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Radio Astronomy

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What is Radio Astronomy?

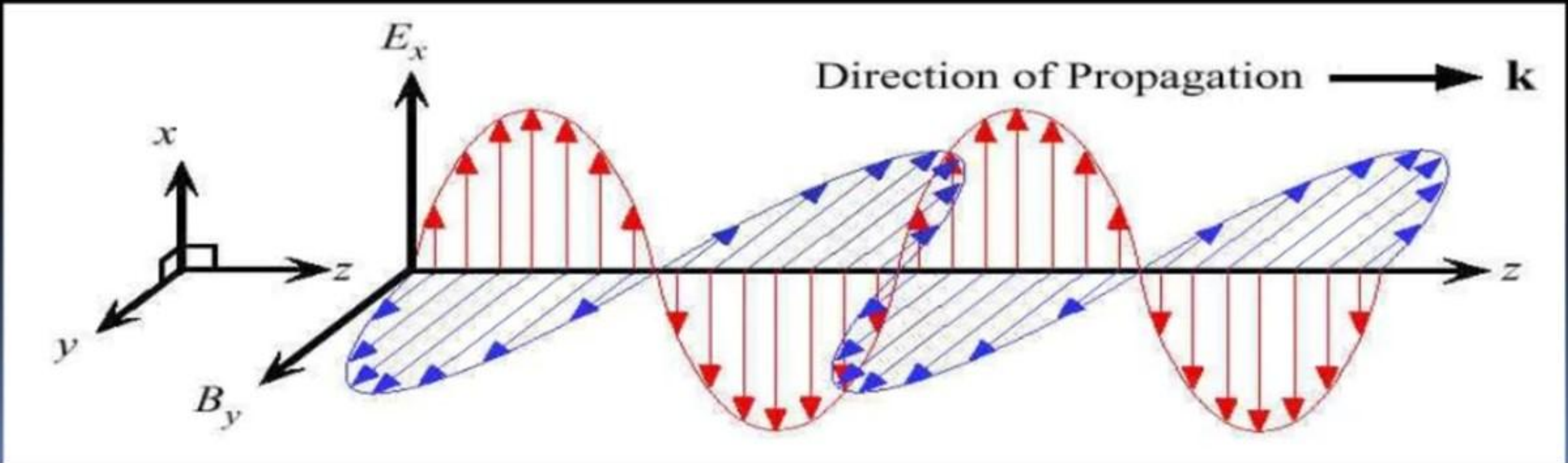
- Astronomy at wavelengths from a few mm to tens of meters
- Visible light has wavelengths in the region of 500nm, that is, 5×10^{-7} meters
- From a physics standpoint, there's no difference between visible light, and microwave/radio-wave "light".
- Living things have receptors for only a tiny part of the EM spectrum

History of Radio Astronomy

- Like much in science, it was discovered accidentally
- Karl Jansky, 1933, working on sources of static on international radio-telephone circuits at wavelengths of 10-20m.
- Discovered that static rose and fell with a period of 23 hours, 56 minutes.
- Must be of celestial origin
- Built directional antenna
- Pinpointed source at galactic centre, in Sagittarius

James Clerk Maxwell

Tied together theories of electricity and magnetism (Maxwell's equations) to derive the electromagnetic theory of light

