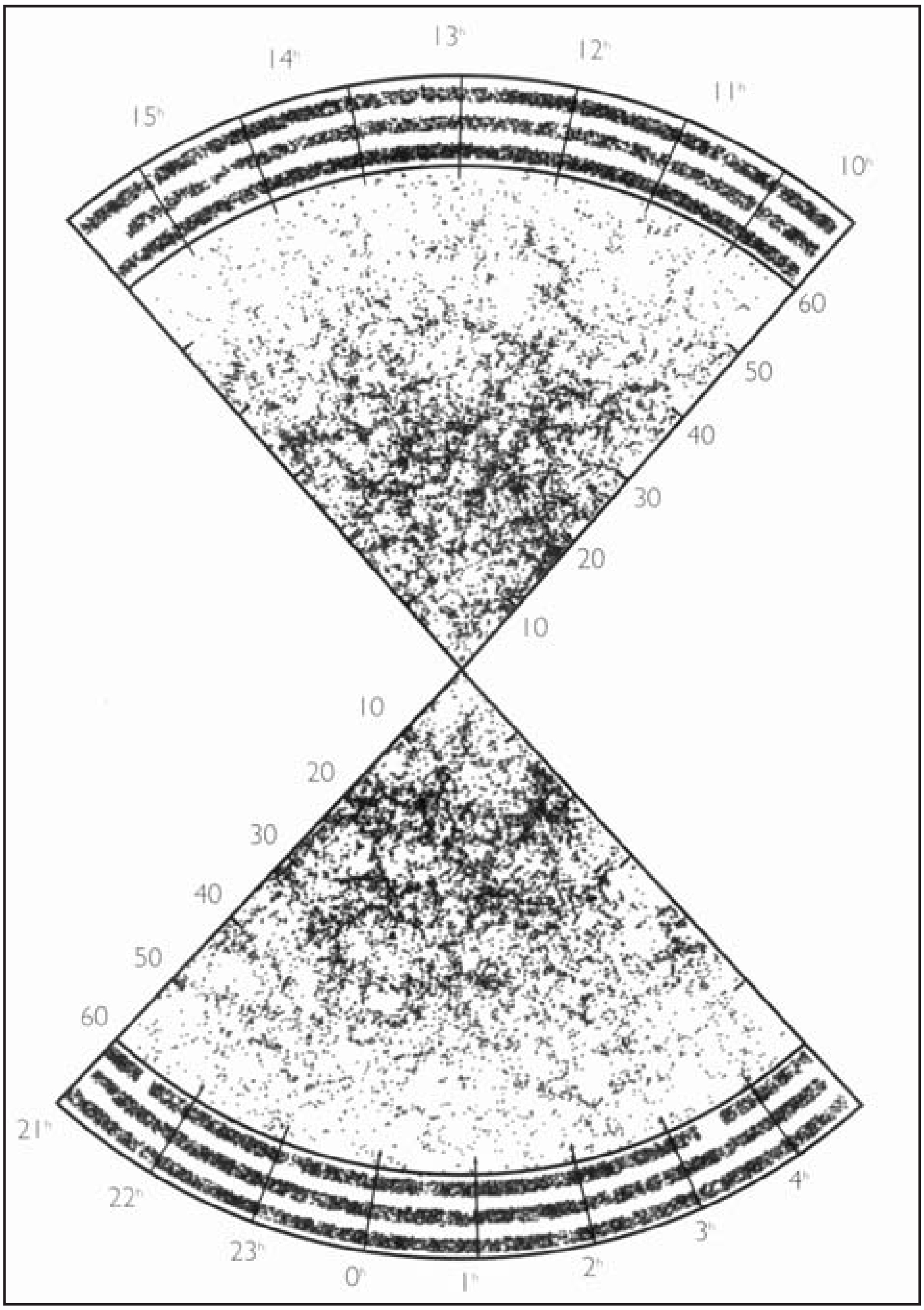

Fig. 83 Malcolm Godwin, *The Distribution of Galaxies*.

