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:

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

where Δ is the optical path difference.

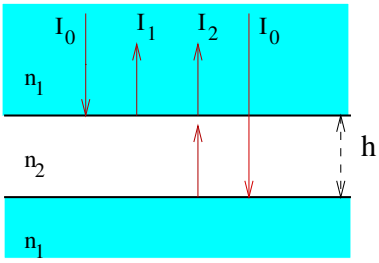

fig. 1 *Reflection and transmission of the incident beam I_0 at the different film interfaces*

Consider the Fresnel equations, using the following notation:

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

one obtains:

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

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

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

where

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

We have maximum intensity when:

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

and minimum when:

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

Results and Observations

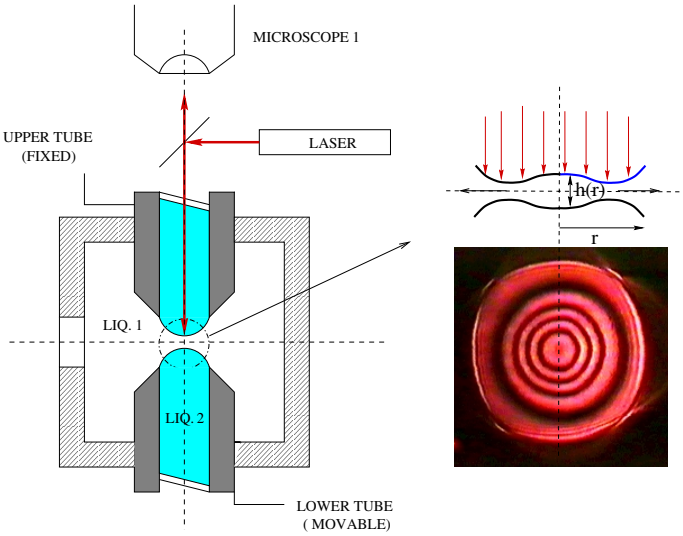

fig. 2 *The experimental set up and resulting interference pattern*

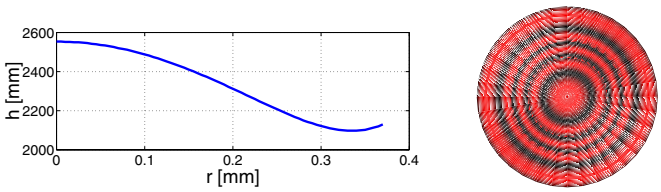

fig. 3 *Interference pattern obtained by solving eq.(4) for a given profile of the film (on left), $n_2 = 1.4$ and $\lambda = 632.8nm$*

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.