Microwave Optics: Refraction And Polarization

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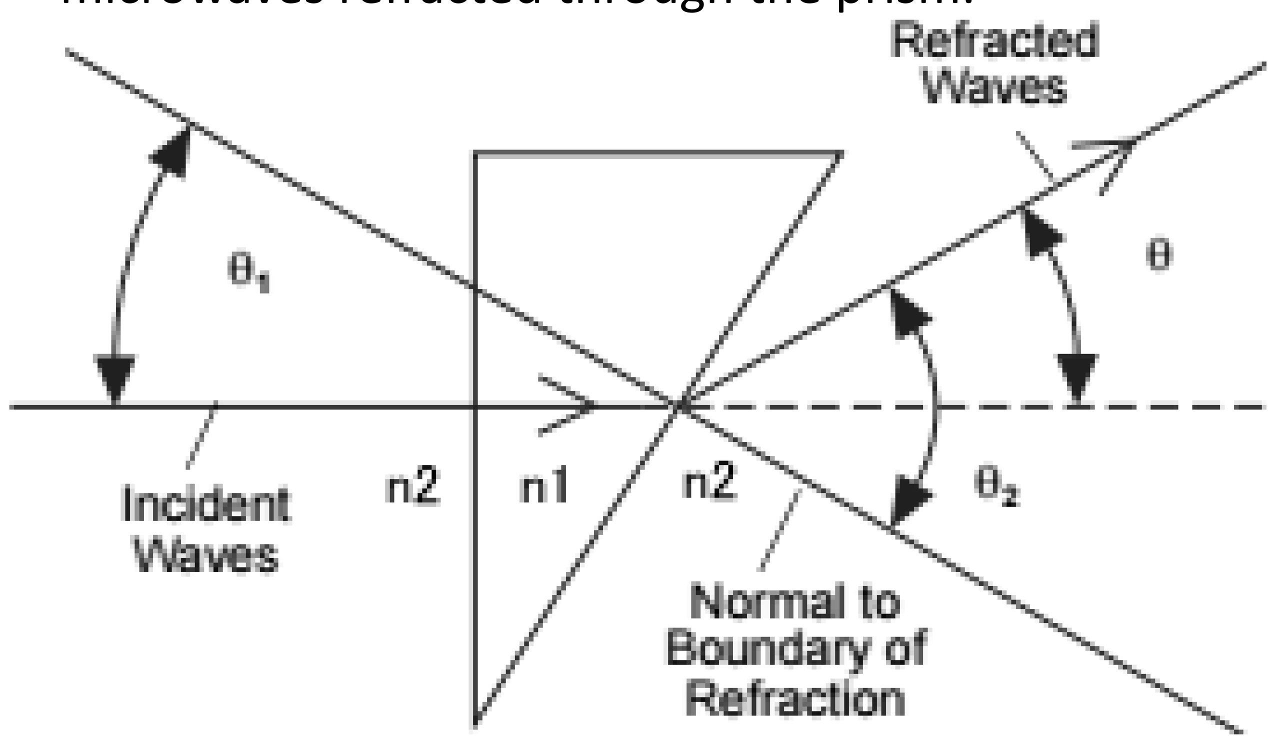
Introduction

Light is the visible part of the electromagnetic wave spectrum. Just as light is filtered with polarizing lenses to in osculate in a parallel direction to them, can microwaves which are also in the electromagnetic wave spectrum be polarized? We also know that light can be focused/refracted by transparent materials. Since light and microwaves are both apart of the electromagnetic wave spectrum, can microwaves be refracted as well?

When light is already polarized and passes through a polarizing lens with a relative angle difference θ, the incoming/incident intensity I should be related to the transmitted intensity I 0 by **Malus's law | I = I 0cos2θ |.** As light passes from one material into another the light is "bent" or slightly changes direction. Based on the incoming/incident angle θ1 with the normal of the boundary surface and the refraction indices of the materials n1 & n2 (an intrinsic property of materials) the transmitted angle θ2 is related by **Snell's law |n1sinθ1=n2sinθ2|**.

