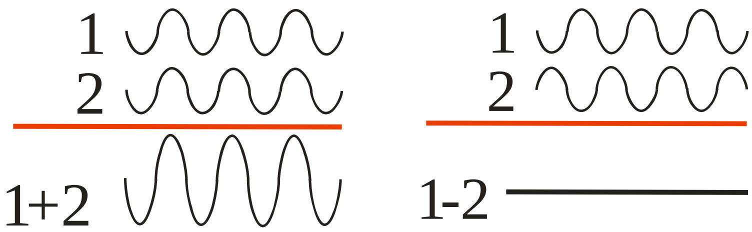
6. Fine dust and destructive interference.

Content

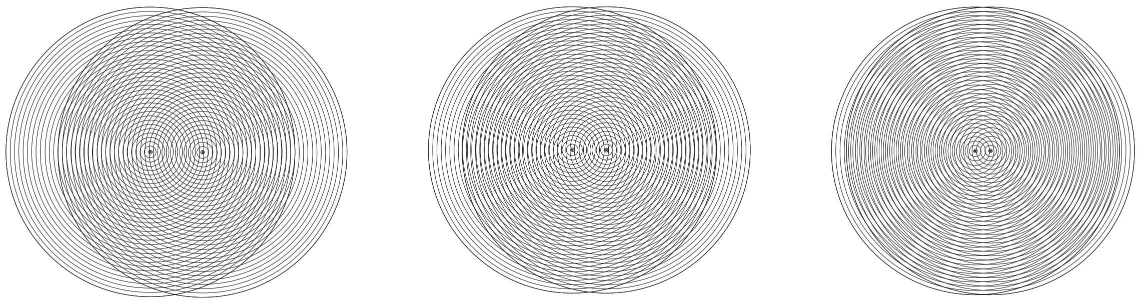
6.1. Not flat circles but spatial spheres

Constructive and destructive interference were already discussed in the fourth chapter. We illustrated it with waves in water created by throwing two stones into the water at the same time.

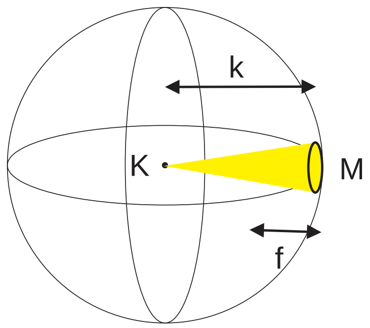


Destructive interference is had when a peak fills a valley. The water then remains at its original level. An analogous phenomenon occurs with light waves, where the merging of a top with a valley leads to darkness.

Illustrate it again with two sets of concentric circles that gradually penetrate each other more and more. We see lines forming at the top and bottom and widening a bit. On the left side and on the right side, we see that the common parts of the circumference of the circle become much larger as the centers of the distinct circles get closer and closer together.



Think back to the glass ball and our spherical mirror that was a piece of it. It is that situation that we want to achieve as much as possible in our arrangement.



6.2 'Nulling'- interferometry

Think of the stellar world. The question of whether other planets like our Earth exist elsewhere in the universe is very topical in our time. Finding such planets, however, is not so easy. If they are too far from a star, they are too faintly dim. If they are too close, the blinding light intensity of this celestial object prevents observation of the planet. That is why one uses, among other things, destructive interference: light beams can, under certain conditions, extinguish themselves. We have already explained this. The light from two closely spaced and equivalent telescopes aligned on the same star can be united, however, with a difference of half a wavelength or an unpaired multiple. Thus starlight is neutralized. But this does not necessarily apply to the light of the planet located near that star. In conclusion, the light of the star is attenuated or extinguished, but that of the planet, which is at a different distance from the telescopes, is not. Thus, the latter becomes visible.