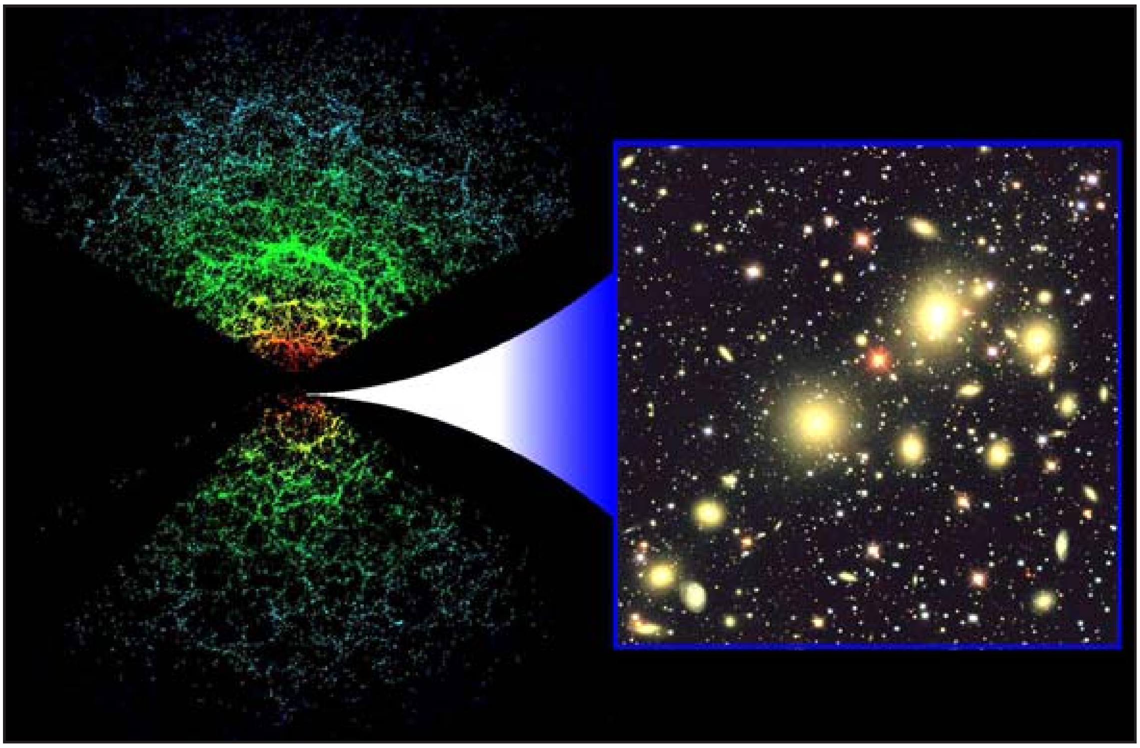

Fig. 84 *The Sloan Digital Sky Survey 3 D. Universe Map*.

universe the distribution of galaxies form bubble–like patterns similar to those seen as waves wash over a sandy shore. As described on the website:

> [t]he survey will map in detail one-quarter of the entire sky, determining the positions and absolute brightnesses of more than 100 million celestial objects. It will also measure the distances to more than a million galaxies and quasars.[59]

This is an enormously ambitious process that causes me to re-visit Fra Mauro's speculations in James Cowan's novel as he gazes into the sky:

> [w]ho am I to be so convinced that all this emptiness is not the manifestation of some invisible substance? Even the lazy flight of an albatross cannot diminish the sheer presence of what is not there in the first place. [60]

A *Chart of the Web-Like Topography of the Large Scale Structure of the Universe* (see fig.85), indicates the way in which more mature structures have formed from the clumps of energy seen in the *WMAP* image, (fig. 82). It is thought that gravity, dark matter and dark energy, which are not visible, contribute to sculpting the hollows and clumps seen at such scales.

