

# Radio Waves

Why are they so important?



# What is a Radio Wave?

- Radio waves are one of many forms of electromagnetic (EM) radiation, or waves
- The EM spectrum is divided into bands: Radio Waves, Infrared, Visible, Ultraviolet, X-Rays, and Gamma Rays
- Scientists use the terms *EM wave* and *EM radiation* interchangeably



# The Electromagnetic Spectrum

- The visible light we see is only a small fraction of the total EM spectrum
- Radio waves can be as short as 1 mm or many kilometers long!

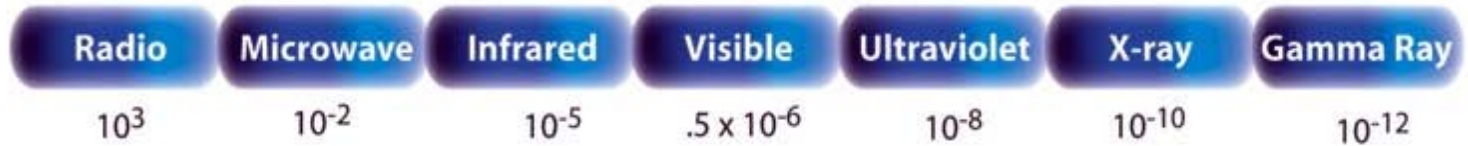


# THE ELECTROMAGNETIC SPECTRUM

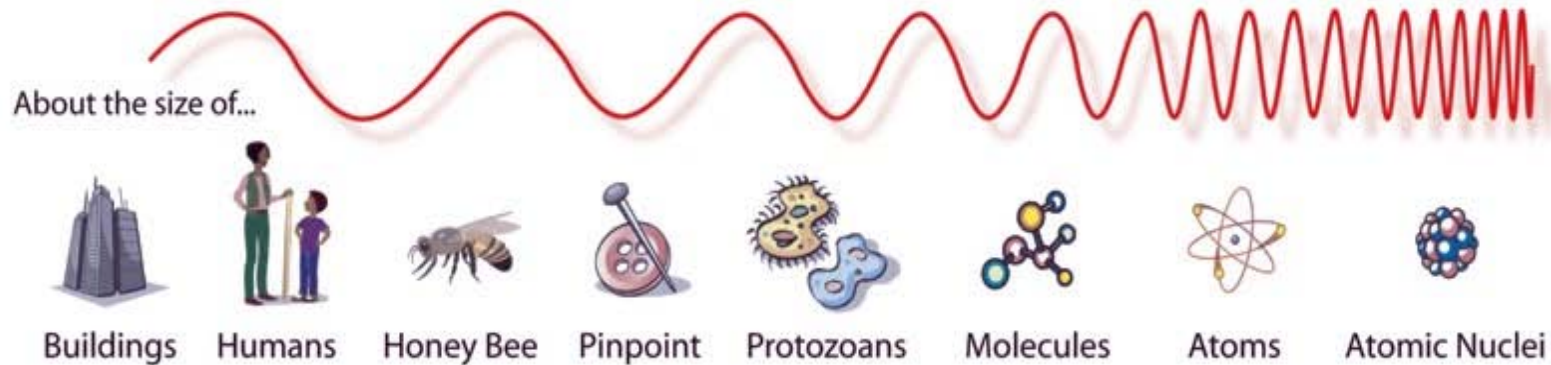
Penetrates  
Earth  
Atmosphere?



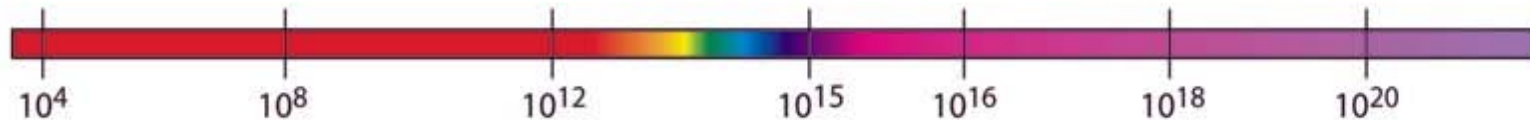
Wavelength  
(meters)



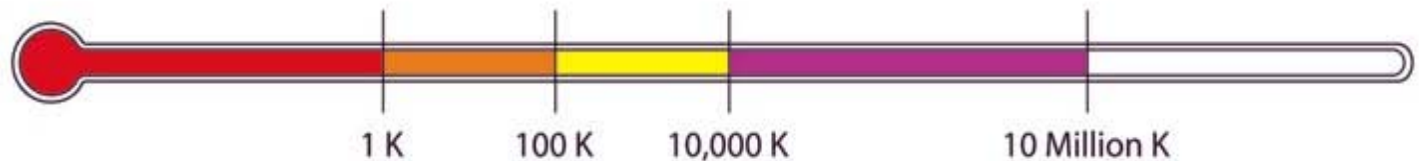
About the size of...



