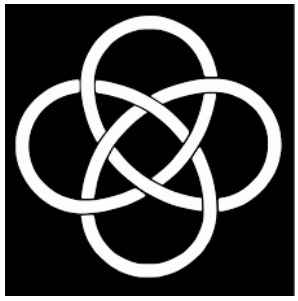
IUCAA NCRA

RADIO ASTRONOMY WINTER SCHOOL 2020

SEA SURFACE INTERFEROMETER



Submitted by

Group 10

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ABSTRACT

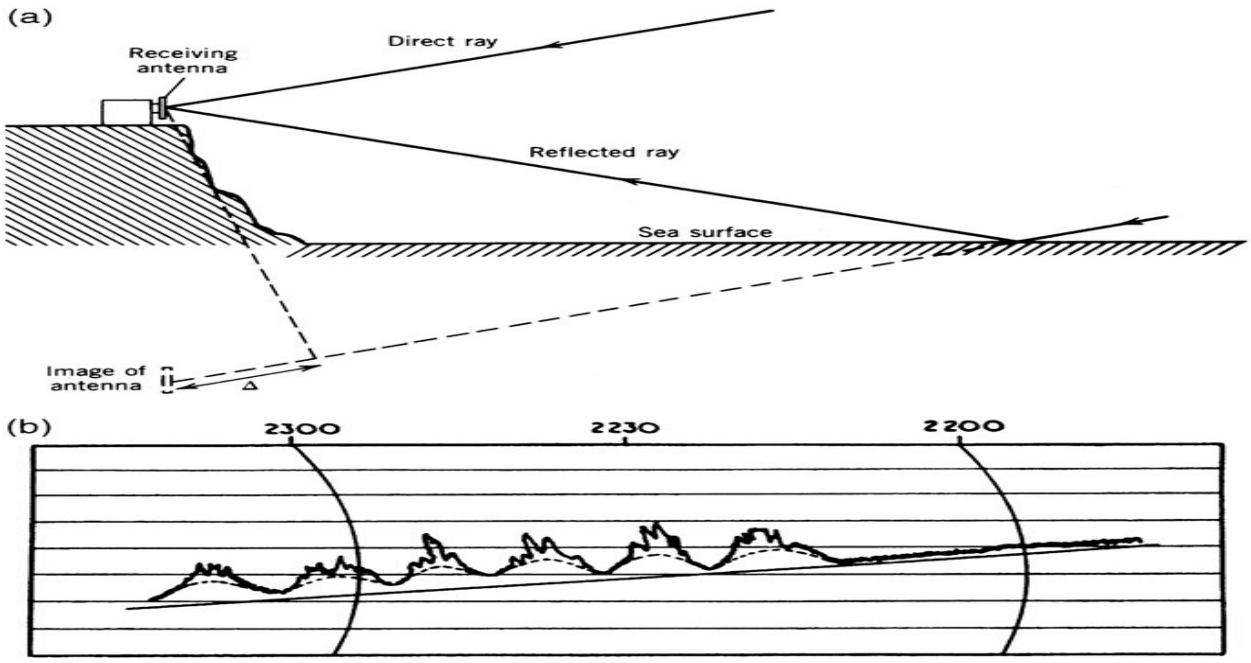
This experiment was done as a part of RAWS 2020. Here we studied the wave interference phenomenon with the help of Wi-Fi signals. Our setup allows the signal to travel in two paths of two different path lengths. This gives us a interference on the plane of receiver while conducting the experiment.

APPARATUS REQUIRED

- Mobile phone with hotspot
- Laptop running the signal strength measurement software
- Aluminium foil (or any other metallic reflector)
- Measuring tape.