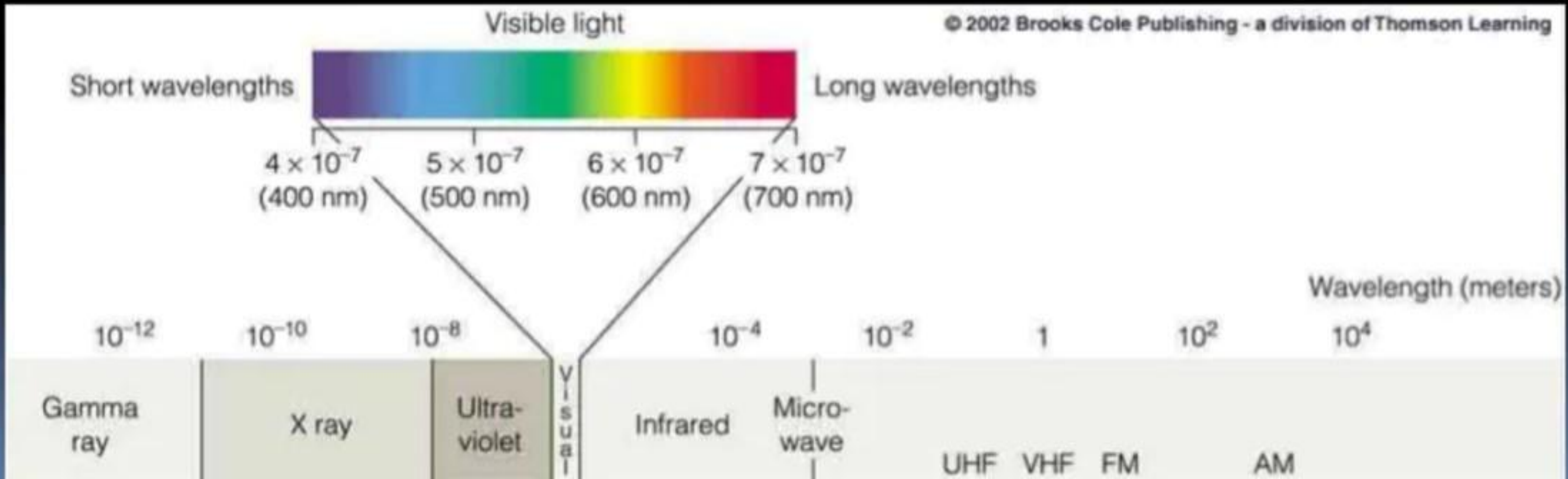


- Electric and magnetic fields oscillate together with the same frequency and period

- Electromagnetic waves do not require a medium!

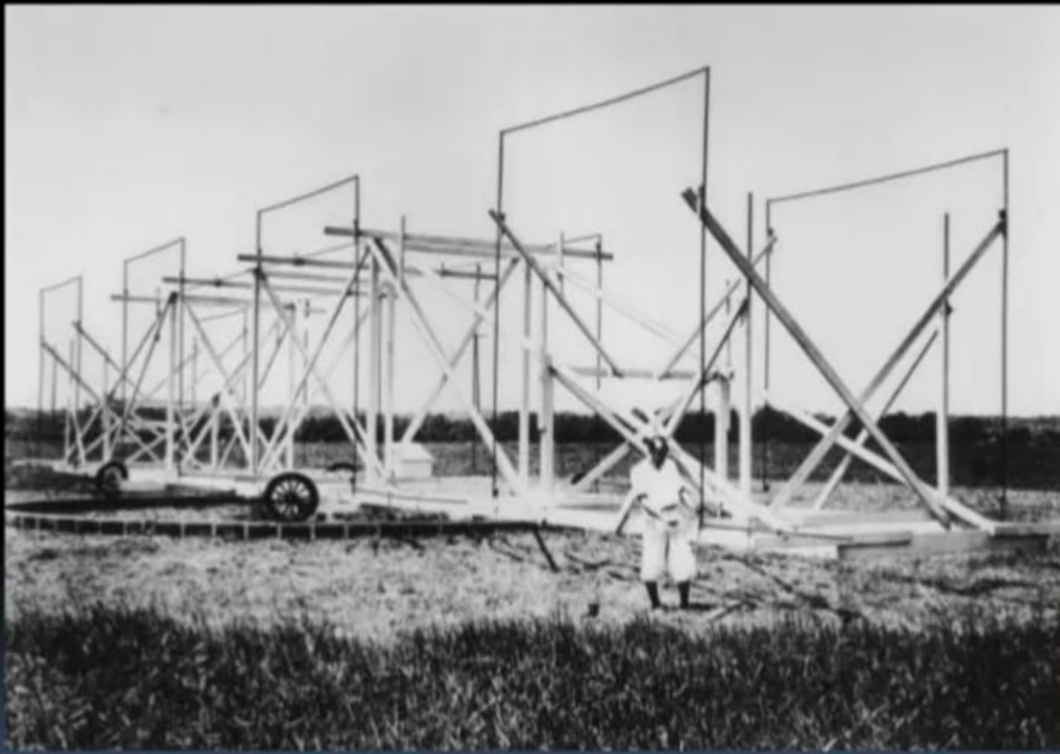
- The velocity and wavelength spectrum are define

