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Holographic Materiality

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Abstract: This paper was presented at the National Institute for Experimental Arts (NIEA) Conference at the University of New South Wales, Sydney, Australia, in August 2011. It explores types of hypotheses which can arise from viewing holographic imagery through an analogy to interference. Holographic images exist through the diffraction of light from various types of nanoscale structures, which are optically or mechanically formed. Optical formation of the hologram by the direct exposure of objects to laser light results in a virtual image of extreme spatial verisimilitude. The experimental nature and scope of holographic imaging is demonstrated by highlighting three of my works. There's No Place Like Home (1980), which engages the viewer with the simultaneous existence and non-existence of a familiar place, a lounge room, by moving between sides of the holographic picture plane. Shrine of the Sacred Heart (1997) at St Brigid's Church, Coogee, engages beholders in the intangibility of a flame-like form by inviting them to place their hands into the space of the virtual image. Luminous Presence (2007), made from thousands of holographic pixels, each a single frame of a computer graphic environment of translucent raster-scanned figures illuminated by rays of light, animates light and darkness. By referencing holograms in film, this work takes its place as material evidence, a "real" hologram.

Keywords: Holographic imagery, interference, memory, after image

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What Is Experimentation?

Summarizing Bruno Latour, Lisa Disch has commented: “It is not that science manages somehow to enable things to speak on their own, rather it is that experimental practice stages phenomena that vote either for or against the hypotheses of the experimenter”. (Disch, 2008, p. 91)

In order to predict whether or not a recording of a hologram is likely to succeed, it has become customary to perform an experiment, known as the Michelson Interferometer. In essence the Michelson Interferometer causes the collimated light emitted from a single laser to be split by a tilted semi-silvered mirror and recombined—the beams being superimposed onto each other and expanded. Michelson designed and invented many interferometers, which were used to test a variety of hypotheses. The famous Michelson-Morley experiment of 1887, which had a profound influence on our view of the universe in proving for the first time that the measured speed of light was identical in all directions. Similarly, we could employ the Michelson Interferometer experiment to test the hypothesis, “If light is added to light there will be more light”

By observation of the visual results of the experiment we can disprove or prove our hypothesis. The combination of the two beams of laser light gives rise to “fringes”, dark and light bands. One observation of this experiment is that light added to light can produce darkness and also light more than twice as bright as the two initial beams. As Hecht has stated more technically: “…optical interference may be termed an interaction of two or more lightwaves yielding a resultant irradiance that deviates from the sum of the component irradiances.” (Hecht 1990, p.333)

In the context of preparing for making a hologram, the hypothesis “This environment is suitable for making holograms” is tested through the Michelson Interferometer experiment. The assessment of the stability includes the componentry of the apparatus, the functioning of the laser and environmental factors impinging on the holographic environment, including the experimenter/holographer making the image. The movement of the bands of darkness and light of the Michelson Interferometer magnify the minute material deflections of the physical components of the system in meaningful, quantifiable terms. (Abramson, 1986)

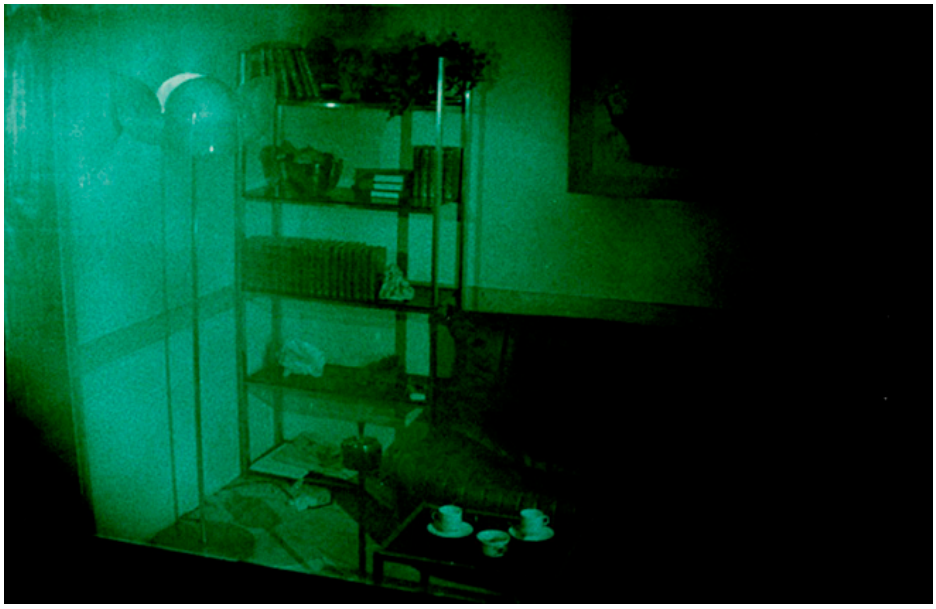
This is significant, as the recording of an optical hologram requires that all elements in the system cannot move more than a quarter of a wavelength of light throughout the duration of the exposure. If we lightly touch any of the components of the system the slight pressure of our touch is immediately registered in a wild fluctuation of the interference bands of dark and light. Changing weight between our feet when standing close to a table holding the Michelson Interferometer will cause the fringes to move more slowly and over a smaller distance. We can observe, over different periods of time, the effects of displacements of material things from walking, cars passing, breathing, sliding of componentry mirrors when stands are not tightened, and the movement of air currents through the beams. We observe the movement of the dark and light interference fringes to see if they are less than a quarter of a wavelength of light over the proposed exposure time over time. This observation of interference tests our hypothesis.

