TAP 702- 2: Doppler shift using microwaves

The frequency shift in waves reflected from a moving reflector

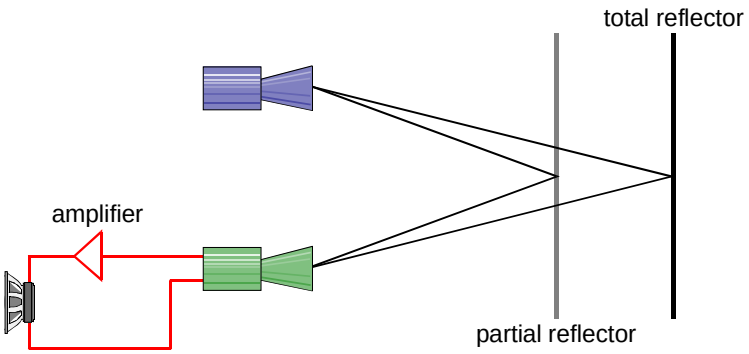
In this experiment, a moving metal sheet is used to reflect microwaves and, because the sheet is moving, the frequency of the reflected waves is shifted. The frequency shift depends on the speed and direction of the movement.

You will need

- ✓ microwave transmitter
- ✓ microwave receiver
- ✓ audio amplifier
- ✓ loudspeaker (if not built into amplifier)
- ✓ metal reflector about 0.3 m square
- ✓ hardboard reflector about 0.3 m square

The experiment

Set up the apparatus as shown below:



If necessary, set the transmitter to unmodulated microwaves. Put the hardboard sheet near the transmitter and receiver. Make sure that you have room to swing the metal sheet and then move it as fast as possible away from the hardboard.

Try to explain your observations. Why is the hardboard sheet necessary? The diagram above gives a clue.

You have learned

1. That when the metal sheet is moved away from the hardboard, a sound is heard from the loudspeaker.
2. That this sound is the result of a frequency shift in the waves reflected from the metal sheet produced by the movement of the sheet.

Practical advice

The effect here is produced by the beats between the microwaves reflected from the hardboard and from the metal sheet being converted into an audio signal by the loudspeaker. No beats are produced when the reflector is stationary because the reflected frequencies from both hardboard and metal are the same.

The beat frequency is given by

$| f_1 - f_2| / 2$

where f_1 and f_2 are the frequencies reflected from the hardboard and the metal sheet. So there is no audible difference between the sound heard when the sheet is moved away from the hardboard compared with when it is moved towards it despite the fact that the Doppler shift is in different directions in the two cases. This may need careful explanation for some students who may expect a higher pitched sound when the sheet is moved towards the hardboard compared with when it is moved away.

Social and human context

There are many everyday examples of Doppler shifts with sound such as the passing of racing cars. It is important to emphasise the difference between these and the Doppler effect with electromagnetic waves. The speed of sound waves is affected by the motion of the air, whereas the speed of light is constant for all observers.

External reference

This activity is taken from Advancing Physics, chapter 12, 120D