

Astronomy 330



This class (Lecture 23):
Future of Civilization
Sean White
Lindsay Ellech

Next Class:
Rockets

Rough Drafts due on Thursday!!

Music: <http://youtube.com/watch?v=eFAxumuzmN0>

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Presentations



- **Sean White** : [Aliens in the Media](#)
- **Lindsay Ellech**: [Abducted](#)

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Outline



- How can we communicate with ET?
- Is there a magic frequency?
- Need the frequency, channel size, the code, and the location of a signal.

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Drake Equation

That's 333 advanced civilizations in our Galaxy!!!!!!!!!!!!

Frank Drake



$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

of
advanced
civilizations
we can
contact in
our Galaxy
today

Star
formation
rate

Fraction
of stars
with
planets

of
Earthlike
planets
per
system

Fraction
on which
life arises

Fraction
that evolve
intelligence

Fraction
that commu-
nicate

Lifetime of
advanced
civilizations

15
stars/
yr

0.5
systems/
star

2.7×0.134
 $= 0.36$
planets/
system

0.95
life/
planet

0.1
intel./
life

0.40
comm./
intel.

3250
yrs/
comm.

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How to Communicate?



- Remember space is big!
- Best way to communicate (that we know of) is by light waves.
- Need to know the frequency, the channel size, the code, and the location.. this is hard!

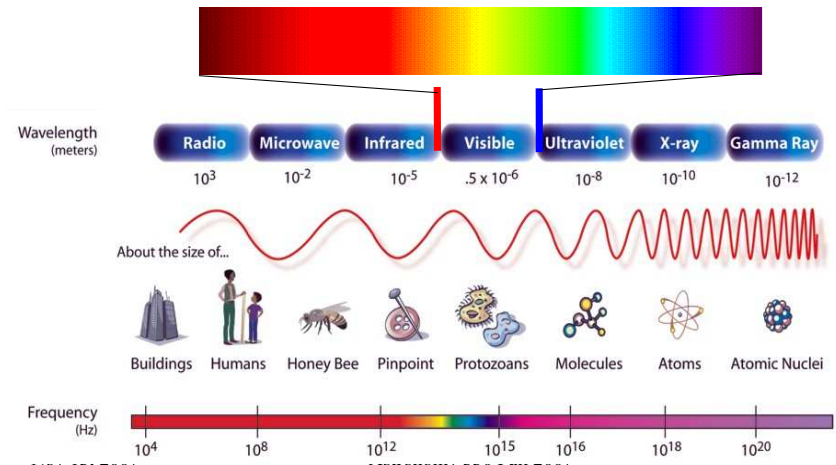
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Light me up



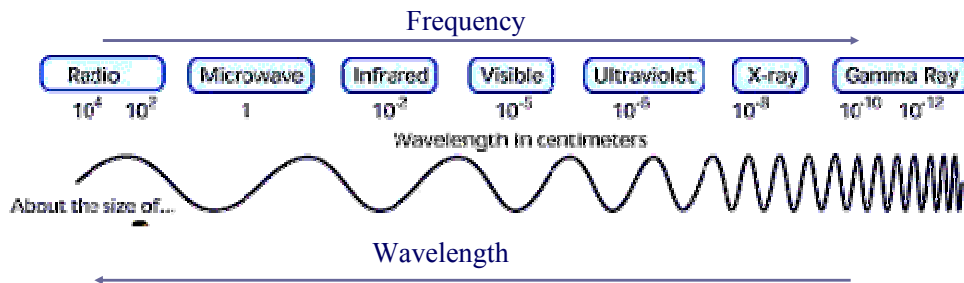
- Visible light is only a tiny portion of the full electromagnetic spectrum
- Red light has longer wavelength and lower frequency than blue light.
- Divisions between regions are from biology or technologies.



Frequency



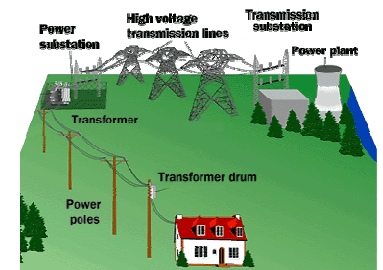
- The frequency of light depends on its color.
- The unit is Hertz, equivalent to 1 cycle a second.
- For radio waves, we normally use larger units
 - 1 kHz = 1000 Hz
 - 1 MHz = 10^6 Hz
 - 1 GHz = 10^9 Hz



What's the Frequency Kenneth?



- We can't broadcast over the whole range—too much power = expensive.
- So what kind of reasoning can we use to limit our search or any broadcasts?
- Keep in mind that ET must make the same decisions.
- May be very alien decisions.



