

# Study the Effective a Temperature and Concentration on Refractive Index of Water by Using Michelson Interferometer

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**Abstract:** The refractive index of pure water is measured at temperature rang (25-50)<sup>o</sup>C and four different concentration of Nail solution. The effect of temperature and concentration on the refractive index of water are explained using the Michelson interferometer.

**Keywords:** Michelson interferometer, Effect temperature, Refractive index

## 1. Introduction

Refractive index is one of the most important optical properties of a medium. It plays vital role in many areas of material science with special reference to thin film technology fiber optics, underwater optical communication [1, 2]. The refractive index can provide information for us about the behavior of light and optical properties of mediums. When light passes through the different mediums) its velocity decreases by increasing of the refractive index of these mediums, and its always smaller than the speed of light in vacuum [3], the refractive index of mediums is a higher than unity. also in the most mediums the refractive index decreases by increasing of the temperature [4]. The refractive index of water its measure by various methods, the commonly instrument used know Abbe refractometer [5], there is also by analysis of dn/dc The dn/dc, also called differential refractive index is the variation of the real refractive index due to a change in concentration of a solute. The present paper reports a relatively simple and effective technique, which can be used to measure the refractive index of the liquid at different temperatures and concentration, it Michelson interferometer.

## 2. Principle of Method

There are many instruments that produce optical interference. These instruments are grouped under the generic name of interferometers. Michelson interferometer is one of example of the optical interferometer. Some of parameters can be measure by this Michelson interferometer as wavelength of light, refractive index of materials and the width of spectral lines. A Michelson interferometer was constructed from He-Ne laser, a beam splitter, two mirrors and white screen, if used this instrument to measure the refractive index of water placed in one of the two interferometer arms optical cell content sample water [6]. After the laser beam interferes with another beam from the second arms of interferometer, the interference fringes appears on a screen placed in front of the laser. If the temperature changes then so does the refractive index of the water, which affects the manner in which laser beam from each arm the interferometer [7], . this is seen as measurement of the interference fringes on screen. The change in the refractive index of water as a function of temperature is given by [8].

$$\frac{\Delta n}{\Delta T} = \frac{\Delta N}{\Delta T} \cdot \frac{\lambda}{2L} \text{-----} 1$$

Where:

$\Delta n$  is the change in refractive index  $\Delta n = n_2 - n_1$

$\Delta T$  is the change in temperature  $\Delta T = T_2 - T_1$

$\Delta N$  is the change in interferometer fringes  $\Delta N = N_2 - N_1$

$\lambda$  = wavelength of laser beam

$L$  = the thickness of the glass cell

The refractive index  $n$  of water is linearly dependent on temperature and determined the change in the refractive index at any change in temperature by equation [9].

$$n_2 = n_1 [T_1] - [\Delta T] \cdot \left[ \frac{\Delta n}{\Delta T} \right] \text{-----} 2$$

Also we can used the Michelson interferometer to measure the change of refractive index as function of concentration as same as above but one different it placed the optical cell content sample water on rotating stage and determine the refractive index by equation [10].

$$n = \frac{(2L - N\lambda)(1 - \cos\theta)}{2L(1 - \cos\theta) - N\lambda} \text{-----} 3$$

where:

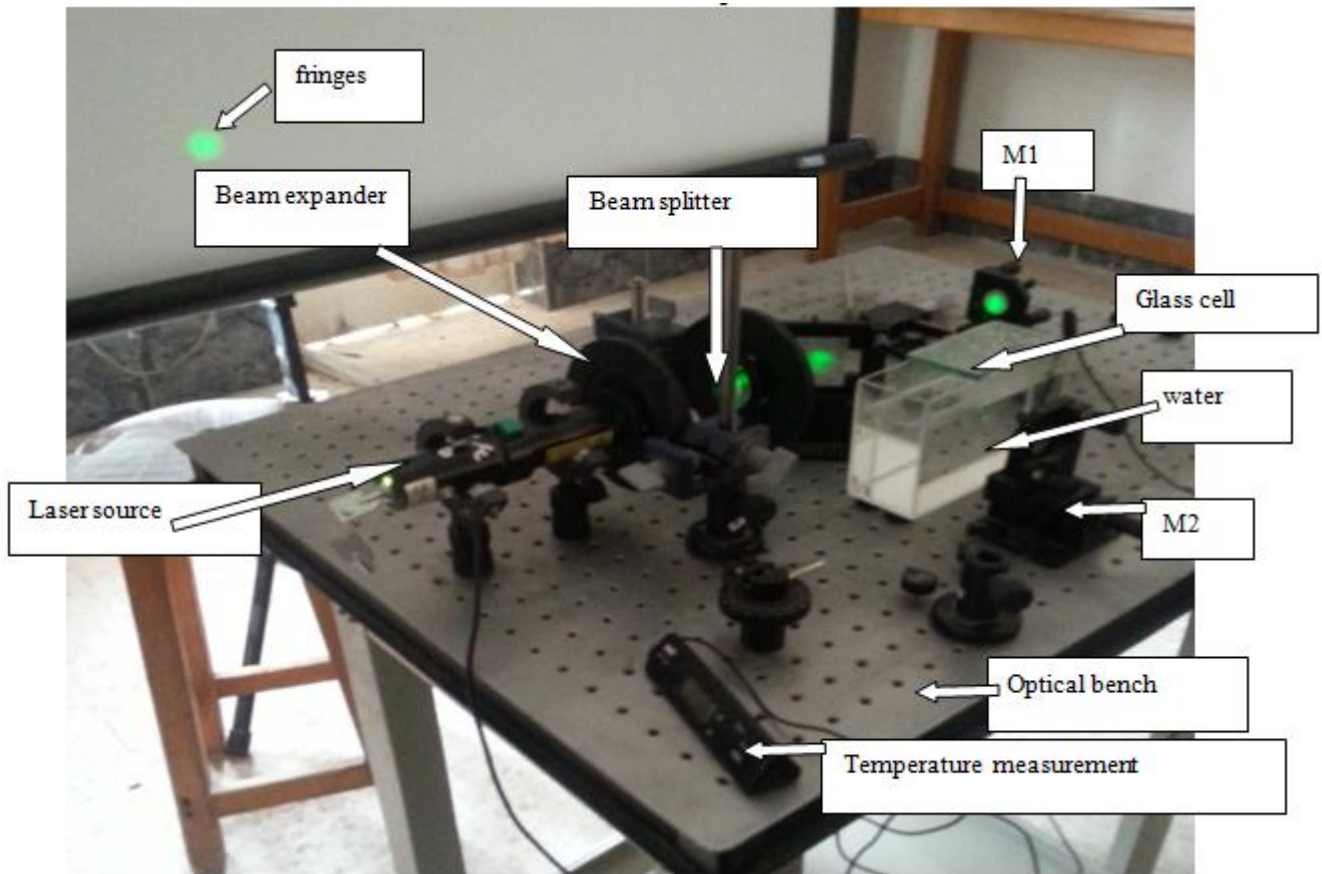
$\theta$  is the angle of rotation in degree

## 3. Experimental Set Up

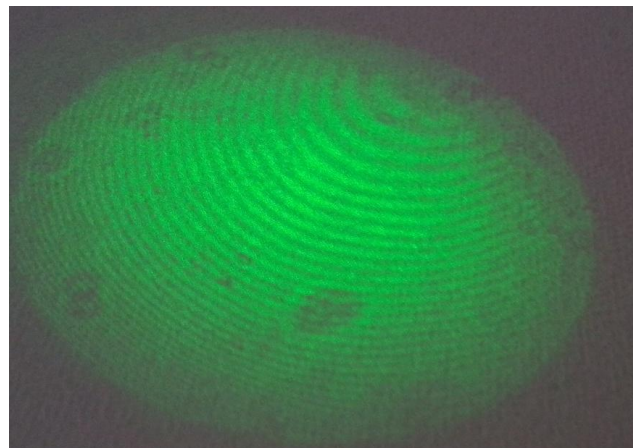
A sketch of the experimental set up used to measured the refractive index as a function of temperature is shown in a photograph figure (1). The water sample is placed in a glass cell have dimensions ( $d_1=55\text{mm}$  and  $d_2=100\text{mm}$ ), first the water sample is heated by used the electrical heater to  $50\text{ }^\circ\text{C}$  and then let the water sample cooled until reach the laboratory temperature about  $30\text{ }^\circ\text{C}$  this temperature is measured by thermometer have resolution about  $[\pm 0.1\text{ }^\circ\text{C}]$ . The laser light source is Helium-Neon laser operating at wavelength  $532\text{ nm}$  and power  $5\text{ mw}$ , the light from the laser

is pass through beam expander to improve beam quality and split by the beam splitter in to two beams, these two beams were reflected back by two mirrors. The cell with the water sample was place in one of the two interferometer arms, at the

exit of the interferometer the in interference fringes it observation shown in figure (2) and we can counted it's with changing a temperature.



