A VHF/UHF PHENOMENON

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Every ham radio operator has observed the following four types of effects:

1 – When an airplane passes, the open TV channels images flicker periodically with the airplane position.

2 – An amateur cannot trigger a VHF/UHF repeater at certain position where its signal strength is weak, but, walking a couple of feet away, the repeater signal becomes strong and it is easy to trigger it.

3 – Two amateurs, both using omnidirectional antennas as fixed operators on VHF/UHF, get very weak mutual signals at some frequencies of the band, but, shifting it by some kHz, the signal becomes very strong. If we shift the frequency by the same amount again the signal falls down, that is, the maxima and minima are equally spaced by the same amount. This amount is characteristic of the relative position of that specific pair of operators. The amount is generally different for any other pair of operators.

4 – The selective fading that occurs on HF, distorting mainly shortwave receptions. This is indeed a special type of case 3, as we will see later on.

These four phenomena are intimately related. All are the result of the interference between the signal via two different paths, normally the direct and reflected ones.
The first occurs when both stations are fixed, but the reflector moves; in the second case one station (the repeater) and the reflector are fixed, but the second station is moving; the third one happens when both stations and the reflector are fixed, but the frequency is varying.
This third case (and fourth case) is just the object of the present article, where the phenomenon is analyzed.

What happens?

Figure 1 shows two stations **1** and **2** distant **d** one from another and a reflector with respective distances to the stations **d1** and **d2**. We consider here only the case of only one reflector. Both antennas must be

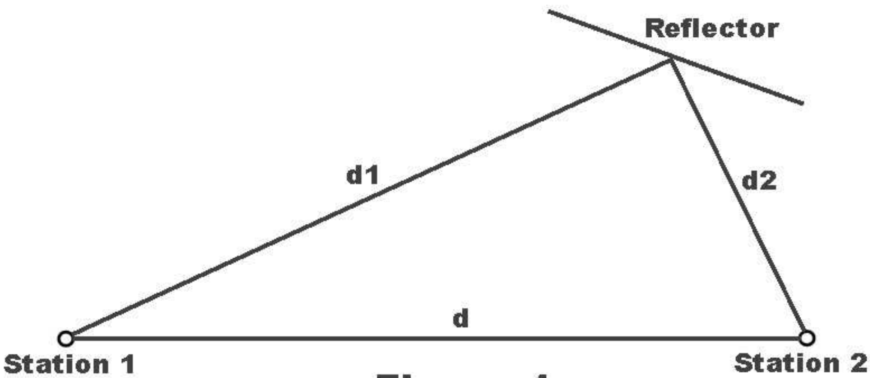

Figure 1

omnidirectional for signals to exist in all directions.
The direct path has a length **d** and the reflected one a total length **d1+ d2**. When arriving to the receiver, both signals can reinforce or weaken mutually, depending upon their relative phases. When this difference of phase is an integer multiple of **2π** both signals sum their strength and we get a peak at that operating frequency. If the relative phase is an odd multiple of **π**, their intensities tend to cancel mutually and we get a minimum signal.

This can be expressed in terms of the lengths of the paths. A peak occurs when the difference of the paths is a multiple of the wavelength **λ** and a valley when that difference is an odd multiple of **$\lambda/2$**. Let's write all of this.
The paths difference is **$D = d1+d2-d$**. So **$D = n.\lambda$** with **n** integer for the peaks. As **$\lambda = c/f$**, where **c** is the speed of light and **f** the frequency of operation, then:

$D = n.c/f$ or **$f = n.c/D$**

We want to search for the difference of frequency between two neighbor peaks.
Let be **f1** and **f2** those frequencies and **F** their difference.
We can write:

$f1 = n.c/D$

$f2= (n+1).c/D$

This because **n** and **n+1** are neighbor integers (**f2>f1**)

$F = f2-f1 = (n+1).c/D-n.c/D = c/D$

The difference of frequencies **F** is independent of the chosen peak as it doesn't contain **n**. So, it is independent of the band of operation.
Finally the expression for **D** is:

$D = c/F$ [I]

This means that if one knows the difference between two neighbor peaks, he can know the difference of the paths **D**. If we used the expression for the valleys:

$D = (2.n+1).l/2$, where **2.n+1** is an odd number, we would get the same result **[I]** (note that here two neighbor odd numbers are **2.n+1** and **2.n+3**)
To know **D** is not enough for determining the position of the reflector. But we know that the curve whose points have a constant sum of the distances (**d1** and **d2**) to two fixed points (the stations) is an ellipse, where the fixed points are its foci, as in Figure 2.

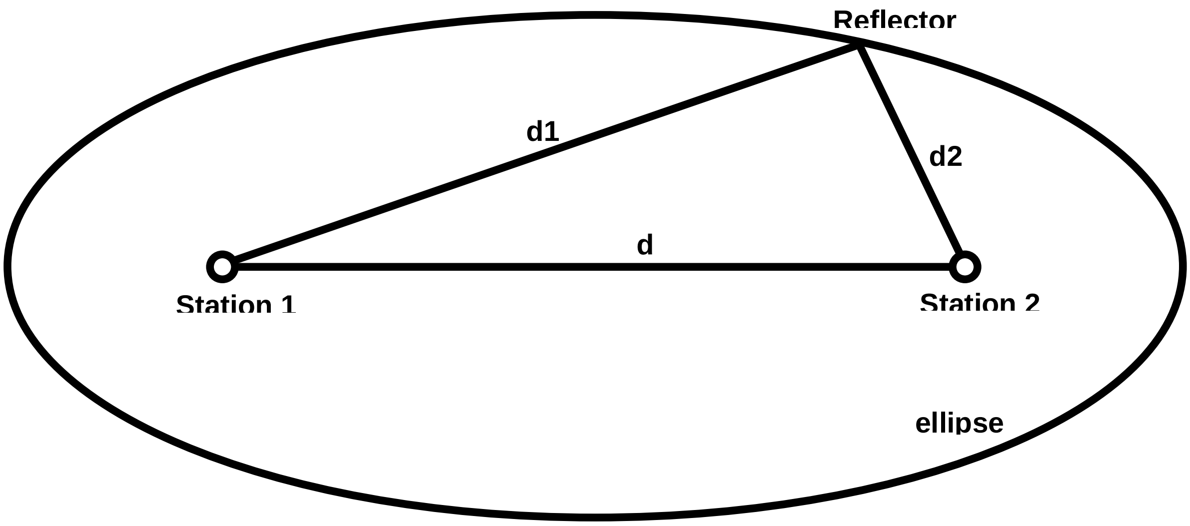

Figure 2

So, we don't know exactly where the reflector is, but it is on an ellipse like that of Figure 2.
Then get a printed map that contains all mountains, if possible also buildings of the region (like Google™ or Yahoo™ ones), and draw an ellipse with both stations on the foci and the calculated **d1+d2=D+d**. The point where the ellipse meets an obstacle is the sought reflector. **D** is got from the experiment by measuring the frequency difference between two neighbor peaks (or valleys) and using **D=c/F**. The band is at choice of the operators.
For drawing the ellipse, we can use two thumbtacks put on the stations positions of the map. We anchor on them a piece of string with length **d1+d2** and keeping the string stretched with a pencil we trace the ellipse one half each time (to avoid twisting the string). The two referred halves are the parts of the ellipse above and below the line **A-B** of the Figure 3, where the method is sketched (it can also be seen in this internet page: http://en.wikipedia.org/wiki/Ellipse#Elements_of_an_ellipse).
Important points for the entire process:

1 – Both radios must have fine frequency resolution for greater precision.
2 – **d1+d2** above is the length of the reflected path taken on the map, that is, taking into account the scale of the map; **d1+d2=2a**, the major-axis of the ellipse as in Figure 3.
3 – Bigger the difference between paths, closer the peaks (or valleys) and vice-versa (**F=c/D**).
By using a directional antenna in the reception end, it is possible to confirm the results observing in the suitable directions (use a compass on the map). The direct and reflected signals must be stronger than those of other directions.
4 – The reflector is an obstacle on the map that is just touching the ellipse line.
5 – The existence of more than one reflected path can make difficult the determination of the peaks and valleys clearly.