From the above-mentioned examples of application of the Michelson Interferometer experiment it is evident that the same experiment can be employed to deduce many different things depending on the framing of the enquiry. My familiarity with interference phenomena led me to bring the analogy of interference into an art practice as a means for enabling the beholder to develop new hypotheses about familiar things or ideas. Over the past 3 decades

there have been significant changes in the cultural context in which holographic images are viewed and in each decade my approach to locating the holographic image has shifted. By presenting multiple elements within each work beholders were encouraged to engage in conceptual interference between absent and present spatial and temporal elements.

There's No Place Like Home 1980 (Coyle, 1995), an installation shown in the gallery context, was my first major hologram work. Even though in 1972 Jonathan Benthall's book, Science and *Technology in Art Today*, had featured the holograms of pioneering artist Margaret Benyon, by 1980 there was still no specific theorization of the hologram. (Benthall, 1972) There was, however, the general context of structuralism, semiotics and conceptual art, which provided a backdrop, specifically, the 1970s legacy of "the phenomenological turn", based on the work of Maurice Merlau Ponty and the reception of minimalist sculpture. (Potts, 2000, p.207)

The subject matter of the holographic image was something presumed to be well known to all the viewers and to be understood as something subjective and personal, the indexical sign of an absolutely "normal" and unextraordinary middle-class existence.



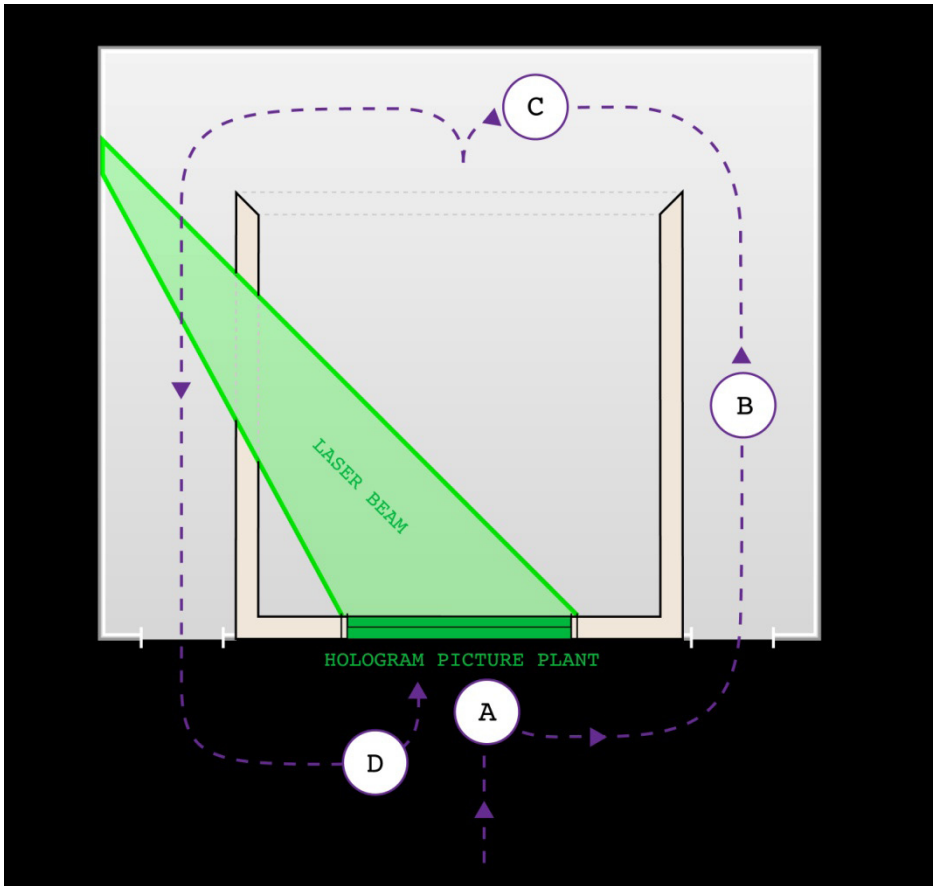
The holographic technique used, the off axis laser transmission hologram, was one of the earliest incarnations of the hologram. At the time of making this image, several white light viewable image types had already been invented, for example, the reflection and rainbow hologram, but the use of the laser transmission as a retrospective gesture went against the grain of new types of hologram production.

The work, an installation, sets up an iterative viewing and thinking pattern in the viewer by shifting between visible and non-visible, yet spatially defined, elements of the installation and hologram. The viewer first sees the installation of the section of a timber house exterior, with a large green window-like optical laser transmission hologram though which can be seen a lounge room. (The hologram was recorded directly from a full-size facsimile lounge room, which had been built within a vibration-isolated laboratory.) The viewer looks though the 1500 x 950mm holographic plate into virtual 3000 x 3000 x 2800mm lounge room space illuminated by a laser beam of 514.5 nm green wavelength—the color of the "sciency" oscilloscope. The complete replication of the 3D space by the light field diffracted by the holographic plate engages bodily with accommodation and fusion, stereopsis of the eyes and with the vestibular system through motion parallax. This, in combination with the exceedingly high resolution of the image, in excess of that perceptible by the eye, gives the beholder the sensation that

the spatial aspect of the room actually exists beyond the glass windowpane.

The beholder then walks the distance of the room to the door of the house in low light, seeing the strong red afterimage and smelling the aroma of freshly sawn pine.

The inside house structure is overtly made as a stage set—roughly made for functionality. The beholder sees the green laser beam expanded to illuminate the back of the holographic plate, the faces of other beholders watching and pointing to things in the virtual holographic images (which the beholder cannot see) and an empty space the same size as the image. The holographic image is not at all visible—simply because the hologram is NOT on the surface of the windowpane but diffracted from it.