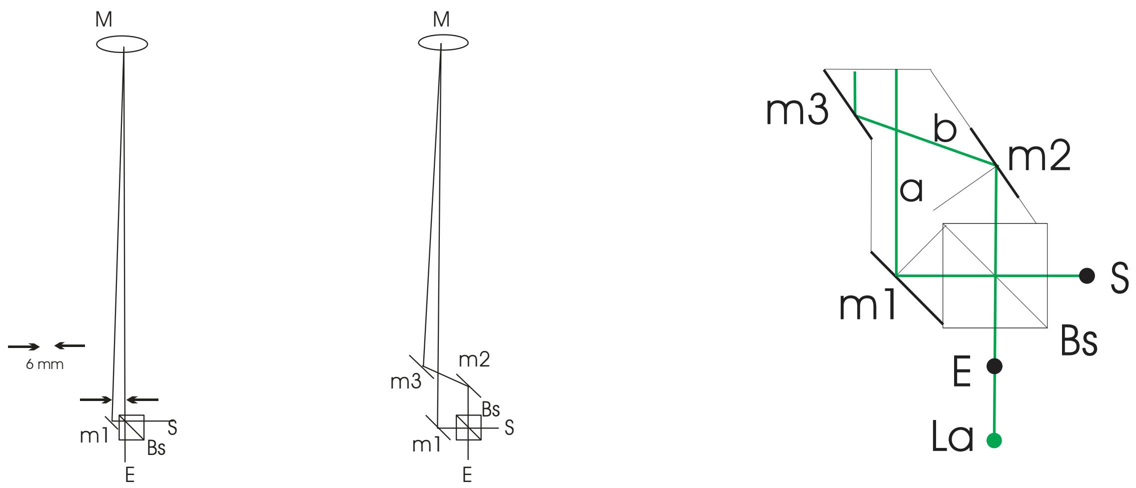
We also find this far-reaching accuracy in tuning at the *James Webb* telescope. The 18 individual hexagonal segments of the main mirror are aligned so that the light from these segments can be aligned to the nearest nanometer (1×10-9 m, or one millionth of a millimeter (!)).

In what follows, we check whether we manage to achieve destructive interference in our setup as well.

6.3. A 'closed' setup with equal light path

In our 'closed' basic setup, - the triangular shape - we still had an 'unequal' light path. The object distance v1 there was longer than the object distance 2. It is obvious to assume that as the light paths v1 and v2 will become more and more equal to each other, we will more easily achieve wide interference. So the question becomes how to devise an arrangement in which both light paths to the mirror, v1 and v1, can become equal to each other. To do this, let's look at the following drawings. On the left we see the basic setup. The light path to M via m1 is longer than the light path going from Bs directly to M. The smallest path difference we could achieve in our setup was still 6 mm.

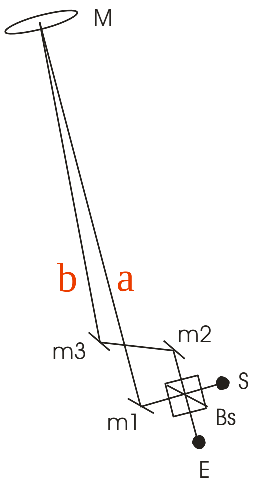
Next, let's look at the drawing in the middle. By adding two additional plane mirrors, m2 and m3, the 6 mm path difference can be eliminated. We used the card on the far right for this purpose. In a drawing program it was drawn out as large as possible, and both light paths were made equal to each other. Afterwards, everything was reduced in size and printed on a cardboard card that came under Bs. This way the mirrors m1, m2 and m3 could be placed more accurately.

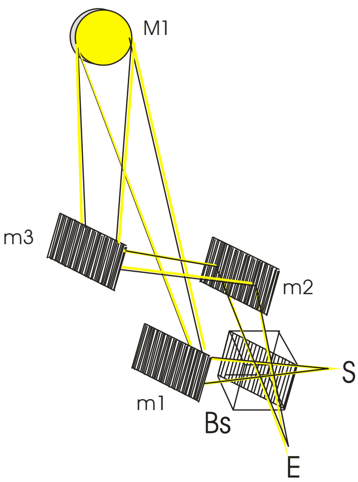


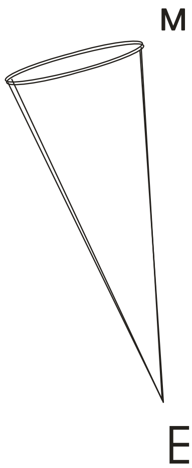
Below is a detail of this setup. We recognize the beamsplitter in the middle, to the right of it the 'point' light source, Below the splitter we see the card and next to it the place for the three flat mirrors that still have to be installed.