I see what I see not was a project about visibility and invisibility established in 2003 by the German artist, Tim Otto Roth. It was conducted in conjunction with the Internet Art Façade at the House of Communication in Munich to create dialogues between art and science. Roth works with ideas surrounding the pixel, which through telescopes and digital imaging technologies represents an astronomical object or a subatomic particle. By working with 10 by 10 picture elements, coloured boxes of light dominating the exterior walls of the gallery, he constructs various models of pixel patterns. These represent a 'zoomed in' fragment of astronomical phenomena. They are mapped through state-of-the-art telescopes and satellites in co-operation with several observatories and laboratories around the world. These images can be seen almost in real time via the internet.

59 www.sdss.org/ [accessed 16/11/04]. A quasar is a quasi-stellar radio source …they are the wildly energetic cores of delinquent young galaxies and are powered by super-massive black holes – exotic gravitational sink holes in space from which not even light can escape. Watson, *Stargazer,* 280. It is thought that that the centre of the Milky Way might be a black hole. The SDSS 3D Map can be seen at http://antwrp.gsfc.nasa.gov/apod/ap031028.html [accessed 15/02/05]. .

60 Cowan, *The Meditations of Fra Mauro*, p.11.

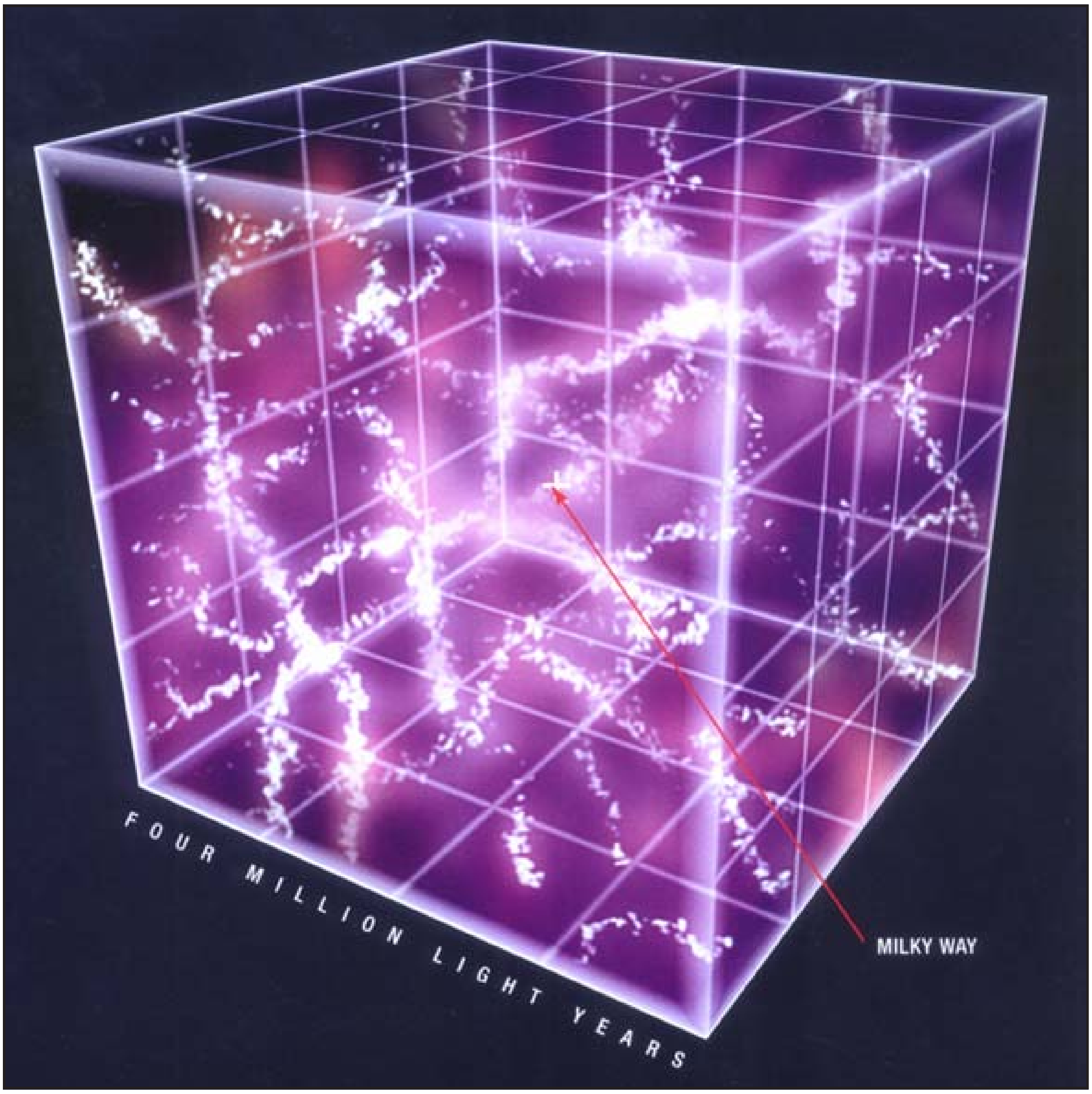

Fig. 85 *Chart of the Web-Like Topography of the Large Scale Structure of the Universe*.

Roth describes it as ‘a beautiful game about the autonomous extension of art by the means of physics.’ [61]

These works appear on the website and can be viewed at various degrees of the proximate or distant via the ability to zoom in or out from them. Further information can be accessed by clicking on the images. They have a title and a small description which stimulates curiosity, and further web sites and images are presented about the scientific basis