Outline of lecture notes
(Handed out Tuesday Nov. 25, will complete Tuesday Dec. 2)
SETI: Search for Extraterrestrial Intelligence

● Distances to nearby stars—speed of light requires decades-to-centuries for two-way messages.
● Must assume photons are vehicles of choice. (Comparison with star travel)

Intentional, nonintentional signals.

Four types of nonintentional signals:

- Leakage radiation
  Earth TV power vs. time, spectrum, geographical distribution, observed pattern due to Earth's rotation. Incoherence. [*Not* in textbook]
- Alien communications
- Products of technological activity
- Dyson spheres (discussed in class; see textbook if missed)

Searching for intentional signals: "The cosmic haystack"

Where to point? Targeted vs. all-sky searches

- Relation between sensitivity, observing time, fraction of sky surveyed.
- Current projects (see table in Ch. 12 and below)

Wavelength region: Why have most searches concentrated on radio?

- Transmission of planetary atmosphere
- Interstellar dust
- Cost per photon
- Background interference: "Noise"
  Supernova remnants at largest radio wavelengths
  H2O, O2 atmospheric band emission at IR wavelengths
  Quantum noise of instrument if no atmosphere
  Cosmic microwave background sets "floor"

Result: minimum interference in radio 1-10 GHz.

Bandwidth: Want to cover lots of *narrow* bands

- Can get higher signal relative to background.
- No natural phenomena produce radio signals whose width is less than about 1 Hz.

Unfortunate conclusion: Billions of bands to "listen" to.

Guessing at magic frequencies: Narrow down the wavelength range

- Neutral hydrogen HI 21 cm line at 1420 GHz seems like viable universal choice.
  Doppler shifting; swamped by background HI
- "The waterhole" (now historical interest only)
- Too many magic frequencies—use fundamental constants of nature? (*Many* suggestions!)
  Intergalactic standard based on cosmic background radiation?

Alternatives:

1. Search for **Dyson spheres**. Confusion with circumstellar dust shells.

Dyson spheres not expanding, need radial velocities. How to see the central star?

2. **Optical SETI**

Beaming advantage: No inverse square law!
Advantages of pulsed radiation. Power *and* recognition.
Current OSETI programs.

Recognizing a message

Analog or digital? "Clear" preference for digital.

Distinction from natural physical phenomena

- Lesson from pulsars, gamma-ray bursts.
- Repetition, switching bands, small duration (but remember gamma-ray bursts down to 1 sec or less), small bandwidth.

Encoding: How to devise code that *any* other intelligence can decode?

- The "picture strategy": encode picture in binary string using two prime numbers. e.g. 551 = 29 x 19 (or 19 x 29); 1679 = 23 x 73 (1974 Arecibo transmission)

  Example: Make pictures of letters of alphabet
- More realistically: (?) Why send out signals *anyone* could decode? What if searching for contact "at the same level?" What would be a difficult complex signal to recognize?

Searches to date (all radio except Optical SETI)

Cocconi and Morrison paper: 1960. Schialow and Townes 1961; Frank Drake and **Ozma.**

Proposal to NASA: Cyclops: 1000 100m telescopes on far side of Moon.

Still SETI dream.

Use of existing telescopes:

Ohio State "Wow' signal

META, BETA: the Horowitz and Sagan report

NASA enters: 20 years of MOP development, 1 year of search (1992).

NASA drops ball: Phoenix rises from ashes—SETI institute, Planetary Society, private donors.

Phoenix (SETI Institute, NASA Ames): piggyback off large existing radio telescopes.

SERENDIP (Berkeley), **Southern SERENDIP** (Univ. Western Sydney).

All sky searches.

SETI@home: Most important for future of distributed computing in biology, climate simulation,…

August 2008: Changeover to search for *pulsed* radio radiation.

Amateur observing networks (Argus, … see course web site)

Allen Telescope Array (AKA)

Very high sensitivity, small bandwidth, 350 antennas (eventually).
First 42 dishes in operation Oct. 2007.
Other applications, testbed for SKA (Square Kilometer Array)

Optical SETI searches going strong (Berkeley, Harvard, …). Recent reports of results.