Physics 155: Lecture 9  Radio Telescopes

Announcements

1931 Jansky at Bell Labs first noticed radio sources from sky
1937 first telescope built for radio range by Reber

We now see radio signals from the sun, moon, planets, galactic
gas clouds, other galaxies and special stars.

Radio waves are Electromagnetic Waves like visible light—you do
not "hear" radio waves. Radio waves do have special properties
by virtue of their long wavelength (8 mm to 17 m). They are
reflected off of atmospheric layers (which are lowered during
the day by sunlight). They are not affected by weather or clouds
(though do show "twinkling" or scintillation due to ions in
space). Manmade interference is a big problem. The Daytime sky
is "black" in radio range so we see further even though signals
are weaker.

Radio telescopes are similar to optical: rays are focused by a
"dish". There are two differences compared to visible telescopes:

a) in general any optical surface must have no holes or
bumps larger than \( \lambda / 10 \) (one tenth wave) in order for dif-
fraction not to be a problem. This means for the 200 inch Hale
in visible, the surface must be better than 2 millionths of an
inch. For radio waves of \( \lambda = 8 \) inches, surface needs to be
accurate to 1 inch so chicken wire is fine.

b) resolving power. In visible
\[
\alpha \leq 210,000 \times \frac{\lambda}{A} = 5/A
\]
\( \alpha \) is in seconds of arc
\( \lambda \) is in inches
\( A \) is in inches

However, in the radio range we must use the first equation
and insert radio wavelengths. Thus for 8 in wavelength waves ( a
half million times longer than visible) to resolve the same
stars we resolve with the roof telescopes (where A= 6 inches and
\( \alpha = 1 \) second in visible), you'd need a radio telescope 30 miles
in diameter (or again, a half million times the aperture)!

Another example: a 50 foot dish tuned to the 21 cm radiation has
a resolving power of 10 (less than the human eye's).

Astronomers use clever tricks to avoid the natural poor
resolution of radio telescopes:

- two dishes operating as an interferometer
- long based interferometry (CA and Sweden)
- a large fully steerable dish--biggest is Jodrell Bank,
England (which stole the Sputnik data showing the backside of
the moon for the first time!)
- a large partially steerable dish like the famous 300 foot
one at the National Radio Observatory in Greenbank, WV (which
totally collapsed in 1988)
Mills' Cross arrangement (antennas on crossed rails) aperture synthesis telescope (simulates huge aperture with precisely spaced few dishes)

Arecibo Radio Telescope in Puerto Rico -- uses 1000 foot collapsed sinkhole spherical to within 1%, lined at first with mesh, more recently with thin aluminum. The single antenna is suspended on cables and can point to 20° of zenith; since it's near the equator the maximum number of objects drift overhead.

Other "tricks" to help radio astronomy:

- use of fancy electronic detectors such as H masers
- use of occultations by the moon's sharp airless limb to help pinpoint vague sources, provided they lie along the ecliptic.

A few words about SETI: in honor of upcoming Columbus Day (the 500th anniversary of Columbus' landing in North America) NASA plans to turn on a $100 million dollar ten-year Search for Extraterrestrial Life, using Arecibo and Goldstone Deep Space Telescope in CA. A number of earlier searches have been made starting in the 60's (Project Ozma) but the proposed search fully exploits modern signal processing and offers a good chance for success if anything's out there. 14 million channels (frequencies) will be monitored at a time (concentrating on the "water hole" optimal spectral range) in a detailed study of 800 solar type stars within 50 light years of earth in the targeted search. A second component is an all-sky sweep over wider frequency band and lower sensitivity. Total cost is 5 cents/U.S. citizen annually and the opportunity is fast disappearing with the ever-expanding radio interference problem. Consequences of contact are enormous.