Physics 401

Physics of Ham Radio – Spring 2013

Patricia Reiff, W5TAR, Physics & Astronomy Dept,
Rice U

Text: "Ham Radio License Manual" from ARRL

With help from members of….

W5NC Northwest Amateur Radio Society

And the VE team

Why be a Ham?

- Radio is fun
- Radio is not expensive
- Radio is a great hobby
- You can help in disasters
- You can talk for free to people around the world
- New friends can help you get jobs
- You can help the community in service projects (MS150, etc)

Jamboree On The Air at Rice University Campus, October 20, 2001

But isn't a cellphone better?

- Cellphones cost per minute to use
- If you're not within 10 miles of a highway, your service can be bad (camping, hiking, in the boonies)
- Ham can get you new friends with common interests
- In emergencies, cellphones are busy or not functional (on Sept 11, only ham communication got thru in New York City; in Tsunami- and hurricane-ravaged areas, only hams can communicate!)

But isn't the internet better?

- Internet lets you leave a message when they are asleep. (But you can do that too with ham packets)
- Many foreign hams don't have computers.
- Can be used while camping or sailing!
- Can be used in power outages or in emergencies
- No monthly charges
- Can be linked to computers
- Morse code is a universal language (QST)
- Meet new people with similar interests without dangers of a chat room

CB's and Family Radios

- CB's and Family Radios allow only local communication - range only a few miles
- Lot of traffic on the bands… crowded and unfriendly.
- No license needed - easy to get into, but no control over users who hog the airwaves or make rude comments

With a minimum "technician" ham radio license, you can talk to astronauts in space like Frank Culbertson KD5OPQ!

This semester's schedule

Tentative: check the website frequently:
http://space.rice.edu/PHYS401/ all classes 6:15 - 9:15 pm

- Monday Jan 7- General introduction, Welcome to Ham radio, light and spectroscopy, speed of light and wavelengths (Ch 1, 2a)
- Monday Jan 14- Electrical principles, practical electronics (Ch 2b, 3a)
- Monday Jan 21 - : Operating Equipment, Propagation and Ants (Ch 3b, 4)
- Mon Jan 28 - Basic circuit Lab: electrical circuits, capacitors, resistors, multimeters, etc.
- Mon Feb 4: Equipment (5) and Communicating (Ch 6)
- Mon Feb 11: Licensing and Operating Regulations (Ch 7 & 8); Safety (ch 9)
- March 23: Field trip to Houston HamFest (Rosenberg)
- TBD: Midterm test (VE exam)

To earn your ham License

We will have a special "technician" FCC ham license test, in class or at the Red Cross (date TBD). VE's (Volunteer Examiners) will come and give the test, as a courtesy.

You are required to try the test. You are NOT required to pass it (but you'd better!). If you can't be in class that day, you can take makeups in Tomball or at the Red Cross. (price to take the exam, either place and each time: $15, given once a month).

Morse code test: no longer needed (but encouraged!)

General Test: Can be taken after passing the tech test. Anyone interested? If so, we might delay the test for a week or so.

Cost: another $15.

The Basics of Radio

Radio Wave Propagation

Book, introduction; Chapters 1-2A

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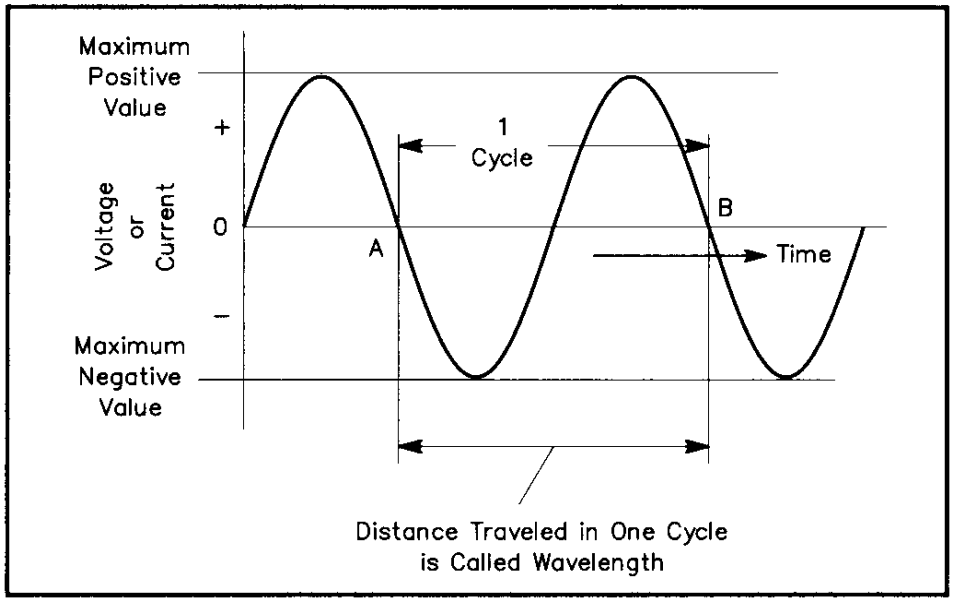
CQ means I'm Seeking You

