Arago Spot Verification

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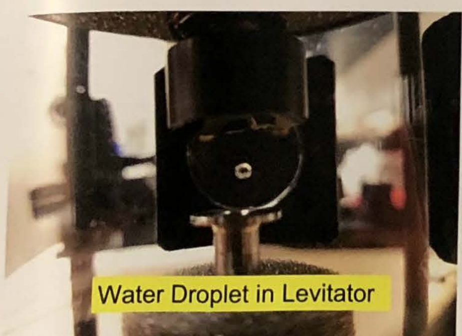
Abstract

In the shadow of an object, there is a small bright spot created by diffraction called the Arago spot. Using a 10 mW laser, the Arago effect was studied on different types of liquid spheres. The goal of this experiment was to develop a deeper understanding of the influence of object opacity on the Arago effect.

Background

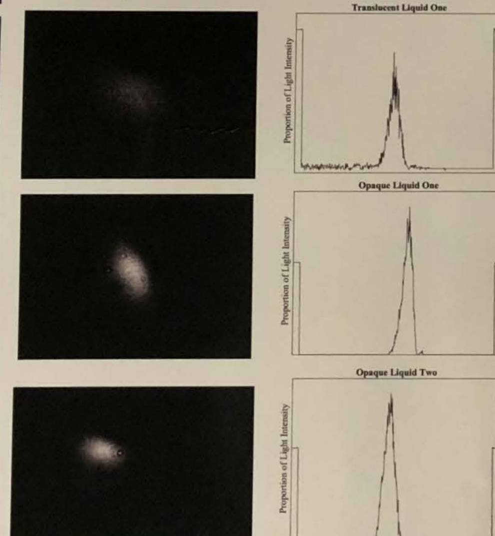
Laser systems have become prominent in naval warfare with regards to communication and sensors; understanding the effect that the operating environment has on beams is crucial to accurate and effective deployment. The "Arago Spot" phenomenon, a bright point that appears at the center of a circular object's shadow due to Fresnel diffraction, was discovered by Simeon Poisson when he placed a circular object in front of a light. These findings had tremendous impact upon the physics community, confirming the wave-like nature of light propagation. Our experiment attempted to refine these findings by levitating liquid droplets, shooting lasers through them, and analyzing the shadow cast by the substance.



Methods

- Materials gathered: Levitator, ThorLabs Model HNL050L Laser, laser camera, camera filter, pipet, liquid for Arago Spot, computer (BeamGauge & MATLAB)
  - Water, White Milk (Opaque 1), Chocolate Milk (Opaque 2)
- Align the laser, levitator, and the camera to the correct height and angle
- Using a 10 μL pipette, place a liquid drop in the levitator
- Take a picture of the beam using BeamGauge software
- Analyze the picture in MATLAB to make the Arago spot graph

Graphs



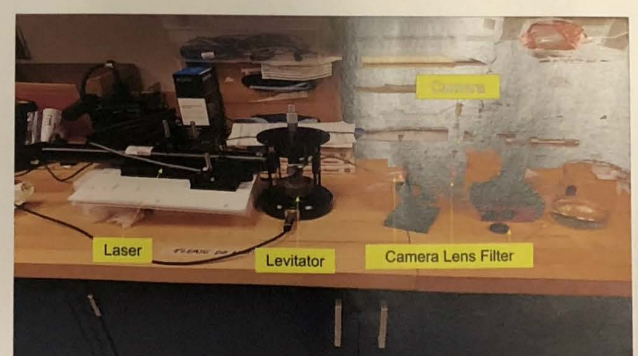
Results

We observed bright spots in the middle of the first grayscale photo taken when the laser was shined through the first opaque droplet. Although the image does not portray a perfect circular shape, the brightness of the laser is greatest at the center of the oval object. The second opaque test further corroborates these findings, showing a more defined and sharper bright spot in the center of the shadow. The tendency of the laser to trail to the bottom right is due to large laser beam imperfectly aligned.

Huygens-Fresnel Principle

$$U(P_1) = \frac{Ae^{ikr_0}}{r_0}\int_S \frac{e^{ikr_1}}{r_1}K(\chi)\,dS,$$

r: distance of the point P_1 on the screen from the optical axis
d: diameter of circular object
Λ: wavelength
b: distance between circular object and screen



Conclusion

The Arago spot is present in all of the liquids. The white and chocolate milk were used as opaque substances. The white milk had a very smooth surface compared to the chocolate milk, likely due to a lower sugar content, which caused the light intensity at the Arago spot to be brighter. The Fresnel diffraction was also affected by the distance between the laser and the drop, the size of the drop, and the distance from the camera to the drop. The Arago spot increases proportionally to increases in radius and distance from the camera to the droplet. The brightness is determined by the substance that the laser travels through. In order to achieve more precise results, a more advanced levitator would be required to levitate solid objects to gauge more opaque substances. It would also be beneficial to attain a precise measurement of the liquid drops, in order to observe accurate trends with varying volumes.

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