IUCAA NCRA

RADIO ASTRONOMY WINTER SCHOOL 2020

EFFECTS OF INTRODUCING A BACK REFLECTOR

NCRA • TIFR

Submitted by

Group 10

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ABSTRACT

This experiment was conducted as a part of Radio Astronomy Winter School (RAWS) 2020 to analyse the effect of putting a reflector at the back of the antenna. An antenna reflector is a device that reflects electromagnetic waves. Antenna reflectors can exist as a standalone device for redirecting radio frequency (RF) energy, or can be integrated as part of an antenna assembly. Planar reflector antennas attracted enormous attention of many designers during last decade. The antennas exhibit

comparable efficiency as the standard curved reflector antennas but have the advantage of ease of manufacture at low cost. We used aluminium foil as reflecting sheet to reduce the backward radiation. With small spacing between the antenna & the sheet reflector yields a substantial gain in forward direction.

APPARATUS REQUIRED

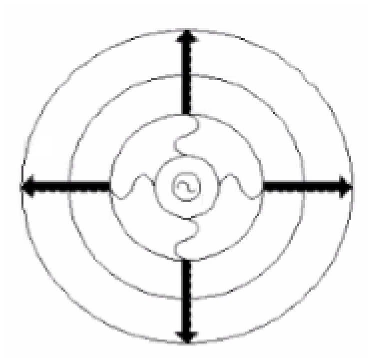
- Mobile phone with a hotspot
- laptop running the power measurement software
- measuring tape
- aluminium sheet.

PRINCIPLES INVOLVED

Reflection occurs when the radio wave is incident on a surface which has much larger dimensions than its wavelength. In an outdoor environment, these would occur off the surface of the earth, buildings etc. In an indoor environment, it would be walls, people and other obstructions. The reflected waves follow the typical laws of reflection in that the incident angle is equal to the angle of reflection and that the wave undergoes a phase change of 180 degrees. Depending on the material of the reflecting surface a portion of the signal may also be absorbed. Perfectly conducting materials are perfect reflectors, while poorer conductors involve more absorption of the signal before reflection. The conductivity of a material further depends on its dielectric properties.

Why was aluminium foil used as the reflecting plate?
The surface of aluminium has the ability NOT TO ABSORB, but TO REFLECT 95% of the infrared rays which strike it. Since aluminium foil has such a low mass to air ratio, very little conduction can take place, particularly when only 5% of the rays are absorbed. The purity of aluminium materials has obvious effects on the reflectivity of the aluminium foil. In addition to this it is also easily available. Foils in general are easily bent or crinkled so bonding the foil to a rigid backing (in our case cardboard) is often a solution.

An electromagnetic wave is created by a local disturbance in the electric and magnetic fields. From its origin, the wave will propagate outwards in all directions. If the medium in which it is propagating (air for example) is the same everywhere, the wave will spread out uniformly in all directions.

