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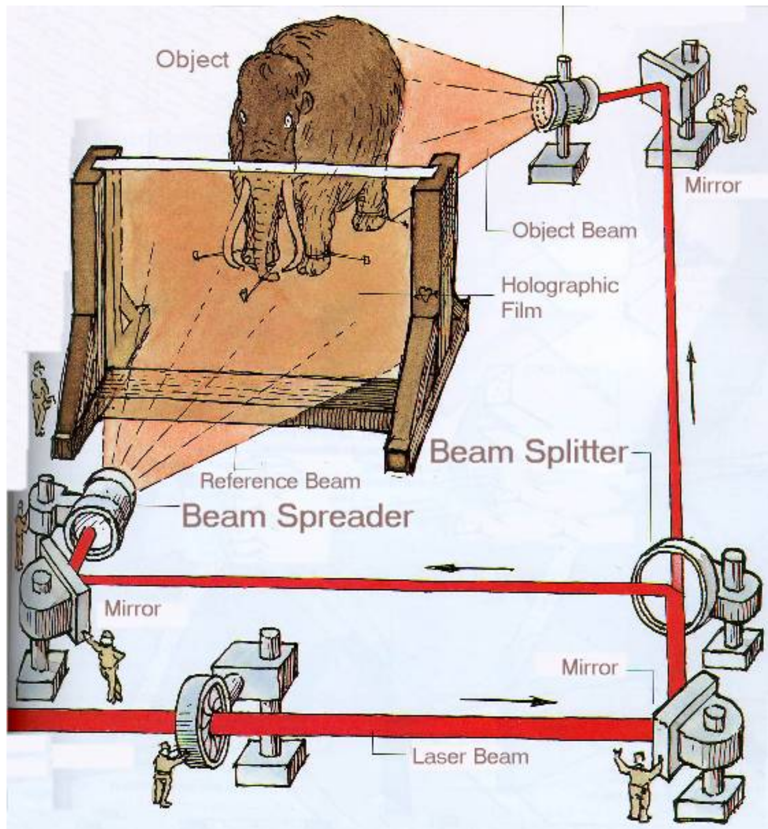
How Do You Make a Hologram?

Holography is one of the most significant discoveries humankind has ever made. It was discovered in 1947, and was considered so important that its discoverer, Dennis Gabor, received the Nobel Prize for Physics in 1972. Holography is the only process able to record our three-dimensional on a two-dimensional recording medium and show the original scene as a three-dimensional image to the unaided eye. The image demonstrates complete parallax (the ability to look around one object to see another hidden behind) and depth. The image in a hologram appears to float in space, either behind, in front of, or straddling the recording medium.

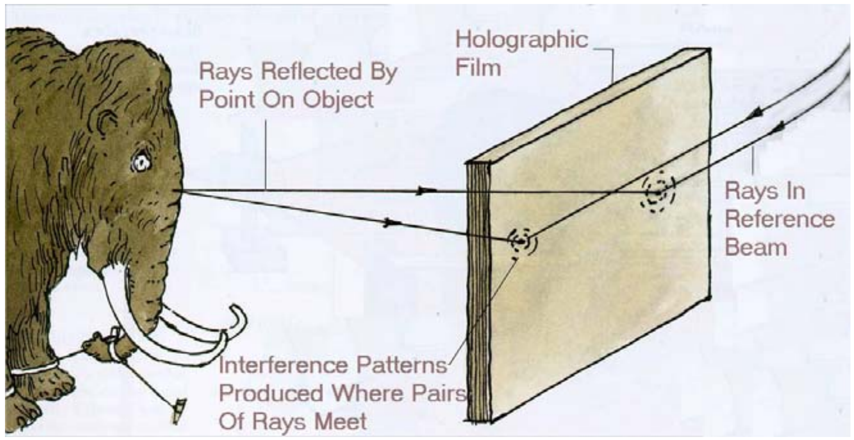
There are many types of holograms, but the proceeding is a description of how display holograms are made. Display holograms are exactly what their name implies: they are holograms that display three-dimensional scenes, complete with parallax and depth.

