

# Astronomy 230

Section 1— MWF 1400-1450  
106 B1 Eng Hall



This Class (Lecture 35):

**Astronomy Public Lecture  
Tonight!**

Communication 2

Next Class:

**HW #6 is due on Nov 19th!**

Brian Fields  
KILLER SUPERNOVAE!

**Rough Drafts are Due by  
Nov19th!**

Music: *I Still Haven't Found What I'm Looking For* – U2

Nov 17, 2004

Astronomy 230 Fall 2004

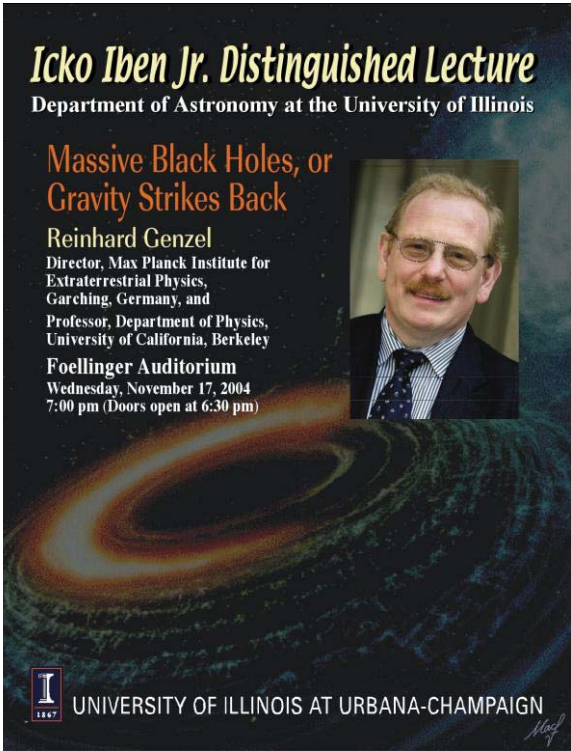

L.W. Looney

**Icko Iben Jr. Distinguished Lecture**  
Department of Astronomy at the University of Illinois

**Massive Black Holes, or  
Gravity Strikes Back**

Reinhard Genzel  
Director, Max Planck Institute for  
Extraterrestrial Physics,  
Garching, Germany, and  
Professor, Department of Physics,  
University of California, Berkeley

Foellinger Auditorium  
Wednesday, November 17, 2004  
7:00 pm (Doors open at 6:30 pm)



UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

## Extra Credit:



Go to the public  
lecture and write a  
short 1-page  
summary including :

- A topic discussed  
that was very  
cool.
- A topic discussed  
that you found  
surprising.

Equivalent to 1  
homework grade

L.W. Looney

## HW #7– Due Dec 1<sup>st</sup>



- Read the short story by Isaac Asimov, *The Last Question*.
  - <http://www.maddad.org/asimov01.htm>
  - [http://dookaloosy.dyndns.org/wail\\_-\\_thoughts\\_on\\_a\\_book\\_-\\_Asimov1.htm](http://dookaloosy.dyndns.org/wail_-_thoughts_on_a_book_-_Asimov1.htm)
  - <http://mit.edu/tylerc/www/twt/LQ1.htm>
- Write a 1-2 page (typed) critique of the story with relevance to this class (space travel, civilization lifetime, energy, etc.). I'm interested in how reading this story with your class facts affect your view of the story. Ignore the obvious errors.

Nov 17, 2004

Astronomy 230 Fall 2004

L.W. Looney

## Outline



- Needle in a haystack.
- Sensitivity of telescope– Does size matter?
- The history of SETI.
- The future?

