

Article

Material Light—In the Realm of the Photon

August Muth 

Independent Researcher, Artist, Santa Fe, NM 87507, USA; august@augustmuth.com

Received: 13 November 2019; Accepted: 11 December 2019; Published: 2 January 2020



Abstract: The artist discusses his work and concepts within the context of the true hologram. He examines the character and attributes of the holographic medium that can assist in the evolution of human perception. Artists and their creative expressions have always had a place at the forefront of change, catalyzing ideas into perceptual evolution. Artistic endeavors that continue to incorporate light as a material will foster the evolving field of the hologram as fine art and influence how light is perceived and used within the expanding world culture.

Keywords: light; photon; nano-interferometric; light–space–time phenomenon; hologram; material light; holographic space; wave interference; multi-dimensional

1. Introduction

Light is, at least to me, mysterious—because on one level, it really defines our reality. It's maybe the most defining characteristic of our reality. Everything we see, how we perceive reality, is based on light bouncing off of objects, or bending around objects, or diffracting around objects, and then being sensed by our eyes, and then sending signals into our brain that create models of the world we see around us. So it really is, almost, the defining characteristic of our reality. But at the same time, when you really go down to experiment and observe with light, it starts to have a bunch of mysterious properties. And to a large degree it is not fully understood yet.

—Excerpt from Sal Khan at Khan Academy

1.1. What Is a Hologram?

The Grecian etymological root for hologram is 'whole message' or 'whole writing'. Every point-perspective within the hologram contains the entirety of the light information generated within the recorded subject's interaction with laser light. If a true hologram is broken then each piece, when illuminated with laser light, describes the entire original subject from that unique point or angle of view. Holograms create a record of light originating from a monochromatic process. Any subsequent illumination of the hologram with white light diffracts that white light, revealing an additive color palette present within that white light.

1.2. The Most Famous Hologram That Is Not a Hologram

The word hologram is misunderstood and misused in contemporary culture. The confusion runs as deep as the difference between reality and a magician's sleight of hand. An online search of the word hologram results in pages of digital video display systems touting holograms of dead celebrities. These video display systems are based upon a "Pepper's Ghost" illusion and have next to nothing in common with holograms, nor do the majority of other related online listings. Princess Leia of Star Wars' fame is only a cinematic special effect. Yet she is probably the most famous hologram that is not a hologram. The misunderstanding and misuse of the word hologram contributes to the devaluing of the hologram, especially as an art medium.

Illusions fool us—we make them up in our minds. An illusion is an act of deception. Some optical illusions are interesting to observe, but an illusion can also point to an erroneous belief or false perception of reality. Even within the field of holography, some professionals refer to the material light forms created by true holograms as illusions. I refute this perception based on a simple example: If you make a true hologram of a lens, that hologram will manipulate and restructure the light in the exact same manner as the originating lens when illuminated with that same laser light. If that hologram of a lens is then illuminated with white light it begins to reveal the character of the illuminating white light. The hologram acts like a prism by separating the white light into spectral colors that reveal the realm of the photon. This phenomenon is the essence of the hologram and demonstrates its inherent character. Holograms exist as an intermediary between our material existence and the mysteries held within light.

I perceive true holograms as one of the most beautiful and elegant discoveries in human history. They transform light—often perceived as non-material in character—into a tactile, multi-dimensional, and ethereal creation of material light. They are not illusions. They are true manifestations of light as material that call out to be experienced.

1.3. Holograms and Their Source Information

I define holograms as existing within two families: True holograms and illusionary holograms. At their foundation, true holograms are multi-dimensional manifestations of material light. The technique used in this process begins with a field of interfering coherent laser light. This light field then interacts with human-scaled three-dimensional subject matter. This interface translates the 3-dimensional content into a multi-dimensional field of light information. The accumulated laser light information is then recorded onto a glass plate coated with light-sensitive emulsion. The resulting light archive—the hologram—contains the content of the multi-dimensional laser light field. This hologram contains an extraordinary level of detail, quintessential to the realm of the photon. When you view a true hologram you are experiencing it in the present as well as seeing the period of time in which it was originally created. This ability to record time is a function of the light–space–time phenomenon. The light used to illuminate the hologram is restructured by that hologram, duplicating the time of its origination. Holograms are tangible, readable archives of light information that have been rendered directly from the realm of the photon.