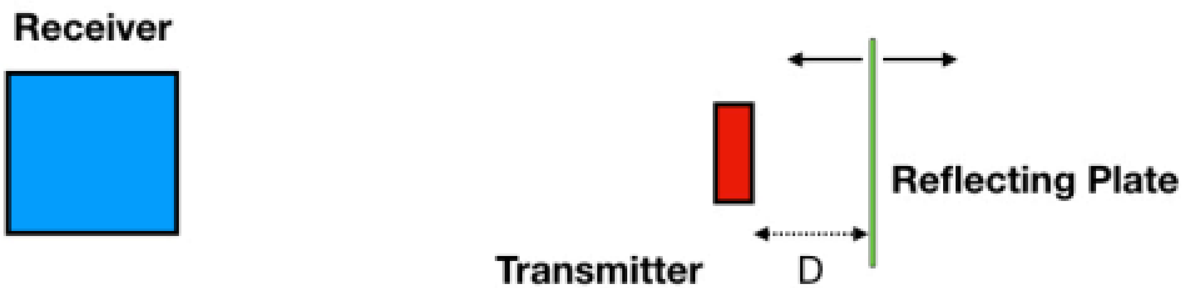


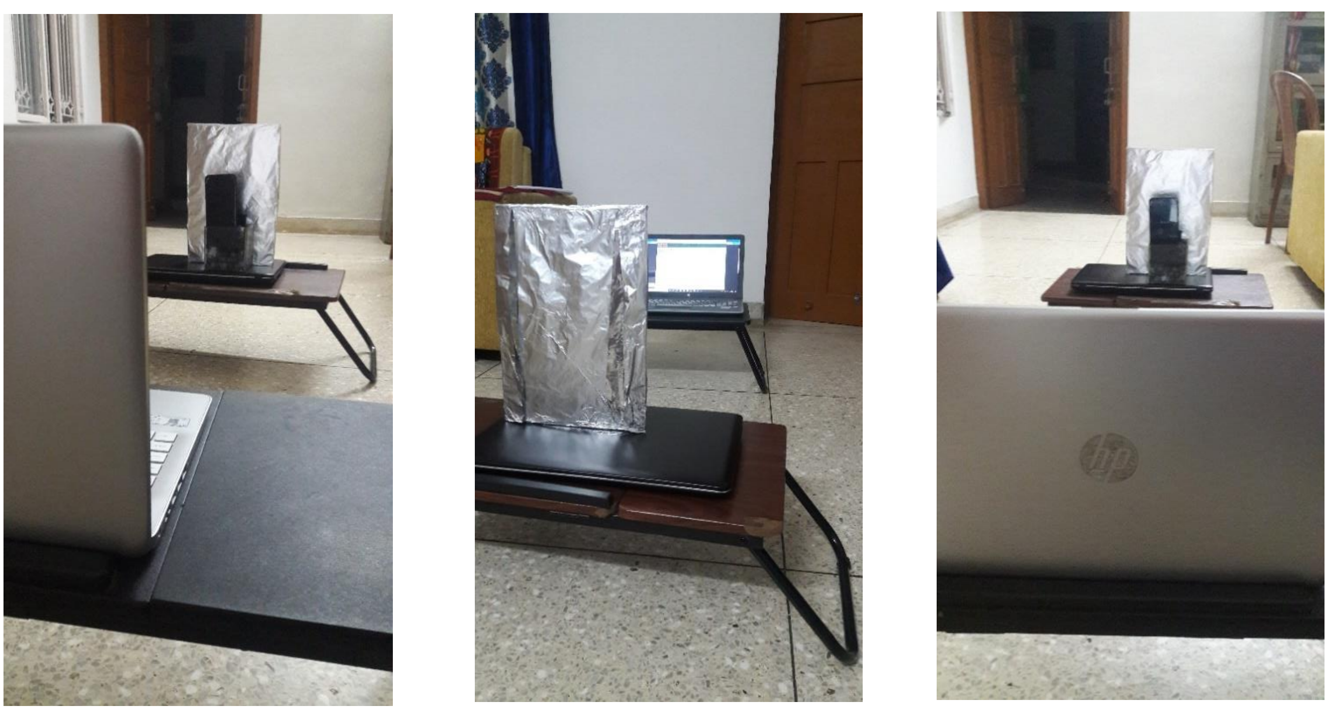
Electromagnetic waves propagate at the speed of light in a vacuum. In other medium, like air or glass, the speed of propagation is slower. If speed of light in a vacuum is given by the symbol c_0 , and the speed in some medium is c, we can define the index of refraction n as

$$n = \frac{c_0}{c}$$

PROCEDURE

- Place the transmitter and receiver at a fixed distance, preferably on two chairs.
- Keep the mobile phone vertical with support on sides.
- Take a metallic plate and place it at the back of the mobile phone.
- Move the plate slowly and note down the distances for maxima and minima.
- Note the differences between the power with and without reflector.