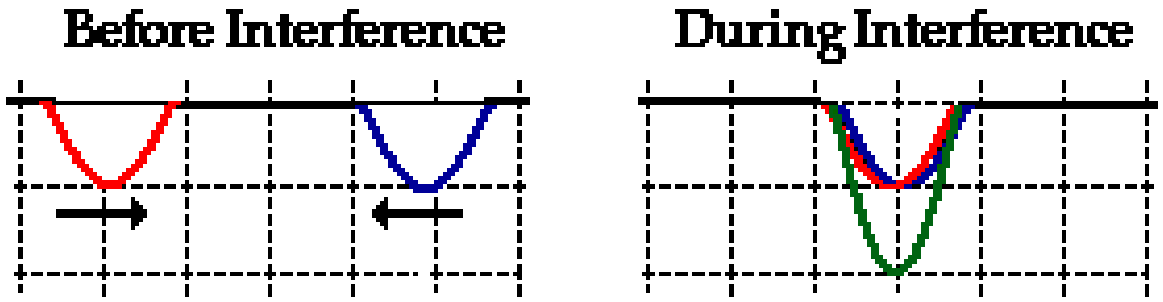
PRINCIPLES INVOLVED

Wave interference is the phenomenon that occurs when two waves meet while traveling along the same medium. The interference of waves causes the medium to take on a shape that results from the net effect of the two individual waves upon the particles of the medium.



1. Constructive interference-

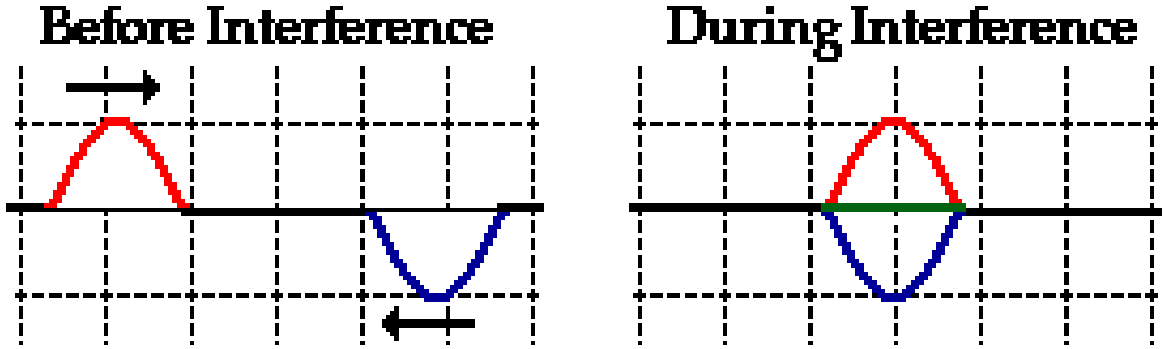
   Constructive interference is a type of interference that occurs at any location along the medium where the two interfering waves have a displacement in the same direction. In this case, both waves have an upward displacement;



   consequently, the medium has an upward displacement that is greater than the displacement of the two interfering pulses. Constructive interference is observed at any location where the two interfering waves are displaced upward. But it is also observed when both interfering waves are displaced downward. This is shown in the diagram below for two downward displaced pulses.

2. Destructive interference-

   Destructive interference is a type of interference that occurs at any location along the medium where the two interfering waves have a displacement in the opposite direction. For instance, when a sine pulse with a maximum displacement of +1 unit meets a sine pulse with a maximum displacement of -1 unit, destructive interference occurs. This is depicted in the diagram below.



The principle of superposition of waves states that when two or more waves of the same type are incident on the same point, the resultant amplitude at that point is

equal to the vector sum of the amplitudes of the individual waves. If the crest of a wave meets the crest of another wave of the same frequency at the same point, then the resultant amplitude is the sum of individual amplitudes – this is known as constructive interference. Similarly, if the crest of a wave meets the trough of another wave, then the resultant amplitude is equal to the difference in the individual amplitudes – this is known as destructive interference. The formula for the sum of two waves can be derived as follows:

The amplitude of a sinusoidal wave travelling to the right along the x-axis is given by,

$$W_1(x,t) = Acos(kx - \omega t)$$

Where A is the peak amplitude, k = 2π/λ is the wavenumber and ω = 2πf is the angular frequency of the wave

Consider another wave of the same frequency and amplitude but with a different phase travelling to the right.