and astronomical research surrounding them. There are titles such as *Redshift 6.4 Quasar*, (see fig. 86), in which he references the most distant quasar ever discovered at the time in the *Sloan Digital Sky Survey*, and *Cosmic blush*, about the way the colour trend of the universe has changed over billions of years. Also *Echo of the big bang – the cosmic background radiation*, which is the result of research with the *Wilkinson Microwave Anisotropy Probe*, and finally *Deep Fields,* which are the long time exposures from far distant sky regions by the Hubble Space Telescope and others. As the Gallery states, these interactive images investigate ‘extreme views from astronomy and particle physics creat[ing] a visual trip to the pixeling edges of the universe, but as well to the edges of technical perception.’ [62]

At the beginning of this research project I photographed the sky at dusk while flying over Torres Strait, *Flight EK 405*. (See fig. 87). The curve of the jet window framed the view of a liminal space between the upper atmosphere and an infinite deepening blue distance above. Stratas of cloud formed a surreal landscape. Cocooned in the capsule of the jet, I could metaphorically wander into the space beyond the window without being sucked into thin air. At this altitude where could I go but up, into invisibility, to the limits of perception. I was caught between nature and culture, between curiosity and desire, ‘wandering above the mist.’

In his work titled *The Edge of Space*, 1999, Dan Holdsworth, a British artist, also explores the limits of perception and time and space beyond the visible. He works with large-scale photographs, This work was made at the Arecibo Space Telescope at the National Astronomy and Ionosphere Centre in

[61] As quoted in Tim Otto Roth ‘ I see what I see not ’, *Internet Art Façade at the House of Communication*, www.photograms.net/kunstfassade2003/tor/index_e.html p.1 [accessed 13/04/2006].
[62] Ibid., p. 1.

