Eclipse Radio

IU Eclipse Workshop 2024

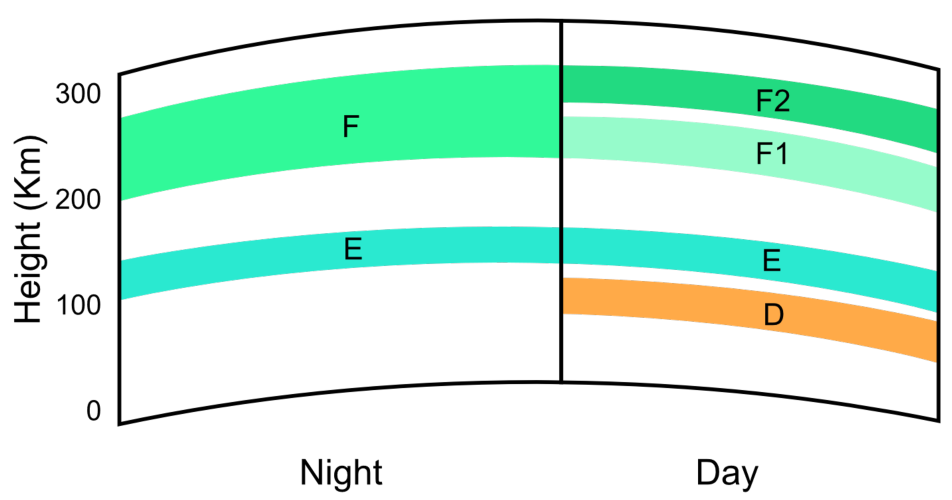
Ionospheric Radio

Solar UV/X-ray radiation and cosmic rays create regions of ionization at various heights above the Earth, forming a layer known as the ionosphere that starts ~50 km above the surface. It has three regions (heights are approximate and vary diurnally):

D region (50-90 km): absorptive, disappears at night

E region (90-150 km): weakens at night

F region (150-more than 400 km): splits into lower (F1) and higher (F2) regions during the day; less absorptive, good for long-distance radio communication (see right)



Regions of the ionosphere [1]

The ionospheric index of refraction n depends on electron density: $n = \sqrt{\epsilon_r}$ where the dielectric constant ϵ_r is

$$\epsilon_r = 1 - \left(f_p/f\right)^2; \qquad (1)$$

here f is the operating frequency and $f_p \propto \sqrt{n_e}$ is called the plasma frequency. A signal reflecting at h = 200 km can travel a straight-line distance $d \approx 2\sqrt{2R_{Earth}h}$ > 3000 km.

