The Ionosphere and HF Propagation

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- Generally you have two types of propagation problems:
  - For HF (2 – 30 MHz) the Sun dictates the communication process (ionization layers).
  - At VHF/UHF/SHF, almost every structure acts like an antenna since its physical size is close to the signal's wavelength. At high microwave frequencies, the molecular properties of the 'channel' severely impact the path losses.

HF Signal Polarization
HF: 2 - 30 MHz (generally)

- It pretty much all depends on the sun (sunspots, 11-year sunspot cycle)

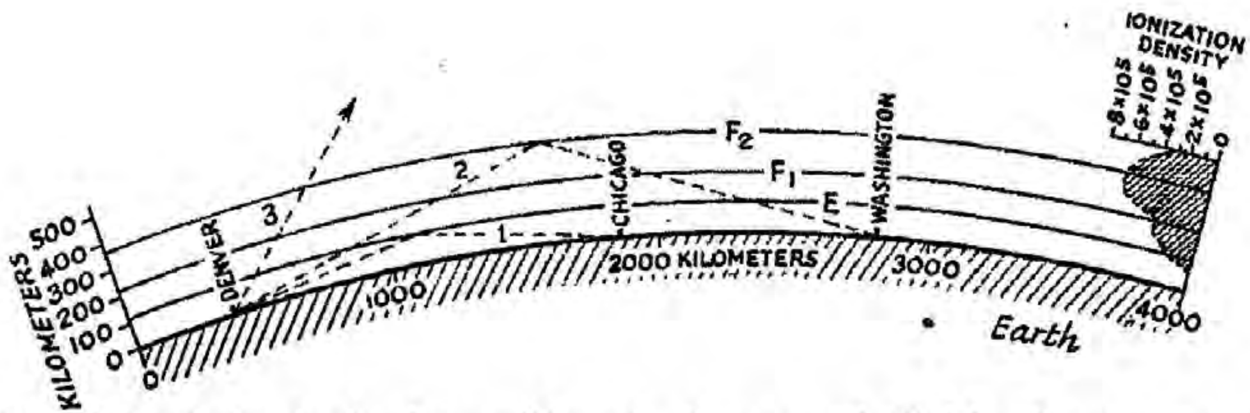
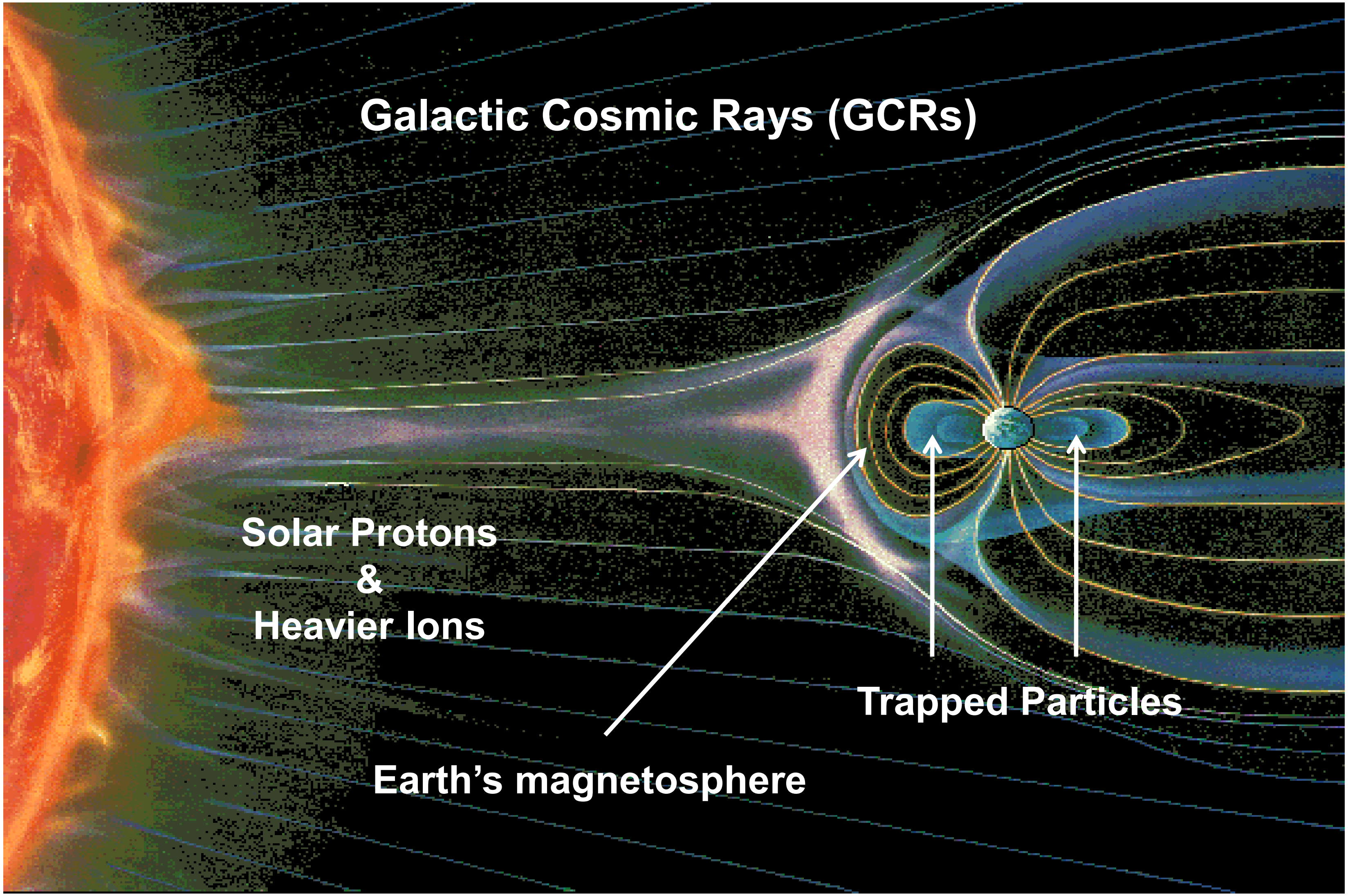