Refraction Experiment

To study refraction of microwaves, we setup a triangular ethafoam prism mold filled with styrene pellets, similar to how one can use a glass prism to study refraction of light. The triangular prism was in between a microwave transmitter to emit microwaves and a receiver to measure microwaves that were received. By moving the receiver, we were able to determine the angle at which the receiver displayed the greatest reading of microwaves refracted through the prism.



$\theta_1 := 20.5\ deg \quad \theta := 180\ deg - 171.5\ deg$

$\theta_2 := \theta + \theta_1 = 29\ deg \qquad n_2 := 1$

$n_1\ sin(\theta_1) = n_2\ sin(\theta_2)$

Snell's Law:

$$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$$

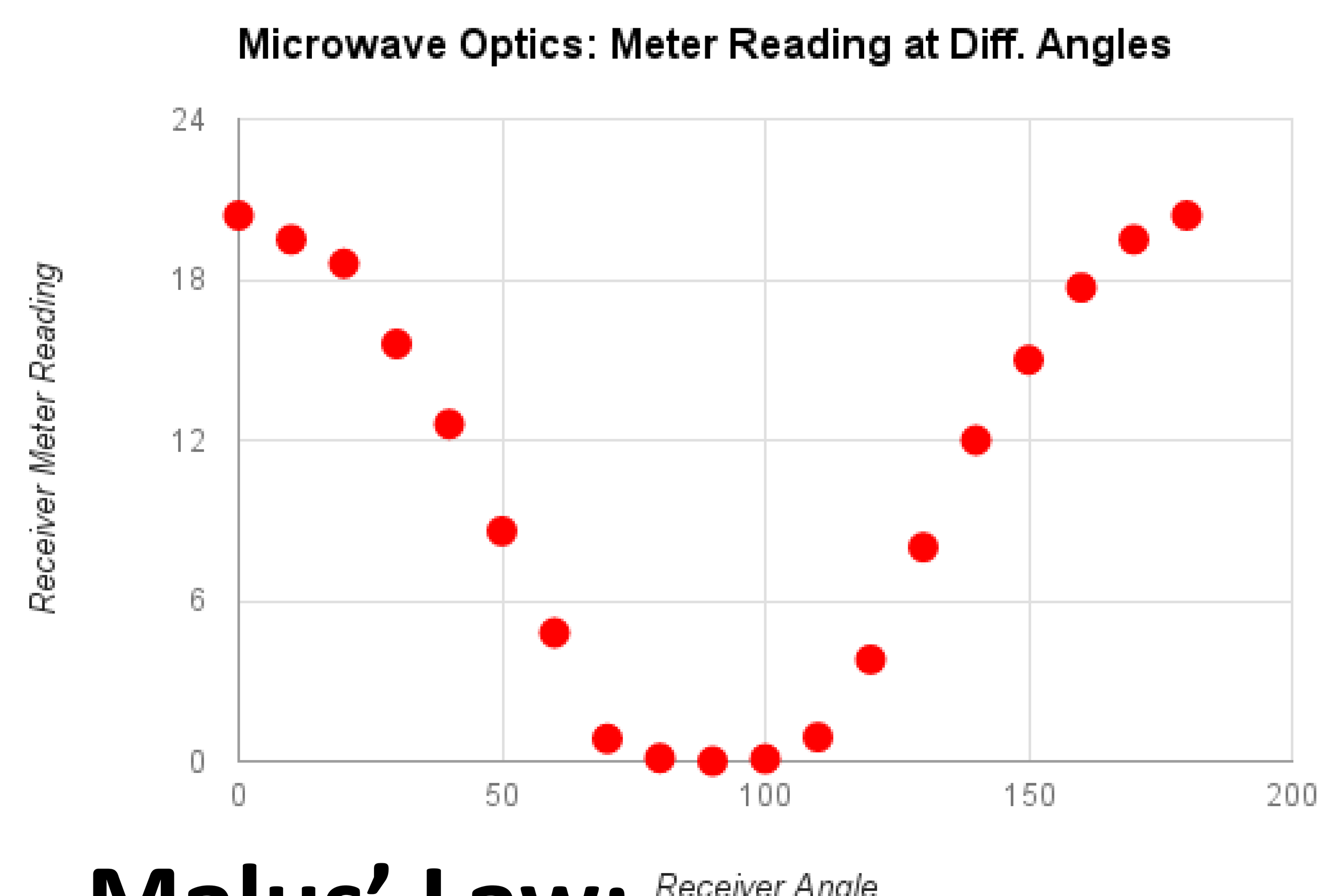
So,

$$n_1 := \frac{\sin(\theta_2)}{\sin(\theta_1)} \cdot n_2 = 1.384$$

$$n_{1.actual} := 1.546 \qquad \frac{(n_{1.actual} - n_1)}{n_{1.actual}} = 0.105$$

Polarization Experiment

To study polarization of microwaves, we setup thin pentagonal sheets of stainless steel which had slots in between a transmitter and receiver, like our experiment to study refraction. One part of this experiment involved observing the receiver's reading at various angles without a polarizer in between the transmitter and receiver, and another part of the experiment involved observing the reading with the polarizer slits at various angles (with the receiver facing the same direction as the transmitter and also at 90 degrees to the transmitter).



Malus' Law:

$$I_1 = I_0 cos^2(\theta)$$