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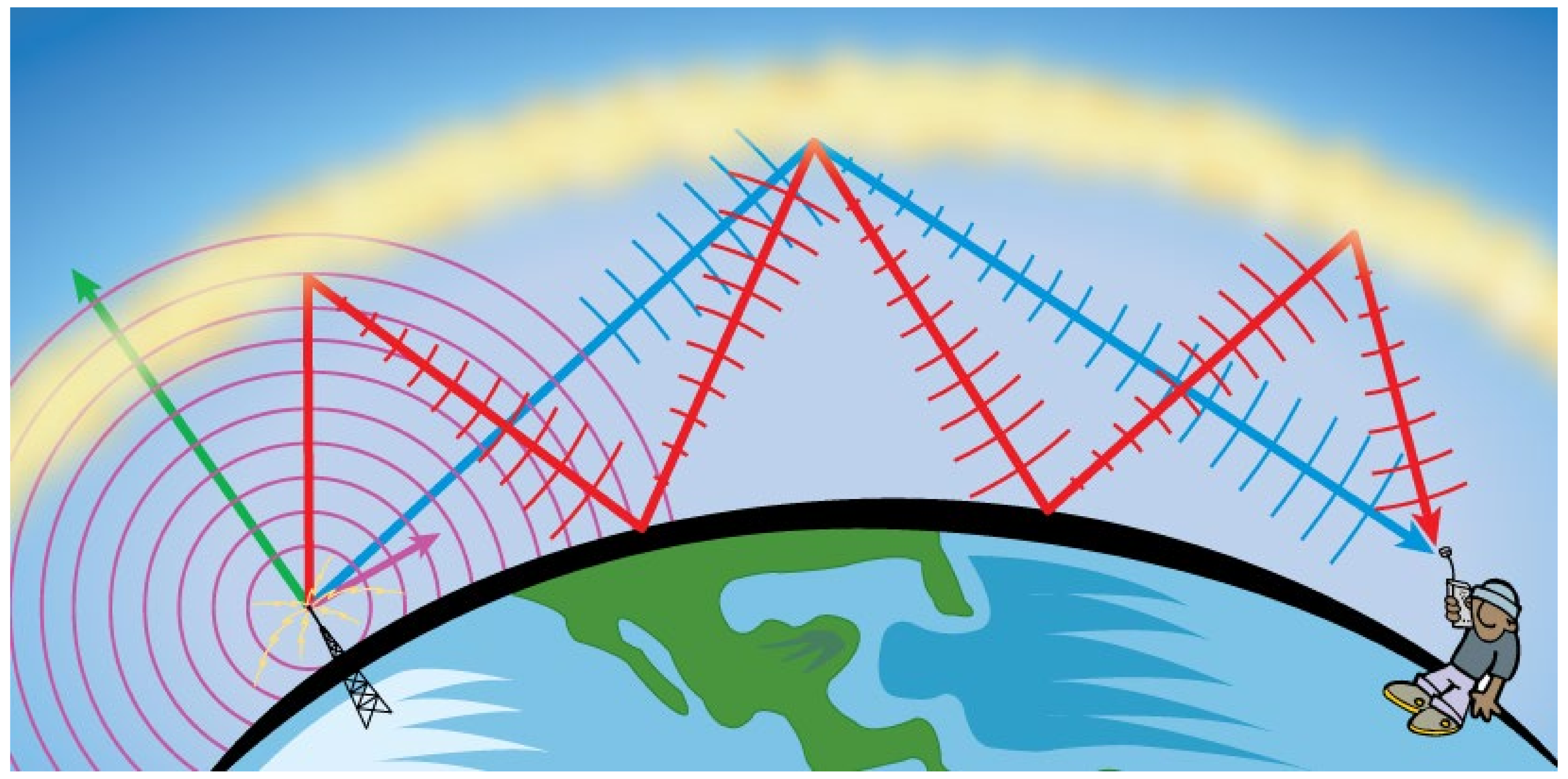
During the day, MF/HF radio signals are absorbed by the D region, but at night they can reflect from the F region and travel long distances as a "skywave". This is responsible for, e.g., receiving distant AM stations at night.