Fig. 1 — Simplified scale drawing showing possible paths of wave travel. (1) A low-frequency-wave reflected by the *E* layer; (2) a wave of higher frequency reflected from the F_2 layer; (3) wave which passes completely through the ionosphere because its frequency is too high to permit reflection.

- All ionospherically refracted signals are elliptically polarized - a general case of circular polarization.

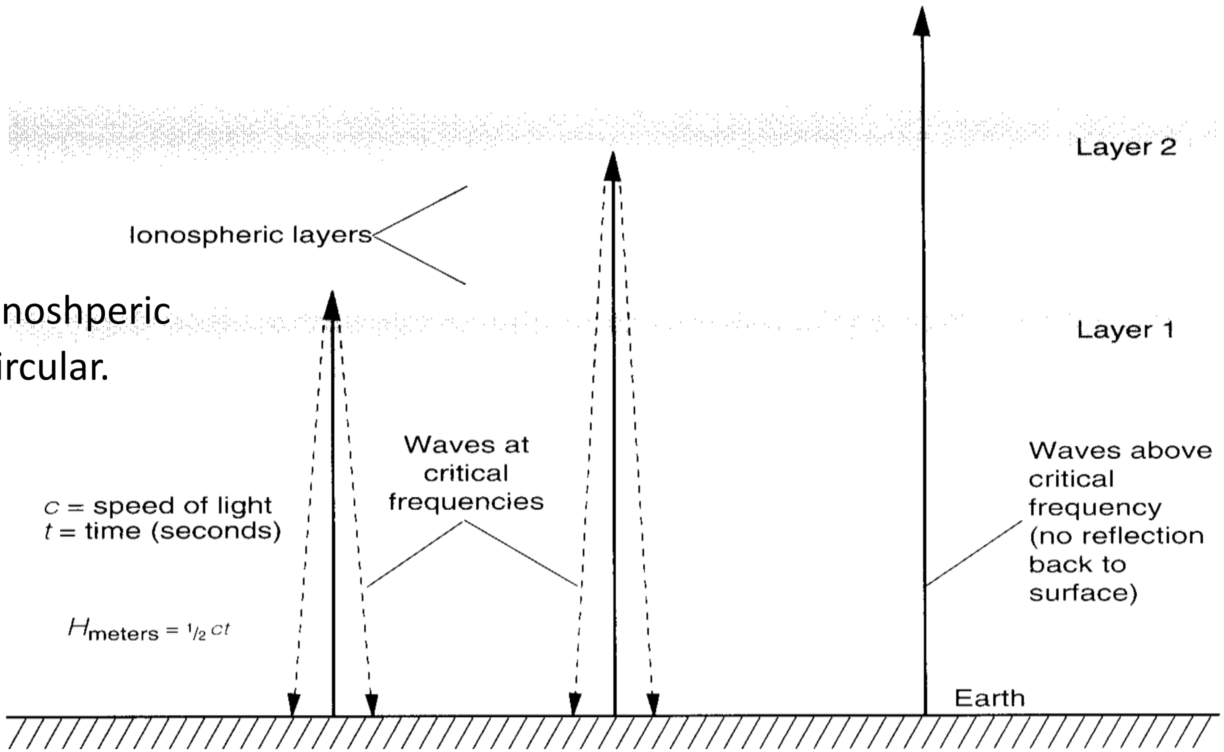
This plasma imparts radical changes to a passing through radio wave.

The Space Radiation Environment



- If a linearly polarized electromagnetic wave (vertical, horizontal polarization – a TEM wave) is launched into a magnetized plasma (the ionosphere), it splits into two separate counter rotating elliptical polarized waves.
- O-mode for ordinary wave (right hand circular polarization)
- X-mode for eXtraordinary wave (left hand circular polarization)
- The Appleton-Hartree dispersion formula on ionospheric propagation forbids the propagation of linearly polarized signals (it is the Ohm's Law of ionospheric propagation).
- The two waves have a different velocity factor due to there being two different but simultaneous refractive indices.
- Real-time characteristics of the ionosphere are determined by vertically transmitted signals swept from 1 to 8 MHz resulting in an ionogram generated by a digisonde

