Experiments with faros software and wsjt: azimuthal errors in HF propagation

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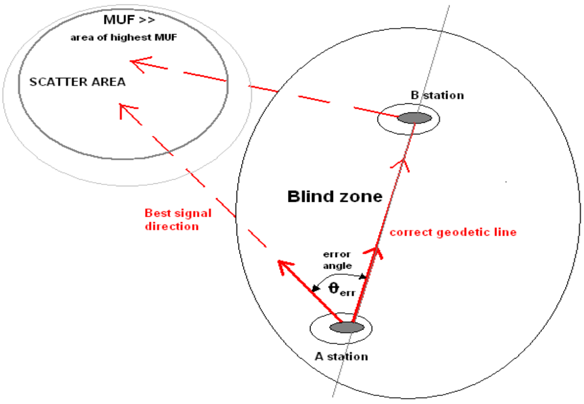
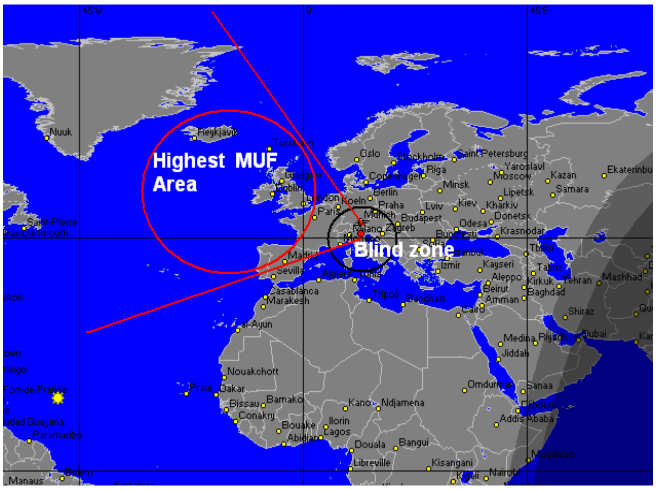
Abstract

This research aimed to study a propagation phenomenon that often occurs on HF bands. It is a systematic error reception where some signal arriving not from the correct azimuthal direction but from another side with a different antenna beaming (azimuthal error). It is difficult to establish exactly what cause this difference. We are beginning from the study of some experimental test, many of this already described in a previous publication (please the archives section on http://www.qsl.net/ik3xtv/archivio.htm). In this present document I try to consider some possible explanations.The instruments used are the digital transmission WSJT in the JT65A mode, because it is able to trace and draw signal, and the software Faros designed for detecting and monitoring NCDX beacons chain.





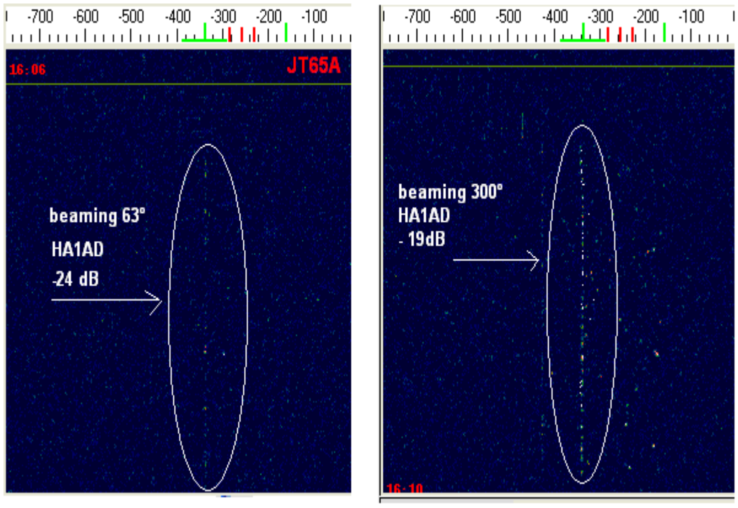
The assumptions : some possible explanation

- Backscatter
- Ionospheric Scatter
- Fresnel effects (from the law of Augustin-Jean Fresnel)