By making the two light paths equal to each other as much as possible, the common part of the circular arcs of the distinct light points becomes ever wider, which facilitates the achievement of the intended interference.

Imagine it spatially again below. From the drawing on the right we understand that from E the two mirror images now practically coincide.

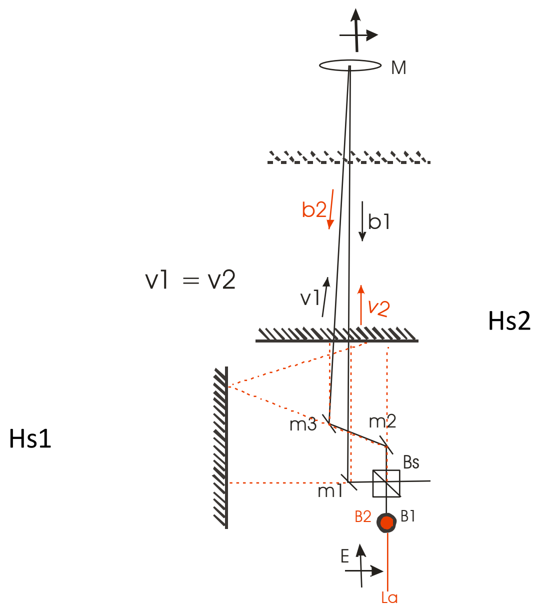






6.4. Adjusting the setup: not so easy.

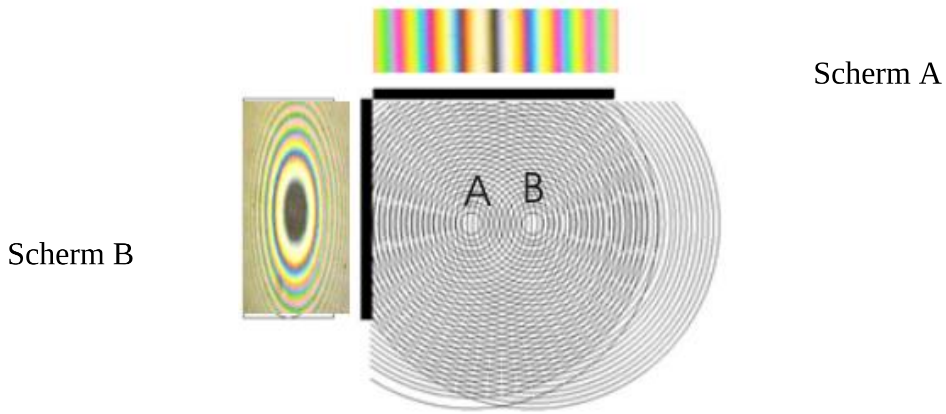
Again, accurate adjustment requires some auxiliary mirrors. Hs1 and Hs2. Both plane mirrors must be oriented so that they reflect the laser light back to Bs. Then the plane mirror m3 can also be adjusted to Hs2 so that this laser light is also reflected to Bs. The plane mirror m2 must be adjusted according to the direction, indicated on the piece of cardboard on which the splitter rests and the laser light reaches Hs1,then reflected to Hs2. There this should intersect the laser light coming from m1. Then Hs2 can be taken away. Mirror M is placed so that the light from m1 falls on it in the middle. Then m3 is placed and aimed at the center of mirror M. The latter can then be adjusted so that the laser light goes back into the setup. The plane mirror Mv indicates that everything is reflected back to the observer so that the observer himself can hold his hand in front of the mirror while looking. Keep in mind that all this requires about a hundred adjustment screws, all tapered out and fitted with a ball to reduce friction as much as possible. Each adjusting screw, moreover, rests on a piece of hard plastic.