Frequency  
(Hz)



Temperature  
of bodies emitting  
the wavelength  
(K)



# The Radio Band

- No, not the latest music group from Seattle!
- The Radio spectrum has many sub-bands, grouped by frequency

Band	Frequencies	Band	Frequencies
VLF (Very Low)	10 - 30 kHz	VHF (Very High)	30 - 300 MHz
LF (Low)	30 - 300 kHz	UHF (Ultra High)	300 MHz - 2.9 GHz
MF (Medium)	300 kHz - 3 MHz	SHF (Super High)	2.9 GHz - 30 GHz
HF (High)	3 - 30 MHz	EHF (Extremely High)	30 GHz and above



# Microwave/Radar frequencies

Radar Band	Frequencies
L	1 - 2 GHz
S	2 - 4 GHz
C	4 - 8 GHz
X	8 - 12 GHz
Ku	12 - 18 GHz
K	18 - 27 GHz
Ka	27 - 40 GHz
mm (millimeter)	40 - 300 GHz

# What's going on in all those bands?

- Not all radio waves are the same!
- Lower frequencies = longer wavelengths
- In the US, the FCC allocates frequencies for specific uses (commercial, military)
- Not enough consideration is given to scientific uses and needs!!!



# The radio spectrum is a busy place!

## UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM

**RADIO SERVICES COLOR LEGEND**

AERIAL BEACON	AIR-SATELLITE	AIR-TERRESTRIAL
AERIAL MOBILE SATELLITE	LAND MOBILE	RADIO DETERMINATION SATELLITE
AERIAL RADIOLOCATION	LAND MOBILE SATELLITE	RADIOLOCATION
MARINE	MARITIME MOBILE	RADIOLOCATION SATELLITE
MARINE SATELLITE	MARITIME MOBILE SATELLITE	RADIOLOCATION
BROADCASTING	MARINE RADIOLOCATION	RADIOLOCATION SATELLITE
BROADCASTING SATELLITE	METEOROLOGICAL SATELLITE	SPACE OPERATION
BROADCASTING SATELLITE	METEOROLOGICAL SATELLITE	SPACE RESEARCH
FIXED	MOBILE	SPACE RESEARCH
FIXED SATELLITE	MOBILE SATELLITE	SPACE RESEARCH

