October 2023 Annular Eclipse Propagation Anomalies at HF: Preview of FST4W Observations

Part 5: Temporary transition from one-hop to two-hop sidescatter and back

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Two-hop sidescatter

Two-hop sidescatter is an above-the-basic-MUF propagation mode [1]. With a receiver within the skip zone for one-hop propagation a path is possible via sidescatter from an area a transmitter at each site would 'illuminate'. Our previous work has identified two-hop sidescatter through its low signal level and high frequency spread [2,3]. It is a relatively common mode before and after a band opens: when the F2 region critical frequency (foF2) is not able to support one-hop propagation.

Eclipse-induced two-hop sidescatter at 14 MHz

Our example is on the 1055 km path at 193° from W7WKR (CN97uj, WA, 84% obscured) to KPH (CM88mc, CA, 83% obscured). The path transited the annular eclipse with maximum obscuration at 16:17 UTC. The W7WKR transmitter was a single-band QRP Labs QDX with a 25 MHz GPSDO from N6GN. The receiver at KPH was an RX888 SDR running 'KA9Q Radio' [4] within the WsprDaemon reporting package [5]. The KPH antenna was a TCI530 omnidirectional log periodic.

Figure 1 shows the signal level, derived from SNR and noise level, and the frequency spread from FST4W on 14 October 2023. Until 16:00 and after 17:00 signal level was high and frequency spread low (median 25 mHz) - indicating one-hop propagation. The scattered measurements between 16:00 and 17:00 were not outliers: rather, they indicate different propagation modes.

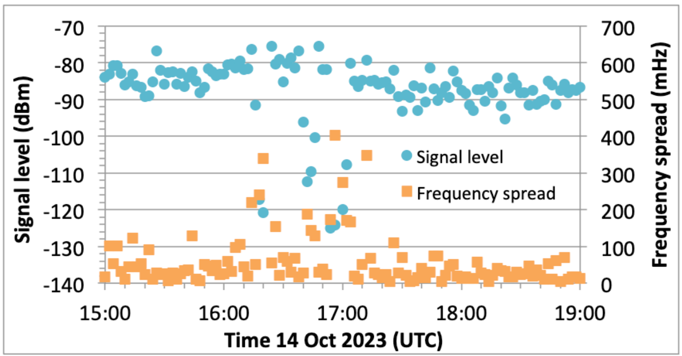

Figure 1. Signal level and frequency spread on the 1055 km path between W7WKR and KPH on 14.097035 MHz showing signal level and frequency spread characteristic of one-hop propagation prior to 16:00 UTC and after 17:00 UTC with different propagation modes between those times.

Figure 2 is a scatterplot of frequency spread against signal level, with non-parametric density contours to aid interpretation. The tight cluster **A** is typical of one-hop. In our previous work two-hop sidescatter also formed clusters [2,3]. What we have here is different: we have an arc **B** of spots with low signal level and high frequency spread. There is no sidescatter steady-state cluster: the different form is because of the transient nature of the electron density reduction caused by the eclipse. Spots at times 16:18 and 16:20 were immediately after peak obscuration. There followed a period of one-hop, with sidescatter returning from 16:42 to 17:02 except for two one-hop spots at 16:48 and 16:50. The picture is one of dynamic changes over minutes in the F2 region electron density resulting in these switches of propagation modes.

Model predicted likely region of sidescatter

Using PyLap ray tracing [6] in 3D mode landing spots of rays from the transmitter can be found. Figure 3 shows the transmit and receive sites, with the white arc showing the inner boundary of the one-hop skip zone at 16:45 UTC for the effective smoothed sunspot number (SSNe) of 125 [7]. This ray trace result is in keeping with the observed one-hop propagation in Figure 1. By reducing SSNe in PyLap to 50 we can put the skip zone 44 km beyond KPH - suppressing one-hop propagation. We then derive a sidescatter likelihood metric by assuming reciprocity - placing a pseudo-transmitter at the receiver - and forming the product of transmitter and receiver landing spots in 2° longitude by 1° latitude rectangles [8]. The red contours in Figure 3 show the likely sidescatter source area in this simple model.

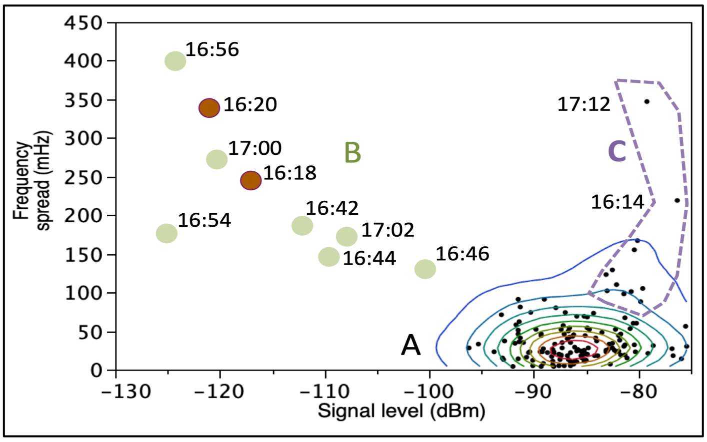

*Figure 2. Scatterplot of frequency spread against signal level on the 1055 km path between W7WKR and KPH on 14.097035 MHz showing one-hop propagation dominating in cluster **A** but with dynamic switches to two-hop sidescatter forming the arc **B**. We have yet to identify what was happening in the arced cluster **C**.*

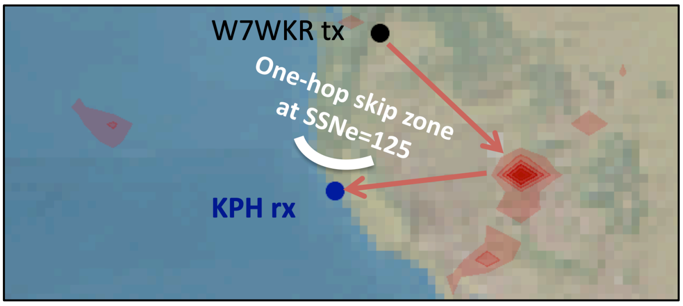

Figure 3. Map showing the W7WKR and KPH sites with a white arc marking the inner boundary of the undisturbed one-hop skip zone. The likely source regions for sidescatter observed during the eclipse from the simple model responding to a drop in SSNe from 125 to 50 are shown in red.

Data availability

All data is open access. A Guide is available [5], with an Annex on access methods. Sites wspr.rocks and wspr.live also provide access and graphical outputs. Please acknowledge Rob Robinett AI6VN and individual data contributors in any output as below.

References

1. https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-P.2011-1997-PDF-E.pdf

2. http://wsprdaemon.org/ Griffiths_FST4W_2023_HamSCI.pdf

3. Griffiths, G., 2023. Insights into HF propagation using FST4W. *RSGB RadCom*, 99(9): 30-32

4. https://github.com/ka9q/ka9q-radio

5. http://wsprdaemon.org - see guide on the Timescale page.

6. https://github.com/hamsci/pylap

7. https://spawx.nwra.com/spawx/ssne.html

8. Griffiths et al., 2023. HF Two-hop Sidescatter: Identification, Modelling and Observations of an Underappreciated Propagation Mode. *AGU Fall Meeting* Abstract ID 1301410.

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