Illusionary holograms originate from two-dimensional information bundles, primarily generated using digital information. These holograms use two or more sets of stereographic data to develop a stereoscopic illusion that the mind interprets as three-dimensional space. These stereo-holograms have the ability to display animated imagery—reproducing an illusion of time and depth. This enables the creator to fabricate a stereoscopic view manipulating a purely perceptual reality. This type of hologram is easier to realize as the needed two-dimensional source information for their production can be digitally produced.

The artworks I create are all one-of-a-kind true holograms produced using holographic emulsions developed and individually formulated in my studio. I view these emulsions as having a painterly quality. The varied formulas of emulsions I blend are analogous to an artist's paint and color palette. I work with laser light as if it were my brush. Both of these elements are integral in the methodology of content and process within my finished works. To add another layer of creative manipulation I sometimes paint, drip, and carve the emulsions on the glass substrate used in the finished works. I also integrate textured laser light during the exposure of the emulsions to texturize the material light forms—increasing their material context. Because of the simplicity of the holographic methodology I utilize, my artworks exhibit 180 degrees of parallax viewing. This broad parallax makes possible a metamorphosis of material light forms and color that can be seen from anywhere within visual sight of the artwork. I see this kinetic viewing character infused with multi-dimensionality as important elements in the evolution and appreciation of true holograms as a fine art medium.

1.4. Early History of Holograms as Fine Art and Beyond into Quantum Holography

In 1968 the American artist Bruce Nauman produced a series of holograms entitled “Making Faces (A-K)” (Nauman 1968). This series were the first holograms created by an artist of prominence. Nauman’s holograms were recorded in the infinitesimally small time frame of approximately twelve nano-seconds. In this almost instantaneous exposure of the holographic emulsion, Nauman physically articulated his body and face into distorted facial expressions. He said about these contortions “I guess I was interested in doing a really extreme thing” (Nauman 2003). During the twelve nano-second exposure the laser light entered the surface of his skin, potentially integrating with his DNA, and archived its composition into the laser light via the light–space–time phenomenon. This laser light reflected from his body recorded its light information holographically into the light sensitive emulsion. DNA has a diameter of approximately 2 nanometers (Wikipedia 2019). This is only a factor of 300 times smaller than the wavelength of light used to record the holograms of Nauman. A photon of laser light, being smaller than an electron, is a factor of more than one million times smaller than DNA (Quora 2017). Considering the immense information storage capacity of photons (Emerging Technology 2016) within a field of laser light and combining that with the nature of the true hologram and its ability to record the entirety of the subject from an almost infinite number of point locations across its dimension, I hypothesize that the holograms of Bruce Nauman contain a composite holographic recording of his DNA. Currently I know of no device that would allow this DNA information to be retrieved. I view this series of holograms as one of the most profound artifacts created within the sphere of fine art. The recording of this instantaneous moment combined with the potential to document Nauman’s DNA exemplifies the realm of the photon and the true hologram. Between 1966 and 1970 Nauman made several artworks in which he used his body to explore the role of the artist—and explore possibilities within the context of art to investigate psychological states and behavioral codes. Who better than Bruce Nauman to potentially be the first artist to convey the truth of his physical composition infused within the light information recorded in a true hologram?

2. A Discussion of Artworks as Pollinators between the Terrestrial and Photonic Realms

2.1. Spherical Light Series: 2000 to Present

The “Spherical Light” series (Figure 1) investigates the multi-dimensional expression of the hologram. These works encompass the realm of the photon interpreted through the true hologram as an expressive, immersive medium. The series began as an exploration into the impossibility of creating a two-dimensional flat hologram. Upon completion of the first piece, the realm of the photon began to reveal itself to me. As I moved around the piece an extraordinary polychromatic palette became evident. I realized that what I was observing was an elongation and layering of multiple color spectrums over one another. This palette of light expanded my vision of how I could use the medium of holography. I realized it could translate light’s mysteries into the sphere of human existence. The work of Agnes Martin came to mind. Her work in exploring white and its disassembly into constituent colors—as evident below (cut) in “Untitled #2” (Miranda 2016) inspired an expansion of my insight and strengthened my explorations within the realm of the photon.