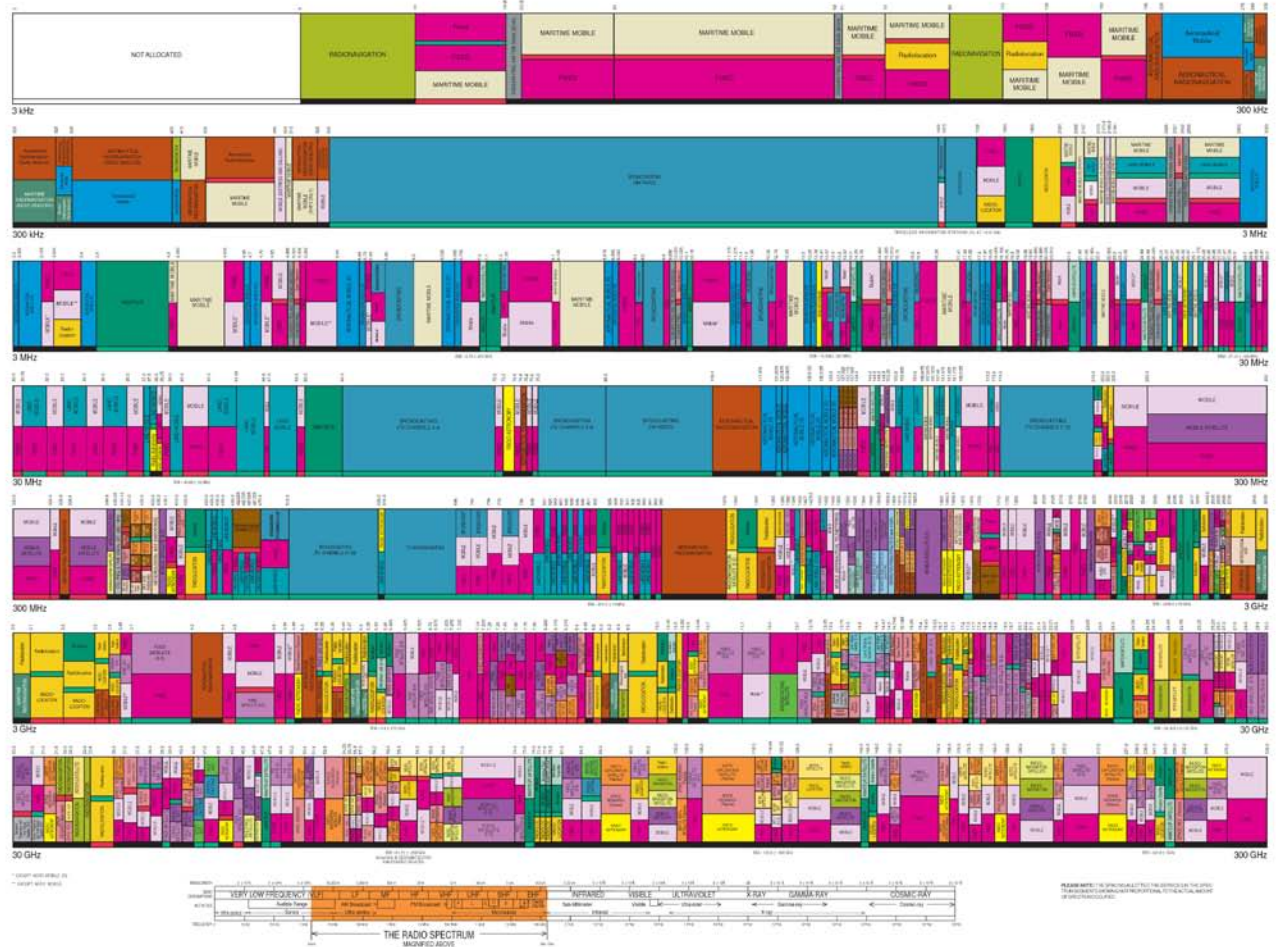
**ACTIVITY CODE**

GOVERNMENT EXCLUSIVE	GOVERNMENT NON-GOVERNMENT SHARED
NON-GOVERNMENT EXCLUSIVE	

**ALLOCATION USAGE DESIGNATION**

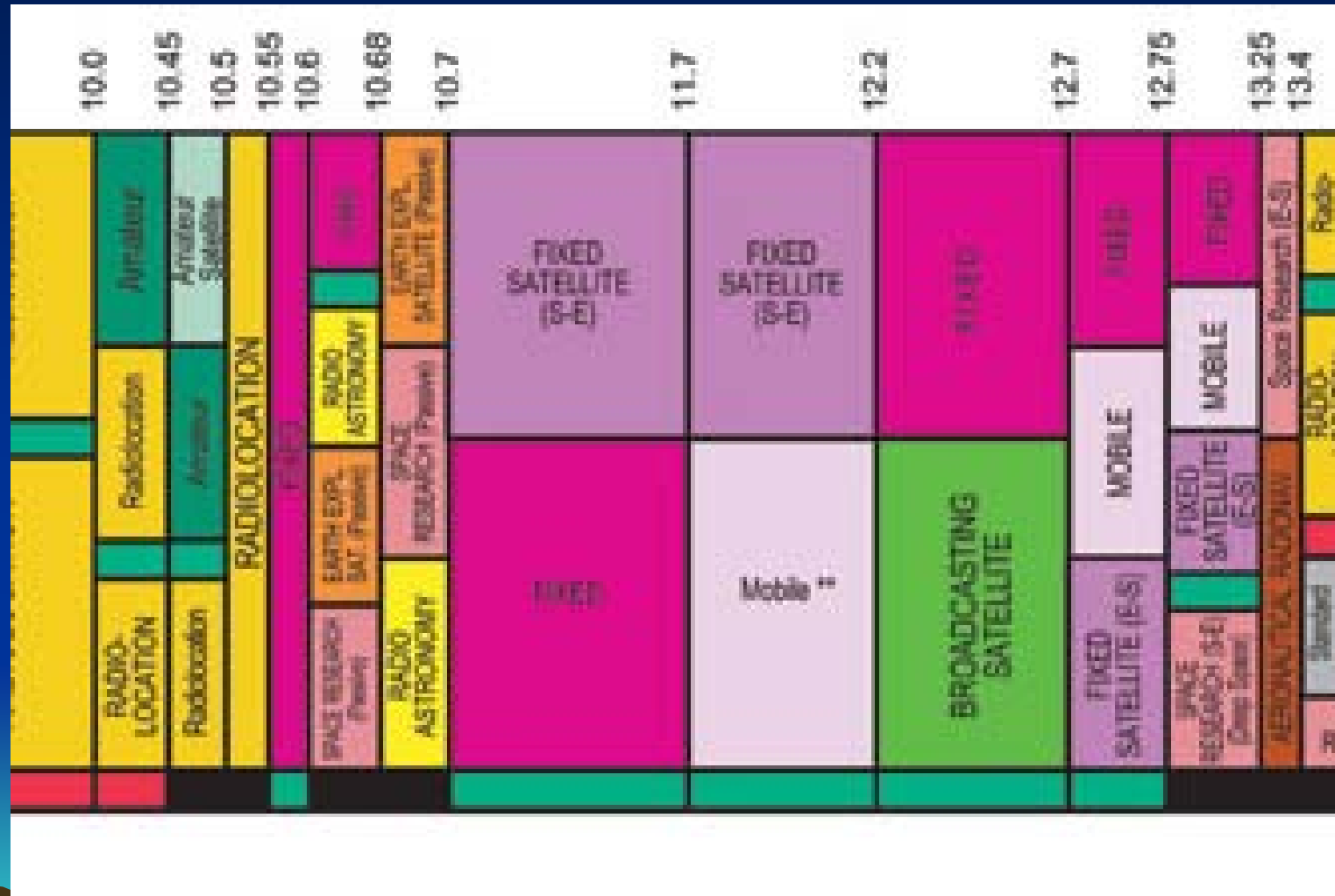
SERVICE	EXAMPLE	DESCRIPTION
Primary	Fixed	Channel Linking
Secondary	Mobile	For Coexist with lower class service

THIS CHART IS A SUMMARY OF THE FREQUENCY ALLOCATIONS OF THE UNITED STATES OF AMERICA AND IS NOT INTENDED TO BE USED AS A BASIS FOR REGULATORY ACTION. FOR THE MOST CURRENT AND COMPLETE INFORMATION ON THE RADIO SPECTRUM, REFER TO THE FEDERAL REGISTER AND THE FEDERAL COMMUNICATIONS COMMISSION'S (FCC) PART 27 OF THE CODE OF FEDERAL REGULATIONS. ADDITIONAL INFORMATION IS AVAILABLE ON THE FCC'S WEBSITE AT WWW.FCC.GOV.





# A close-up around 11 GHz



# How do we use radio waves?

- Cellular telephones
- Wireless LANs
- Keyless entry
- AM & FM radio
- Garage-door openers
- Satellite radio
- Dog collars
- Microwave ovens
- Police radar
- Radar detectors
- Doppler radar
- GPS
- Satellite tracking & communications



# Nature is sending us messages

- Many natural occurring phenomena can create radio waves (see [Radio Sources](#))
- Spectral lines and their intensities identify the source – like celestial fingerprints (who says CSI has all the fun?)
- Man-made sources interfere with scientists' ability to detect natural events



# Radio Astronomy

- Uses Radio Telescopes to watch for radio signals from natural sources
- Compare results to other methods of detection (optical, X-Ray, etc)
- Form theories about the origins of those sources based on spectral output
- Must subtract earth's atmospheric contamination of incoming signals



# Atmospheric Sciences

- Use the “contamination” that Radio Astronomers throw away to deduce what is happening in our upper atmosphere
- Use radar to probe the conditions of the earth’s atmosphere, especially the charged part called the ionosphere
- Use transmissions from GPS satellites to measure Total Electron Count (TEC)



# Geodesy

- Use points at the edge of the universe to accurately determine the location of the radio telescopes
- The earth isn't as solid as you think!
  - Plate tectonics
  - Orbital precession and wobble
  - Land tides