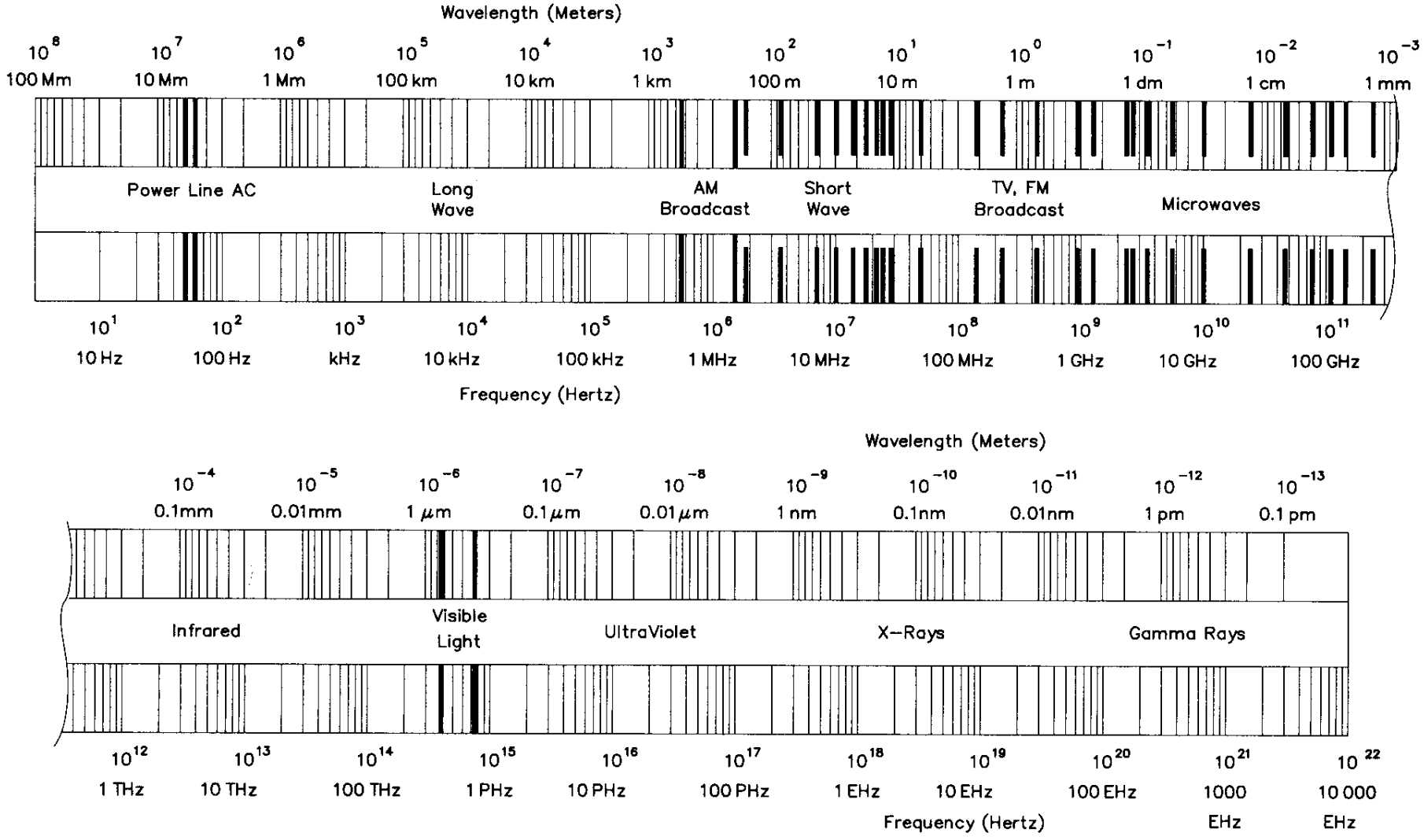
Figures in this course book are reproduced with the permission of the American Radio Relay League. This booklet was compiled by John P. Cross AB5OX

Frequency and Wavelength



- Frequency is measured in cycles per second.
- The unit of frequency is Hertz (Hz)
- Audio frequency is 20 Hz to 20,000 Hz (20 kHz)
- Radio frequency is above 20,000 Hz (20 kHz)
- Radio frequency and wavelength are related:
  - $c = f\ (Hz) \times \lambda\ (meters)$
  - c (speed of light) = 3×10^8 m/sec
  - $\lambda\ (meters) = 300 / f\ (MHz)$