Ionospheric Scatter

Small scale Irregularities within the ionosphere are clearly areas of discontinuity able to support propagation with a complicated system than a simple ionospheric reflection. These irregularities may produce local interesting effects especially when they occur in large quantity. The Ionospheric scatter plays a role in many pathways, many effects are positive, others negative. To understand how is the mechanism of the scatter phenomenon, we have to imagine a different situation compare to the normal situation where the entire horizontal section of the ionosphere contributes to reflection. The Ionospheric scatter skip has a different supported by a multitude of scatter cells where we have reflected or refractive action normally very small. The problem is that occurs when the signal encounters a large number of cells. This mechanism is similar to the refraction of a bubble of ionized gas, the size of these cells may vary from tens of meters to several hundreds of km. When a wave encounters one of these bubbles, it is spread in all directions from this derives scatter. Because the cells are hit at different distance from the point of transmission or reception, the signal arrives with different paths and with different phase, as well as normally the cells are moving in the ionosphere, so the signal could be affected of Doppler. There are two magneto-geographical regions where the ionospheric scatter Is common: The tropical area and the area near the magnetic poles. At the tropics area the phenomenon is associated to the equatorial anomaly, the strong current that moves electrons from the E layer to F1 and F2 region. This mechanism produces huge clusters of turbulence plasma following the magnetic field lines.

The top figure compares the experiment with the



transmission wsjt in digital mode jt65a of Hungarian HA1AD station on 14076 mhz. The azimuth to Hungary is 60 °while the signal was detected with the antenna beaming 300 °.

These agglomerates are composed of a large number of cells plasma producing significant scatter phenomena. In the case by some ionospheric test with ionosonde to measure the critical frequency, instead to see a single F layer, the echoes returned back show a widespread area where echoes find an area extending up to 800 km in height,
this condition as known as Spread F.The scatter supported by the equatorial spread F that intensifies during
the equinoxes and almost cancelled when the geomagnetic field is disturbed. We have previously mentioned the presence of abnormal layers near the poles similar to equatorial anomaly, in this case we have cells of plasma positioned vertically along the lines of magnetic field. We are also in this case the presence of regions can supported spread F scatter that intensified during the equinoxes with a decline in the summer and winter months. It seems that the phenomenon also intensifies in the time of maximum solar activity. The effect is responsible for the metal modulation effect that often afflicts the signals crossing the polar areas.

Fresnel law

When a light ray travels from one medium with a refractive index n1 to a second medium with index n2 , may occur is the refraction that the wave reflection In the figure below, an incident light beam strikes at point PO Or the interface between two media with refractive indices n1 and n2. Part the beam reflected as ray OQ and part refracted according to the trajectory OS. The angles that the incident wave, reflected and refracted formed with the normal interface are θi, θr and θt, respectively. The relationships between these angles are lead by the reflection law and Snell law. The indices of refraction vary with wavelength. It should be noted that the discussion above assumes that the

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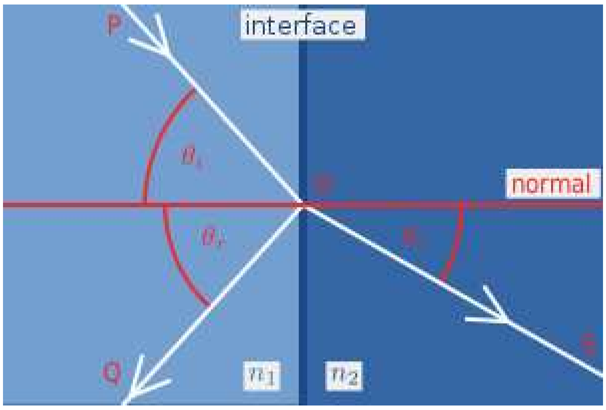
magnetic permeability μ is equal to the permeability of vacuum μ0 in both methods. This is true in most of the dielectric media but not for other types of materials. The complete equations of Fresnel are more complicated. Moreover, because these laws are applicable it assumed that the magnetization M, the field and the tangential electric and surface magnetic field B normal to the surface are uniform. The azimuthal error in HF propagation could be due to something of similar, where the interface between two media could be attributed to the difference in gradient (ionization) in two parts of neighbouring ionosphere (for example in the grey line area)



Backscatter theory

The phenomenon of backscatter propagation often occurs when the MUF rise significantly. The signals characterized by an unmistakable sound, as if echoes (hollow sound) and generally, they are never very strong and usually without fading. Most likely the effect is due to the reflections of the signal on the surface, and specifically

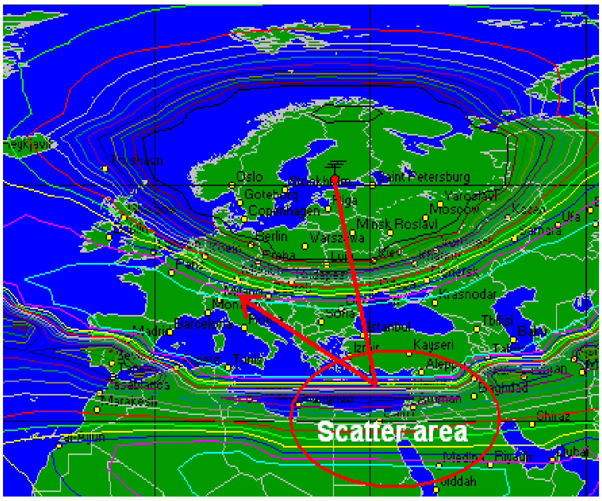
On mountain ranges, desert areas, or areas of water, usually on surfaces that have different indices of refraction, for that reason