Nov 17, 2004

Astronomy 230 Fall 2004

L.W. Looney

= 69,525

Civilizations

## Drake Equation



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

# of advanced civilizations we can contact	Rate of star formation	Fraction of stars with planets	# of Earthlike planets per system	Fraction on which life arises	Fraction that evolve intelligence	Fraction that commun- icate	Lifetime of advanced civilizations
25	0.34	.396	0.54	.425	0.9	100000	
stars/ yr	systems /star	life planets /system	life /planet	intelligence /life	life /comm.	years	

## Does ET Love Lucy?



- One solution is to look for unintentional leakage signals.
- Leakage, as it “leaks” from the planet’s ionosphere.
- We can not currently detect this, but maybe other civilizations can.
- This is the scenario explored in the novel *Contact* by Carl Sagan and the movie based on the novel.
- What leakage do we have? TV, FM Radio, radar
- Television transmission exceeds  $10^7$  watts (10 MW).



L.W. Looney

<http://www.time.com/time/time100/scientist/profile/farnsworth.html>

Nov 17, 2004



## Does ET Love Lucy?



- ET would be unable to really distinguish individual stations due to the rotation of the Earth.
- To detect early carrier signals at 50 lyrs, need 3000 acres of antenna.
- To watch the TV show, need antenna the size of Colorado. It is possible.
- Still Earth would produce a regular 24 hour pattern for the last 60 years.
- Military radar is more promising. Highly focused and powerful.
- Only requires a 1000 foot antenna.



L.W. Looney

[http://www.space.com/searchforlife/seti\\_shostak\\_alien\\_031023.html](http://www.space.com/searchforlife/seti_shostak_alien_031023.html)

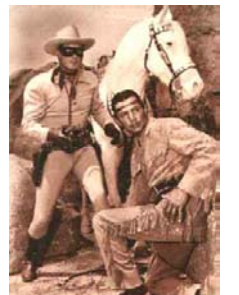
Nov 17, 2004

Astronomy 230 Fall 2004

## Does ET Love Lucy?



- As radio travels at speed of light, our leakage signals have reached the nearest 5000 stars!
- Still, this is way too few for our estimate.
- It is unlikely that a civilization is within 50 lyrs.  
→  $N = 10^7$
- So probably ET does not love Lucy, at least yet.



L.W. Looney

Nov 17, 2004

Astronomy 230 Fall 2004

## Problems...Problems



- Assume that an advanced civilization is broadcasting either in all directions or toward us.
- Where and when do we listen?
- Which frequency?
- Which channel?
- Which polarization?
- What is the code?
- The problem is worse than searching for a needle in a haystack.
- We have to assume that they are constantly broadcasting, or the problem is impossible.



[http://nl.ijs.si/et/talks/essli02/metadata\\_files/Haystack-FINALb.jpg](http://nl.ijs.si/et/talks/essli02/metadata_files/Haystack-FINALb.jpg)

Nov 17, 2004

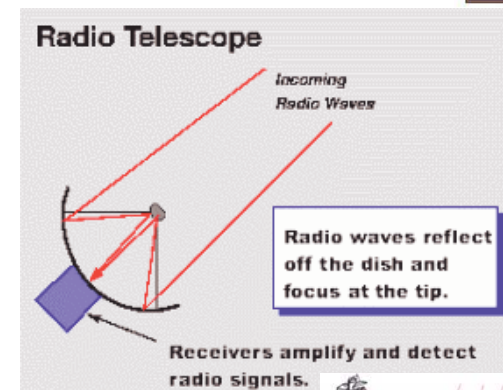
Astronomy 230 Fall 2004

L.W. Looney

## Sky Dishes

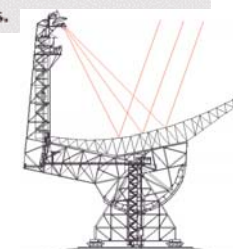


- Radio telescopes are similar to optical telescopes.
- Most radio telescopes are Parabolic Cassegrains.
- Radio telescopes measure the source intensity– flux density– in  $\text{W m}^{-2} \text{Hz}^{-1}$ .
- The bigger the dish, the more sensitive.
- So a big dish is best, right?



