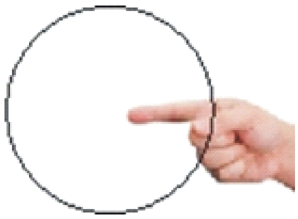
7. Fine dust in a reversal interferometer.

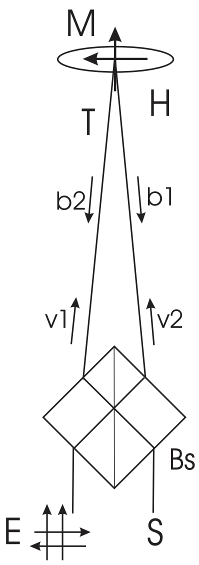
Content

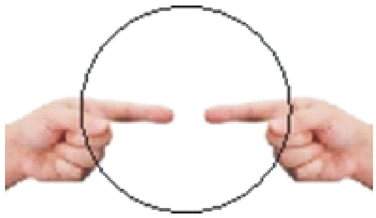
7.1. An image together with a left-right reversal

A reversal interferometer gives an image together with the mirror image. If we bring e.g. the finger in the first half of the light path, e.g. in the left half, then we see in the right half of the mirror the same finger appearing, but now left-right reversed.

Looking at the drawing below on the left. We see the index finger pointing to the left. Imagine that finger in drawing 2 just in front of the mirror M, in the place of the letter H (of Hand). Both the finger and the arrow point to the right.



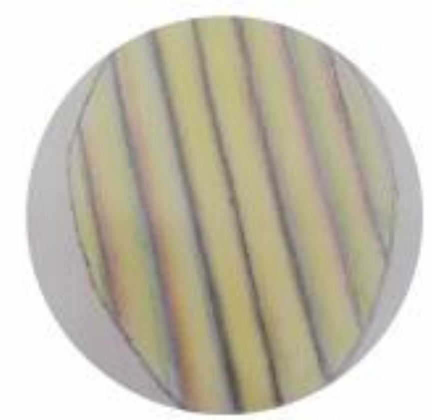




The image is upright. Follow this image through the image distance b1 via Bs to E. We notice that the splitter Bs is on its rib. In E, the image of the finger continues to point straight up to the left. Now follow the path of the finger via b2. In Bs, this image on the half-permeable mirror in Bs makes a left-right image reversal. In E, this image will still be upright, but left-right reversed. If we stay with the finger within the right half of the mirror, then the left-right reversed image will stay within the left half of the mirror. We then see the merging of two images, as shown in the drawing above on the right.

Build the setup and see what shows up. We see a number of interference lines neatly parallel side by side. If we put a finger in one half of the mirror, of course we also see the mirror image of this, but we notice that the finger pushes the lines together.

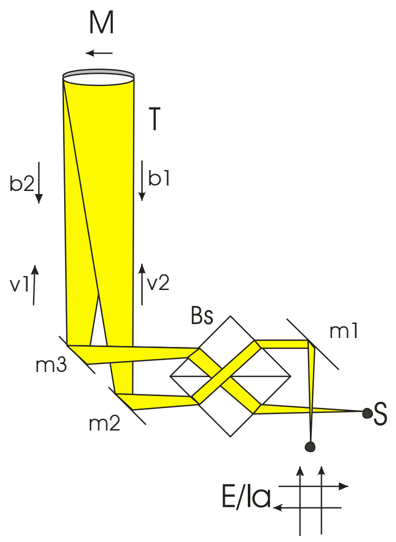
The virtual light source and the image do not coincide, but have a small separation and some aberrations are introduced in the plane of exit to the prism[1]. This leads to image errors.



7.2. A second version of a reversal

We solve this simply by adding two plane mirrors m1 and m2. The laser light leaves the splitter parallel and, after reflection, enters it parallel again.

[1] The virtual light source and image do not coïncide, but have a small separation and some abberations are introduced on the plane exit face to the prism (Malacara, Optical Shop testing, Wiley and sons, 1978, p.174).



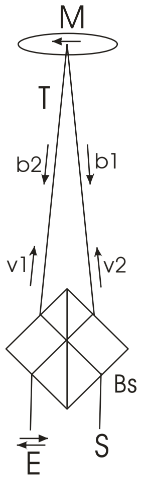
Do we try to widen the lines of interference with this last arrangement. Then look at what shows up. The picture is particularly unstable. Constantly we get a storm of changing interference colors. There is a good explanation for that. We compare it to the basic setup with uneven light path. If the mirror moves there in a minimal way, then the images in E also move, but in the same sense. In a reversal interferometer, of course, the partial beams and the images move in opposite directions.

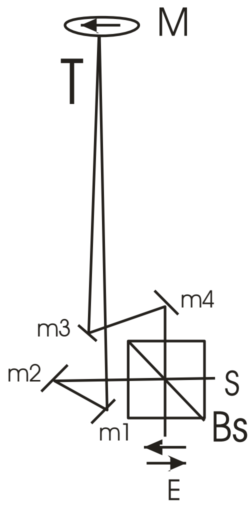
If we bring the hand into the light path, then the image obviously remains very unstable, but if we try to reproduce a general impression in the fragile image, then we see what is shown below.

