# Light interferometric investigation of drop coalescence

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## Introduction

During the drainage of a thin liquid film, formed between two colliding drops, several phenomena such as dimple formation, thinning of plane-parallel film, transition to a black film and rupture can occur. These phenomena can be observed using light interferometry.

### *Objective*

- □ develop and analyse interferometric patterns to study drop coalescence.

## Theory

### *Assumptions*

- □ linearly polarised, monochromatic incident light
- □ angle of incidence $90°$
- □ reflection and transmission at the different film interfaces (fig.1)
- □ interference of the two resulting reflected waves.

### *General Concept*

Using these assumptions, it is easy to derive an equation for the light intensity:

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2} cos(\frac{2\pi}{\lambda_0}\Delta), \qquad (1)$$

where $\Delta$ is the optical path difference.

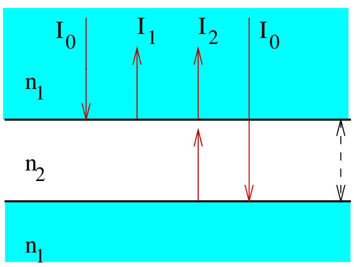


**fig. 1** *Reflection and transmission of the incident beam $I_0$ at the different film interfaces*

Consider the Fresnel equations, using the following notation:

$$s \equiv \frac{n_1 - n_2}{n_1 + n_2}, \quad 1 - s^2 = \frac{4 n_1 n_2}{(n_1 + n_2)^2} \qquad (2)$$

one obtains:

$$I_1 = s^2 I_0, \quad I_2 = I_0 s^2 (1 - s^2)^2 \qquad (3)$$

Combining equations (1) and (3) we can write:

$$I = I_0 s^2 [1 + (1 - s^2)^2 + 2(1 - s^2)(1 - 2 sin^2 \delta/2)], \qquad (4)$$

where

$$\delta = \frac{2\pi}{\lambda_0} n_2 2h + \pi. \qquad (5)$$

We have maximum intensity when:

$$h = (2k+1)\frac{\lambda_0}{4n_2}, \qquad (6)$$

and minimum when:

$$h = 2k\frac{\lambda_0}{4n_2}, \quad k = 0, 1, 2, 3... \qquad (7)$$

## Results and Observations

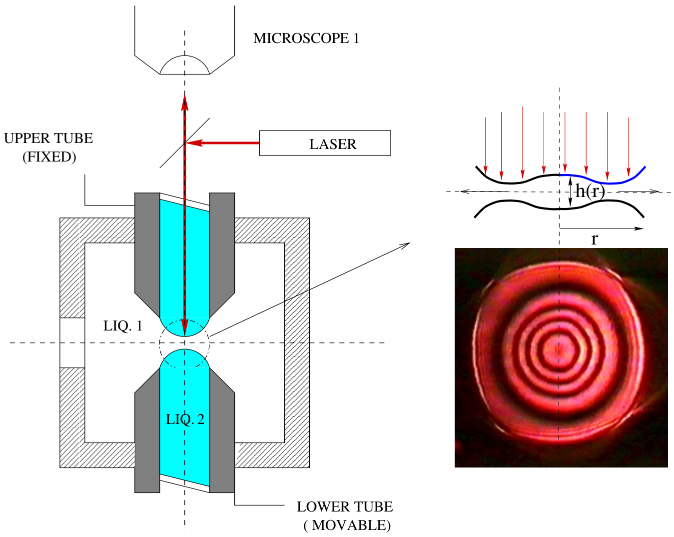


**fig. 2** *The experimental set up and resulting interference pattern*

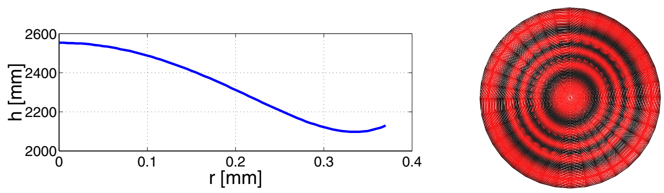


**fig. 3** *Interference pattern obtained by solving eq.(4) for a given profile of the film ( on left ), $n_2 = 1.4$ and $\lambda = 632.8nm$*

## Conclusions

- □ the interference pattern obtained using the set up shown in fig.2, was reproduced qualitatively by solving eq.(4)
- □ further improvement of the set up in order to obtain quantitative agreement
- □ develop a program for image analyses
- □ application to coalescence of viscoelastic drops.