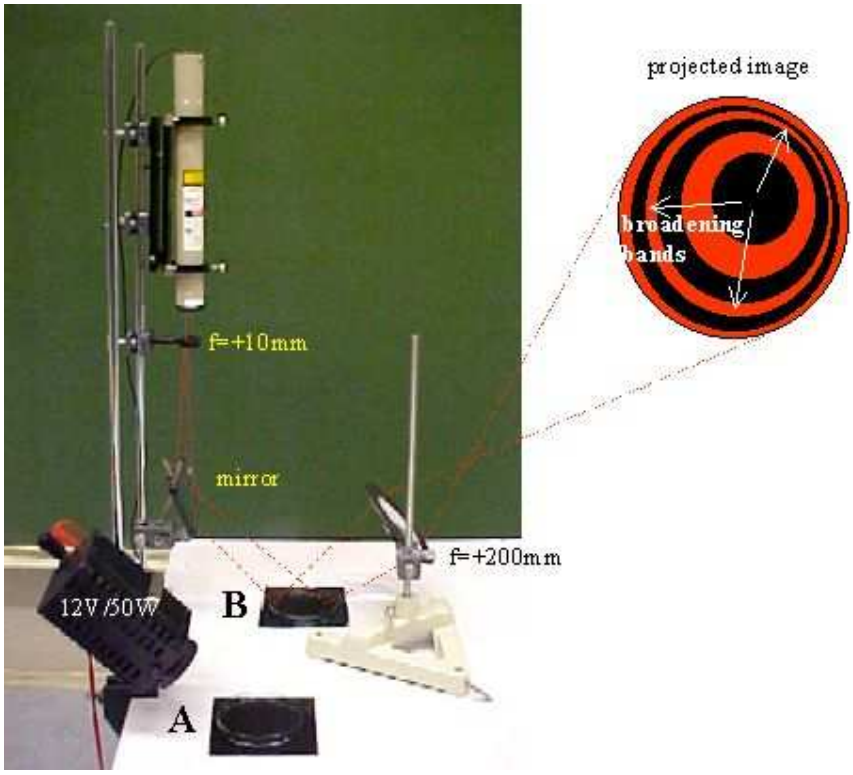
Oil film

Aim: To show the interference in thin oil films.

Subjects: 6D30 (Thin Films)

Diagram:



Equipment:

- Two Petri dishes, diam.=12cm.
- Two square pieces of mat black paper, wetted and put under Petri dishes.
- Lamp, 12V/90W.
- Condensorlens, f=50mm
- Lens, f=200mm, diam.=12cm (we use Leybold 46010).
- Laser, red, 15mW.
- Lens, f=10mm.
- Adjustable mirror.
- Motor oil in wash bottle.
- Stick, diam.=2.5mm.

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Presentation: The demonstration is prepared as shown in Diagram.
First the demonstration is performed with white light, so the 200mm lens should be placed near the Petri dish A. The dish is filled with a layer tapwater. The lens projects an image of the watersurface on the wall (see Figure1A). By means of the wash bottle a drop of oil is deposited on the watersurface. The drop spreads out quickly, no colors are observed; only the very attentive students have seen colors at the rim of the oil spot that moved quickly outwards.