<http://www.nrao.edu/whatisra/radiotel.shtml>

Unblocked Aperture



Nov 17, 2004

Astronomy 230 Fall 2004

## Haystack: Sensitivity



- Sensitivity of a radio telescope:
- The smaller the sensitivity the better.
- We have to detect a weak signal in the presence of noise.
- So, ideally look in a fixed direction for a long time– better sensitivity to weak signals.
- But it may be the wrong direction.
- And a big dish is best, right?

$$S \propto \frac{1}{D^2 \sqrt{\Delta \nu \times t}}$$

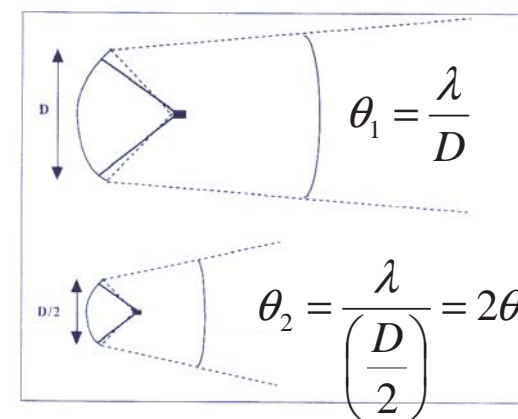
Nov 17, 2004

Astronomy 230 Fall 2004

## Haystack: Direction



- We can not *a priori* know which direction to look, so we must look in many directions.
- Tradeoff: The most sensitive radio telescope has the largest diameter but the smallest field of view.
- Beam size decreases as the diameter increases.
- The number of times you have to point to cover a certain area of the sky increase as diameter squared.



$\theta$  is in radians.

Nov 17, 2004

Astronomy 230 Fall 2004

L.W. Looney



## Dish Decision



- If ET signals are a few strong signals, we can use a small telescope and listen for a short time in any direction. The small diameter dish covers more area.
- If ET signal is many weak signals, we can use a bigger telescope and observe in a single direction for a long time. A weak signal requires a big dish.



<http://www.noao.edu/staff/mighell/sacpeak/jpina/VLA%20in%20dish%204.jpg>

Nov 17, 2004

Astronomy 230 Fall 2004

L.W. Looney

## Haystack: Frequency



- Would the signal be concentrated in a small range of freqs?
- What size should a channel be?
- Could argue that the best choice is around 1 Hz.
- Then in the 1-10 GHz band there are  $9 \times 10^9$  channels!
- With modern electronics we can survey large numbers of channels, but not that many.
- What's the history of SETI?

Nov 17, 2004

Astronomy 230 Fall 2004

L.W. Looney

## Project Ozma



- The first look for ET radio signals by Frank Drake in 1960.
- Used a 26 meter telescope in W.V. using the H atom frequency band of 1.42 GHz.
- Targeted search of 2 nearby stars that are the same age as our Sun: Tau Ceti in the Constellation Cetus (the Whale) and Epsilon Eridani in the Constellation Eridanus (the River), both around 11 lyrs away.
- 200 hours over 3 months.
- A single 100 Hz channel scanned 400 kHz.
- 1 false alarm due to a secret military experiment.
- Nothing detected at a sensitivity of  $10^{-22} \text{ W m}^{-2} \text{ Hz}^{-1}$



<http://www.angelfire.com/pa/maryanne/images/ozma.jpg>



Nov 17, 2004

Astronomy 230 Fall 2004

L.W. Looney

<http://216.120.234.103/setiprime/setiprime/images/images-2003.html>

## Ozma II



- Ben Zuckerman and Pat Palmer used the 91m telescope in W.V. to survey the 670 nearest "suitable" stars.
- Targeted Search of stars with low mass and binaries that allowed stable planet orbits.
- Also observed at 1.42 GHz with 192 channels of 4 kHz and 192 channels of 52 kHz.
- Could have detected a 40 MW transmitter on a 100m telescope.
- Observed for 500 hours.
- No detection at a sensitivity of  $10^{-23} \text{ W m}^{-2} \text{ Hz}^{-1}$  (10 times better than Ozma)

Nov 17, 2004

Astronomy 230 Fall 2004

L.W. Looney

## Ohio State



- In 1973 by F. Dixon and D. Cole.
- Used Ohio State radio telescope for a continuous survey of sky.
- Not steerable— sort of like Arecibo, so cuts a swath through the sky: A Sky Survey
- Searched overhead for signals.
- Modest sensitivity  $10^{-21} \text{ W m}^{-2} \text{ Hz}^{-1}$
- 100 times worse than Ozma II
- But not just looking at stars.
- Could only detect extremely strong transmissions.
- Again, 1.42 GHz with 50 channels of 10 kHz.
- Land was sold to a golf course development.