$$c = \lambda f$$



Karl Guthe Jansky

Founder of Radio Astronomy



Hired by Bell Labs in the late 1920's, Jansky's mission was to find sources of radio interference

- Jansky constructed a directional 20.5 MHz antenna on a turntable to locate radio noise source positions

- Sources of noise
  - Nearby storms
  - Distant storms
  - A faint hiss that returned every 23 hours 56 minutes

Grote Reber

Radio Astronomy Pioneer

- After Jansky's project ended, Bell Labs was not interested in studying radio astronomy
- Reber continued Jansky's original work, by constructing his own radio telescope in 1937
- Provided the first maps of the radio sky at 160 and 480 MHz

Radio Astronomy Today

- Radio Astronomy at the cutting-edge of astrophysical research
  - Roughly 70% of what we know today about the universe and its dynamics is due to radio astronomy observations, rather than optical observations
- Big projects all over the world
  - VLA, New Mexico
  - Arecibo, Puerto Rico
  - GBT, Green Bank, West Virginia
  - Westerbork, Jodrell Bank, ALMA, Hat Creek, SKA, etc

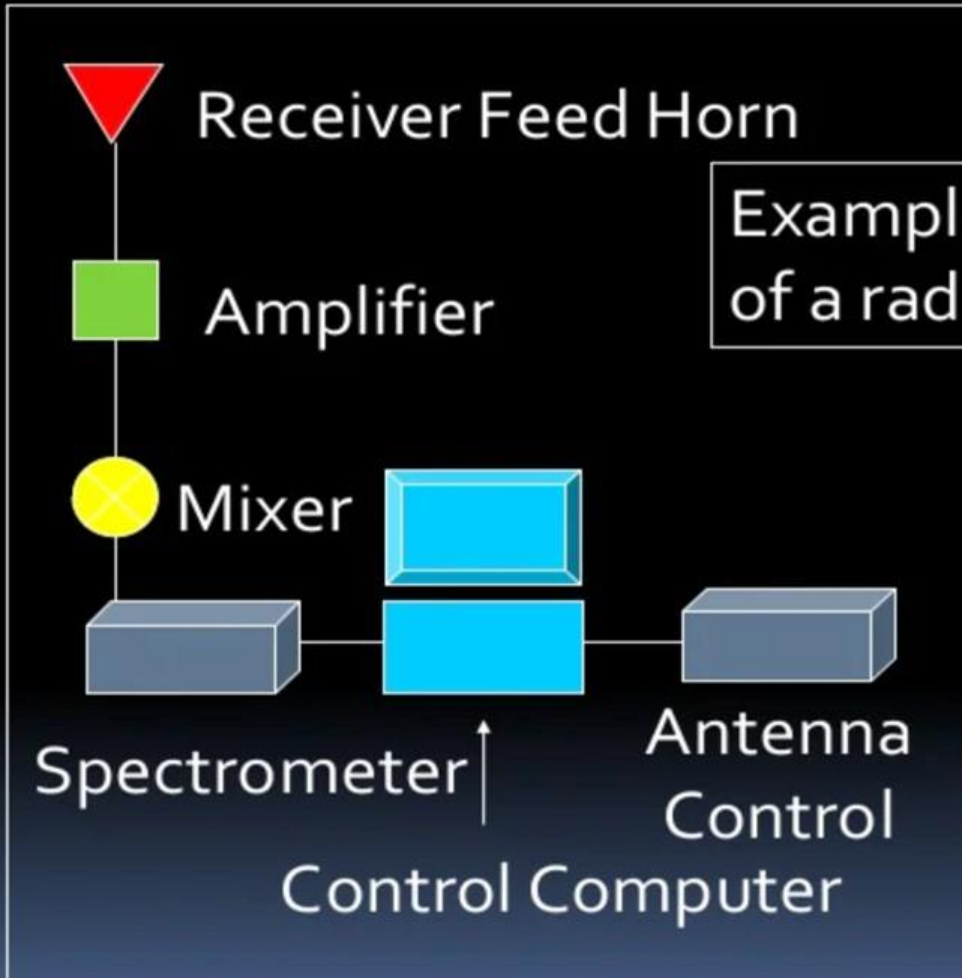
Scientists named the basic flux unit after Karl Jansky