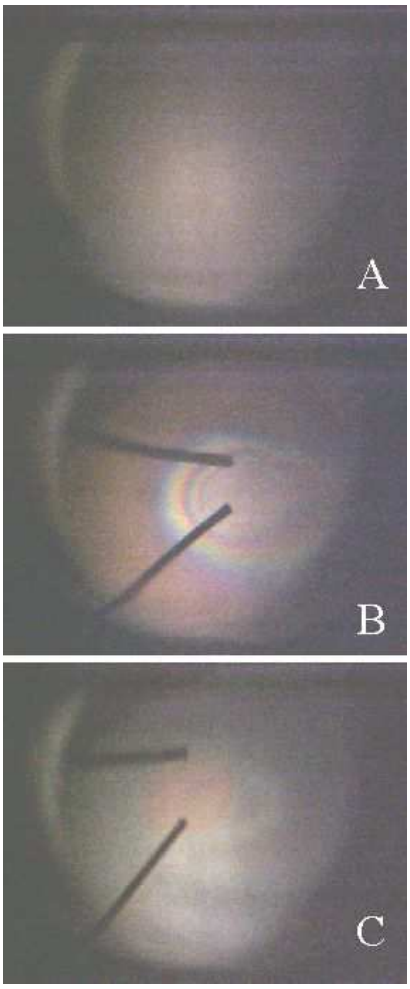

Figure 1

The Petri dish is cleaned and a new layer of tapwater is poured in it. The thin stick is dipped in the oil and by tipping the stick on the watersurface a small oildrop is positioned on it. Immediately it spreads outward in a spot and clearly colors are observed (see Figure1B). After a short while the broadening stops and the oilspot is seen showing one color only (sometimes reddish or yellowish or green or blue or.. -see Figure1C). In applying more small drops of oil on the preceding oilspot, the proces of observing changing colorpatterns can be repeated. The advantager of placing drops on the preceding oilspots is that the speed by which the colors move and change diminishes and the proces can be followed better.

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The demonstration is repeated in monochromatic red laserlight. The 10mm-lens makes a diverging bundle of light and via the surfacemirror the water in Petri dish B is exposed. Using the stick, a small drop of oil is put on the watersurface. It is really amazing how clearly visible the fringed pattern of closely spaced black and red circles appears and broadens. Also in this demonstration the proces of broadening is slowed down when applying more drops of oil on the foregoing oilspots.

Explanation: The thin oilfilm (thickness in the order of the wavelength used) serves as an amplitude-splitting device (see Figure2).

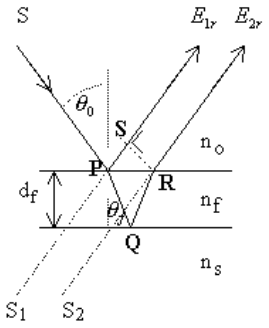

Figure 2

Light reflects from the top and from the bottom of the oilfilm (from the first - and the second interface), so that E_{1r} and E_{2r} may be considered as arising from two coherent sources (S_1 and S_2). When the two parallel reflected rays are brought together on the retina of the eye, they add up, producing interference of light. (In this demonstration the 200mm lens brings the parallel rays together in the projection on the wall.) There is a phasedifference between the two rays of

$\delta = k_0\{[PQR]-[P)S]\} = k_0\left\{\frac{2n_f d_f}{\cos\theta_f} - 2n_0 d_f \tan\theta_f \sin\theta_0\right\}$. Using Snell's law $n_0 \sin\theta_0 = n_f \sin\theta_f$, we obtain $\delta = 2k_0 n_f d_f \cos\theta_f$. So the phasedifference is proportional to *d*, and for a certain thickness of film some wavelength add up out of phase and are cancelled while other wavelength add up in phase and are strengthened: Different thicknesses of oilfilm cancel/strengthen different colors.

While the oil spreads out across the watersurface, thickness varies and a changing colorpattern appears. When the spreading stops, the oilfilm will finally have equal thickness everywhere and only one color appears.

When the oilfilm is very thick (the first demonstration described in "Presentation") E_{2r} becomes too weak to give a visible result in interference. This is also observed in the part of the demonstration where we heap oilspot on oilspot and colors appear weaker and weaker.

When the demonstration is performed in monochromatic light k_0 in $\delta = 2k_0 n_f d_f \cos\theta_f$ has only one value and for a number of thicknesses $\delta=\pi$ or $\delta=n\pi$, (n being any odd integer) giving the possibility of complete extinguishing that light.

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Remarks:
- The black paper under the Petri dishes is wetted in order to make the underground more black.
- See also the demonstration "Soap film" in this database.

Sources:
- Giancoli, D.G., Physics for scientists and engineers with modern physics, pag. 877-879
- Hecht, Eugene, Optics, pag. 393-399
- Karel Knip, Alledaagse wetenschap, Wetenschapsbijlage, pag. 17mei-2003