$$W_2(x,t) = Acos(kx - \omega t + \varphi)$$

where φ is the phase difference between the waves in radians

The two waves superimpose and add; the resultant wave is given by the equation,

$$W_1(x,t)+W_2(x,t) = A[cos(kx - \omega t) + \cos(kx - wt + \varphi)]$$

Further simplification will lead to the following equation.

$$W_1(x,t)+W_2(x,t) = 2Acos\left(\frac{\varphi}{2}\right)\cos\left(\frac{kx - wt + \varphi}{2}\right)$$

Constructive Interference: When the phase difference is an even multiple of π

φ = ….., –4π, –2π, 0, 2π, 4π,……

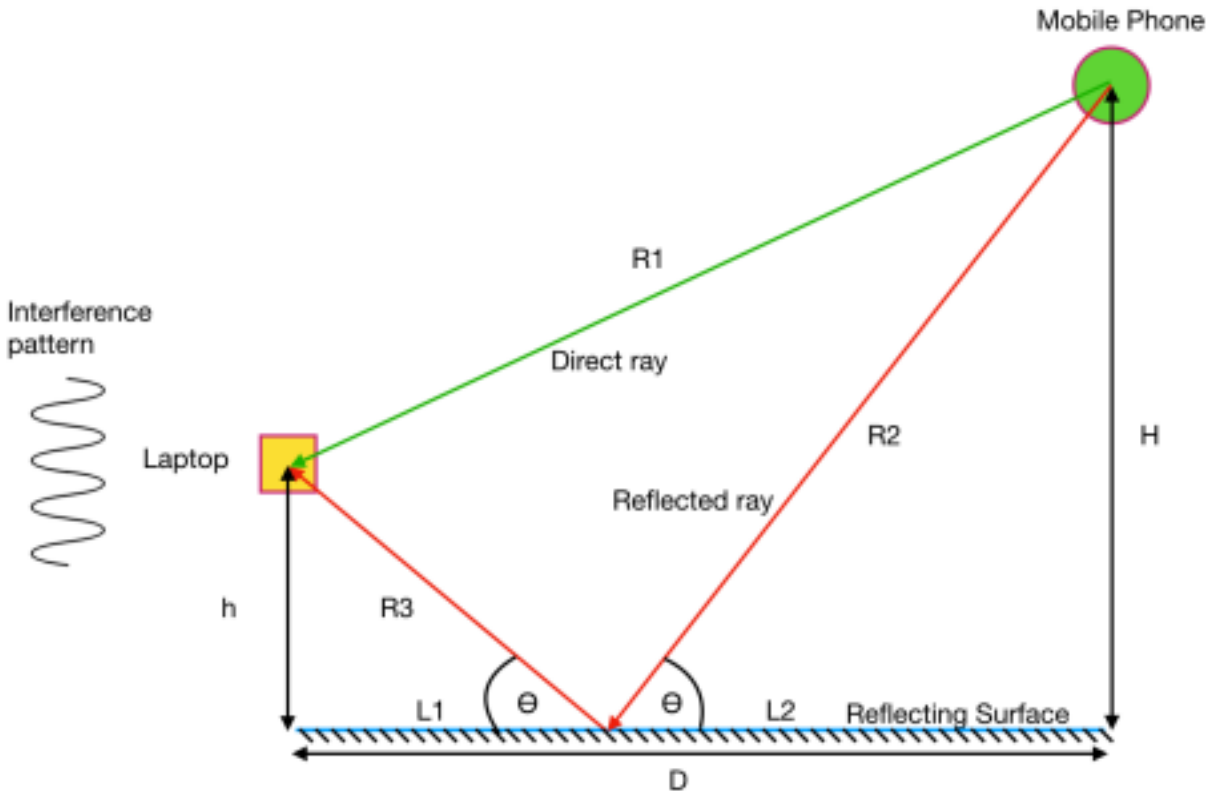
then cos φ/2 =1, so the sum of the two waves is a wave with twice the amplitude.