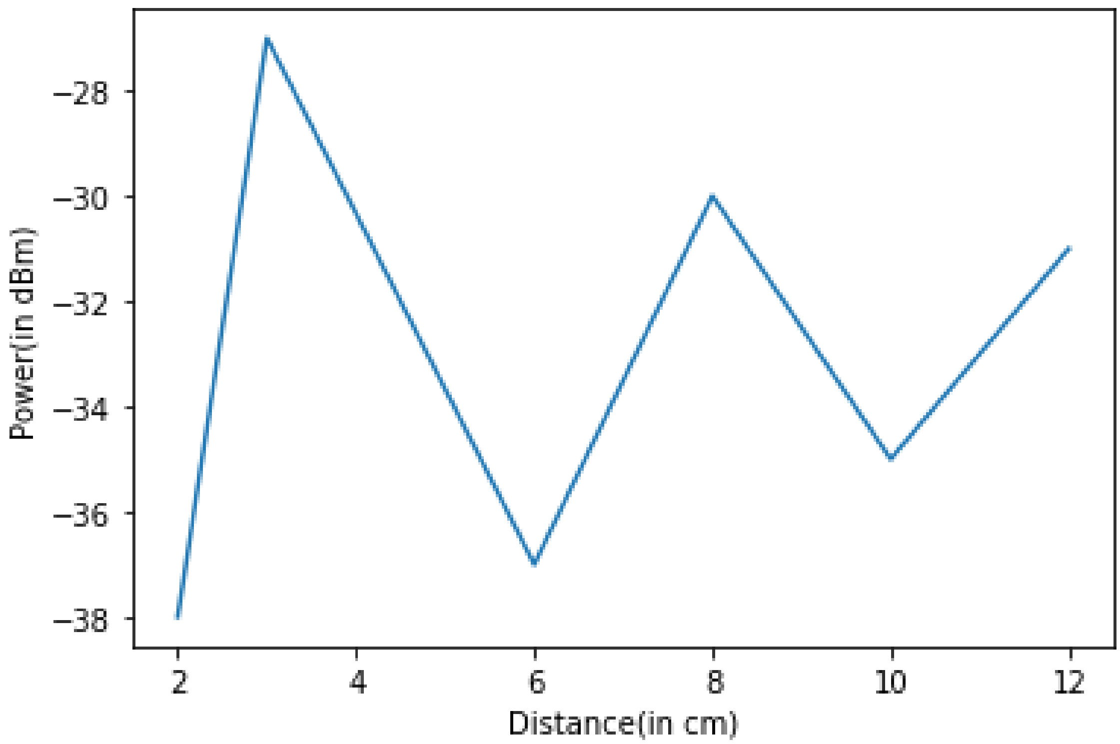




SETUP

RESULTS AND DISCUSSION

As expected we can see a maxima-minima trend in the graph. Extra path length travelled by the ray and a phase shift of 180’ due to reflection results in



interference of signals thus giving us a maxima at certain point and minima at the other.

We know that for constructive interference

$$\delta = \pm(2n+1)\frac{\lambda}{4}, where\ n = 0,1,2,3..$$

While for destructive interference

$$\delta = \pm n\frac{\lambda}{2}, where\ n = 0,1,2,3..$$

Where δ is the distance of the transmitter from the back reflector.

In our experiment, a mobile hotspot of frequency 2.4 GHz was used which corresponds to a wavelength of 12.5 cm. As per the theory maxima should come around $\lambda/4$ = 3.2cm but we got a maxima at 3 cm corresponding to a power of -27 dBm.

Similarly, theoretically a minima should be a $\lambda/2$ = 6.25 cm but in our plot we got minima at 6 cm corresponding to power of -37 dBm.

This deviation from the predicted maxima and minima clearly indicates the additional interference caused by the radio waves reflected from laptop screen.