Quantum-like behavior at Macroscopic Scale (Analysis)

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Write this at last

When imagining a drops colliding with an interface of the same fluid it is acceptable to assume that the drop will merge with the fluid in order to minimize the surface area. While doing experiments with soap solutions under vertical vibration, J. Walker observed that the solution could keep a stable drop floating on the surface of the fluid.[?] A bath filled with a fluid can hold a droplet of the same fluid when put into vertical vibration of surface acceleration greater than g.[?]
(img 1)
The droplet is kept bouncing over the fluid and is then free to move horizontally due to vertical stabilization. At first, this horizontal movement seemed very random. Couder and Fort first noticed that the random nature of the horizontal movement of the droplet could be described by diffraction and interference waves.[?]. During a series of experiments, Couder and Fort placed a single slit on the vibrating bath. After successive repetitions, the final positions of the droplet described a diffraction wave.
(img 2)

I. SIMILARITIES BETWEEN LIGHT DIFFRACTION PATTERNS AND THE DROPLET DIFFRACTION

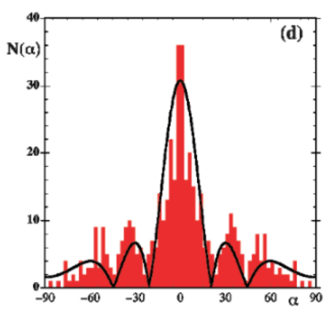

FIG. 1. Histogram obtained by Couder and Fort using a slit of width L = 14.8mm and a Faraday wavelength of λ_F = 6.95mm [?]

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A. Fraunhofer diffraction theory

The diffraction pattern curve provides an approximate fit to the histogram found by Couder and Fort's experiments. In Fraunhofer Wave Optics, the diffraction pattern can be observed when a beam of light passes through a narrow slit. If a screen is placed at a certain distance from the slit, a Fraunhofer diffraction pattern can be observed on the screen.[?] The pattern drawn by light is the one show in figure 1. The intensity can be calculated using the following formula

$$I = I_{max}\left[\frac{\sin(\pi a\sin\theta/\lambda)}{\pi a\sin\theta/\lambda}\right]^2$$

where I_{max} is the intensity at $\theta = 0$,a is the length of the slit,θ is the angle of deviation after the slit and λ is the wavelength of the beam. The expression can be simplified when considering only the position of the minima. The condition for intensity minima on a single slit problem states that

$$\frac{\pi a\sin\theta_{minima}}{\lambda} = m\pi$$

or

$$\sin\theta_{minima} = m\frac{\lambda}{a}$$

where $m = \pm1, \pm2, \pm3, \ldots$

B. Couder and Fort's approximation

The histogram produced after several trials with the vibrating bath single slit setup could be compared to a diffraction wave produced by a Fraunhofer diffraction as shown in figure 1. Couder and Fort approximated the formula for the intensity of a Fraunhofer diffraction pattern to the pattern drawn by the final position of the droplet. The function for this specific problem in diffraction of a droplet can be represented as

$$f(\alpha) = A\left|\frac{\sin(\pi L\sin\alpha/\lambda_F)}{\pi L\sin\alpha/\lambda_F}\right|$$

where A is the maximum amplitude, L is the width of the slit and α the deviation angle of the droplet after the slit.

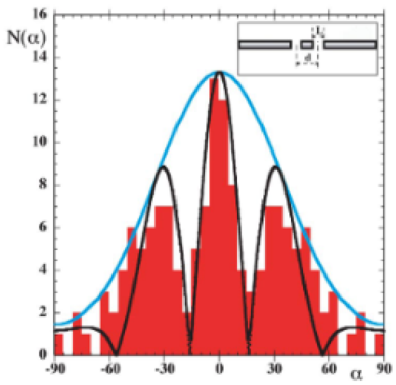

FIG. 2. Histogram for the deviation of 75 particles through two slits of width $L = 7.6$ mm, a distance $d = 14.3$ mm apart, the droplet's wavelength being $\lambda_F = 6.95$ mm ($L/\lambda_F = 1.1$ and $d/\lambda_F = 1.87$). The blue(light) line is the envelope due to the diffraction of a single slit while the curve in black is the optimum fit by the equation that is based on the interference pattern obtained for effective values $L/\lambda_F = 0.9$ and $d/\lambda_F = 1.7$. Source:[**?**]

II. SIMILARITIES BETWEEN LIGHT INTERFERENCE PATTERNS AND THE DROPLET HISTOGRAM

Couder and Fort proceeded then to study the possibility of producing an interference pattern with the vibrating bath system that was built for the study of the single slit diffraction. The single slit was replace by a double slit in order to reproduce Young's double slit experiment with a droplet on a vibrating bath. The droplet drew clear interference fringes that are well fitted by the following formula:

$$f(\alpha) = A \left| \frac{\sin(\pi L \sin\alpha/\lambda_F)}{\pi L \sin\alpha/\lambda_F} \cos(\pi d \sin\alpha/\lambda_F) \right|$$

where d is the distance between the centers of the slits. In the domain of wave optics, the interference produced by a double slit diffraction pattern is given by the expression:

$$I = I_{max} \cos^2 \left(\frac{\pi d \sin\theta}{\lambda} \right) \left[\frac{\sin(\pi a \sin\theta/\lambda)}{\pi a \sin\theta/\lambda} \right]^2$$

The approximation fits closely as shown in figure 2. This brought up many questions concerning the physical engine behind this phenomenon. The conclusions Couder and Fort brought are discussed further on.

III. QUANTUM-LIKE BEHAVIOR

Oh my god