Electromagnetic Spectrum

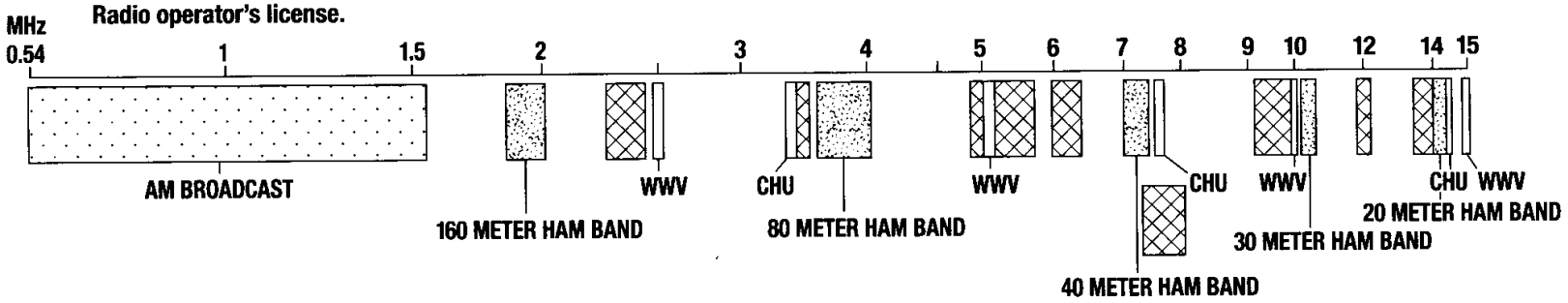


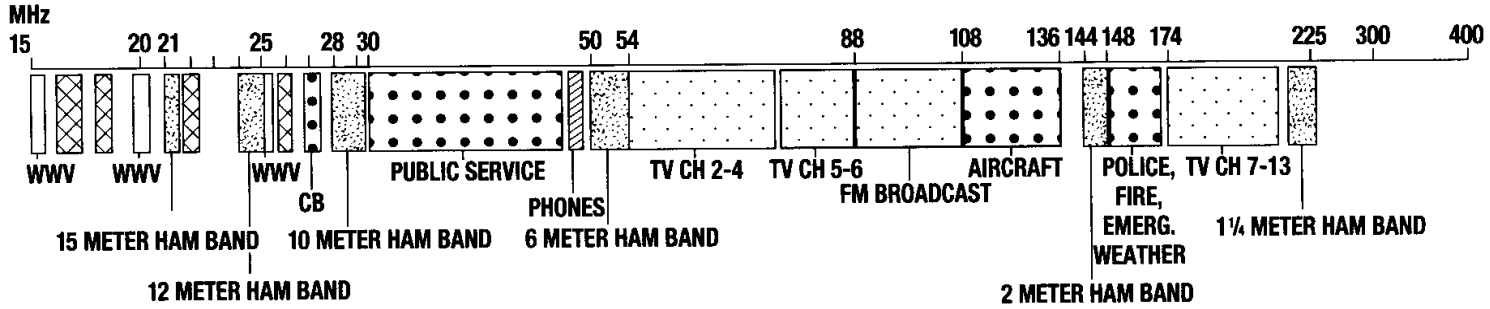
Radio Spectrum

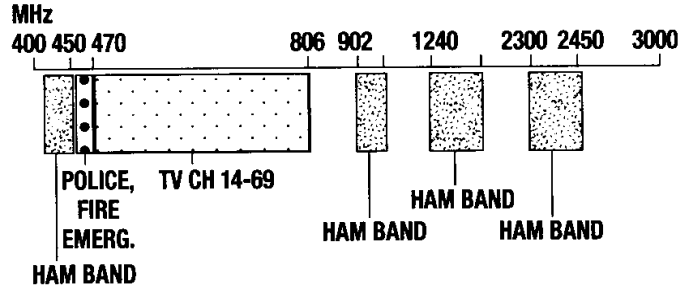
RADIO FREQUENCY SPECTRUM CHART

Since the early part of this century radio amateurs have had bands of frequencies throughout the usable radio spectrum. Some bands work well for long-range communications in the daytime, others provide worldwide communications at night. By choosing the best frequency band for a given time of day, radio amateurs, or "hams," can usually direct their signals to any part of the globe.

Contact the American Radio Relay League for detailed information about the Amateur Radio bands plus study guides for obtaining an Amateur Radio operator's license.







The AMERICAN RADIO RELAY LEAGUE, INC.
225 MAIN ST. NEWINGTON, CT 06111
860-594-0301

LEGEND

- Amatuer Radio "Ham" bands
- AM, FM & TV Broadcasting
- Shortwave Broadcasting
- WWV & CHU Time & Freq Std
- CB, Police, Fire, Weather, Air
- Walkie-Talkies, Cordless Phones,
- Radio Controlled Models

Unmarked spectrum includes ship-to-shore, government & research

RADIO BANDS

30	300	kHz	VLF
0.3	3.0	MHz	MF
3.0	30	MHz	HF
30	300	MHz	VHF
300	3000	MHz	UHF

Types of Radio Signals

- "AM": Amplitude modulation: The strength of the signal is varied. (amplitude of the carrier) (600- 1500 KC is US band).
- "Short Wave": AM at higher frequencies (2 MHz - 25 MHz). Travels very long distances, used for international broadcasts (e.g., BBC, Voice of America, mostly at night)
- "FM": Frequency Modulation: The information is carried by changes in the carrier frequency. (88 - 108 MHz is FM broadcast band)
- "SSB" - Single sideband - uses a sideband of AM to reduce noise and increase range. Used for HF radio transmission
- "CW" - Continuous wave. The signal is on or off, and letters are sent in Morse Code. ("let the Morse be with you!"). Longest range. (Why?)

•-- •- -•-- -•-• --- --- •-•• !