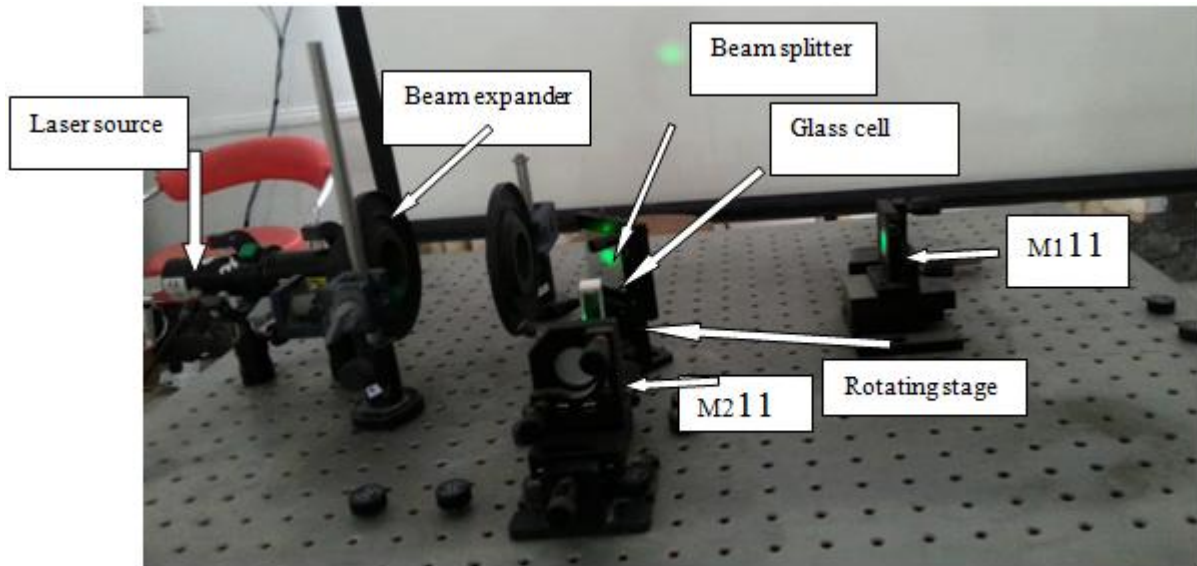
**Figure 1:** Experimental setup to measure the refractive index of water as a function of temperature



**Figure 2:** Produce Fringes

Another a glass cell with dimensions  $d_1=10\text{mm}$  and  $d_2=20\text{mm}$  used for this experiment is placed on the rotation stage it rotating in order to select the desired angle of

incidence. A photograph of the experiment setup used is show in figure (3).



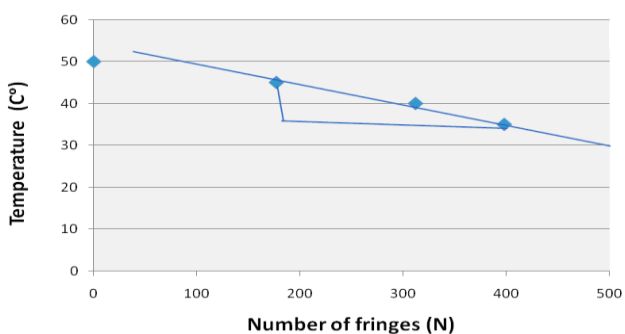
**Figure 3:** experiment setup of measure the Refractive index of water as a function of potassium chloride solution concentration

Also the rotating stage with glass cell was place in one of the two interferometer arms, then the laser beam must be perpendicular with walls of cell ( $\theta=0$ ). this was checked by rotation of the cell and observation of the interface fringes. After this step we can change the concentration of water sample and observation the changing in interference fringe also counted.