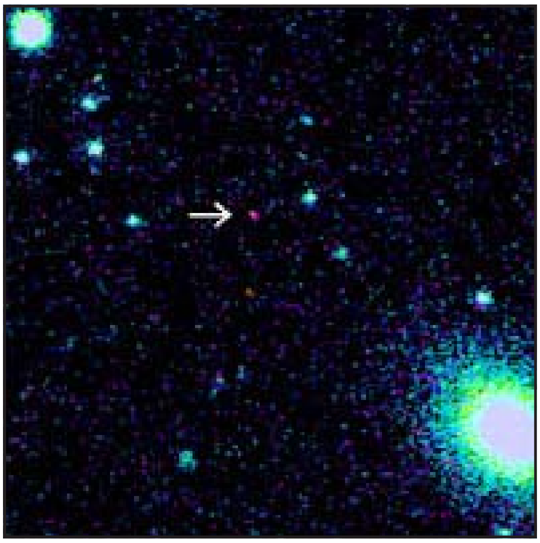

Fig. 86 Tim Otto Roth *Redshift 6.4 Quasar*, 2003, digital image. Internet Art Façade, House of Communication, Munich.

Fig. 87 Felicity Spear, *Flight EK 405, 2004,* digital photograph, archival pigmented inkjet print on rag paper, 120 by 90 cm.

Puerto Rico, (the world's largest single dish radio telescope). Most recently his work titled *The Gregorian* 2005, and *Untitled* from *Hyperborea,* 2006, (see fig.88), looked at the Northern lights seen from the limits of Reykjavik in Iceland and from the Andoya Rocket Range above the Arctic Circle in Norway. In 2006 he was the artist selected for the New Visions contemporary art programme at the National Maritime Museum at Greenwich in the U. K. His photographs depict as the Museum describes it, 'a collision of nature and culture where the natural world and the limits of the most advanced technology sit side by side.' [63] Holdsworth says of his latest work:

> [t]he experience of photographing the Northern Lights felt like I was entering a different time space. Whilst being alone in the arctic wilderness, I became aware of the cycle of the Earth. The lights are a visual representation of everything that we cannot see but which goes on around us all the time. It's like being given a glimpse of the rhythm of the universe. [64]

The night sky has motivated earth-bound observers to map what are believed to be hidden forces, 'out there', that animate and drive the universe. Through the prism of science what is revealed is the complex process of its mapping, and also an ambivalence to the enormity of its scope. When we talk of science Merleau Ponty makes the observation that:

> [s]ince the end of the nineteenth century, scientists have got used to the idea that their laws and theories do not provide a perfect image of Nature but must rather be considered ever simpler schematic representations of natural events, destined to be honed by increasingly minute investigations; or, in other words, these laws and theories constitute knowledge by approximation. Science subjects the data of our experience to a form of analysis that we can never expect will be completed since there are no intrinsic limits to the process of observation: we could always envisage that it might be more thorough or more exact than it is at any given moment. [65]

Art is also constituted by approximation, operating in unstable territories, at the threshold, at the border, in ruptures and folds. It is with this in mind that I have undertaken this research. In a cosmic metaphysical mix I have engaged in my own individual process of mapping across different fields of knowledge and relations. This allows for a dialectic between nature and culture, the

[63] Dan Holdsworth: At the Edge of Space, Parts 1-3. www.nmm.ac.uk/server/show/ConWebDoc.20911 p. 2, [accessed 8/06/2006].
[64] Ibid., p. 3.
[65] Merleau-Ponty, *The World of Perception*, p. 43-44.

Fig. 88 Dan Holdsworth, *Untitled* from *Hyperborea*, 2006, photograph. National Maritime Museum, Greenwich, United Kingdom.

material and immaterial, art and science, the real and the representation, the visible and the invisible, between the Nietzschean Apollonian (structure) and the Dionysian (anti-structure), the replete and the void. We live in a contested site called 'culture', in which we all participate and to some extent share. The increasing influence of communication and imaging technologies suggests that the images we make reflect the way we perceive ourselves. As Bachelard noted, 'Je suis l'espace ou je suis' (I am the space where I am). [66]