W A Y C O O L

Propagation - How Signals Travel

- Radio waves travel to their destinations by three ways:
  - line-of-sight, typically above 30MHz. What you see is what you get.
  - ground-wave propagation, travels along the surface of the earth, even over hills.
  - Sky-wave propagation (skip), refracted back from the ionosphere.
- Other variations are the result of atmospheric phenomena and occur randomly.
- Weird things can happen - listen and learn!

Line-Of-Sight Propagation

- Radio signals travel in a straight line from transmitting to receiving antennas.
- This is the mode of propagation for VHF, UHF and microwave frequencies.
- FM radio and TV are also propagated in this manner.
- As far as antennas are concerned, the higher the better (limited by the curvature of the Earth).
- Direct communications with the space shuttle during SAREX contacts is line-of-sight.
- Reflections can also occur: they may be stronger than the direct signal some times. They also cause "picket fencing".

Repeaters Extend Range

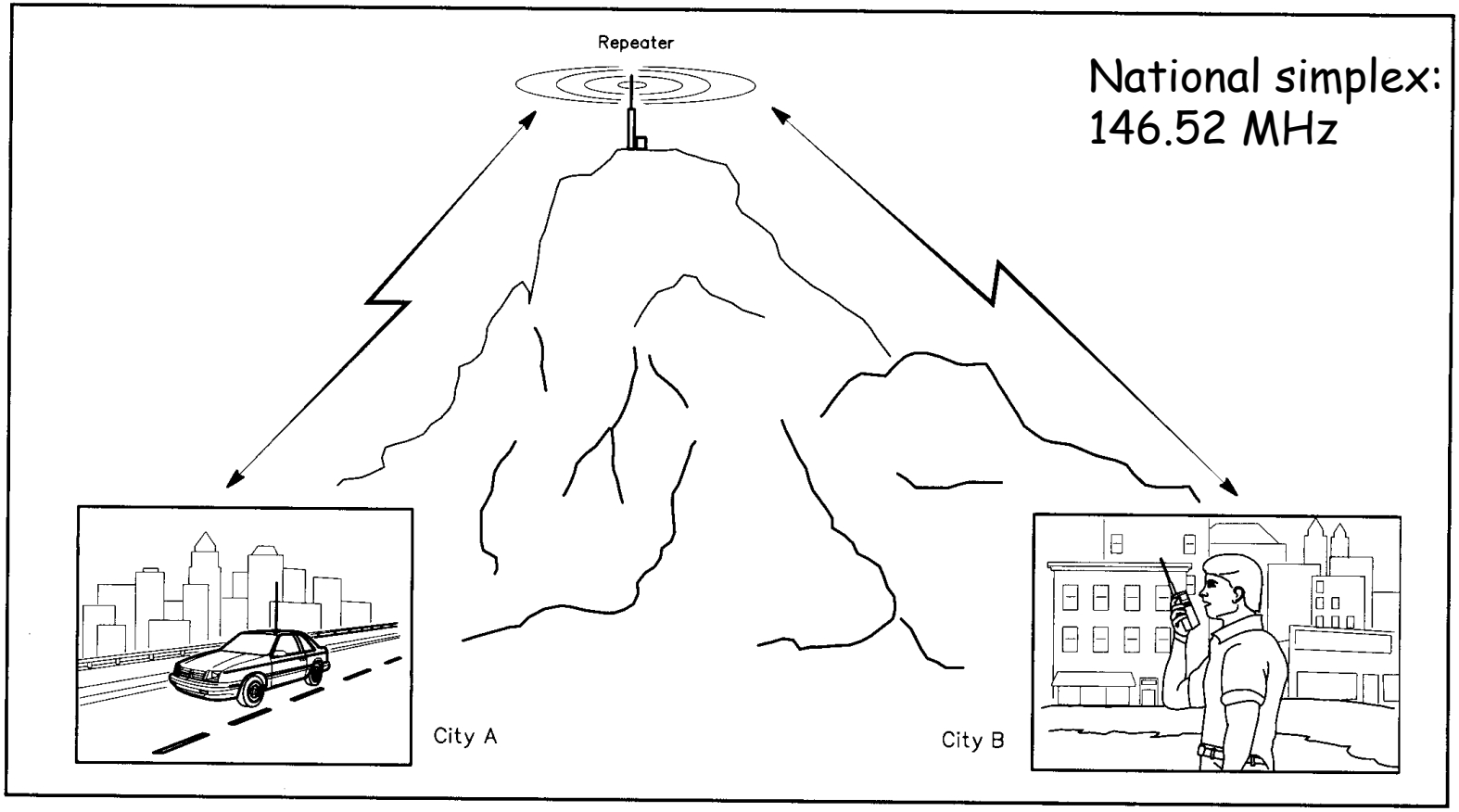


Figure 2-2 — Stations in city A can easily communicate with each other, but the hill blocks their communications with city B. The hilltop repeater enables the groups to communicate with each other.

NARS repeater broadcasts 146.660 MHz; listens 146.060

Repeaters have a "shift" between the frequency they listen to and the frequency they transmit. (NARS also requires a "tone" 103.5 Hz)

Ground-Wave Propagation

- Waves follow the ground, over hills and along the curvature of the earth.
- This is relatively short range propagation.
- AM broadcast stations propagate by this method.
  - High end (1600 kHz) carries less than 100 miles during the day.
  - Low end (540 kHz) will carry about 100 miles.
- Amateur bands are higher frequency and propagate even less distance during the day.
- More on night time propagation later.