Based on my newfound realization of color, I then added dimensional content to the subsequent works in the series. I then genuinely began working in the multi-dimensional real-space of light within the medium of holography.

At first glance, the observed dimensional quality of these works is exceptionally subtle. They appear to be flat fields of color. By moving around the artwork its polychromatic character is realized. This trait is the fingerprint of the full-spectrum composition of white light. Through patient viewing an initially indistinct dimensional form floating within the boundaries of the artwork is discovered. With close examination this nebulous volume possesses a tactile material quality. Subtle textural keys begin to emerge assisting the viewer in spatially defining the multi-dimensional rendering of this tactile field of material light. Continuing to move—broadening the exploration of the artwork—a

transformative morphing character is recognized. What is discovered is a curved form within the hologram. With further observation this form evolves into a fractional section of a large spherical form. This sphere is spatially located deep within the artwork. In my comprehension this spherical form may have a diameter of 30 to 40 feet. Conceptually, this hologram contains the entirety of that dimensional sphere. This exemplifies the definition of the word hologram (whole message). I see this spherical light form as a portal into the realm of the photon that can be perceived with the naked eye.

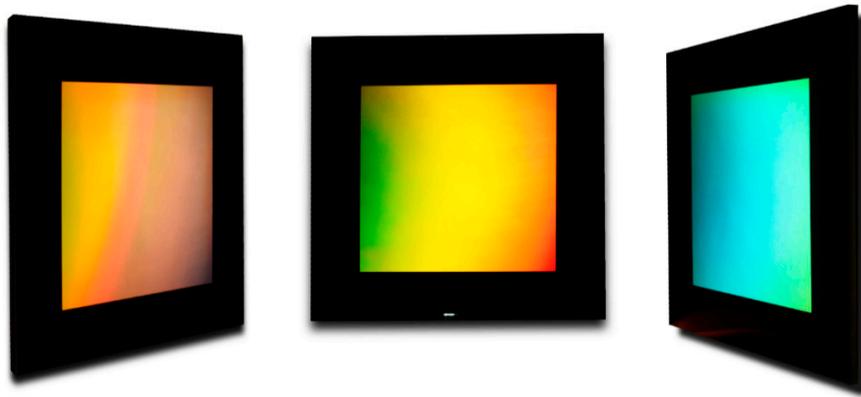


Figure 1. “Apollo” Spherical Light series, 2001. Three views of a single artwork. 54 cm × 54 cm, created by the author.

2.2. Acceleration Series: 2002 to Present

The “Acceleration” series of artworks (Figure 2) addresses the need to accelerate our perceptual evolution to keep pace with our technological revolution. At the time of initiating this series I was reflecting on the work of Joseph Albers’ “Homage to the Square” (Albers 1951). Albers had explored halation, the phenomenon of edge contrast created by color-frequency light-wave interference. The holograms in this series were initially conceived to explore halation. They are compositions of two rectangular forms. In these works one rectangular form occupies a holographic space in front of the glass surface of the hologram while the second rectangular form resides behind the rear surface of the hologram. After the first holograms were made it became apparent that halation did not function within the multi-dimensional context of these works but the use of the rectangle remained a useful tool within my work. What became apparent as the two forms spatially move across each other was their colors and forms cross-pollinated, creating a third polychromatic light field of color and shape. The contours of this light field morph in shape, corresponding to how the two forms spatially overlap. The vivid color these forms present is a result of color mixing as the two rectangles spatially interact. These vibrant colors have their origin within the additive color palette inherent to this process of holography. The dimensional periphery of the light field exhibits a nebulous character, but with contemplation and imagination this subtle dimensional space reveals its multi-dimensional character and form.