- 1 Jansky == 10^{-26} watts/hz/meter^2

Colors of light we can't see…

- Ionizing Radiation
  - UV
  - X-Rays
  - Gamma Rays
- Non-Ionizing Radiation
  - IR
  - Microwave
  - Radio

Example signal path of a radio telescope

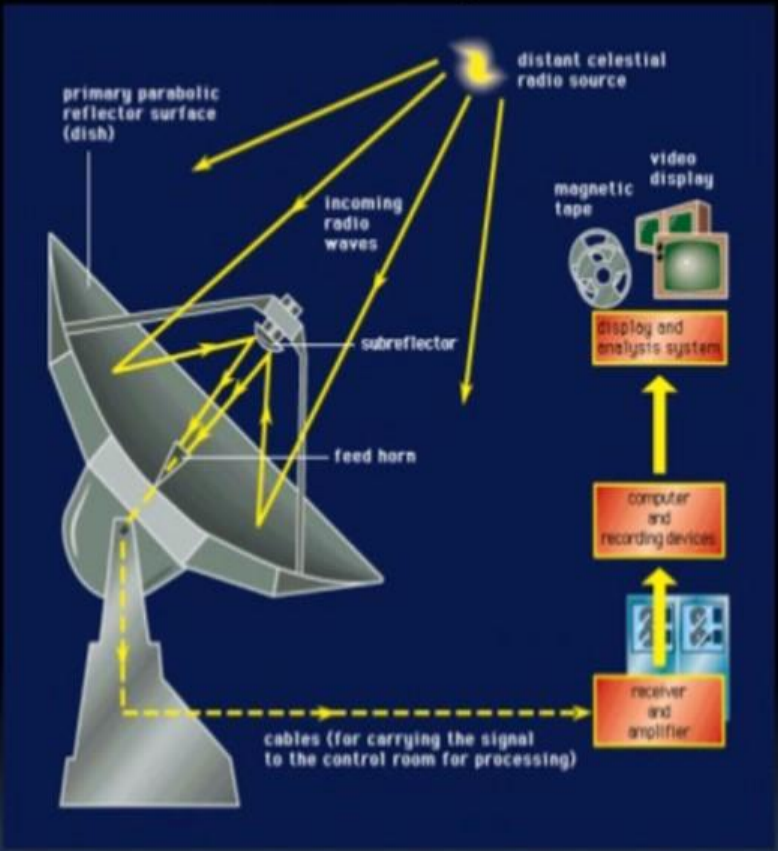


- Radio waves are VERY weak!

- Radio brightness measured in units of Janskys
  - 1 Jansky (Jy) = 10^{-26} W/m^2/Hz

- Typical sources:
  - Sun: 10,000's of Jy
  - Brightest Supernova Remnant: 1000's of Jy
  - Active Galactic Nuclei: 10-100