You must use a laser to make a hologram. A laser is a source of spatially coherent and temporally coherent light. The light from a laser is spatially coherent because it emits light in a very narrow beam and is considered a point source, as opposed to an extended source such as a fluorescent lamp, which is spatially incoherent. This also means that the light is in phase, where all the light waves vibrate together to produce a beam of great intensity. A laser is temporally coherent because it emits light of a single color or wavelength. Temporally incoherent light sources, such as a normal light bulb or the sun, emit light of many wavelengths and colors. We can see that there are many colors in sunlight if we allow it to shine through a prism. The prism splits up the light into many beams of different colors. If the light from a laser were shone through a prism, it would not split because all the laser light is of one color.

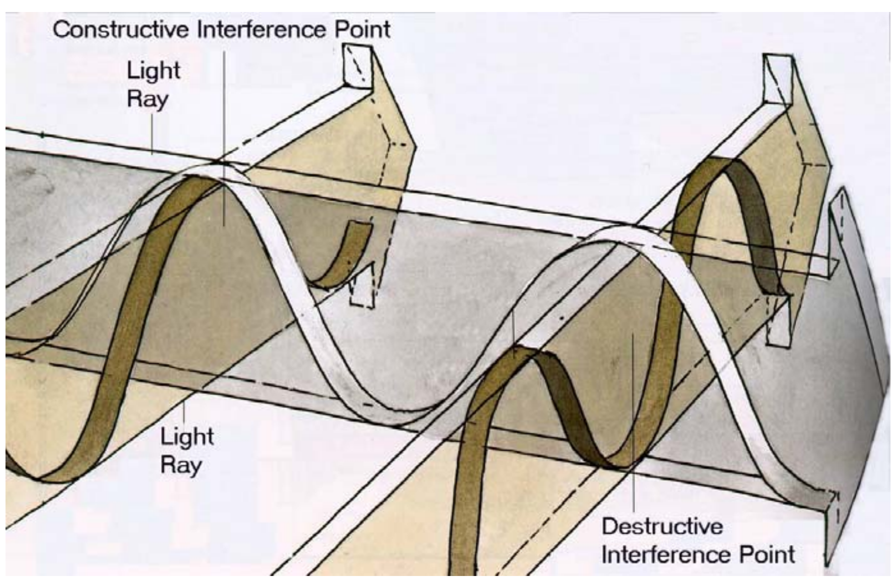


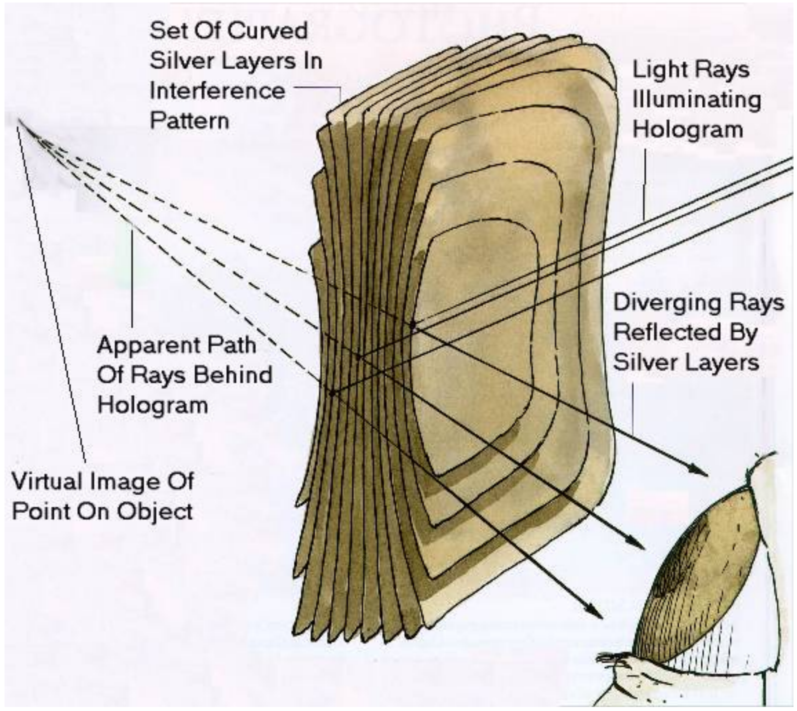
The laser is used to illuminate the object or scene of which you want to make a hologram. The light from the laser beam is split into two beams by a partially reflecting mirror. The first beam, the object beam, is spread and aimed at the object, illuminating it. The second beam, the reference beam, goes to a holographic plate or film placed near the object. Some of the light from the object beam then reflects off the object onto the holographic film. Therefore we now have laser light shining on both sides of the holographic film, and this by exposing the film to laser light, we can produce a three-dimensional image of the object on the film.