6.5. What can we expect?

It occurs to us that the “closed” setup with equal light path is a further perfecting of the setup, described in the previous section, and where the light path was unequal. So we may see the same images, but better, with gradually more precise adjustment. And we will see more. The sensitivity of the arrangement will probably increase as the common part of the circular arcs of the distinct light points, as explained above, becomes wider and wider. With our pursuit of an equal light path, we are moving toward a zero interferometer.

Let us reproduce below the drawing from 5.4. If we imagine that points A and B are gradually getting closer to each other, then, on the one hand, the circles on the B screen will become larger and larger until the entire mirror surface becomes predominantly black. And on the other hand, the vertical lines on screen A will widen more and more.

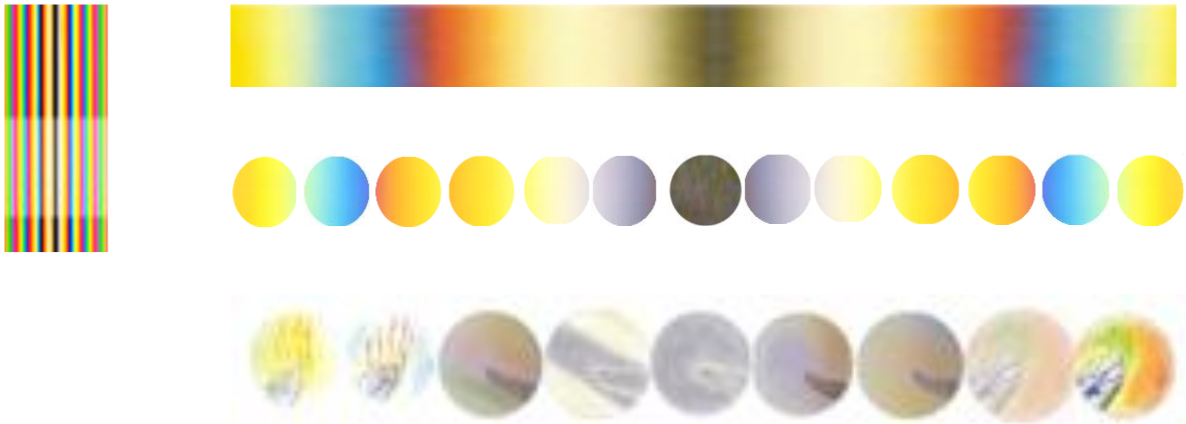


6.6. And what really shows?

Adjusting extremely accurately, we indeed get the entire mirror surface filled with a single interference color.

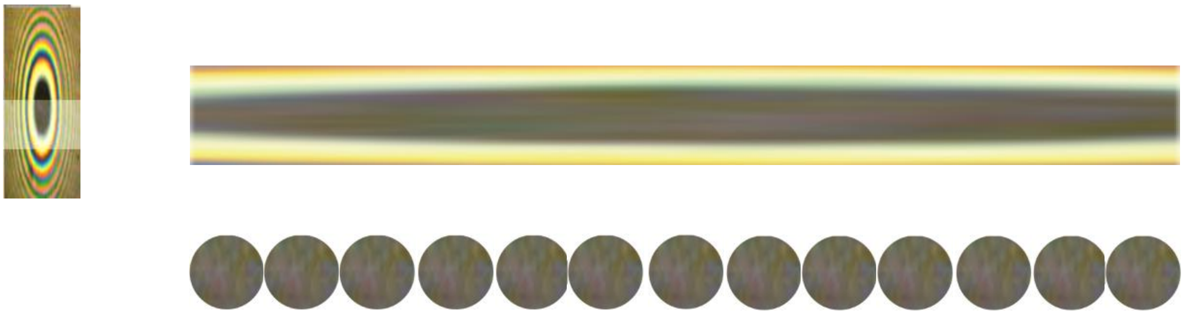
If we turn the adjusting screw of one of the flat mirrors minimally, the color of the mirror surface changes, for example, to blue.

