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Session 8B Paper 1

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On the use of solar eclipses to study the ionosphere

Exploring the effects of solar eclipses on radio wave propagation has been an active area of research since the first experiments in 1912. In the first few decades of ionospheric physics, researchers started to explore the natural laboratory of the upper atmosphere. Solar eclipses offered a rare opportunity to undertake an active experiment. The results stimulated much scientific discussion.

One of the first questions posed by the early researchers was: what factor causes ionization of the upper atmosphere? During the 1920s there were two competing theories. One theory hypothesized that electromagnetic radiation from the sun caused the ionization. Another theory posited that particles from the sun caused the ionization. Since the moon blocks both in a solar eclipse, this phenomenon could be used to address this question.

Early users of radio had noticed that propagation was different at night and during the day. A solar eclipse provided the opportunity to study this day/night effect with much sharper boundaries than at sunrise and sunset. Sunrise and sunset also introduce many other complicating factors such as temperatures changes in the atmosphere and variations in the sun angle.

Plots of amplitude time series were hypothesized to indicate the recombination rates and re-ionization rates of the ionosphere during and after the eclipse - but not all time-amplitude plots showed the same curve shapes. There were a few studies which used multiple receivers paired with the same transmitter for the same eclipse with five receive sites pointed towards the upper limit. With that case, the signal amplitude plots varied greatly in shape.

With the development of very stable local oscillators, researchers could measure any phase shift of the signal as the eclipse starts, through the eclipse and back to a non-eclipse state. Phase shifts were noticed and could be associated with a path length change. Despite the complexity of ionospheric study, the research community started to gain insights into ionospheric dynamics.

Looking back to the very earliest results from the April 17, 1912 eclipse, the difficulty of using a solar eclipse to study propagation is clear. Different researchers used different frequencies from different locations. They were using the same eclipse event but at different locations of the sun and moon. Even still, solar eclipses have been used to study propagation at a range of radio frequencies. For example, the first study in 1912 used a receiver tuned to 5,500 meters, roughly 54.545 kHz. We now have lots of data from solar eclipses at frequencies ranging from VLF through HF from many different sites with many different eclipse effects. The value of this data has greatly contributed to our understanding.

On August 21, 2017, there will be a solar eclipse over the continental United States which presents an opportunity to have many stations receiving from the same transmitters. Experiments will target VLF, LF, and HF using VLF/LF transmitters, NIST's WWVB time station at 60 kHz, and hams using their HF frequency allocations. This effort involves Citizen Science, wideband software defined radios, and the first use of the Reverse Beacon Network and WSPRnet to collect eclipse-related data.

This paper will address the past use of solar eclipses and will discuss plans by multiple groups for the upcoming solar eclipse, using new methods to gain additional insights into the ionosphere and radio wave propagation.

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