Nov 17, 2004

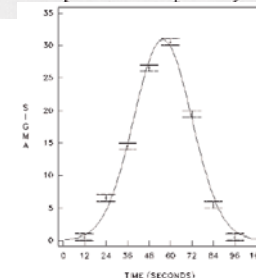
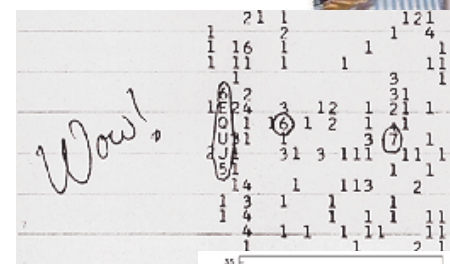
Astronomy 230 Fall 2004

<http://www.bigear.org>  
L.W. Looney

## The Wow Signal



- Aug. 15, 1977, Jerry Ehman was looking through the data when he recorded the Wow! signal.
- A major signal in the telescope—  $30\sigma$  detection!
- Unlikely to be noise, but never seen again.
- "Even if it were intelligent beings sending a signal, they'd do it far more than once."
- <http://www.bigear.org/xfiles.htm>



<http://www.bigear.org/ww.htm>  
Gray & Marvel 2001, ApJ 546, 1171

Nov 17, 2004

Astronomy 230 Fall 2004

L.W. Looney

## Paul Horowitz Searches 1.42 GHz



- Paul Horowitz moved from a small number of channels to many many many channels.
- 1983 Sentinel: 128,000 channels covering 6 kHz each
- 1985 META: 8 million channels with 400 kHz bandwidth.
- 1993: Horowitz and Sagan reported 8 unexplained signals that did not repeat.
- 1995 BETA: Nearly a billion channels ( $2.5 \times 10^8$ ) covering 2 GHz, 10 kHz channels. Windstorm blew the telescope over in late 1990s.

Nov 17, 2004

Astronomy 230 Fall 2004

L.W. Looney

## The NASA Search



- The most ambitious search was planned by NASA on the 500<sup>th</sup> anniversary of the Discovery of America— Oct 12, 1992.
- "In 1993, Nevada Senator Richard Bryan successfully introduced an amendment that eliminated all funding for the NASA SETI program. The cost of the program was less than 0.1% of NASA's annual budget, amounting to about a nickel per taxpayer per year. The Senator cited budget pressures as his reason for ending NASA's involvement with SETI."
- "The Great Martian Chase may finally come to an end. As of today millions have been spent and we have yet to bag a single little green fellow. Not a single Martian has said take me to your leader, and not a single flying saucer has applied for FAA approval."

<http://www.planetary.org/html/UPDATES/seti/history/History12.htm>  
<http://www.seti.org/about-us/faq.html>  
L.W. Looney

Nov 17, 2004

Astronomy 230 Fall 2004

## The NASA Plan



- 2 prong approach using both Targeted Search and Sky Survey
- Sky Survey:
  - NASA's 34 m tracking telescopes in CA and Australia.
  - 6 year plan covering 1-10 GHz with 16 million channels of 20 Hz each and 30 different settings.
  - Would only detect very strong signals.
- Targeted Search:
  - Cover 800 suitable stars within 75 lyrs.
  - 16 million channels with 1 Hz bandwidth
  - 1-3 GHz range and  $10^{-27} \text{ W m}^{-2} \text{ Hz}^{-1}$  sensitivity!

