

“ Broken Holograms : Two for the Price of One! ” -

- “Urban Legend” or “Scientific Reality” ?

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A “statement” is circulating in “holographic circles” (in the broad sense, among both professionals and more or less knowledgeable users). It is commonly stated that if the hologram of an object or scene is “broken” in two, the result is two holograms showing the object or scene “in its entirety,” in 3D!

One of my former students, now a colleague, sent me the following message . . . which was thought-provoking, to say the least :

“ . . . I have a very naïve question I found . . . numerous identical holograms (of jewellery) on glass plates measuring approximately 10 × 15 cm². I think they were bought long ago by my predecessor. ”

Indeed, he has bought a “collection” of postcard-sized holograms from a Russian holographer who mass-produced them and sold them “for next to nothing.” Around the end of the USSR, we were visited by dozens of Russian scientists . . . some of whom were trying to “sell off” series of holographic images of every kind. The USSR had invested enormously in holography applications, particularly military ones, and had more scientists and technicians in the field than we had. When they were able to do so, many came to introduce themselves at Western European laboratories The holograms they sold were often of good quality. They were mainly Denisyuk holograms—reflection holograms.

“ Under incoherent natural light, they are very sharp. ”

Because of their recording process, reflection holograms have the characteristic of behaving as an interference filter. . . . Recorded under coherent illumination—for example, red light from a HeNe LASER—and viewed in white (incoherent) light, they select “their” viewing wavelength. They should therefore appear red, which is generally not the case. They most often appear yellowish-green because the gelatin shrinks during development and drying, bringing the layers of the holographic grating closer together and reducing the wavelength selected during viewing.

“ Feeling very confident, I took one and broke it in two to demonstrate that we would obtain two identical holograms, although obviously a little less precise than the original (though I was not sure that this would be . . . visible). But all I got were two halves I was rather puzzled ”

Indeed, a frequently mentioned property of holograms is that, when they are broken, two holograms of the original scene are obtained . . . which is not always true, as you discovered ! Let us say that it is both true and false . . . it depends on the type of hologram involved and on the recording set-up.

Generally, when a scene is recorded holographically, every photosensitive pixel in the recording material receives a fraction of the light information scattered by each point on the illuminated object surface. This information interferes with the reference beam, creating the complex holographic grating within the thickness of the photosensitive material. This process explains why every part of a hologram contains all the information from the object . . . provided that this information can reach every photosensitive pixel, which is not always the case, depending on the recording set-up.

This is the case of the hologram you broke in two. It is a reflection hologram of small objects (jewellery) that were placed very close to the photosensitive plate, or even directly on it. This arrangement does not make it possible to record all the information characteristic of the entire object at every point on the photosensitive plate, but only what lies in its immediate vicinity. The proximity of the objects can also lead to the formation of a direct silver-based latent image superimposed on the holographic image. You know the result : when the hologram is broken, we get two half-holograms !

On the contrary most transmission holograms are recorded in such a way that all the photosensitive pixels—or at least a large part of them, depending on the perspective—receive all, or a large part, of the light information scattered by the illuminated portion of the holographed object or objects. If you break this type of hologram in two, you do indeed obtain two holograms of the holographed scene, but with narrower fields of view and different viewing angles. The same will happen each time you break one of the pieces in two: you will reduce the field of view and alter the viewing angle. A simple example helps explain the process. If you look at a landscape through a window, you have a certain field of view and a certain angular range—for example, horizontally—from which to observe the scene. If you close a shutter that covers one vertical half of the window, you can still see the entire scene, but through a field of view reduced by half and from different angles in order to see certain parts of the original scene. As the opening is gradually reduced, eventually only « a keyhole » remains, and you will have to contort yourself to see the scene through an extremely narrow field of view.

Since a drawing is often more informative than a long description, I invite you to view the attached simulation.

Interested readers will find further information in the references provided at the end of the attached ppt simulation.