We can bring almost any interference color to the screen when turning a set screw this way and that. If we bring the hand into the setup we get a successive number of disturbances. Below is a table showing the colors and turbulences.

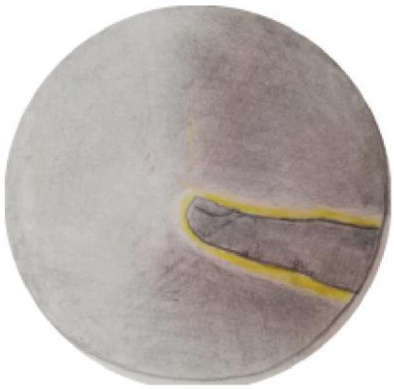


And enlarge this to page width.

With almost perfect adjustment, with quasi-destructive interference, one can no longer really speak of lines or circles, but the entire mirror surface shows itself in a dark color. The concentric circles as we depicted them at the beginning of this text in 7.1. seem to coincide perfectly. Therefore, what is shown below is no more than a theoretical representation. Still, this has its uses; you see more if you know what to expect. We illustrated this with the arc in the mist vessel and the ultrasound of a baby in text 3.1..



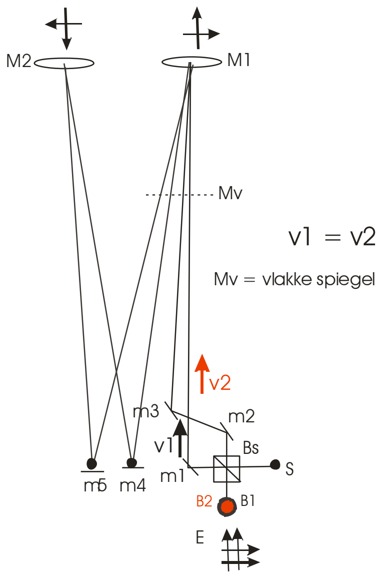
We are naturally fascinated by the picture of very unstable total destructive interference. Do we now bring the hand into the light path then again a luminous band shows itself all around. The yellow color is the interference color which in the overview is just next to the line (or circle) of destructive interference.

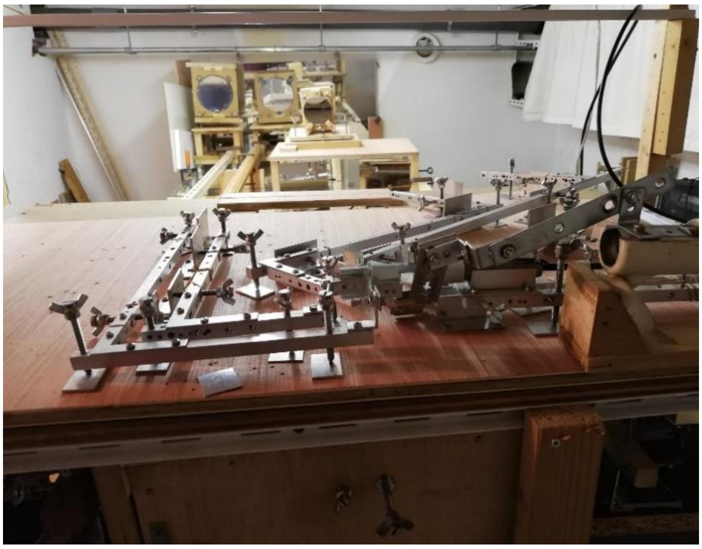


Finally, if we dim the brightness to the maximum, that yellow color disappears and the hazy, luminous band shows up again.

6.7. A quadruple perturbation

In the drawing below on the right we see in system 1 , with M1, the basic setup with equal light path. If we rotate the mirror M1 slightly, the reflected light rays no longer fall back into Bs, but just next to it (or just above it). If we add two flat mirrors m4 and m5 to the setup, we can send everything to a second mirror with similar aperture. After reflecting the light, the first systeeem is then run through again. This means that the hand held in front of M1 can diverge light four times. Once diverging and once converging at M1converging, and after going through system M2, it repeats again. We hoped for a cumulative perturbation effect. We were not able to conduct the experiment in optimal conditions. The light passes through about 15 meters away in the setup, and the spot of our laser diverged too much for accurate adjustment. To the right we see a photograph of this setup.