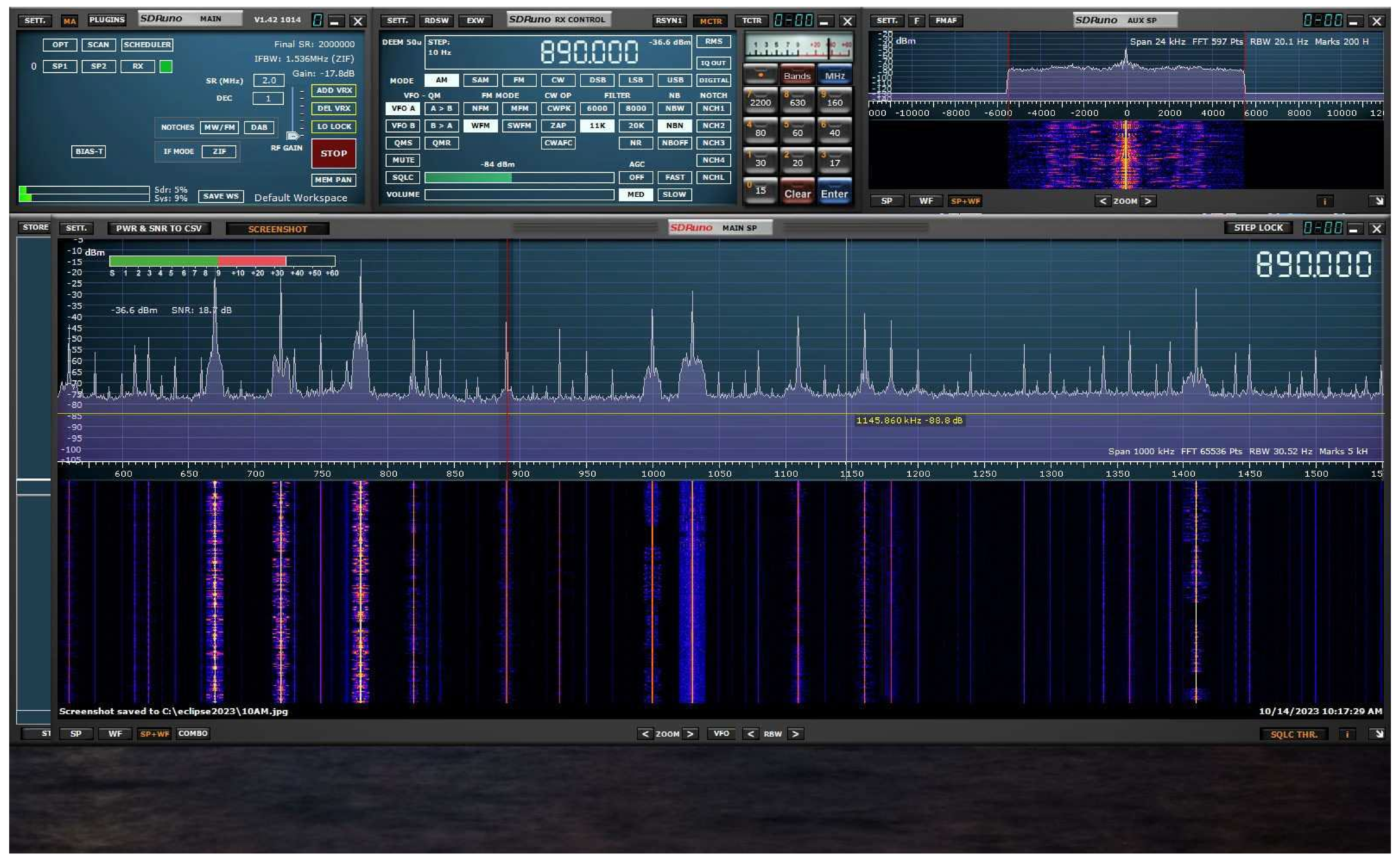
Skywave propagation [2]. Note that reflections are also possible from the D and E regions.

Since it interrupts the solar radiation flux, the eclipse will cause ionospheric conditions like those of nighttime. Thus, we should be able to get signals from remote AM radio stations during totality. There are many fixed-location stations at known places that can act as beacons for this. The effect will vary with frequency as indicated by equation (1).

This effect was first demonstrated in Meudon near Paris during the famous 1919 eclipse[3], and it was studied more quantitatively by Sanders during the 1999 eclipse[4]. The latter showed a complicated dependence of signal intensity on time and transmitter distance due to ionization/recombination dynamics in the D region during the eclipse. This shows how solar eclipses are an opportunity to probe the ionosphere's dynamics using radio waves.

Setup and Plan

A software-defined radio (SDR) will be used to investigate how the eclipse affects radio propagation. We'll be examining a medium-frequency AM broadcast band of 550-1700 kHz before, during, and after totality. How the eclipse affects the received signal will tell us about chemical processes occurring in the ionosphere. Along with other ham radio operators, we'll be studying the ionosphere during the eclipse as a part of a project[5] run by HamSCI, an organization that achieves citizen science through amateur radio.



SDRuno, a software-defined radio program. Shown here is a test run for this demonstration, done near Chicago within the band 550-1150 kHz.

References

[1] https://commons.wikimedia.org/wiki/File:Ionosphere_Layers_en.svg

[2] https://www.noaa.gov/jetstream/ionosphere-max

[3] The Observatory **42**, 321 (1919). Bibcode:1919Obs....42..321.

[4] https://misan.home.xs4all.nl/eclipse.htm

[5] https://www.hamsci.org/mw-recordings