# Ionospherica

Kazimierz “Kai” Siwiak—KE4PT ke4pt@amsat.org

## The First in a Series of Articles on Propagation and Antennas

We QRPers really love to communicate over long distances, and we enjoy challenges such as the Thousand Miles per Watt award. Long distance QRP communications invariably involve the Earth's ionosphere. However, to benefit from an ionosphere we need to be in a solar system with a planet that has an atmosphere and a planetary magnetic field. The Earth-Sun system shown in Figure 1 fits the bill nicely! For added interest and complexity, Earth spins on a tilted axis as it revolves around the Sun. This causes our four seasons, as well as interesting seasonal space-weather in the ionosphere. The ionosphere has been studied for more than a hundred years, and what we thought we knew about the characterization of the ionosphere has been repeated in print for almost that long. However, our understanding of how the ionosphere works is partly a product of the space age. Here we explore some of the legend, lore, and physics (in general terms) about the ionosphere as it pertains to QRP DXing. We also allude to some specific complex phenomena which can make QRP DXing an interesting and memorable pursuit.

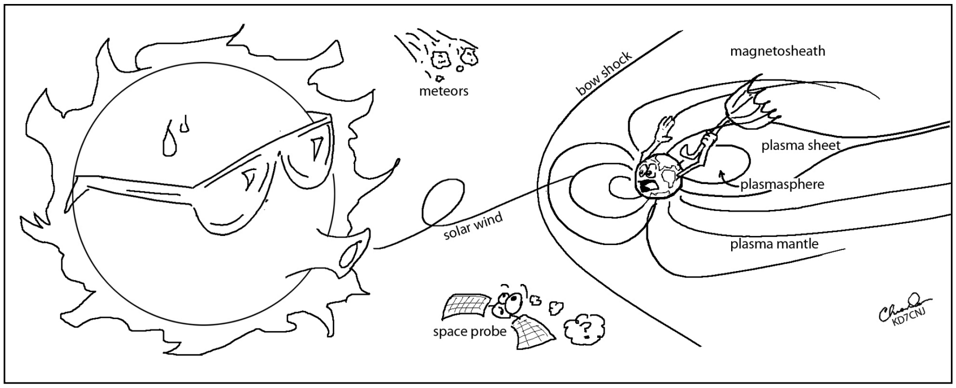

**Figure 1—Space probes are revealing the complexity of our Earth-Sun system which influences the ionosphere.** ***Copyright 2013 Chris Dean, KD7CNJ, used with permission.***

### 200m and Down!

1.5 MHz, a wavelength of 200m, was once thought to be the upper limit of frequencies useful for long range radio communication. In ground wave propagation, range increases with decreasing frequency. So, the “valuable wavelengths” longer than 200m were seized by commercial and government interests, while wavelengths shorter than 200m were deemed “useless” and left to experimenters and radio amateurs. The experiences of those early experimenters and radio amateurs [1], of course, showed that the interesting radio phenomena involving long range terrestrial communications occur at wavelengths considerably shorter than 200m, and that they involve the ionosphere. It turns out that the most useful frequencies for portable communications are in the High Frequency (HF) range, between 3 MHz and 30 MHz. Signals at these HF frequencies are subject to ionospheric phenomena, including reflections and refractions, and hence are the basis of traditional worldwide radio communications.

### The Satellite Era

Recent advances in Earth-orbiting satellites have slowly replaced HF commercial and government services with comparable satellite-based services. An irony of the satellite era is that our modern understanding of how the ionosphere works required the development of the space program that replaced the HF services which used the ionosphere. It also required the satellite probes that were launched recently to monitor solar activity and its effect on modern communications satellites. Space probe-derived measurements of the solar wind and of “space weather” have up-ended our understanding of the ionosphere. Thus most text books, while basically correct in their characterization of the ionosphere, have not yet caught up with this understanding and are not complete!

### Ionization is the Key

The gasses in the ionosphere are in a complex balance between the processes that cause ionization of those gasses, and processes that recombine ions (deionization). Solar and cosmic radiation, meteors and meteorites, natural radioactivity, lightning sprites, and other phenomena serve to dissociate free electrons (negative ions) from gasses in the atmosphere. Because the mixture of gasses varies with altitude, ionization also varies with altitude and tends to peak up in clumpy layers at various heights. There is nothing homogeneous or uniform about this layering in the ionosphere.