Radio Telescope



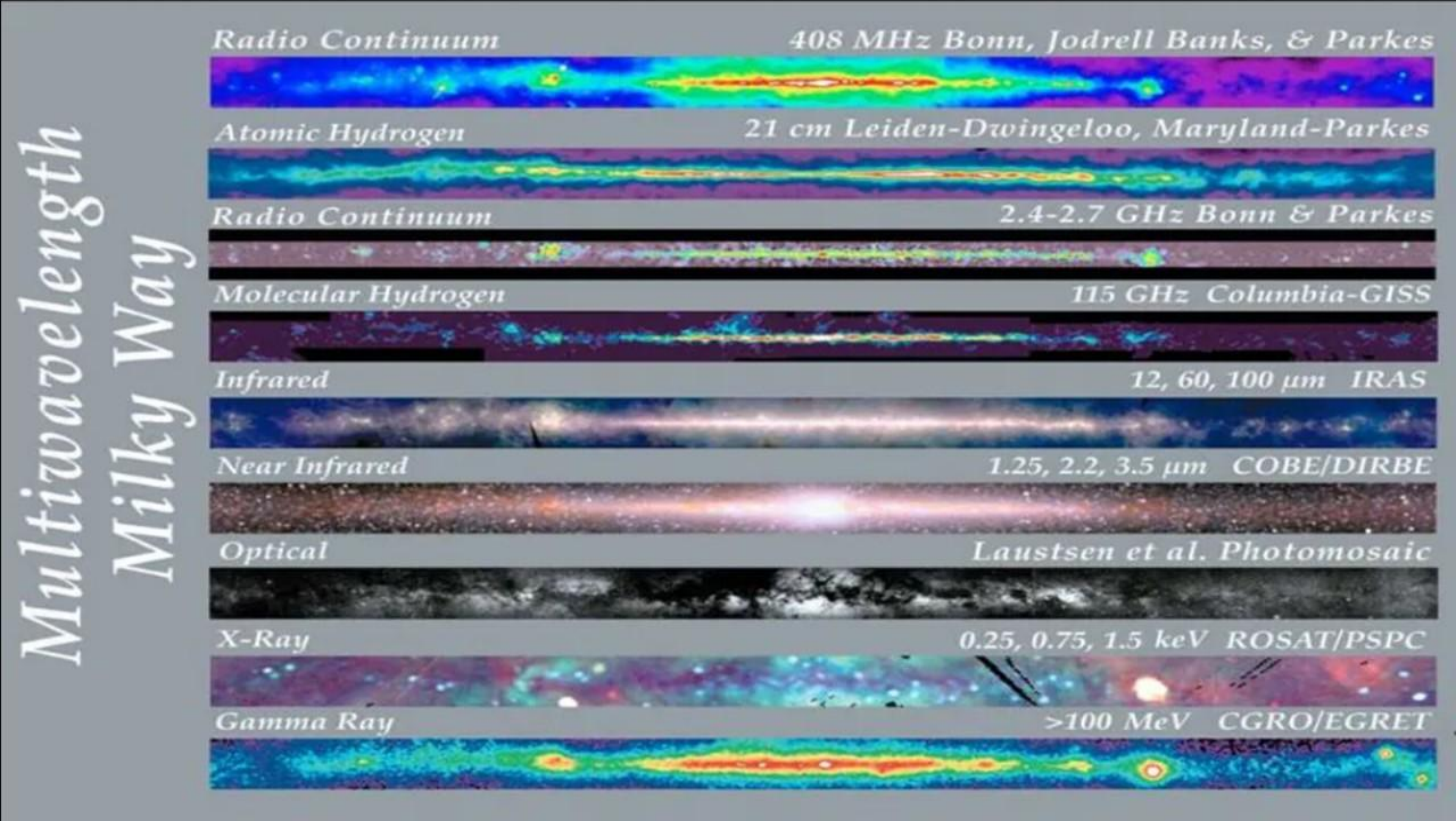
Optical Telescope

Now a days, there are more similarities between optical and radio telescopes than ever before

Multi-wavelength Astronomy

Type of Radiation	Wavelength Range (nanometers [10^{-9} m])	Radiated by Objects at this Temperature	Typical Sources
Gamma rays	Less than 0.01	More than 10^8 K	Few astronomical sources this hot; some gamma rays produced in nuclear reactions
X-rays	0.01 - 20	10^6 - 10^8 K	Gas in clusters of galaxies; supernova remnants, solar corona
Ultraviolet	20 - 400	10^5 - 10^6 K	Supernova remnants, very hot stars
Visible	400 - 700	10^3 - 10^5 K	Exterior of stars
Infrared	10^3 - 10^6	10 - 10^3 K	Cool clouds of dust and gas; planets, satellites
Radio	More than 10^6	Less than 10 K	Dark dust clouds

