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Interferometric Measurement of the index of Refraction of Liquids

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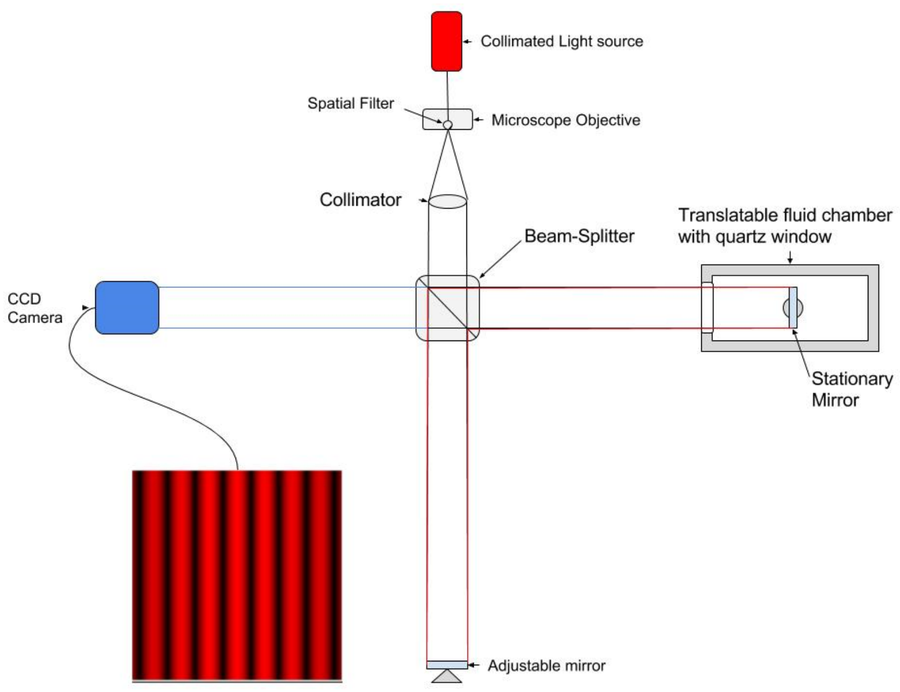
Introduction

The index of refraction (IoR) is a wavelength dependent parameter defined as the velocity of light in a vacuum divided by the velocity of light in a medium. As light travels from one medium to another (as from air into water) its velocity changes but its frequency does not. Light slows down when entering a medium with a higher IoR, and speeds up when entering a medium with a lower IoR. This description extends to all transparent materials, including liquids.

Figure 1



Materials and Methods

Using a Michaelson Interferometer with a movable liquid filled transparent chamber surrounding one of the mirrors, it was possible to monitor interference fringes as they moved across the sensor of a standard CCD camera. The path length that light traveled in the liquid was controlled using a simple translation stage to move the chamber. A computer program was created by Mr. Anderson to analyze the captured images, creating a graph, which was then smoothed to remove noise from vibrations in the room and wander in the laser source. This curve was then interpreted as a series of fringes to be counted by the program. A GUI (Graphical User Interface), created by Mr. Anderson, was used to control the process which terminated in displaying a value for the IoR. Standard optics laboratory equipment was used, with the exception of the chamber holding the liquid, which had been fabricated in advance.

Key Findings/Results

The research this summer has been directed toward determining the index of refraction of various liquids. This topic will be the subject of Josiah Anderson's MS physics thesis. IoR data from various transparent liquids was obtained using a slightly modified Michelson interferometer (Figure 1) Movement in the interference pattern is an indirect measurement of the desired IoR. With the technique developed, the IoR was obtained for the first time for some unique liquids—and with six significant digit precision. The current set of IoR data (Figure 2) comprises mostly common liquids, with the notable exception of D80, a jet fuel.

Impact/Conclusions

Known IoRs can be used to verify the purity (or contaminant concentration) of transparent fluids. This technique is particularly applicable in industrial fields. Jet fuel for airlines, chemical solutions for Bio Technology labs, industrial solvents for factories; the list of applications for IoR sensors is extensive in the oil and gas industry alone. The data collected this summer is precise beyond any previously obtained and the data collection and analysis technique exploited can easily be automated to function in near real-time.

Figure 2

Medium	IoR	STD
Water	1.333676	0.001128
Denatured Alcohol	1.353473	0.000665
Excol D80	1.433529	0.000871
Kerosene	1.446599	0.001099
Glycerin	1.478334	0.003142
Corn Oil	1.498488	0.001035

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References

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