### It’s All in the Spin and Revolution

The Earth spins on a tilted axis, which, with rotation around the Sun, produces our four seasons. The daily spin results in a day-night variation. Couple that with uneven heating on the sea and land and we have weather—lots of it and with great variation. The same happens at high altitudes, except there the atmosphere is comprised of charged, ionized gasses. These gasses are also subject to a daily cycle and to annual seasonal cycles. Solar radiation, likewise, varies most notably in an 11 year cycle of solar activity and solar magnetic field reversals. This is evident by the creation, motion, and disappearance of sunspots. The revolving Earth additionally encounters both annual and sporadic meteor showers. Meteorites dump hundreds of tons per day of new material on the Earth and they also influence ion creation. Hence, we have many inputs to the ionospheric system to keep things stirred up. There is nothing uniform or constant about the ionosphere!

### Bring on Earth’s Magnetic Field

The real fun begins when the whole system is set in motion under the influence of Earth’s magnetic field. Figure 1 shows a rendition of Earth’s magnetic fields distorted by solar wind. High altitude Earthly winds containing ions deflect due to their motion in Earth's magnetic field, just like an electron beam does in a cathode ray tube (CRT). Shearing ionospheric winds can cause ionized gasses to clump together in sporadic fashion, allowing refraction of waves up to VHF in some locations even when the average maximum usable frequency is considerably lower. This may account for some of the to Sporadic-E propagation that we enjoy at VHF.

Waves propagating in the ionic plasma under the influence of the magnetic field will decompose into a pair of counter-rotating elliptically polarized waves having differing propagation characteristics [2]. A linearly polarized wave (horizontal or vertical) will cross-couple into two counter-rotating elliptically polarized waves after refracting through the ionosphere under the influence of Earth's magnetic field. Those two waves might reach differing locations on Earth. If the Earth were compared to an orange, all of this happens within the orange peel. That's proportionally the thickness of the Earth's outline in Figure 1.

### What This Means to QRP DXing

Polarization cross-coupling is good news for our QRP portable operations: we can hang our antennas in whatever way is physically expedient and let the ionosphere take care of rendering the polarization usable by the DX station! We should also be aware of the average cyclic behavior of the ionosphere. We should be prepared to operate frequency bands that are open for DX. During the years of low sun-spot activity in the approximately 11 year solar cycle, we might favor operations at 40m and longer wavelengths. During the years of high solar activity, the ionosphere supports wonderful propagation through 10m wavelengths. Now super-impose the annual behavior on top of that. During winter, the ionosphere tends to be somewhat lower in altitude than in the summer. During winter days, the maximum usable frequencies could be double those of the summer months. Ah, winter DX! Finally, we have the day-night variation. During daylight hours, signals propagate best on 15m-10m. At night time, wavelengths shorter than 17m become quiet as the maximum usable frequency drops. Worldwide propagation then becomes possible on the 80m-20m bands. The QRP station operator should be ready to handle as many ham bands as possible to ensure a high probability of communication success; this means using efficient multiband antennas [3], [4] and multiband / multimode radios.

### Stay Tuned!

Next time we'll poke around some of the details of how our antennas couple RF energy into and out of the ionosphere. Later we'll explore how propagation predictions can enhance our QRP experience. Some propagation resources are at <www.qrparci.org/propagation>. If you have questions or ideas on this topic, please write *QRP Quarterly* and let us know. Finally, don't forget to have fun!

### References:

1. DeSoto, C. B., *Two Hundred Meters and Down*, ARRL, Newington, CT, 1936.

2. Davies, Kenneth, *Ionospheric Radio Propagation*, National Bureau of Standards Monograph 80, April 1, 1965, Washington, D.C.

3. K. Siwiak, KE4PT, Off-Center-End-Fed Dipole on a "DX Fishing Pole" for QRP Operations, *QRP Quarterly*, Spring 2012, pp. 34-35.

4. A. Findling, K9CHP and K. Siwiak, KE4PT, How Efficient is Your QRP Small Loop Antenna?, *QRP Quarterly*, Summer 2012.

*Kazimierz (Kai) Siwiak, Ph.D., KE4PT, holds an Extra Class amateur radio operator license and is QRP ARCI member #2194. Dr. Siwiak specializes professionally in antennas and propagation, and in digital communications. He is an ARRL Technical Advisor and a member of the ARRL RF Safety Committee.*

●●

---

## Is it Time to Renew???

Your original QRP ARCI membership (and your member number) will last forever ... BUT, your continued subscription to *QRP Quarterly* means you are an active, dues-paying, voting member!

We try to send timely renewal notices (by e-mail if we have your address). You can also check your expiration date online at the club web site: www.qrparci.org — just click the "Member Lookup" button on the left side and enter your own callsign.

Send your renewal online using PayPal, or by check to the QRP ARCI Secretary using the form on the last page.

While you're at it ... check out the QRP ARCI Toy Store for QRP clothing and accessories, past FDIM Proceedings, and other items that show your enthusiasm for the QRP side of ham radio!

**QRP ARCI — www.qrparci.org**