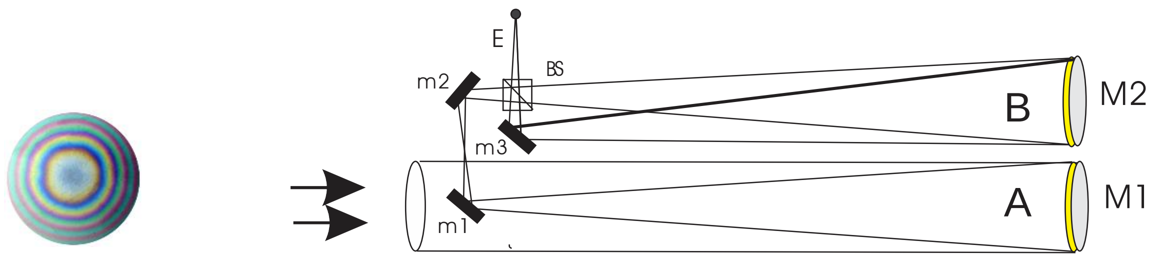


6.8. A newton telescope with destructive interference?

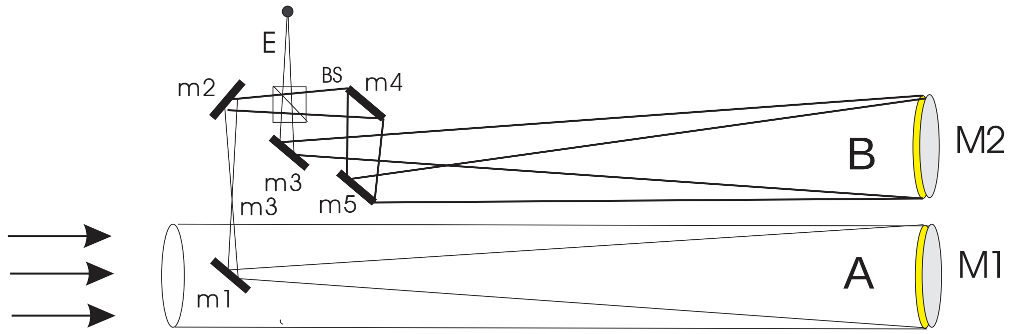
Let's look at the setup below. One recognizes in the system A (M1-m1) a newton viewer, system B is the basic setup with unequal light path. Mirror M1 is illuminated from its focal point. Mirror M2 is illuminated from its curvature center.

Theoretically, this apparatus should give images as we described them in section 6.4.. With the difference that now we are not viewing the hand, but rather the surrounding environment, or if we point the viewer toward the sky, the moon and stars.

We built this apparatus out of curiosity, despite the fact that we did not have a mirror M2 with a center of curvature equal to the focal point of mirror M1. The result was that we saw the trees and nature all around imbued with some wide Newtonian circles.



However, should one wish to ascertain whether the setup could be suitable for 'nulling' interferometry, then in system B the basic setup with unequal light path is not sufficient, but must be provided with the setup with equal light path. Therefore, in the drawing below, the plane mirrors m4 and m5 were added. It will certainly not be technically a simple arrangement.



The question remains whether we can indeed use it to view images of destructive interference. Should this effectively be possible, then one can search for planets with only one telescope. A second similar telescope as described in 6.2. would then in principle be superfluous.

And what would show up if we took a look at the surrounding nature on a stormy day? Could the violent air turbulences then also lead to an intense shift of the interference colors, somewhat analogous to what we saw around our hand? Thinking on this, it seems as if the wind then leads to dark shadows, interrupted by yellow strands. Or indeed, in a violent storm to colors further away from the central destructive line, perhaps even coloring the surroundings red or blue. To get certainty about this, such an instrument must first be built. But that has long since ceased to be a task for an amateur telescope builder.