Exp2: Determination of Gravity-induced gradients in soap-film thickness using thin film interference

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September 2023

Aim

- To study thin film interference in a soap film of variable and setting up favourable set-up.
- Time-evolution of the gradient profile of a vertical soap film.

Apparatus

A commercial soap, bucket, water, glycerine , sugar pills, white light source, copper frame, clamp stand, a software to measure distances using images (Photo measure).

Theory

We demonstrate a direct measurement of thickness gradient in a vertical soap film. A soap drains downwards due to gravity and capillary action. This can be seen by the parallel coloured fringes towards the bottom and a black zone or a microscopically thin newton black film on the top. After long time we observe that from the lower side to the top, we see thin parallel fringes followed by broad parallel fringes followed by a dark black film.

We assumed that the light incident on the film were parallel rays and derived the relation for the thickness of the film required for $\mathrm{n^{th}}$ maxima as:

$$d_n = \left(n + \frac{1}{2}\right) \frac{\lambda}{2\mu}$$

Then we can write the ratio between the $\mathrm{m^{th}}$ and $\mathrm{n^{th}}$ thickness of the film as:

$$\frac{d_n}{d_m} = \frac{n + \frac{1}{2}}{m + \frac{1}{2}}$$

In our analysis we assign the first fringe we observe as the $\mathrm{m^{th}}$ fringe and every fringe after that is taken as $\mathrm{n^{th}}$ fringe where $n = m + N$, Where N is an integer. Then we can simplify the relation as:

$$\left(m + \frac{1}{2}\right)\left(\frac{d_n}{d_m} - 1\right) = N$$

Now we can plot the $\mathrm{N^{th}}$ fringe observed along the distance from the first fringe. This can further be divided by the total number of fringes observed to normalise the graph.

This relates to the thickness profile, which is just $d(x)$ (where x is the distance), as over here we are plotting the d_{n} along x but is scaled with constants and shifted to match what we measured.

Experimental Setup

- We prepared soap solution with a commercial soap film, glycerine and water. A circular metallic frame diameter 6.5 cm was mounted on a clamp inside a plastic box to avoid turbulence as much as possible.
- The film is illuminated with white light and the reflected light and fringes are recorded by a camera.
- The N^{th} fringe was plotted along distances at which fringes occur (which was measured using a photo measure app).

Observations

Distance of N^{th} fringe	N^{th} fringe
0	0
0.29	1
0.74	2
1.24	3
1.82	4
3.28	5
4.12	6

Table 1: Observations at 5 minutes

Distance of N^{th} fringe	N^{th} fringe
0	0
0.47	1
0.96	2
1.57	3
2.72	4
4.38	5

Table 2: Observations at 10 minutes

Distance of N^{th} fringe	N^{th} fringe
0	0
0.55	1
1.13	2
2.27	3
3.69	4

Table 3: Observations at 15 minutes

Distance of N^{th} fringe	N^{th} fringe
0	0
0.55	1
1.53	2
3.01	3

Table 4: Observations at 20 minutes

Inference

We can see from the graph that the ratio of $\dfrac{d_n}{d_m}$ is increasing as x increases. This is the thickness of the film and it increases as we go downwards.