The lounge room at first seems to exist, then, when the viewer moves to the position behind the hologram, it is not visible, yet it seems to exist for other beholders. The beholder returns to the original position, however, the additional knowledge, like the knowledge of all illusions, does not prevent the beholder from experiencing the image as present, yet the resistance of the additional experience of the physical emptiness bears down on the experience. The beholder is in fact in a new position, one, which connects physical, illusory, and conceptual space/time by the interference of present with previous experience of the same thing.

In so doing I had imagined that the beholder would hypothesize something similar to the temporal cycle of "care" discussed by Heidegger in *Being and Time*:

> …In the order of the ways in which things are connected in their ontological foundations and in the order of any possible categorical and existential demonstration, Reality is referred back to the phenomenon of care. But the fact that reality is ontologically grounded in the Being of Dasen, does not signify that only when Dasen exists and as long as Dasen exists, can the Real be as that which in itself is. (Heidegger, 1996, p.255).

The visual analogy was made though the iterative process of observing varying levels of absence of the scene as the beholder moved though the A,B,C and D locations. As Dr Peter Zec observed in *For a Theory of Holography*:

> … because holographic space exists in neither an external nor an internal reality, it is its own simulacrum "the identical copy of something whose origin never existed" as Jean Baudrillard defined it. This space can no more copy reality than create illusions. Both impossibilities form a basic implication of the new "spatial logic" of the simulacrum, which is expressed in the aesthetic effect of holographic space. (Zec, 1990, p. 11)

From overhearing comments of beholders of *There's No Place Like Home*, it seemed their interest was to hypothesise on the realisation of the holographic image. The creative inventiveness of these propositions was not inhibited by technical knowledge. In 1980 it could have been supposed that the novelty of seeing a hologram for the first time was the cause of this reaction. However, three decades later, holographic imagery still seeds a hypothesis of image origin in the beholder. The dependability of the beholder's quest for origin made it possible to provide image information in future works which would intercept and redirect this line of enquiry.

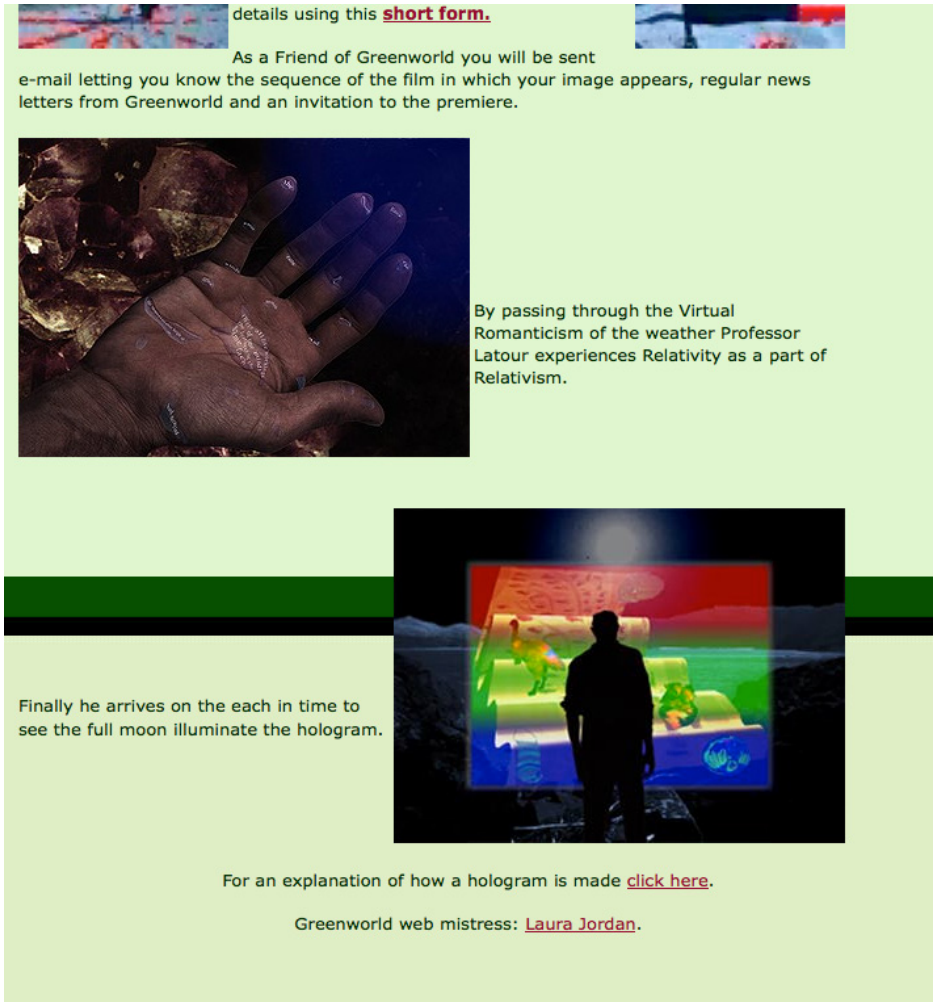
1990s

Throughout the 1990s I made works for communities. These communities had strong clearly defined pre-existing pictorial codes, which I employed. The works were exhibited in contexts outside the gallery environment. These works directly referenced and tested theoretical discourse of the hologram and scientific practice.

One work, for the scientific community, was a rainbow hologram of a scientific visualization of sea level changes over several million years. The hologram was to be seen on the shore of Lizard Island superimposed over the ocean and landscape and illuminated by the light of the full moon. The beholder was to take the position of Friedrich's *Wanderer of the Mist,* staring towards the unfolding landscape but with a hologram of a scientific visualization of sea-level changes over millions of years interceding between the beholder and the "natural" environment. The proposed method of making the hologram was CGH, the mathematical calculation of the image drawn by electron beam lithography.