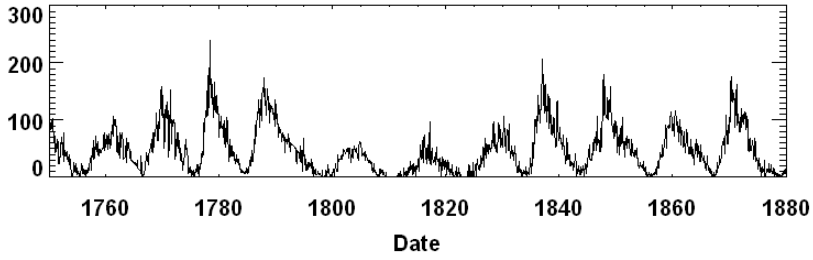
Sky-Wave, The Cool Stuff!

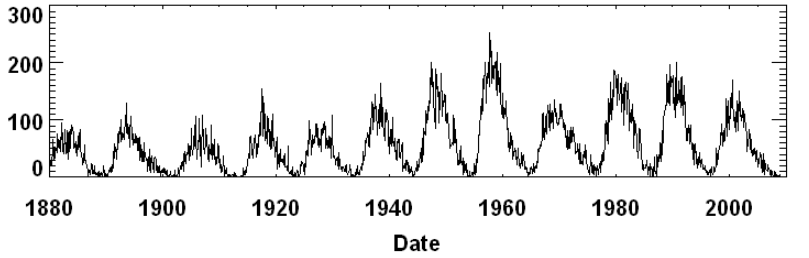
- Upper atmosphere (25 to 200 miles) is where the Sun's UV and X-rays strip electrons, ionizing the gas.
- The ionosphere can refract (bend) radio waves at low frequencies, bouncing them back.
- The determining factors for sky-wave propagation are the frequency in use and the degree of ionization.
- The highest frequency at which the ionosphere will bend radio waves is called the maximum useable frequency (MUF).
- When there are many sunspots, the Sun gives off more UV light, which results in a denser ionosphere, so a higher MUF!

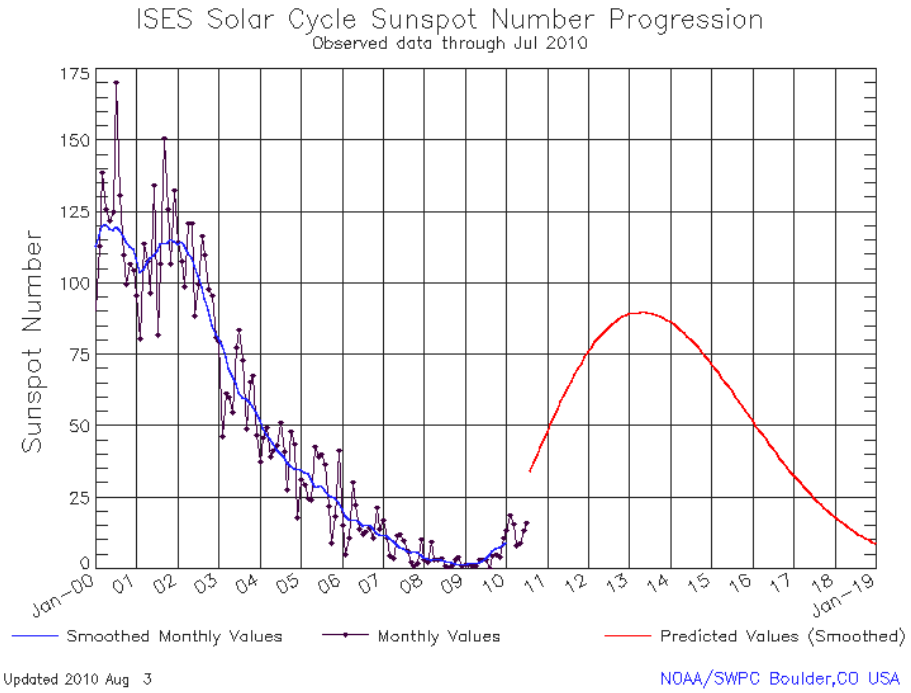
Sunspots - 11 Year cycle

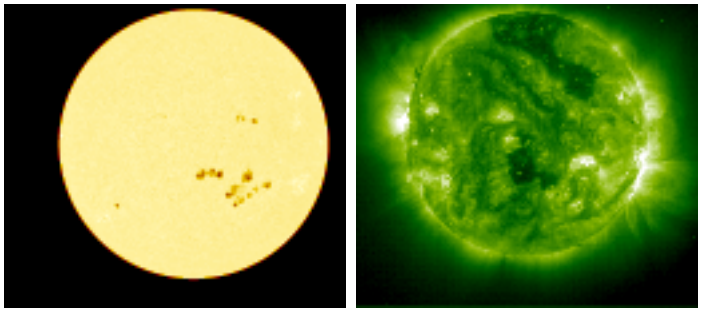
- More ionization means that MUF is higher.
- We are approaching sunspot maximum after a very low minimum