Upon close examination and with total visual immersion within the rectangular form residing in the holographic space in front of the glass surface, this initially small rectangle increases in dimension filling the entire physical area of the artwork. The participatory content of total visual immersion within a field of material light can be a perception-altering event eliciting a degree of mystery and wonderment. These works act as portals assisting to increase the understanding of the conceptual territory of the hologram, the realm of the photon, and our tactile physical existence. My intent in these works is to stimulate a degree of physical and intellectual inquiry. The juxtapose states presented by the artworks, material as solid and material as light which possesses a multi-dimensional character, enabling comprehension of physical and non-physical existence to expand, evolve, and to be put into practice.

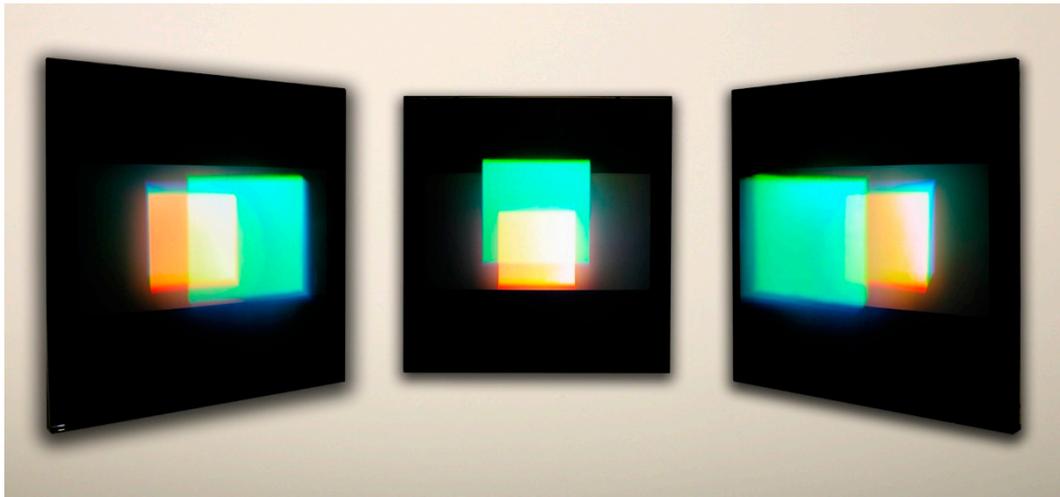


Figure 2. “Acceleration #4” Acceleration series, 2014 Three views of a single artwork. 63 cm × 53 cm, 2014, created by the author.

2.3. Quantum Series: 2004 to Present

These artworks (Figure 3) are a tendrill originating from the Spherical Light series. The “Quantum” series cultivates a visual analogy as well as a potential actual instance of quantum states—a system that allows one single photon to be in two different locations at the same moment (Folger 2005). The series utilizes a system of controlled chaos. During the process of coating the light-sensitive holographic emulsion on the glass plate, centrifugal force combined with serendipitous and intentional aberrations result in holographic emulsions patterned with physical artifacts. These patterned fields of aberrations contain bubbles, have a dimensional surface texture, and are delicate in appearance. These patterns convey an abstracted but system-based motif. In the finished works the emulsion aberrations create a tangible solidity embedded within the piece. The holographic shadows of these aberrations occupy the holographic space in front of the glass surface of the hologram. The entwining of the physical emulsion aberrations with their holographic shadows creates a holographic amalgam. The commingling of the two states of the physical and the holographic, reference quantum states. Coincidentally, this amalgam resembles a cosmic nebula. This blending of light as material and physical matter exemplifies the conceptual holographic sphere of perception. I view these works as doorways into an increased understanding of our quantum actuality, both symbolically and theoretically.