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<http://http://science.howstuffworks.com/power.htm>

What's the Frequency Kenneth?



- Want biggest bang for the buck.
- Interstellar dust is in the Galactic plane
- Attenuates light that is shorter than infrared wavelengths– a few microns.
- Or need very high frequency.
- Energy required for the photon increases with frequency.
- Argues for low frequency or long wavelength operation– radio.



<http://www.beautydish.com/>

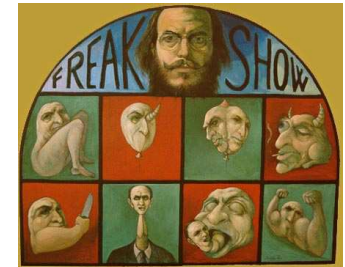
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Freq Show



- Keep in mind that radio stations fade as you get further away.
- In fact, light decrease in amplitude as the square of the distance traveled.
- And like your radio, there can be noise from competing stations or noise from the radio receivers.
- The Galaxy emits lots of emission at low frequencies.



<http://www.micka.cz/f8.jpg>

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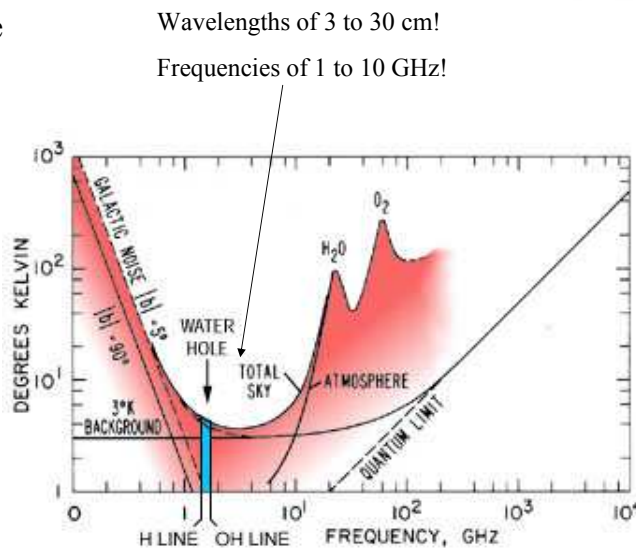
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Freq-ing Out.



The best place to listen– in the “quiet” part of the spectrum

1. The galaxy emits lots of emission at low frequencies.
2. The Big Bang background noise– CMB.
3. Noise of receivers. The perfect receiver has a quantum limit of one photon noise.
4. The Earth's atmosphere blocks many frequencies.



http://setiathome.ssl.berkeley.edu/about_seti/radio_search_2.html

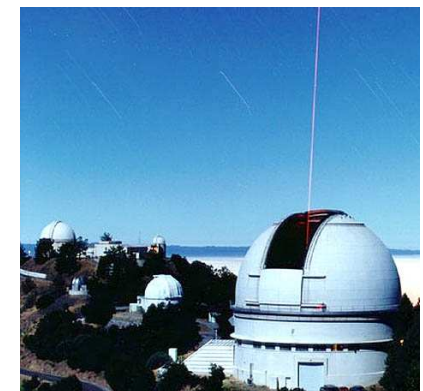
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Or Lasers?



- Charlie Townes has pointed out that sending pulses of laser light could be competitive.
- A number of searches are now underway using visible light– optical SETI.
- The light must be distinguishable from the star.
- It is easy for planets to overwhelm their suns in radio waves, but not visible.
- Powerful lasers have a certain defined wavelength.



Laser for adaptive optics, not optical SETI.

http://www.ucsc.edu/news_events/download/images/laser-lg.jpg

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ETs with Lasers?



- Reines and Marcy in 2002 searched 577 nearby stars with sensitivity to detect >60 kW lasers focuses from a 10m telescope.
- Nothing was detected.
- Laser seems an unlikely communication tool
- Laser is a very small beam of light, only a few stars in transmission beam, so back to radio.



Are aliens trying to contact us with LASERS?

http://www.insomniacmania.com/news/news_771_1.jpg

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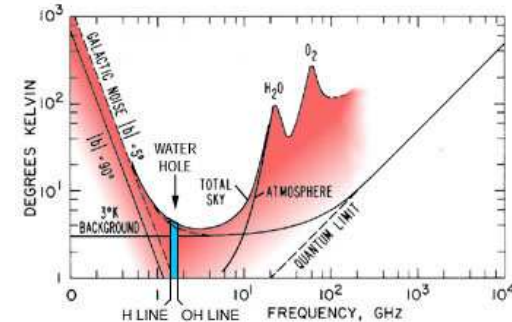
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How to Communicate?