Finding the Critical Frequency of the Ionosphere

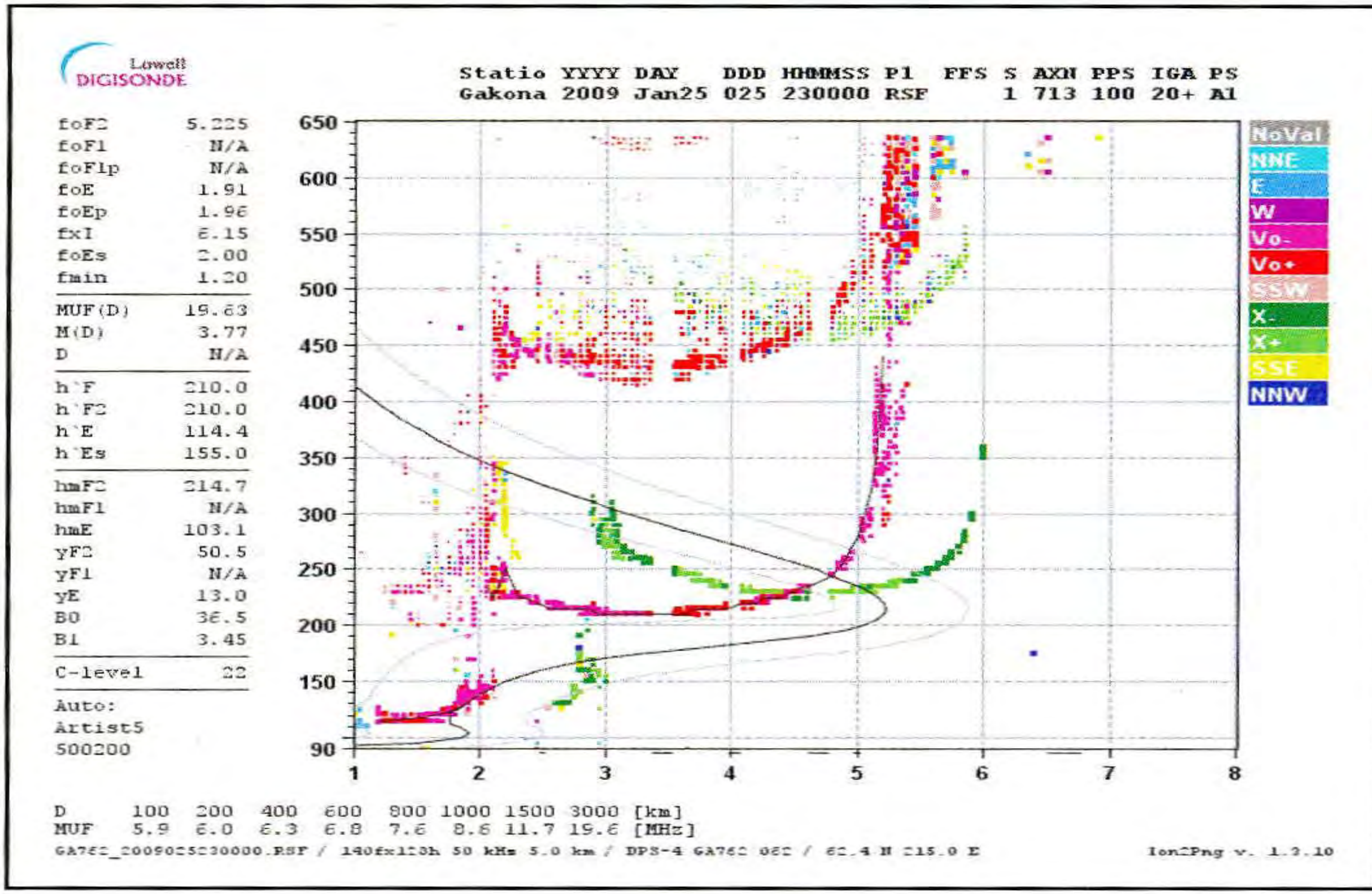


In reality, the ionoshperic layers are not circular.

Using a Verticial Incident Skywave, the virtual height of the Ionospheric Layer is found by measuring the time interval Height (m) = ($3x10^8$ m/s)(round-trip TIME)/2

The critical frequency fc is the highest frequency signal that can be received back at the transmitting site. fc can be as high as 10 to 15 MHz during the day and as low as 3 MHz during the night as the upper/higher ionization layers disappear as the sun goes down.

Ionogram from the Digisonde in Gakona, Alaska



HF (2 to 30 MHz) Propagation Determination

- F1, F2 layers, electron density, critical frequency, MUF, O-mode & X-mode propagation can be separated by different reflection properties. Two-way communication is not necessarily reciprocal, a to b can be different than b to a.
- X-mode critical frequency at 6 MHz (the green trace) > O-mode (red trace) critical frequency at 5 MHz thus showing X-mode propagation can be sustained at a higher frequency. This is more pronounced in Alaska with its geographic relationship to the Earth's magnetic field.
- Ionosphere characteristics are also determined by observing sunspot activity in conjunction with elaborate propagation prediction software (just like the weather)
- Past history is a major factor in the propagation predictions
- Daily analysis results are available on the Internet and broadcast by WWV (USA time standard radio stations).