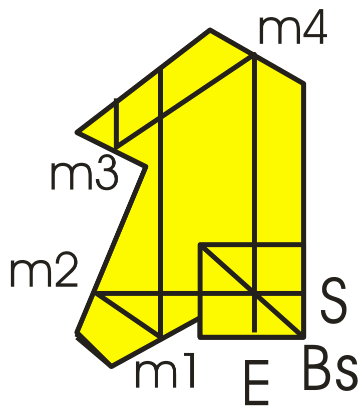
7.3. A third version of a reversal

To avoid the light rays striking the splitter at an angle, we can also set up our reversal as follows. The drawing on the left shows the version with the partial beams incident on the splitter at an angle.

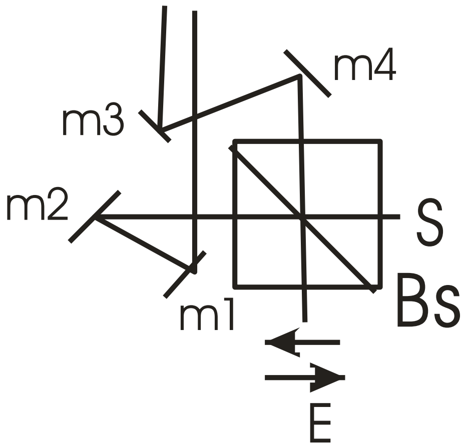
On the drawing in the middle, the plane mirrors m1, m2, m3 and m4 were added. One notices that in E both the image and its inversion can be observed. This inversion is caused by the mirrors m1 and m2. If we replaced them with only one mirror and sent the light directly to Bs, we would have, if properly aligned, a basic setup with equal light path. Now we don't. Now we have a reversal with equal light path. To build the setup accurately, we again used a card as a substrate for the splitter, with on it an accurately aligned and equally long light path for both beams, against which the different plane mirrors can be mounted.







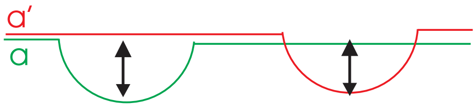
We see below the diagram of the card, next to a preparation of the setup. Notice the mirror m4 in the picture in the middle. We see in it the reflection of the outlined lines on the card. Thus we can adjust by sight as partial. The eye already sees, very accurately whether a mirrored line is in line with the original line. We can see in the reflection that there is still a small error in the adjustment.

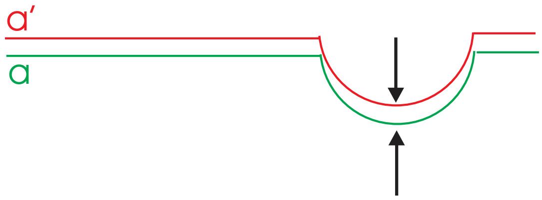


7.4. More sensitive, but therefore less stable

In addition to the fact that each vibration transforms into an opposite motion and leads to violent color storms, there is also what we might call increased sensitivity.

In E we get an amalgamation of two images, in each of which only one half was disturbed. The other half image “untouched. If two such images merge, the disturbance is greater than that caused by two waves undergoing the same disturbance. This is what the two drawings below seek to illustrate. On the left we see the representation of a perturbation in a reversal interferometer, on the right a perturbation in e.g. our basic setup. As a result, a reversal is much more unstable, but because of the greater distortion of the resulting wave, shows us a lot more detail.





Indeed, we notice this in the drawing above, representing the two “burning fingers. We see just above the finger apparently two interference lines, one inside the other, one also somewhat smaller than the other. What is surprising is that they each do somewhat indicate a boundary. We compare it to the smoke of a cigarette. It gradually becomes thinner. You can hardly draw a line between “here is clearly still smoke” and “here is no more smoke.

Back to the drawing. So in reality it is a static reflection of a particularly dynamic event. Periodically the lines open for a moment and escape, let's call them heat bubbles, rising straight up. Each time they create a kaleidoscopic color spectrum. One can keep looking at them with fascination.

It would be all the more fascinating if the whole setup could be made vibration-free. But it is simply not given to an amateur to keep his optical bench still to the order of nanometers, billionths of a meter. Of course the question arises what if all this were built on a professional level. Adjusting the 18 mirrors of the James-Webb telescope to each other shows that such a thing is technically possible.

What has been said so far about the reversal interferometer applies at full brightness. To conclude this text, let's take a look at a near-darkness. We turn the dimmer almost completely closed and look what appears when we hold our finger in the light path. Gone are the colors, gone too are the unstable nature of the arrangement. We see the finger and its reflection, again surrounded by a faint band of light as we saw with the foucault setup and the basic setup.

7.5. The reversal interferometer on the optical bench

Below is a view of optical bench in the “dark” room, where a reversal is under construction. It is a relatively simple solution. One sees the white 'point' light source S, the beamsplitter Bs and the small mirror m1. The observer is in E just behind the optical bench. So in the picture that is at the bottom.

The laser is even further behind the observer, not in the picture, so it can never shine the laser light into the eye. The letters “vm” stand for the plane mirror that is halfway through the diverging (or converging) light beam and reflects the light back to the concave mirror M. This is under the wooden plate just in front of the observer in E. One can see the laser light disappearing under it. The laser light is cropped later in the picture.

The other mirrors in the background are ready drill other setups. All large mirrors (155 mm diameter) are on trolleys that can be moved from the location of E via beams according to the three axes. So they can be moved closer and further, rotated and set higher, lower or more to the left and right. All this is done with set screws.