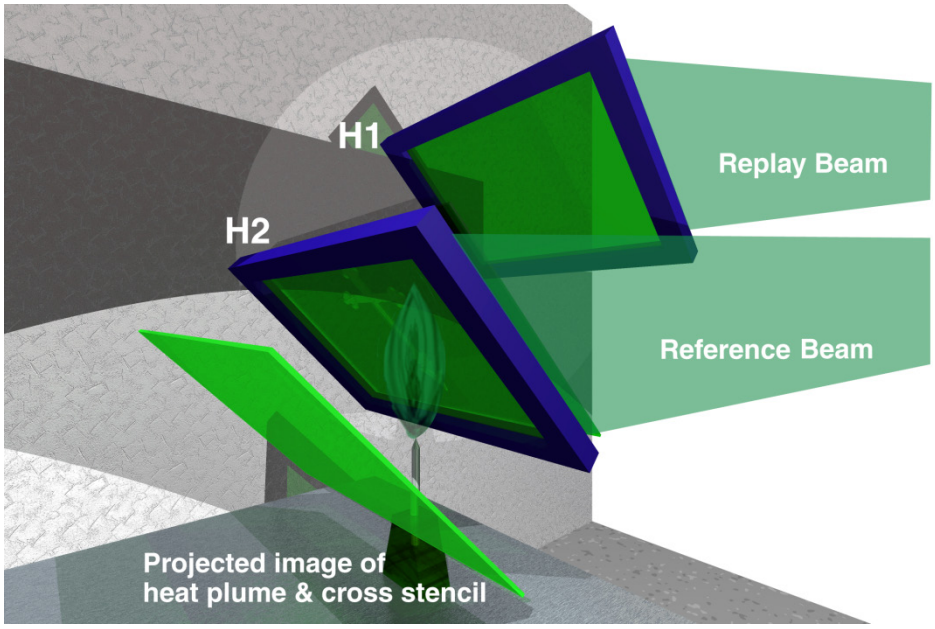
The first viewer of the *You Are Here* hologram was to be the social anthropologist Bruno Latour. As the entry point to the work I made a website Greenworld http://www.vislab.usyd.edu.au/gallery/paula/greenworld/ where Latour's theories regarding opening out, actants, the differences between relativism and relativity were reexamined. Another component of the work was a DVD, co-written with Dr Kevin Murray, *All Days Are Nights*, which further examined these ideas, specifically the processes of abstraction required to circulate information

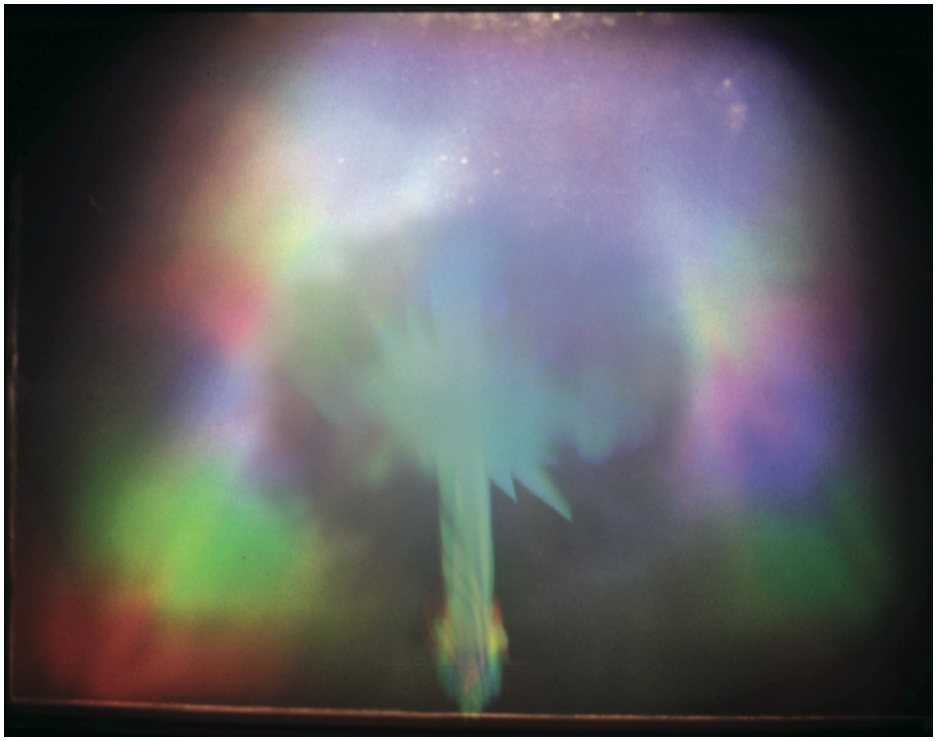
within a network and the authority of the visual language of scientific visualisation.



The other community was the parishioners of St Brigid's Church, Coogee, for whom I was commissioned to make a new *Shrine of the Sacred Heart*. (Dawson, 1999). The brief, following the dictate of Vatican Two, was to make a holographic shrine using non-figurative imagery to convey the three states Father, Son and Holy Spirit, which could easily be recognized by the church community familiar with figurative icons. Representations of the Sacred Heart are all to an extent based on the three 17th century visions of Saint Margaret Mary.