http://www.sec.noaa.gov/SolarCycle/

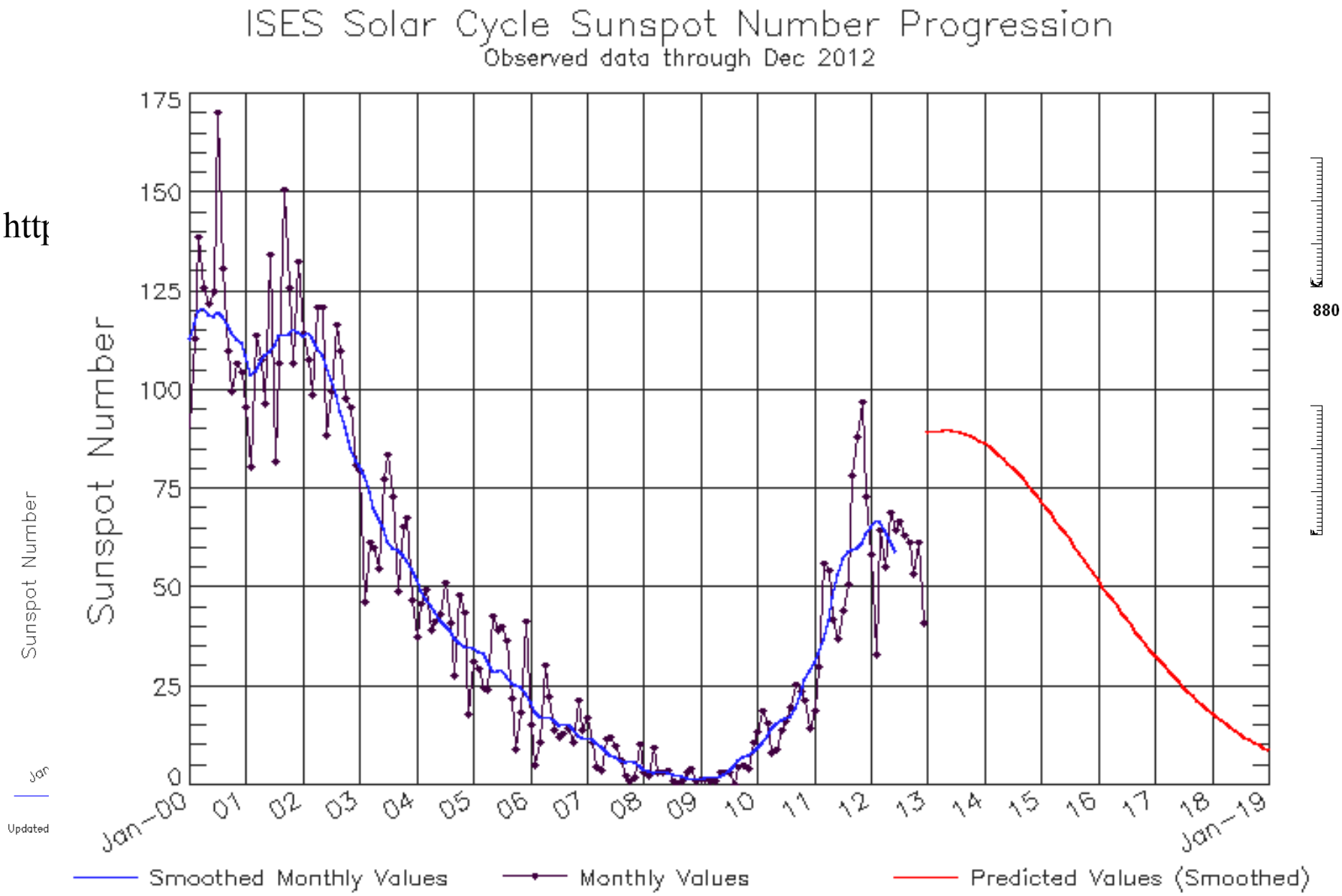








I hope we haven't peaked!