#### 4. Result and Discussions

##### 4.1-Effect of Temperature on Refractive Index of pure Water

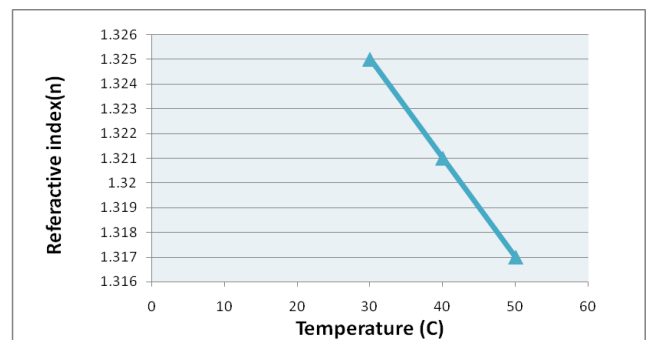
To determined the refractive index of pure water, a temperature is gradually reduce until reach laboratory temperature, during this process the interference fringes draw together and alternating darkness and light is observed at the center. The number of ( N ) appearing is plotted against the corresponding values of pure water temperature is shown in figure (4).



**Figure 4:** Number of N changes as a function of temperature

From the above figure we found the straight line ( $\Delta N/\Delta T$ ) is equal ( 0.045), also Using equation (1) (with  $L= 55$  mm,  $\lambda= 532$  nm and  $n_1 [T30\text{ }^\circ\text{C}= 1.331]$ ) to found the change of refractive index related degree of temperature ( $dn/dT$ ) is equal ( $2.1 \times 10^{-4} \text{ }^\circ\text{C}^{-1}$ ) Corresponding the values found and used equation (2), plotted the changes of refractive index as a function of temperature is shown in figure (5).The result

shows a linear dependence of refractive index of water on temperature in the range ( $30\text{-}50\text{ }^\circ\text{C}$ ). For temperature  $50\text{ }^\circ\text{C}$  refractive index is lower value (1.317) which greater to (1.325) at temperature  $30\text{ }^\circ\text{C}$ .The change in refractive index corresponding the change of density of water at change the temperature.



**Figure 5:** The relation between the refractive index and temperature

##### 4.2- Effect of concentration on Refractive Index of Water

The Refractive Index of Water at different concentration of potassium chloride has been measured using the Michelson interferometer. The value of (N) is counted for different angle of incident is shown in table (1), from this table we observed the number of fringes (N) is nearly equal at nearly incident angles with different concentrations of NaCl.

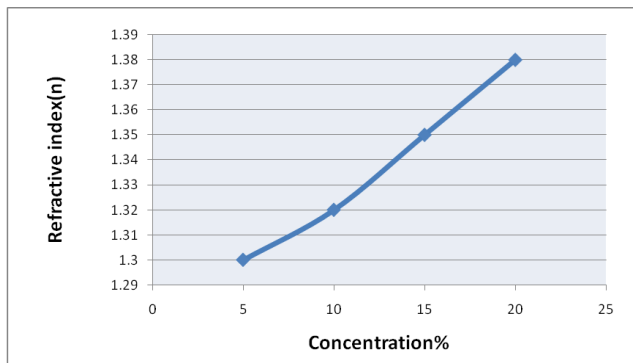
**Table 1:** Number of fringes with differ concentration and incident angles

Concentrations of water (%)	Number of fringes(N)	Angle incident in degree
5	49.5	1
10	49	1
15	47	1
20	48	1

Figure (6) draw by used the information in table (1) and equation (3) is depict the dependence of refractive index of water on the concentration of NaCl, for 20% solution

refractive index is a high (1.38) which reduces to (1.3) when the solution is a concentration (5%), this result is nearly the same of pure water. The density of the solution is increased with concentration increased also increased in refractive index.

[10] Satheesh K. and Abdullakutty, 2009, Determination of refractive index of mirror substrate using laser beam interferometry, Physics Education, 231



**Figure 6:** Refractive index of potassium chloride solution as a function of its concentration expressed in percentage

## 5. Conclusion

The value of refractive index measured by used the Michelson interferometer is a good agreement with their stander values.

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