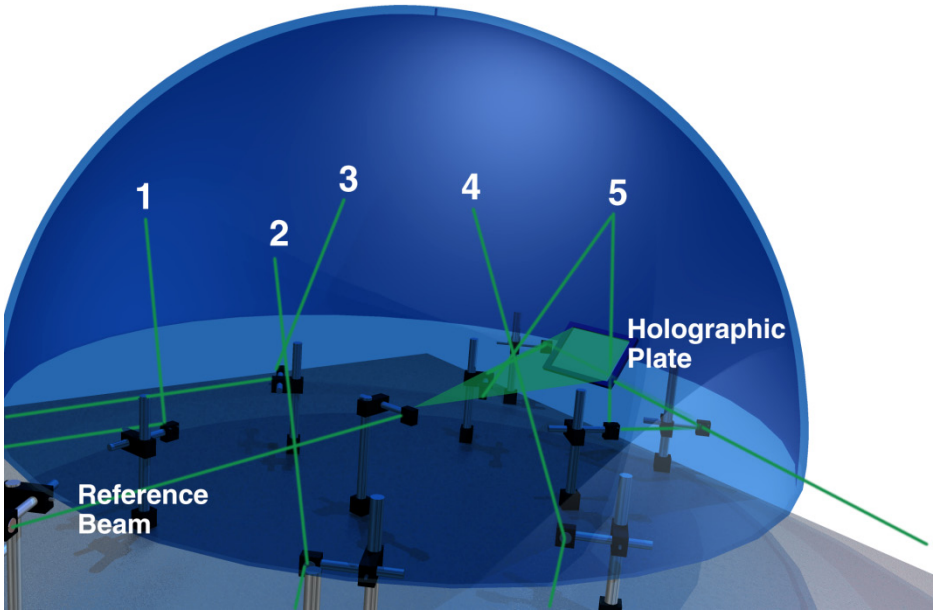
The synchronous facets of the trinity in these visions were simulated by the holographic light field from two superimposed laser transmission holograms. Again the holographic techniques employed were developed in previous decades and generally applied to scientific or industrial holographic subjects. One hologram was made as a single exposure of a plaster dome with frangipani flowers. The other, following the experimental practice of Charles Vest, a leading scientist in the research of non-destructive testing and phase shifts in transparent media, was orchestrated as a double exposure of hot air rising from the tip of a soldering iron through the stencil of a cross. (Vest, 1979)





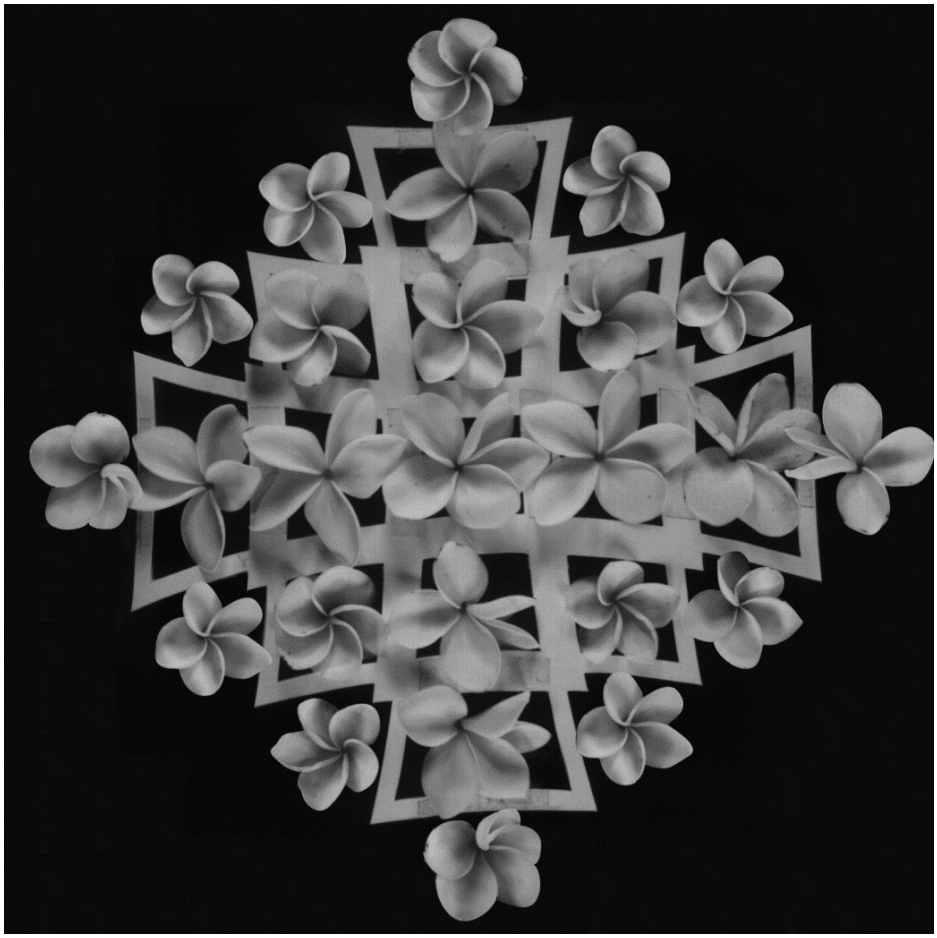
This produced a type of flame/mirage from darkness which emanated from below and through the cross shape, through the holographic plate into the beholder's space.

Using the metaphor of the church as the body of Christ, the risen Christ was conveyed by five rays of light reflected in a dome embossed with designs from the marble carving of the Church.