http

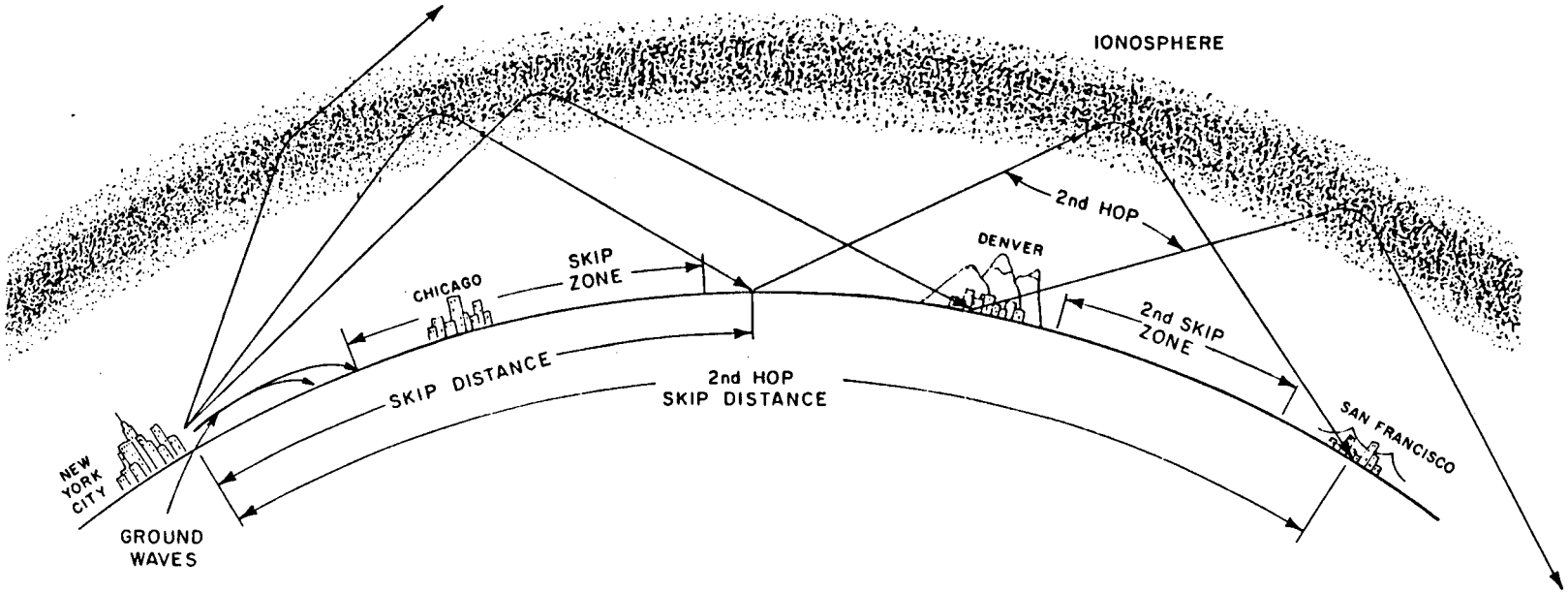
880

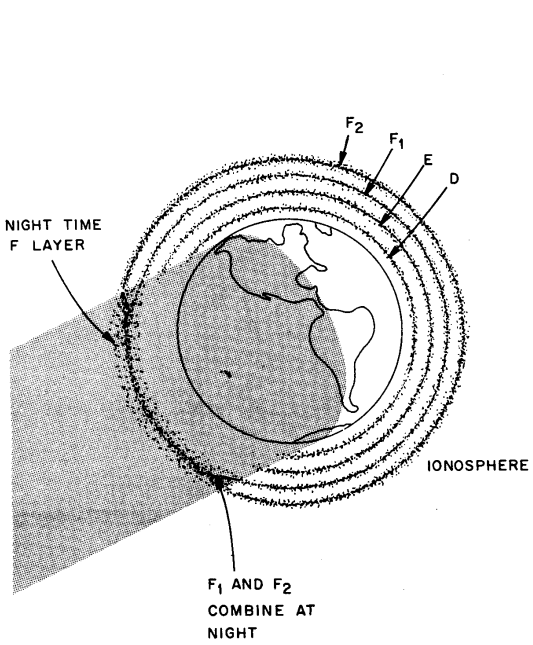
Sunspot Number

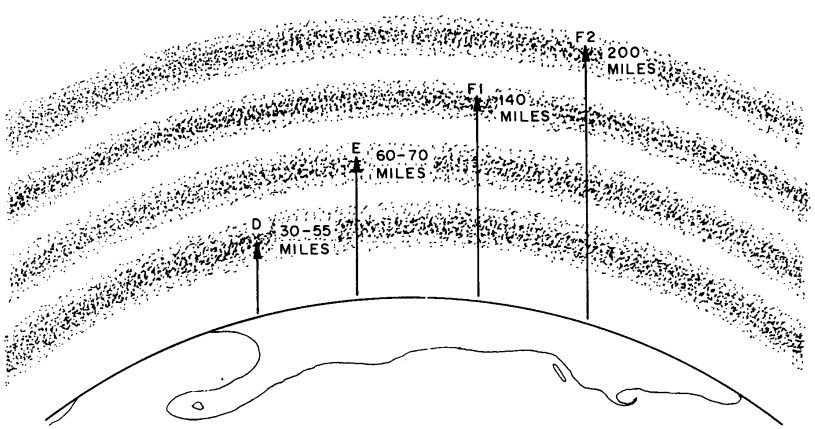
Jan

Updated

Sky-Wave Propagation







- D Region
  - ions don't last very long and ionization reaches peak at noon.
  - Doesn't refract, it absorbs 160, 80 and 40 meters.
- E Region
  - ions don't last long, peaks at noon.
  - can refract radio waves.
  - maximum skip is 1250 miles.
  - sporadic E skip works on VHF
- F Region
  - most responsible for long range communications.
  - ions last a long time, some all night.
  - two regions during the day F1 and F2.
  - F2 is primarily responsible for sky-wave propagation
  - one hop is a maximum of 2500 miles

Other Propagation Modes

- Scattering can be caused by the ionization trail of a meteor or by the atmosphere. The signals are weak and distorted.
- Tropospheric bending and ducting are caused by wide area temperature inversions. These bend radio waves because of differences in air density. This occurs in the VHF range (and higher sometimes).
- Amateur satellites are a popular way of communicating over long distances.
  - Doppler effects must be compensated for by proper tuning. (Higher frequency approaching, lower leaving)
  - Circularly polarized antennas help reduce fading from spin.
  - More power is needed (better antennas) at the horizon.
- Earth-moon-earth (EME) or moon-bounce requires high gain antenna arrays and lots of power.

