techniques

The impossible holographic object

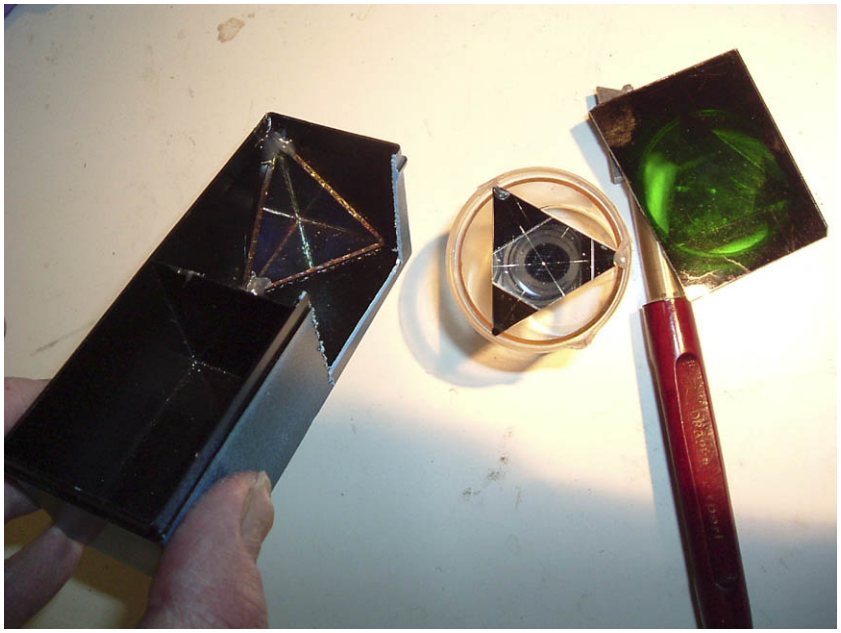
Jeff Blyth
jeff@biotech.cam.ac.uk

About the author

After graduating in 1973 in Applied Chemistry he worked in a company with dichromated gelatin, unrelated to holography. In '77, he was amazed to see a holographic pendant made using the very material he was researching. His life 'changed for ever'. He subsequently worked on photopolymer materials for Ilford, which became the subject for an MPhil at Wolverhampton Polytechnic. Since '91 he has been involved in 'blue sky' research at the Institute of Biotechnology in Cambridge, UK. Jeff is the recipient of the Royal Photographic Society's Saxby award for 2003 (http://www.holography.co.uk/events/saxbyaward/jeffblyth/jeff.htm).

Until recently, I always thought that if a small object reflected laser light well enough, and was kept completely still during any holographic exposure, then you could always make a reflection hologram of it which would reproduce monochromatically the features of that object. Well it turns out I have been deluded for a long time . . .

My object in question is in the centre of the photo here. It is a well made glass "corner-cube"[1]



Anyone who looks at this actual object will see a fascinating sight of a single eye looking back at them from the central section of the cube corner

[1] The £180 corner cube was purchased from Mr. Eric Frisk (opticalworks@btconnect.com) or cube corner, and it is sitting in a plastic beaker for support.

(CC). I also find it interesting to ask people which eye they think it is. Some decide it is their right, others their left, and only a few say it is both eyes equally. It does nicely show that most of us seem to have a dominant eye independently of whether we are right- or left-handed. The fact is that the eye you see is the eye that is looking at it so it can be both eyes simultaneously.

For an experiment I positioned a piece of pre-swollen BB640 holographic plate on the beaker and shot a single beam "in-line" hologram with a 633nm HeNe laser.

Now you can see my camera lens in the photo of the CC but not in the hologram of the CC. Therein lies the heart of the problem – you just cannot reproduce in the hologram that same "eye effect" that follows you around the room from a true retro-reflector.

I had a serious use in mind for getting a holographic corner cube to act as a direction tolerant sensor but it was not to be or at least not entirely so. However, it strangely does do a quasi retro-reflection of a torch beam in 3 positions, 120° apart, and each reflection is triangular and is uniformly orange whereas when the light source is almost directly overhead, the result is a green replay, as you can see in the photo.

Mini corner cube arrays are familiar to all of us as bicycle reflectors on mud guards and pedals. Even those bright fluorescent sash bands that cyclists wear are seen under a microscope to be made of micro corner cube arrays. If you make a hologram of these arrays, just as with the single CC, this hologram can also replay at specific wide angles but again at a longer wavelength than that seen along the normal. I do not have an explanation for this effect – would anyone like to volunteer one please?

The retro-reflectivity of CCs is caused by a reflection from each wall of the CC in turn. But a flat hologram inspite of all its wonderful properties just cannot cause light to carry out three internal reflections. So that was holographic problem number 1.

Now, what happens if you actually make a real holographic CC out of three triangular pieces of flat in-line reflection hologram? Well, I tried doing this using the corner of a common plastic (slide holder) box as a template. It was sprayed black and a side of the box was partially removed as you see in photo. It is then that the inherent holographic problem number 2 crops up. . .

As you move the light source away from the optimum position lighting up any bright reflection hologram, you get some wavelength shift just before it fails to replay at all. Saxby refers to this as the "Venetian blind effect". (As you view through a venetian blind, the distance between the slats seem to shorten as you view them more obliquely. This is analogous to what is happening to the holographic fringes).

So in my three-dimensional holographic CC you can hardly have three consecutive light bounces because the angle change will cause a wavelength shift each time which will simply not match the fringe spacing on each consecutive face.

I then did the simplest experiment in a dark room with a torch beam shining in my eye. I could just make out the light from my pupil only near the apex of the CC in the box. (The holographic grating material had been particularly efficient at acting as a normal diffracting mirror before it was cut into triangles).

I could prove it was a holographic reflection, rather than just a three-fold specular reflection off the smooth surfaces, by allowing breath to condense on the system which was glued down with the emulsion outwards. The feeble spot momentarily changed from green to yellow and slightly brightened up, perhaps because it became more broadband, just enough to increase the tolerance angle for the light between each reflection to reconstruct, but it was still very feeble and restricted to about the first couple of millimetres from the apex.

So I think I can now put the "narrow-band holographic retro-reflector" in that special box marked "holographic howlers", wherein lie those wretched Hollywood perennials of giant three-dimensional real images of people reconstructed in mid-air without any holographic plate producing it in sight and also, dare I say it, full 3D colour holograms looming out of a TV, etc, etc.