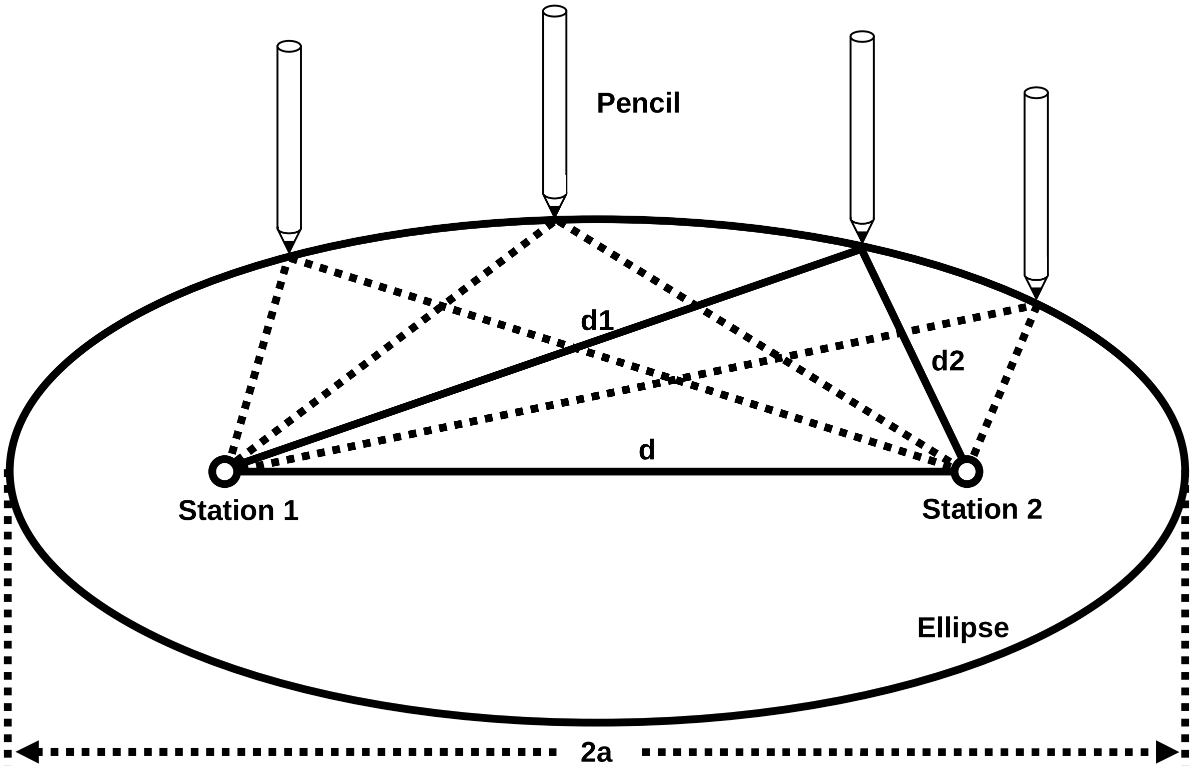

Figure 3

This specific phenomenon is absolutely the same as that of the so called ‘selective fading’, very common on short wave reception. The only difference is that the peaks and valleys fall within the audio band (due the big difference of paths, the space between neighbor peaks/valleys is very small). This is not a stable phenomenon due the dynamic alterations of the ionosphere.

I and other ham made the experiments on 6m and 2m and on both bands the differences between peaks/valleys were the same, confirming the theoretical explanation of the phenomenon, where the peaks space are independent of the band.