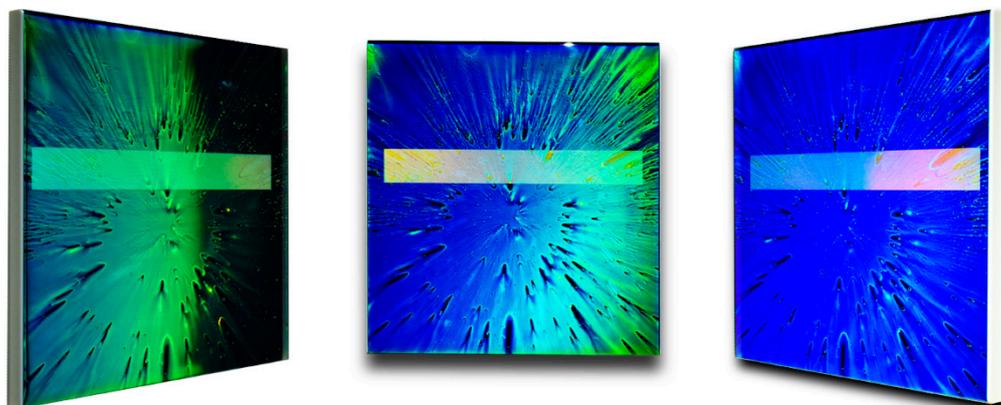


Figure 3. “Driving Through Smoke” Quantum series, 2014 Three views of a single artwork. 56 cm × 53 cm, created by the (cut) author.

3. Personal History within the Medium of Holography

After 10 years of sculpting metal as a sculptor/jeweler in the framework of the pictorial, I saw my first hologram in 1982. Four years later I opened my first holographic studio and continued to make holograms with pictorial content. In 1994 I experienced an exhibition of Bruce Nauman's "Clown Torture" ([Clown Torture 1987](#)) at the Walker Arts Center in Minneapolis, Minnesota. My initial response to the work was revulsion. I noticed a similar reaction from the others who had entered the gallery, most of whom left the gallery shaking their heads in disgust. At that moment, I realized the power of art to elicit a strong physiological and psychological response. One of the primary properties of holography that interested me is its ability to stimulate imagination and curiosity in the viewer. Experiencing "Clown Torture" has influenced my work ever since.

In 1996 I realized that light and the mysteries it holds should be the basis for my creative work. I then began to conceptualize the process of sculpting light and shaping photons into dimensional forms. I continued my studies surrounding light phenomenon and how they manifest in the environment. These included the Aurora Borealis, rainbows, sundogs, and light pillars.

Halo is a term used to describe a ring of light that forms around the sun or moon. I utilized the knowledge of this phenomenon to begin the "Halos" series of holograms in 1996. I used a minimal geometric ring form made of steel as the subject to initiate the conveyance of light's narrative. My intent was to engage the audience in the ideas surrounding light as a material. The reaction was very positive. The experiential content of these works was an added event that I had not fully anticipated. The viewers became tactilely interactive with the golden ring of light that was occupying the holographic space in front of the surface of the hologram. As people attempted to hold the material yet non-material ring of light I sensed expressions of delight. In later conversations about the work, amazement and mystery were common topics. I then realized the importance of integrating the individual human experience when presenting of the story of light through my work. Subsequently my content within the halos series expanded to laminating multiple holograms of the single ring into compositions consisting of multi-dimensional colleagues, utilizing up to three rings, and encouraging a tactile interaction.

This experience confirmed one of the most interesting and unique properties of this medium. True holograms, with their intrinsic content of mystery, have the ability to evoke a physiological and psychological response. I see this response as being similar to what Nauman's "Clown Torture" ([Public Delivery 2019](#)) evoked but having the opposite character of curiosity and sense of wonder. Other mediums such as virtual reality, 3D movies, or James Turrell's "Afrum 1" ([Turrell 1966](#)) a light projection work, are able to kindle similar responses. These are all illusions created within our minds through visual cues. I view illusion as removing the potential for imagination by generating fantasy—they do not expand our awareness of the world. By using the medium of the true hologram I hope to assist in the acceleration of our perceptual evolution into an inclusive, holistic system.

A significant motivation within my artistic practice is to encourage and develop a deep appreciation and understanding of light. It has created and sustained life for eons. We have delighted in its beauty through the spectrum of its color composition. Light as a photon exists as energy. We now exist in a world in which humans are not in equilibrium with the natural world. This imbalance can be resolved by developing a deeper and more integrated relationship with light and the energy that it transports. Through the creation of my holographic light-based artworks I aspire to bring into reality an evolution of human perception. This profundity of thought could result in an awakening, encompassing and developing a methodology that embraces a holistic understanding of light, its mysteries, attributes, and the appropriate use of the solar energy that is supplied to us on a daily bases.