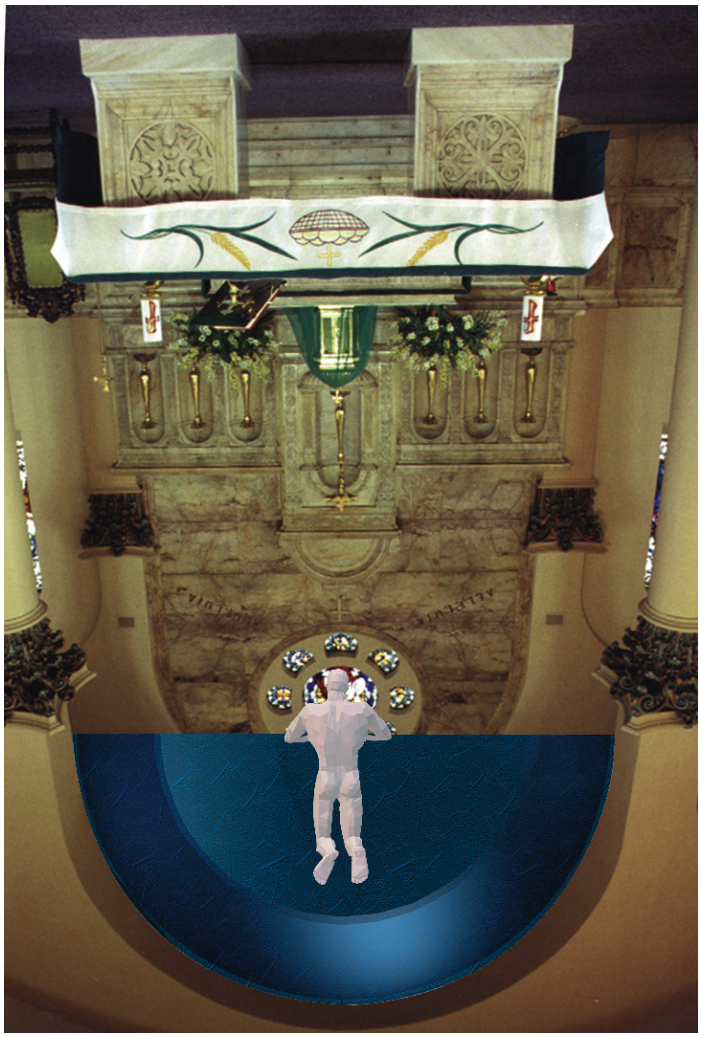
The pattern was decorated with frangipani flowers collected by ladies of the parish on the day the hologram was made. The exposure time of the hologram recorded the inert plaster dome as white while the living flowers, due to their slight movement, were recorded as perfectly formed shapes of darkness. This redirected the “natural” mimetic trail of the origin of the flowers from the day of their gathering to their mysterious transformation, consistent with other

religious light imagery in which the origin of light is darkness.



Finally the “infinite” was conveyed though the laser reference beam illuminating the chest of the beholder with golden light.

The beholder placed their praying hands within the image of the flame confirming the “illusion” of the hologram, tactile information conflicting with the visual. In addition to the experience of the hologram is the memory of the experience of the hologram, which, in situations of lengthy periods of sitting in one place, lets the mind turn to unseen and possibly unrelated things.

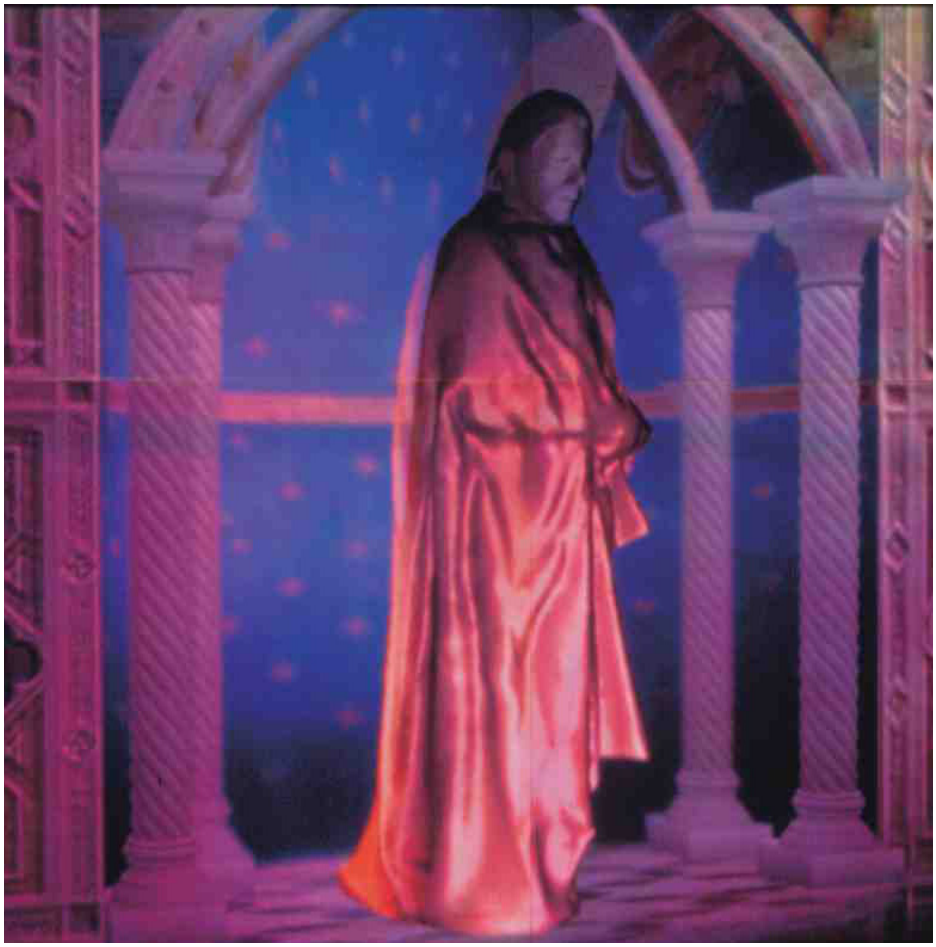


The close replication of key designs of the church in the hologram, but with significant changes to the spatial translation and rotation, invites reciprocation between mental images of the hologram and the real church, which builds a complex spatial/temporal interference inter-relationship.