The process of mapping is not only a process by which we make representations of realities. It is also a process by which we are able to construct realities. Wenyon and Gamble have continued their research into holography over the past decade. Through the history of astronomy and the technologies associated with it, they are interested in mapping the cosmos to reveal through a certain mystery what technology so often dispels.. Popper suggests that they 'wish to imitate this fact on an artistic level by creating their own abstract patterns of light, to be decoded through an optical reading.' [67]

At a residency at the M.I.T.'s Haystack Radio Observatory (which has a covering 'radome' 46 metres in diameter, and is constructed on geodetic principles), they have made a number of works that as Balken suggest 'recast clinical spaces and machines into imaginary, and sometimes ethereal environments.' [68] Their work titled *The Haystack Radome, Mapped With Its Own Telescope,* 2000, (see fig. 89), is a sixteen foot long digitally created image which Balken describes as a 'single, splayed, longitudinal view of the surface of the dome which when flattened in this digital format becomes a mosaic of geometric patterns.' [69] The discovery and use in their work of various photographs (hand made photographic mosaics), of the moon and planets made by astronomers at the Observatory, suggests a common and continued striving for higher resolution, bigger images shared by both the scientist and traditionally, the artist.

---

[66] Gaston Bachelard, *The Poetics Of Space*, quoting Noel Arnaud (Beacon Press: Boston,1964), p. 137

[67] Frank Popper: *Art of the Electronic Age* (Thames and Hudson: London, 1993), p. 46.

[68] Debra Bricker Balkan, Wenyon and Gamble's *Space Waves.* http://wengam.com/balken.html p. 3, [accessed 08/02/2006].

[69] Ibid., p. 2 .

Fig. 89 Wenyon and Gamble, *The Haystack Radome Mapped With Its Own Telescope*, 2000, (detail), iris print on tyvek, 40 by 200 inches. U.S.A.

The science of physical optics dominated early modernist European vision and the European observer with prescriptive and non-negotiable models of vision and space. What developed were mechanistic and materialist concepts associated with the rational and relentless gaze of scientific inquiry and the pursuit of 'truth.' In this chapter I have discussed the eventual merging of this knowledge with other phenomena, notably electricity and magnetism, where light came to be regarded more as the property of the electromagnetic phenomena than a revelation of the visible and human vision. Schlain elaborates:

> [f]rom antiquity to the 1860's, all scientific discoveries of moment were based upon sharp-edged black and white numbers and measurable quantities. Then within the next sixty years, a few physicists stared in childlike wonder at the spectrum of colors and discovered the following: the composition of the stars; the fusion of magnetism, electricity and light; the genesis of quantum mechanics; the structure of the atom; and the expansion of the universe. These five discoveries rank among the most profound insights in the history of science… Einstein's realization that light (which is color) is the quintessence of the universe paralleled the apotheosis of light by artists. [70]

In this chapter I have discussed the unfolding process of mapping the night sky, largely unseen, which involved looking at observation and imaging technologies that map space through light, data and the senses. This reveals both the very small and the very large. Cosmic space is no longer understood as a clockwork mechanism and a quantity of discrete objects. It is now thought of as a set of interacting processes and relational fields which challenge our understandings of what is meant by reality. Whitehead has described it as a 'vibrator organism… [stating that] in a certain sense everything is everywhere at all times.' [71] Eliasson suggests in another but related sense that today, ''[h]ere' is not a place on the map. It is the intersection of trajectories, the meeting up of stories, an encounter. Every 'there' is 'here.'' ' [72] The process of mapping enables the imagining or re-inventing of different realities that bridge the insights of science and art.

[70] Schlain, *Art and Physics*, p. 179.
[71] Shattuck, quoting A.N. Whitehead . 'Science and the Modern World', in *The Innocent Eye*, p. 148.
[72] Olafur Eliasson, quoted in *Olafur Eliasson - The Weather Project*, ed., Susan May, The Unilever Series (Tate Modern Publishing: London, 2004), p. 115.