4. Conclusions

Holograms are truly extraordinary. They exist as an intermediary between our terrestrial existence and the mysteries of light. My holographic artworks transform light with its non-material character into multi-dimensional and tactile creations of material light. In these works I use light as a material, sculpting photons into a luminous essence of polychromatic color and mystery. They exhibit a material

yet ethereal nature that invites examination and exploration. They are intrinsically beautiful and captivating. The experiential qualities presented in my artworks establish an environment conducive to addressing concepts within the light–space–time phenomenon and the mysteries intrinsic to light. I feel that the true holograms can provide a platform for altering awareness within an individual’s sense of reality. This perceptual expansion can result in an evolution in individual perception, initiating a deeper understanding of the realm of the photon, and holistically integrating light and the energy it carries into a sustainable future.

Funding: This research received no external funding.

Acknowledgments: I wish to offer my gratitude to Fred Untersher who ignited my explorations and who continues to inspire me. I would also like to thank my wife, Joan Stango, for her devoted support.

Conflicts of Interest: The author declares no conflict of interest.

Definitions for Clarity and Contemplation

Realm of the Photon	The synergistic totality of all energetic light radiation.
The light–space–time phenomenon	Light as energy, precisely delineating space and material composition, traveling at the speed of light, in the vehicle of time. The photon only exists in the present and holistically determines the totality of our future on earth.
Holographic space	The field of non-physical space that resides outside the boundaries described by the physical mass of the hologram.
Material light	Light as material, infused with time, fabricated into dimension. It is a manifestation of the light–space–time phenomenon. It physically exists within the holographic space.
Multi-dimensional	A region or quanta of energy described as existing within wave particle duality, blanketed by numerous dimensions, time being the fourth dimensional element.

References

- Albers, Josef. 1951. *Homage to the Square (La Tehuana)*. Image. Available online: <https://www.themodern.org/collection/homage-to-the-square-la-tehuana/1223> (accessed on 26 December 2019).
- Clown Torture. 1987. Art Institute of Chicago. Available online: <https://www.youtube.com/watch?v=YorcQscxV5Y> (accessed on 18 December 2019).
- Emerging Technology. 2016. Available online: <https://www.technologyreview.com/s/602454/single-photon-carries-10-bits-of-information/> (accessed on 19 December 2019).
- Folger, Tim. 2005. If an Electron Can Be in Two Places at Once, Why Can’t You? Available online: <http://discovermagazine.com/2005/jun/cover> (accessed on 26 December 2019).
- Miranda, Carolina A. 2016. Q&A: What the World Misunderstands about Artist Agnes Martin and How Her Biographer Unearthed Her Story. Available online: <https://www.latimes.com/entertainment/arts/miranda/la-et-cam-agnes-martin-nancy-princenthal-biography-lacma-20160411-column.html> (accessed on 19 December 2019).
- Nauman, Bruce. 1968. *Making Faces B*. Available online: <https://www.inexhibit.com/marker/bruce-nauman-disappearing-acts-shaulager-basel/> (accessed on 18 December 2019).
- Nauman, Bruce. 2003. *Bruce Nauman’s Words*. Massachusetts Institute of Technology: p. 125. Available online: <https://mitpress.mit.edu/books/please-pay-attention-please-bruce-naumans-words> (accessed on 19 December 2019).
- Public Delivery. 2019. What Makes Bruce Nauman’s Clown Torture so Controversial? Available online: <https://publicdelivery.org/bruce-nauman-clown-torture/> (accessed on 19 December 2019).
- Quora. 2017. Which Is Bigger: Photon or Electron? Available online: <https://www.quora.com/Which-is-bigger-photon-or-electron> (accessed on 19 December 2019).

Turrell, James. 1966. Afrum 1 (White). Available online: <https://collections.lacma.org/node/215590> (accessed on 19 December 2019).

Wikipedia. 2019. Persistence Length, Axial Stiffness. Available online: https://en.wikipedia.org/wiki/Nucleic_acid_double_helix (accessed on 19 December 2019).



© 2020 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).