The Shrine of the Sacred Heart, tested the statement of Jean Baudrillard in his influential chapter on Holograms in *Simulacra and Simulation:* "You bend over the hologram like God over his creation: only God has this power of passing through walls, through people, and finding Himself immaterially in the beyond" (Baudrillard, 1997, p.105)

In the first decade of the twenty-first century holograms were widely understood though their representations in film—specifically holograms were depicted as transparent, generally ROM characters responsible for carrying a message to a real person. Using the rainbow hologram technique, which has been familiar to most people for decades though credit card's "authentic" holographic sticker, I began a series of hologram portraits embossed into bronze cast mirrors. These were to be seen in the private domestic interior. The first in the series, *Mirror Mirror* for Graeme Murphy, Director of the Sydney Dance Company, is in the National Portrait Gallery, Canberra, Australia. http://www.portrait.gov.au/site/collection_info.php?searchtype=basic&searchstring=&irn=995.

Concurrently, I undertook academic research projects investigating pictorial agents within the digital holographic environment. The subjects of these images were images of a range of types: drawings, paintings, frescoes, animated computer-graphics, film and digital video.

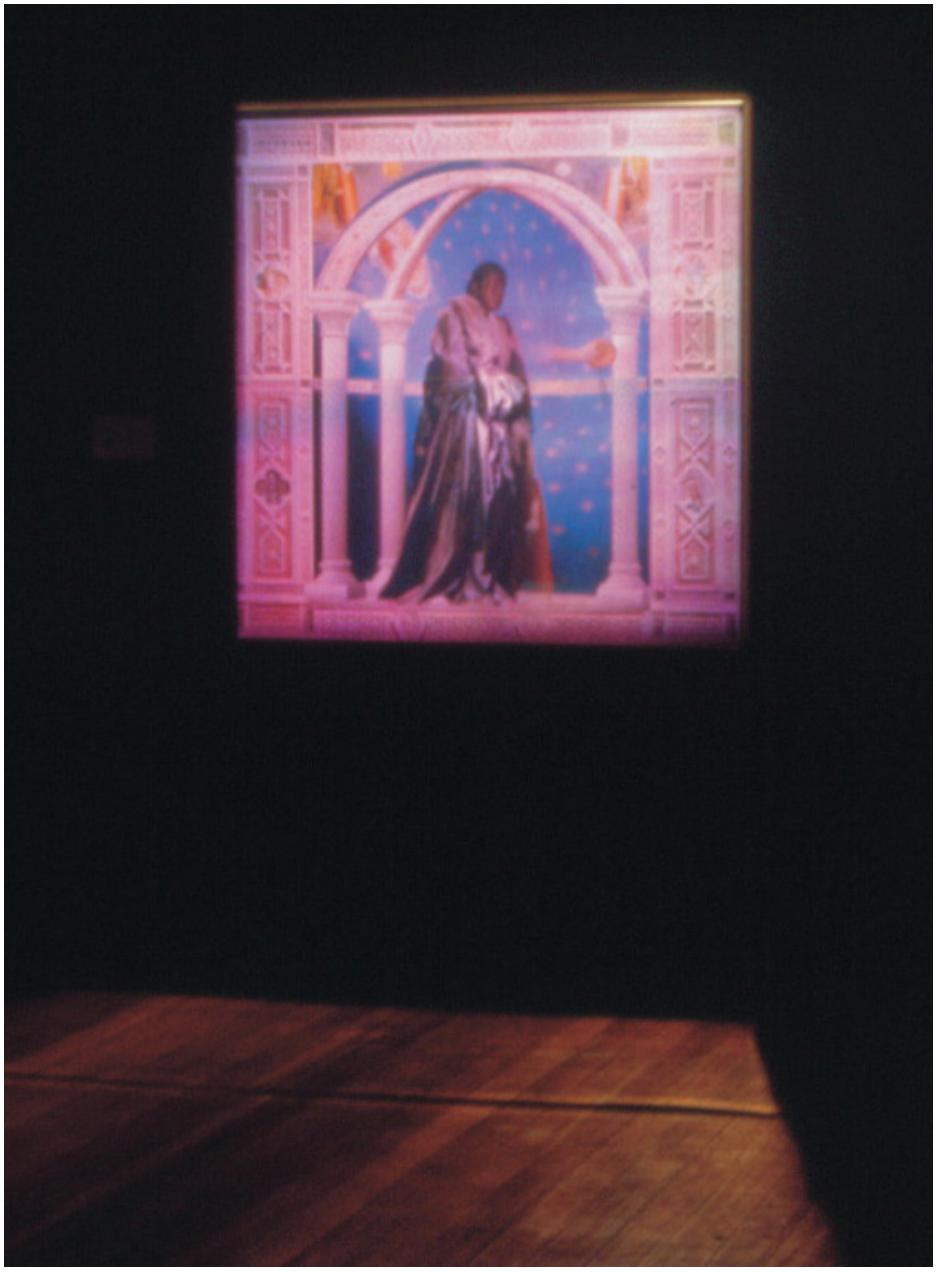


Technically these images were composed of thousands of individual holographic pixels which had each been exposed to digital computer graphic imagery. (Dawson, 2008) The technique of production is described in Benton's *Holographic Imaging*. Michael Klug and Mark Holzbach, the authors of Chapter 20, *Holographic Stereograms and Printing,* refer to the approach:

> Holographic printing represents an amalgamation of 3-D hardcopy concepts proposed, developed and refined over the last one hundred years…In addition, image processing algorithms, derived from models of optical recording system and applied to perspective imagery made it possible to anticipate distortions and pre-distort component imagery to preclude their effects. (Benton, 2007, p. 245)

In the staging of these images as holograms, the light field information was highly structured into sub groups. Taking into account findings of research into perception of images, the works engage with beholders as they navigate the three-dimensional fields in the close, medium and distant ranges. (Cutting, 1995)

The first ARC project, *Shadowy* Figures, 2003 was an investigation of the agency of darkness referencing case studies by Giotto, Masaccio and Leonardo da Vinci identified in Michel Baxandall's book *Shadows and Enlightenment* as pivotal examples of the changing thinking experienced though the pictorial inflection of darkness. (Baxandall, 1995)



The second project, *Luminous Presence*, (Dawson, 2007), was an investigation of the agency of the representation of light, using as subject matter an aggregate of the pictorial styles of holographic special effects seen in films such as *IRobot, Total Recall, Minority Report, Logan's Run, Star Trek, Forbidden Planet* and, best known, Princess Leia in *Star Wars, Episode IV, A New Hope*.

In *Luminous Presence* there is a representation of the light, which replays the holographic character. It appears close to the angle and location of the real light playing back the hologram. The hologram is made from light from the energy of the light existing at the moment of observation. Without this light energy the hologram is not visible. *Luminous Presence* produces a double interference—the hologram depicting a hologram and the light depicting

light as light and darkness. There is a representation of the holographic material—light.

This use of light to suggest a type of energy of being is discussed by Frank Popper, writer on electronic art:

> In order to build an historically legitimate aesthetic of holography one has to detach oneself from dependence upon the photographic paradigm so important in understanding computer art. The persistence of this paradigm reveals itself especially in the over emphasised 'third' dimension of holography. Taking a different viewpoint, one can postulate the 'self-creating power of light' as the creative foundation of the holographic medium. (Popper, 1993, p.37)

The above images show one frame from the sequence of images—first the computer graphic frame which formed one of the more than 3000 images of the final hologram and secondly a photograph of the hologram. A video of the hologram is available at http://www.youtube.com/watch?v=uAWjLKt76dw

From these examples it is not possible to appreciate how the hologram interacts with the beholders vestibular and motor responses yet these are central to the experience of the hologram. (Rogers, 2010) The light diffracted from the nanoscale structure of the surface of the holographic plate generates in real-time a light field which envelopes the beholder and changes as they walk before the image between the dominance of light or light as darkness. (Dawson, 2011)

The representation of black as light, or dark light in painting, in the work of Matisse (influenced by Le Bon's experiments of emanating rays from the human body) engage with the beholder in an entirely different way than for a hologram due to the materiality of paint and its adherence to the material surface of the support. (Gage, 1999) Darkness as a type of light in the holographic image *Luminous Presence* refers to the observation of short pulses of light and relativistic effects in the ongoing experimental practice of Professor Nils Abramson. (Abramson, 2011). *Luminous Presence*, *Shadowy Figures* and the related holographic projects of the 2000s are in some respects experiments in non-material materialisation:

> …some anonymous Greek ancestors have sought blindly, in order to subsist, a space everywhere else absent, full of impossible objects. Eventually they appropriated a place without place—the pure space of abstract exactitude, this perfect utopia outside the world without which knowledge will only be laughable, only be an accumulation, a copy. To be sure, no one has ever seen, touched, felt, heard or tasted this strange non-sensible space, no one has ever experienced the curious objects within it, and yet we know nothing about our world without that space and without these objects. (Serres 1989, p.75)

Conclusion

The uses of experiment are diverse. Direct experience of and engagement with experiments before our very eyes can lead to questioning the development of new hypothesis. From the demonstrated Michelson Interferometer experiment it has been shown that when we add something (light) to it interference occurs. Interference results in the production of something entirely different from the sum of the parts. In viewing and contemplating holographic works conceptual interference can occur between virtual images, real images, after images, mental images, real objects and bodily sensations. The projects discussed engage with experimental approaches to spatio-temporal consciousness, where cognitive acts of perception questioning and belief enable the beholder to expand their ways of thinking about being.

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Paula Dawson's art works simulate and/or evoke complex states of being. Dawson has held residencies at the Laboratoire de Physique et Optique Besancon, France; RMIT Applied Physics Department, Melbourne Australia; the Holocentre, New York, and the Centre for Advanced Visual Studies, Massachusetts Institute of Technology, Cambridge, Massachusetts. Her first major holographic work, *There's No Place Like Home* (1980) is in the collection of the National Gallery of Australia, Canberra http://nga.gov.au/exhibitions/Dawson/index.htm and her best-known installation *To Absent Friends* (1988), a bar room in which holograms replace all reflective surfaces, was awarded the Grand Prix of the First High Tec Art Biennale in Nagoya, Japan in 1989. Many of her holographic works were shown at Virtual Encounters in her retrospective exhibitions at Macquarie University Gallery, Sydney and Newcastle Region Gallery, Newcastle in 2010 http://pauladawson.com/. Dawson's 1999 PhD, dealing with the spatial and temporal properties of the concrete holographic image, led to major ARC funded research projects investigating the pictorial agents of darkness http://www.shadowyfigures.com, light and currently modelling light. Dawson's bronze hologram mirror portrait projects, which combine aspects of early caryatid mirrors (Egyptian, Greek and Roman) with Chinese magic mirrors, are ongoing http://www.portrait.gov.au/site/collection_info.php?searchtype=basic&searchstring=general&irn=995 . Dawson is currently an Associate Professor in the School of Art, at the College of Fine Arts, University of New South Wales, Sydney.

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