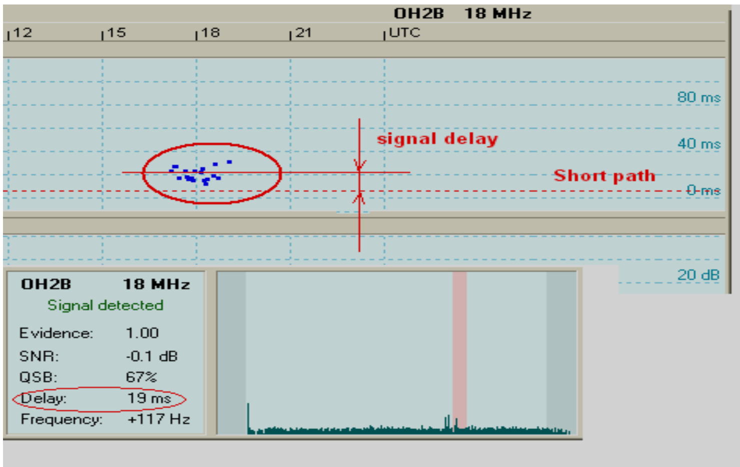
the phenomenon should be analyzed in relation to each geographical location. In my case, the position very close to the Alps is a limit on the one hand and the other give a further complication to interpret the information because we can have back any possible mountain refraction. The phenomenon of Backscatter is more pronounced with increasing frequency

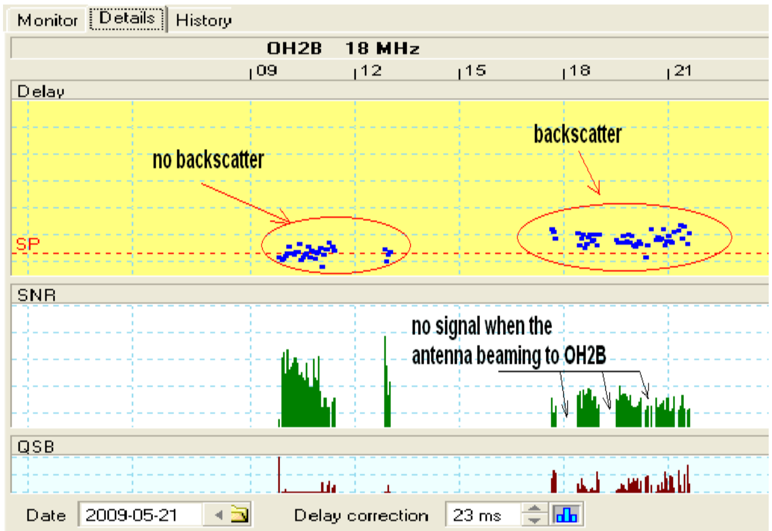
There are many observations and specific research made by OM, which confirm the backscatter due to the refraction of the Sahara desert or on the Ural mountains. Another possible explanation of the phenomenon derives from the spread in many directions by the surface of the sea. Only a small part of the spread signal go back to the transmitter: two stations between 100 and 2000 km, pointing in the same direction, towards the zone of diffusion, can listen even if they are inside the shadow area for radio signal.

Beacons experiments OH2B

I used a very fast internet connection with optic fiber technology connected with faros software Wich is able to detect and to display the signal delay of the beacons. The experiment has been conducted mainly on 18 mhz band, when the short skip to OH2B was closed. I found that for a short time interval, the beacon was clearly receivable only from the south-east direction about 150 °/ 160 °azimuth fr om my location. The recorded signal with Faros calculation an average delay of approximately 15 msec compared to the short path. this Means a signal path of about 4500 km. The hypothesis of a possible reflection in the area of Eastern Mediterranean or in the Sinai peninsula That is also the area of increased ionization. (map below) where the MUF in that time are increasing. The experiment conducted also on 14 MHz band with similar results, but with a shorter interval time.







Picture Above: The faros software experiments conducted on different days always highlights the phenomenon of backscatter in the late afternoon and evening.
The test conducted by alternating the reception beaming short path to the beacon and beaming
Towards the area of scatter (see the graph with green colour of SNR display)

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bibliography:
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software faros by Alex Shovkoplyas, VE3NEA
software WSJT (JT65A mode) by Joe Taylor, K1JT
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