Receiver Angle: 0 deg		Receiver Angle: 90 deg	
$angle_{polarizer}$ (deg)	$reading_{meter}$	$angle_{slits}$ (deg)	$reading_{meter2}$
00.0	0.00	00	0.2
22.5	0.90	45	9.6
45.0	2.55	90	0.9
67.5	0.30		
90.0	0.00		

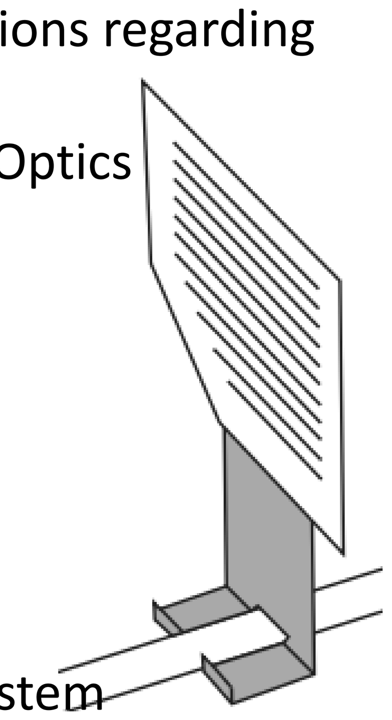
Conclusion

Our experiments demonstrated that microwaves do follow the same laws as the visible light section of electromagnetic radiation. Microwaves are identical to light having a different wavelength and frequency. The data we obtained from our polarization experiment matched the expected curve based on Malus's law, and the value we obtained for the index of Styrofoam was close to the actual value (10.5 % error).

Both refraction and polarization have several applications in everyday life. Applications of refraction and polarization of visible light are well known, for instance polarized glasses and lenses. One application of polarization of microwaves is the protective mesh polarizer on microwave oven doors. This works by overlapping two polarizing sheets to absorb both longitudinal and transversal waves. An application of refraction of microwaves is the bending of microwaves toward the earth from line of sight towers due to the lower air pressure and humidity in the higher parts of Earth's atmosphere. Microwaves also have applications in fiber optics, radar, hypothermia treatment for cancer, and dehydrating foods.

Future Work

Future work could include more investigations regarding Microwaves, for instance:
Double Slit Interference, Reflection, Fiber Optics



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