$$W_1(x,t)+W_2(x,t) = 2A\cos(kx - wt)$$

Destructive Interference: When the phase difference is an odd multiple of π

φ =….., –3π, –π, 0, π, 3π, 5π,……

then cos φ/2 = 0, so the sum of the two waves will be zero.



$$W_1(x,t)+W_2(x,t) = 0$$

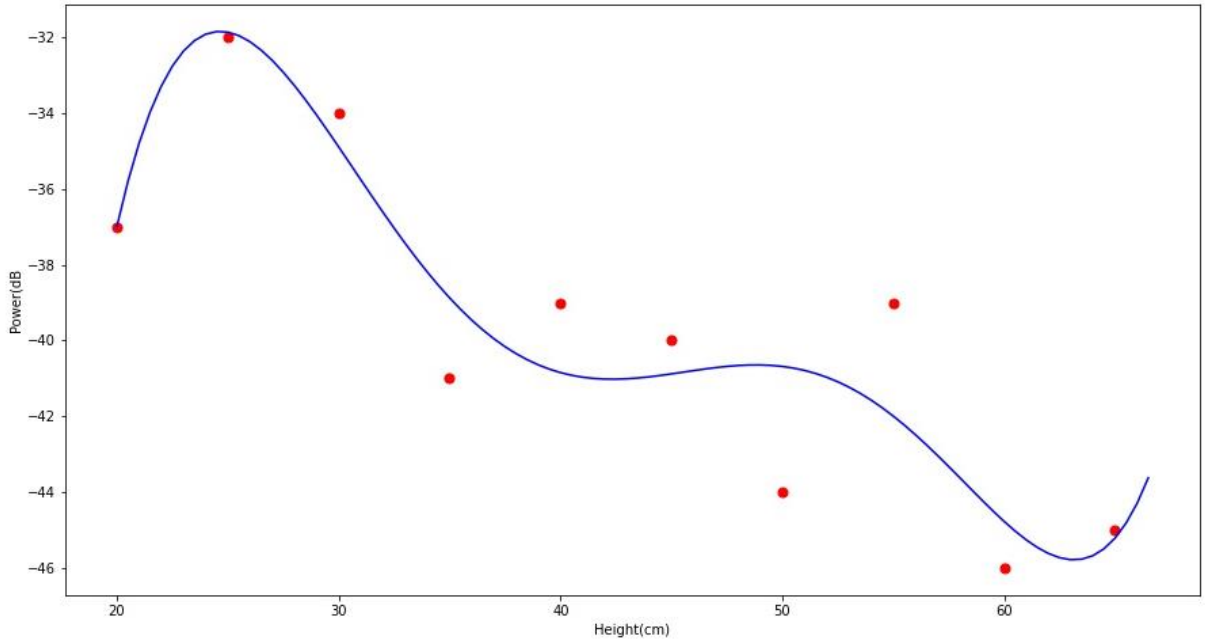
PROCEDURE

- Place the receiver at some height from the ground (h), typically 12 cm to 24cm.
- Place an aluminium foil (or any other reflecting metallic surface) on the ground as a reflector.
- Place the transmitter at a distance D, typically 1m or more.
- Move the transmitter vertically and observe the power variation.
- Measure the heights at which you get maxima and minima.
- Verify the measurements with the calculations

Note: Distances were measured from the location of wifi antennas in the device for accurate results.

RESULTS AND DISCUSSION

Receiver (in our laptop) was kept at a fixed distance from the ground. An aluminium sheet was used as a reflector. A fixed distance of 75 cm was maintained between the transmitter and the receiver. The transmitter(here mobile phone) was moved vertically and power variation was observed at the receiver end. A plot between Power(in dBm) and the vertical distance of the transmitter in cm was obtained as below



We got results similar to what one would expect in the case of Lloyd's experiment. In case of constructive interference we get a maxima while in destructive interference we get a minima. From our plot, we can clearly see that we got our maxima at 25 cm which corresponds to - 32 dBm power. We got our minima at a vertical height of 60 cm of the mobile phone from the ground.