Radio is probably best.

1. Dust extinction is reduced.
2. Lower frequency means less energy/photon, so cheaper.
3. There is a natural dip from about 1 to 10 GHz in the radio where the atmosphere and the galaxy are the quietest.



http://setiathome.ssl.berkeley.edu/about_seti/radio_search_2.html

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Big Band



- Still, 1-100 GHz or even 1-10 GHz is a lot of frequency to search.
- FM radio is only 20 MHz!!
 - And can be hard to search too.
- Is there a magic frequency that advanced civilizations would choose?



<http://www.stamps.net/40band.jpg>

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The Magical 1420



- Morrison and Cocconi (1959) suggested the first magical frequency of 1420 MHz or 1.420 GHz.
- It's the frequency at which H atoms in space emit and absorb radiation (21 cm line).
- Not a bad choice as H is the most abundant atom in the Universe.
- But, now we have detected over 100 molecular transitions, some crucial to life, so maybe not as an important argument as it once was.



<http://www.leapsecond.com/pages/unix/>

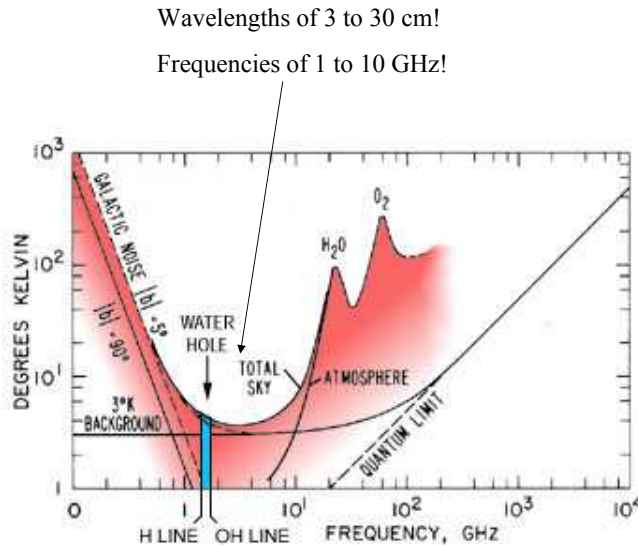
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The Water Hole?



- Carl Sagan and Frank Drake suggested that species on Earth always gathered around the water hole.
- There is a molecular fragment of OH that absorbs at 4 frequencies between 1.612 and 1.720 GHz.
- These molecules were well studied at the time, so it was biased.
- And, now we know about more exciting transitions at higher frequencies.



http://setiathome.ssl.berkeley.edu/about_seti/radio_search_2.html

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Fundamental Freqs



- What are constants that every civilization would be aware of?
- Speed of light
- Fine structure constant (1/137)
- Divide the speed of light as many time as necessary to get a frequency in the radio range.
- In that case you get 2.5568 GHz.
- First suggested by Kuiper and Morris.

$$\alpha = \frac{e^2}{\hbar c}$$

http://astronomy.swin.edu.au/sao/guest/davis/eqn_a.gif

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Magical Frequency?



- No.
- Nothing is really obvious.
- So, we're screwed.
- We have to look through a lot of radio frequencies.
- So, we better understand radio techniques a little.



<http://www.funbrain.com/guess/magic.gif>

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Radio



- The basic concept of radio astronomy, radio communications, television, mobile phones, etc. is the same.
- Information is transmitted by low energy light.



<http://www.itsrealstuff.com/assets/images/antenna.jpg>

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Radio



- How does the antenna on your car work?
- The electro-magnetic wave cause electrons to move up and down in your antenna.
- That signal is amplified and decoded.
- For frequencies in the band of interest, parabolic antennas are common used.



<http://www.itsrealstuff.com/assets/images/antenna.jpg>

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Radio telescopes



Pioneering work by Grote Reber in back yard, Wheaton, Illinois. (He died in 2002).



Arecibo Observatory, Puerto Rico

Largest radio telescope– 300 meters.