Nov 17, 2004

Astronomy 230 Fall 2004

L.W. Looney

## The SETI Institute



- An independent institute that was working with NASA on their SETI project.
- Once NASA cut funding, they went ahead with a more modest version of the Targeted Search—Project Phoenix.
- Now funded by private donors.
- Initially a search of 200 stars within 150 ly younger than  $3 \times 10^9$  yrs using an Australian 63 m telescope for 5 minutes on each target.
- Scanned 28 million channels each 1 Hz wide, used multiple settings to scan 1.2 to 13.0 GHz

Nov 17, 2004

Astronomy 230 Fall 2004

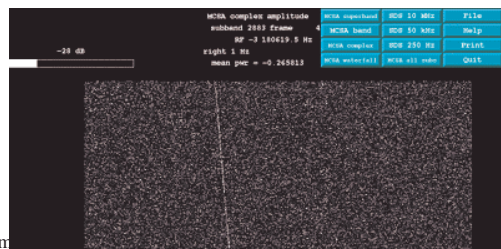
[http://www.seti.org/seti/our\\_projects/project\\_phoenix/overview/overview.html](http://www.seti.org/seti/our_projects/project_phoenix/overview/overview.html)

L.W. Looney

## Project Phoenix



- Still operating, but now at Arecibo
- ([http://www.seti.org/seti/our\\_projects/project\\_phoenix/overview/Welcome.html](http://www.seti.org/seti/our_projects/project_phoenix/overview/Welcome.html)).
- About 2-3 weeks a year of telescope time to scan a total of 1000 stars.
- They are about 1/2 way through their list.
- As of yet, no ET signals.
- Proof of concept was shown by tracking the Pioneer 10 spacecraft (launched in 1973) that is 6 billion miles away and broadcasting with a few Watts of power.
- The signal was detected.
- As the Earth and object are moving, there is a small Doppler shift in the frequency of the light received over time.



Nov 17, 2004

Astronomy

## Allen Telescope Array



- At the BIMA site, UC Berkeley and the SETI Institute with majority of funding from Paul Allen are building the ATA.
- 350 antennas that are 6.1 m in diameter.
- Area comparison: Arecibo (70650 m<sup>2</sup>) & ATA (10200 m<sup>2</sup>) but still > 100 m single dish.
- And small dishes—larger field of view.
- With advanced electronics it will cover 1-10 GHz with many channels.
- Can image a few stars per field.
- 100% SETI
- Will increase search to 100,000 or 1 Million stars.



Nov 17, 2004

Astronomy 230 Fall 2004

L.W. Looney

## *End All*



- The modern SETI searches are really expanding the frequency range in which we search, but we are still sensitivity limited.
- In any SETI experiment, what does a null result mean?

Nov 17, 2004

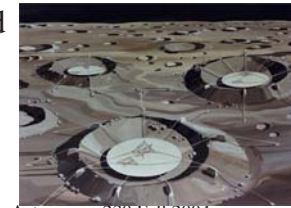
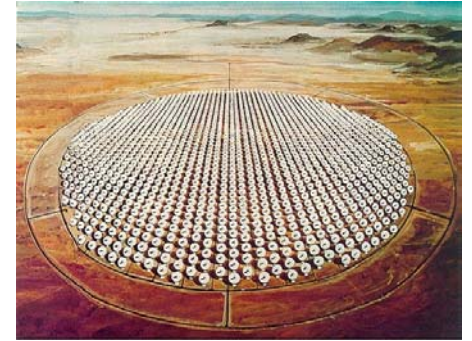
Astronomy 230 Fall 2004

L.W. Looney

## *The Future?*



- Cyclops – 1000 telescopes each 100 m in diameter.
- Resembles a giant eye.
- Could detect leakage transmission at 100 ly.
- Could detect a 1000 MW transmission at 1000 lyrs.
- Bucco Bucks– \$50B and 10-20 yrs to build.



Astronomy 230 Fall 2004

Nov 17, 2004

L.W. Looney  
<http://www.astrosurf.com/lombry/ovni-bioastronomie-et.htm>