International Morse Code

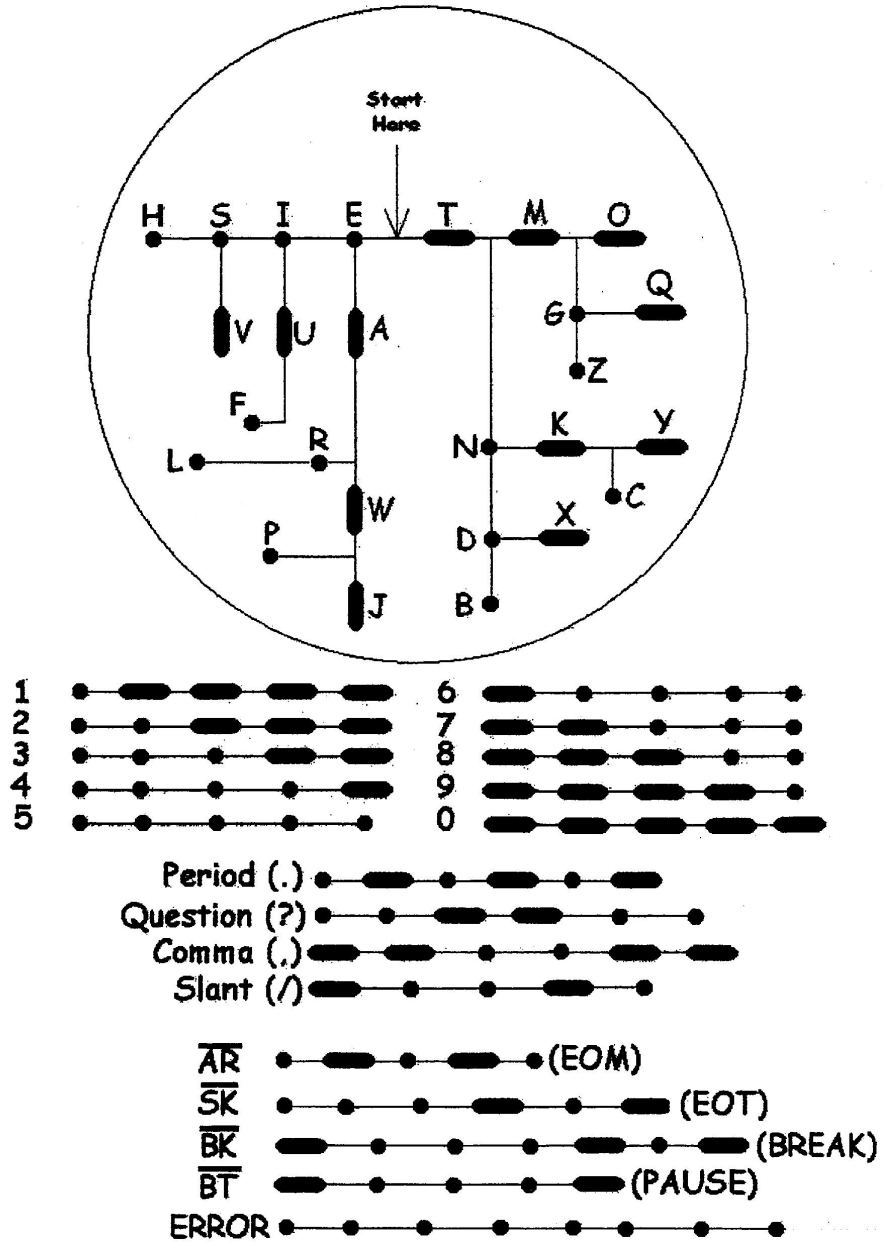
MORSE CODE FOR USE WITH LIGHTS, SOUND, OR FLAG

A • —	H • • • •	O — — —	V • • • —
B — • • •	I • •	P • — — •	W • — —
C — • — •	J • — — —	Q — — • —	X — • • —
D — • •	K — • —	R • — •	Y — • — —
E •	L • — • •	S • • •	Z — — • •
F • • — •	M — —	T —	
G — — •	N — •	U • • —	

NUMERALS AND COMMON SIGNALS

1 • — — — —	4 • • • • —	7 — — • • •	0 — — — — —
2 • • — — —	5 • • • • •	8 — — — • •	HEY! • — • — • — • —
3 • • • — —	6 — • • • •	9 — — — — •	ROGER • — •

HELP! • • • — — — • • • (repeat)



Morse Code "COIN" (flow chart) (used by railroad telegraphers)

Useful links:

Repeater directory/map/search:
http://www.artscipub.com/repeaters

Lookup of Ham by callsign:
(also practice tests, online or offline)
http://www.qrz.com/

ARRL organization (many resources, pubs):
http://www.arrl.org/

IRLP Directory (internet hop): http://status.irlp.net/index.php
local IRLP's: 444.300,

Echolink (from your computer or iPhone): http://www.echolink.org/
local echolinks: 145.17 (node 5551); 443.000