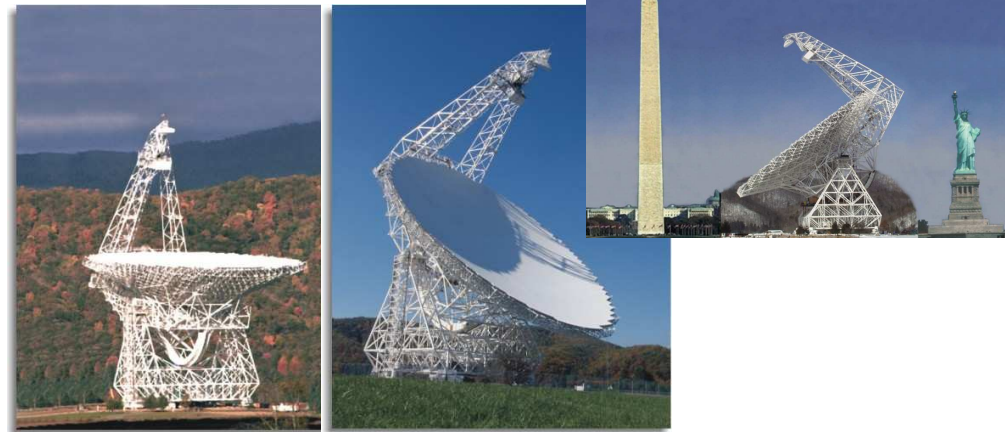
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The Green Bank Telescope– W.V.



- The largest fully steerable dish in the world– 100 meters



<http://www.gb.nrao.edu/epo/GBT/gbtpix.html>

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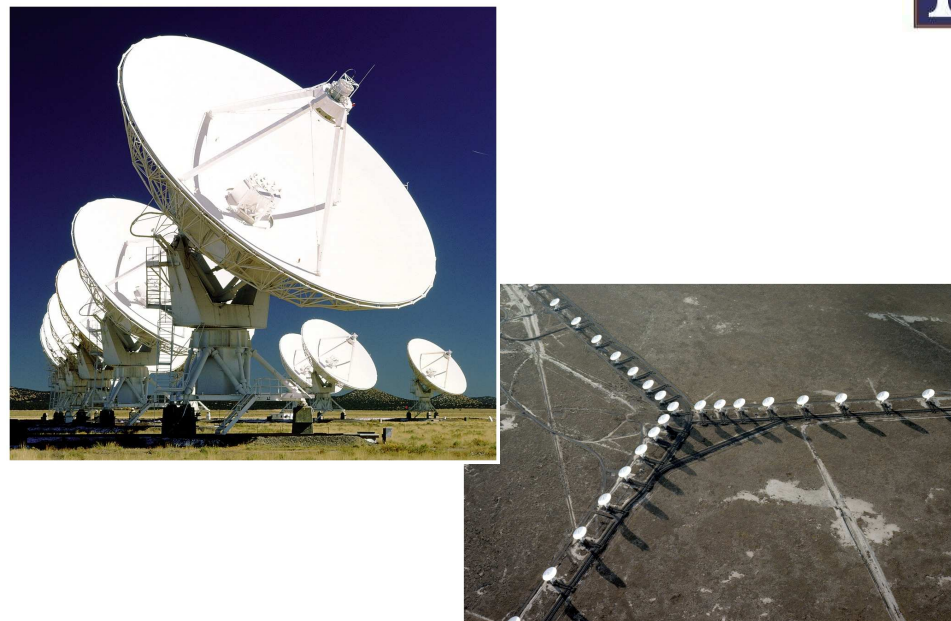
Greenbank WV



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Very Large Array, near Magdalena, NM



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Decoder Ring



- After receiving and amplifying the signals, one has to decode the signals.
- Naturally created signals do not usually vary with time and are unpolarized.
- This is non-trivial.



<http://theimaginaryworld.com/box678.jpg>

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Decoder Ring



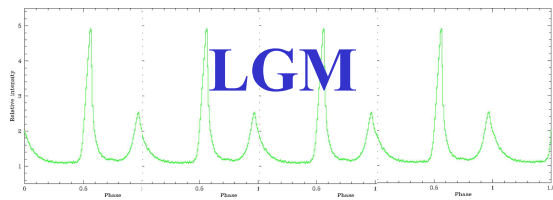
- Normally, artificial signals encode data:
 - FM : frequency modulation (frequency varies with time)
 - AM : amplitude modulation (brightness varies with time)
 - Usually analog, but digital is more robust
 - Can turn on/off to signify 1 or 0 (most likely for ET)
- Note, most astronomers do not look for fast varying signals, but weak non-varying signals.



<http://theimaginaryworld.com/box678.jpg>

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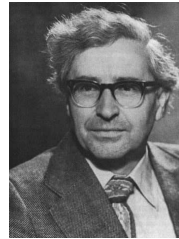
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- But, astronomers studying the short variations in the interstellar medium did look at fast varying signals.
- Jocelyn Bell noticed a regularly repeating signal.
- Perfect timing, but no real encoding.
- Jokingly called LGMs, then Pulsars.
- Eventually realized to be from neutron stars.
- The lighthouse beam from the rapid rotator sometimes intersecting the Earth.



Jocelyn Bell Burnell



Anthony Hewish