Cave Holography – Out of the lab and under the ground

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Abstract. This paper describes the combination of my hobbies, caving and holography. Most traditional holography involves bringing the objects to a lab with all the necessary holography equipment mounted on a stable table. I instead bring all the equipment assembled as a portable unit to the natural formations in a cave with the cave itself being the stable table. The first successes were Denisyuks made with a HeNe or laser diode and spatial filter mounted on a tripod. For greater depth, transmission holograms were made with a DPSS laser in several configurations sometimes using fiber optics to route the reference beam and sometimes a spatial filter and mirrors. The cave environment presents unique obstacles that have been overcome as evidenced by the beautiful holograms made.

1. Beginning
I developed an interest in caving and holography about the same time in my life so naturally I tried to combine the two hobbies. Unfortunately the low power HeNe lasers and homemade power supplies available in the 1970s were not up to the task of doing the split beam transmission holograms I was attempting in a cave. Discouraged, I put the cave holography on hold but continued my other holography interests on and off as I could afford over the years.

2. Starting Again
In the 1990s I revived my cave holography interest due to the availability of efficient DC HeNe power supplies and inexpensive long coherence length red laser pointers and diodes. These lasers allowed me to make Denisyuks of limited depth using the HeNe or pointer with a spatial filter mounted on a tripod and the hologram plate simply leaning on the cave formation (Figures 1, 2, 3).

HeNe laser powers were limited by the available DC power supplies and diodes much larger than 5mW tend to mode hop thus again frustrating my desire to do split beam work in the cave environment.

Figure 1. A typical cave Denisyuk.
3. Going Green

High power green DPSS lasers with long coherence lengths are on the surplus market now making split beam holograms possible with no need to match path lengths. Experiment found that multimode fibers can carry the reference beam thus greatly simplifying the portable apparatus being hauled into the cave but some grain is introduced into the image (Figure 4).

Split beam transmission holograms are desirable because they have extreme depth of field and parallax, viewable from all angles and get better looking as the observer gets closer.

The first DPSS setup I made used a fixed beam splitter sending the object beam through a diffuser to the object and the reference through a multimode fiber to the plate (Figure 5). No holograms resulted from the first apparatus. Though somewhat discouraged, I built a second smaller apparatus that used a variable density microscope slide beam splitter (Figures 6, 7). That effort yielded some decent holograms (Figure 8). I later substituted a \(\frac{1}{2}\) wave plate and polarizing cube beam splitter for the slide to improve the reference to object ratio adjustment.

My latest apparatus uses a spatial filter and mirrors in place of the fiber to eliminate some of the grain in the final image (Figures 9, 10).

Setting the reference beam at a 70 degree angle allows the apparatus to be placed much closer to the objects and upon reconstruction greatly reduces the amount of laser light directed toward the observer.
Figure 4. The experiment demonstrating that a multimode fiber can carry the reference beam.

Figure 5. The first apparatus using a fixed beam splitter.
Figure 6. The second apparatus is smaller and uses a variable beam splitter.

Figure 7. The second apparatus set up in a cave.
Figure 8. A hologram made with the second apparatus.

Figure 9. The newest apparatus uses a spatial filter and mirrors.
4. Obstacles Overcome
My first several split beam attempts were failures which were very frustrating because interferometer
tests confirmed the cave to be rock solid. Finally the last shot of one set had an image so I figured a
certain waiting time is needed for temperature stabilization. Now I routinely place the apparatus in the
cave to temperature soak for a few hours before returning to do the shots.

Among other minor problems are bats flying about; the solution is to not set up during the morning
and evening while they are active. The occasional salamander will crawl around and insects fly. A
mouse once tried to steal a storage bag. Weather changes sometimes causing a breeze through the
cave. The optics can become fogged by the steam from my body so I use a long wire for the shutter
release. The high humidity causes dripping from the ceiling. Condensation forms on the apparatus
when it is removed from the cold cave back to the outside air.

5. Future plans
I would like to produce larger holograms and find an inexpensive yellow laser for reconstruction or
perhaps produce some H2 reflection copies. I will keep making cave holograms (Figure 11).
Figure 11. Entering a cave with the holography equipment in protective packaging.