When the laser light hits the holographic film, it creates an interference pattern from the interaction of the light between the object beam and the reference beam. Light reflecting off the object meets light coming directly from the laser. Every pair of light rays - one from every point on the surface of the object and one in the reference beam - interferes. On the holographic film, the two rays produce light spots if the interference is constructive, or they cancel each other out to give dark spots if the interference is destructive. By this method, an interference pattern can be formed over the entire holographic film as all the pairs of light rays meet. You've seen interference patterns before when you're near a pond and you throw two pebbles in. Sometimes the waves in the water made by the pebbles meet and seem to cancel each other out; this is called destructive interference. Similarly, if the waves in the water meet to make larger ripples, this is called constructive interference. If you now imagine that instead of throwing two pebbles into a pond, you throw thousands of pebbles, the waves formed by the pebbles could form an image depending on how the pebbles are thrown. This is similar to what happens on a holographic film. Billions of light beams interact to form patterns on the holographic film that combine to form a three-dimensional image. The interference pattern formed on the holographic film is dependent on the energy of the light coming from the object, which varies in brightness depending on how it reflected off the surface of the object.



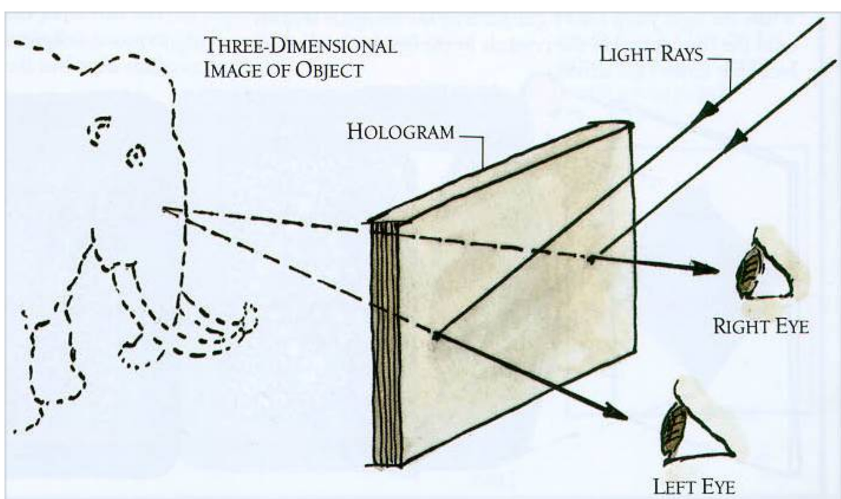
When developed, a hologram will contain the interference pattern, which is preserved in layers of silver from the photographic developing process.





This interference pattern can be viewed under normal lighting, and will appear as a three-dimensional image. In the holographic film, there are many sets of the curved silver layers, each layer having a different interference pattern. Each layer contains a interference pattern created by light that reflected off the original object at different angles. Therefore with the multiple layers in the holographic film, we are able to effectively preserve what the object looked like from many different angles.

When light rays illuminate the hologram, the layers reflect them so that they diverge. The eye then sees a virtual image of a point on the object. This point is where light from the object beam reflected off that point on the object, onto the holographic film, forming a part of the interference pattern on that silver layer.



In a hologram, each eye sees many points formed by the interference patterns in different sets of layers of the holographic film. The image in each eye is produced by various parts of the hologram formed by rays that left the original object at different angles. Each side of the hologram is formed by rays coming from that side of the object. Your two eyes look at the different parts of the hologram and see separate images of the object. The brain combines them to give a three-dimensional image. Moving your head around the hologram brings another side of the object into view and your view of the image changes, creating parallax.

The ability to view a three-dimensional object on a two-dimensional medium is what makes holography an amazing process. Holograms can be made for a variety of applications, and can already been seen in various products. Holographic art is shown in museums. Holograms are used on some postage stamp and on credit cards and identification cards to prevent forgery. Medical applications include making three-dimensional CAT scans or ultrasound images with holograms. These applications and the many new ones being will soon make holography a ever present part of our lives.