Astronomy expands to the entire spectrum



The Ideal Radio Telescope

- Directional antennae, such as those with reflectors, isolate the radio power from single sources to reduce confusing radiation from others

- Low temperature receivers are more sensitive

- Large collecting areas increase gain and resolution

- Resolution: roughly 57.3 λ/D degrees (λ: observing wavelength, D: diameter of aperture)

- Optical telescopes have an advantage on radio telescopes in angular resolution

- A one meter optical telescope has a resolution of 0.1 seconds of arc.

- Since radio telescopes cannot be built large enough to match optical resolution, they can be combined as an interferometer to emulate a large single dish

Radio Telescope

receiver

parabolic reflector

control room

The 140 Foot Telescope

Green Bank, WV

Reception of Radio Waves

Radio Telescope Arrays

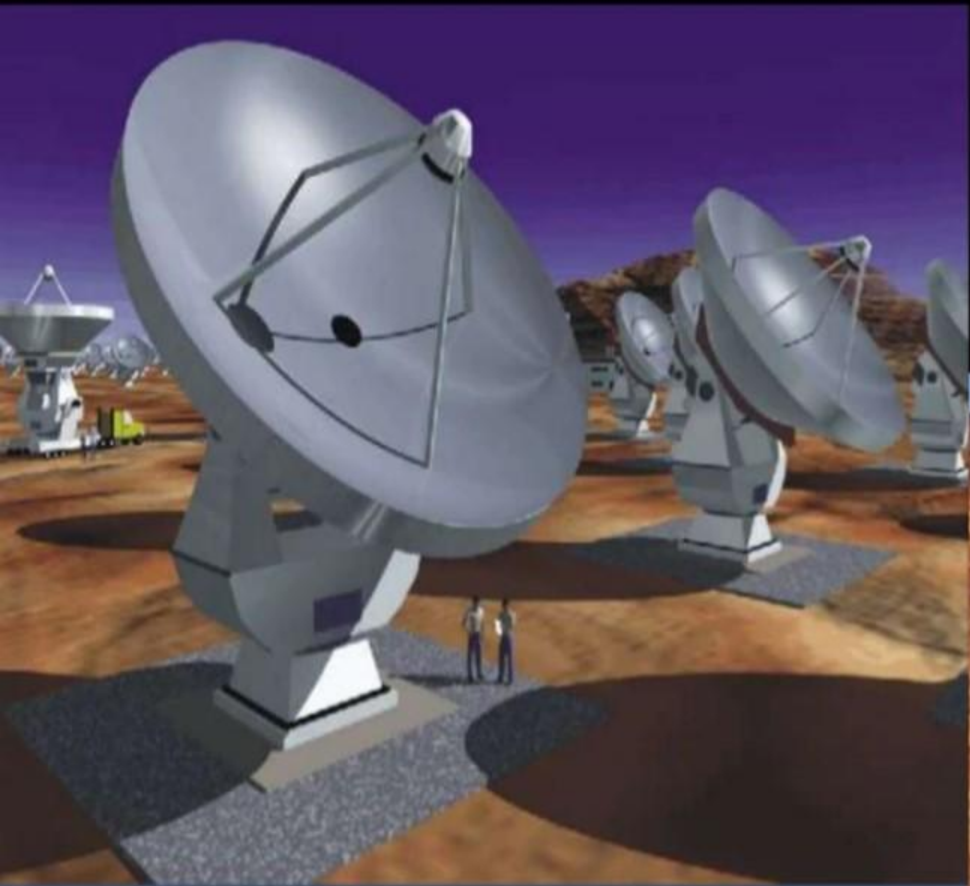
The VLA:

An array of 27 antennas with 25 meter apertures

maximum baseline: 36 km

75 Mhz to 43 GHz

Radio Telescope Arrays



ALMA:

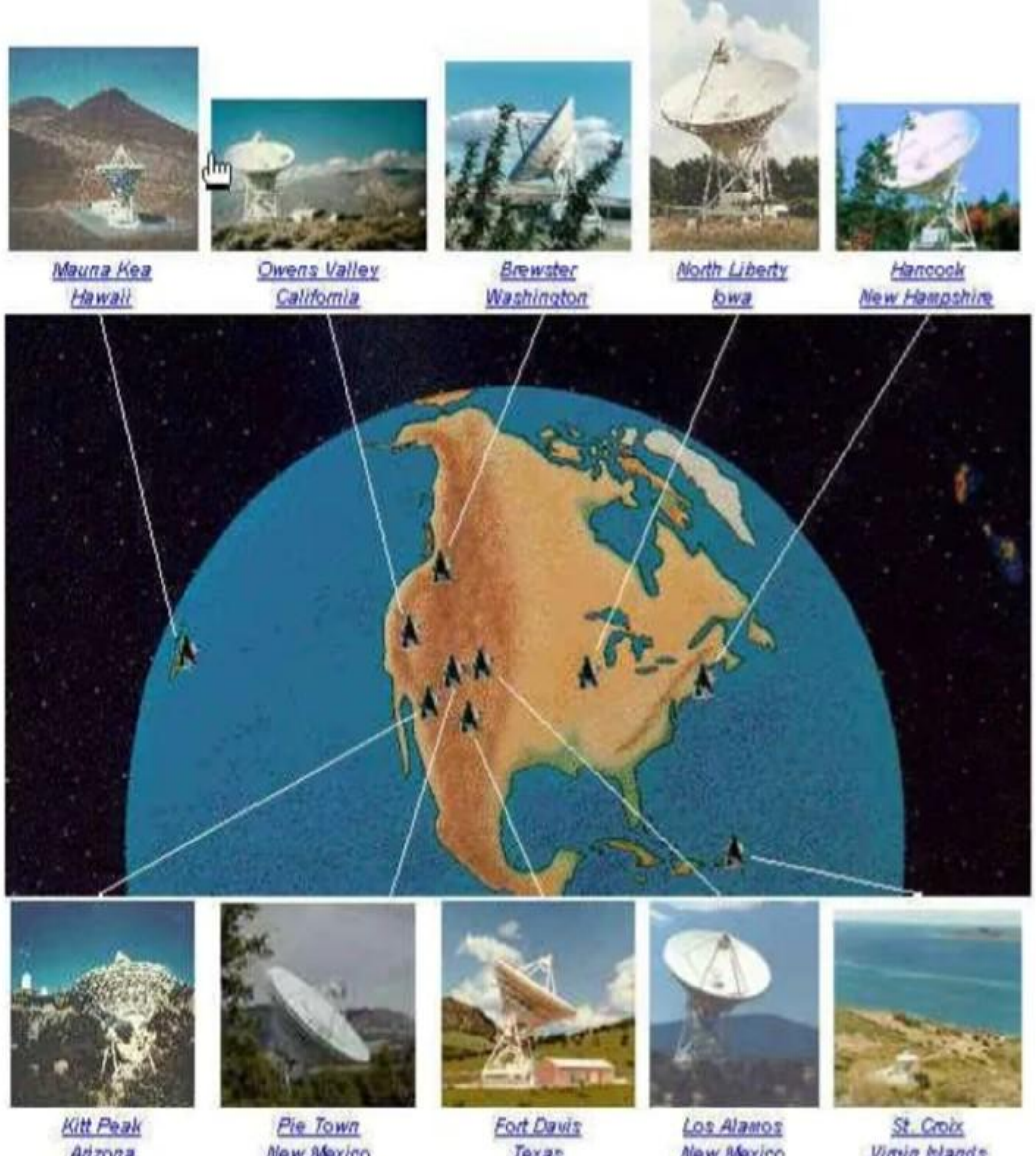
An array of 64 antennas with 12 meter apertures

maximum baseline: 10 km

35 GHz to 850 GHz

Greenbank (WV) 100-m telescope in has a resolution of 7 arc-minutes

300-m telescope in Arecibo, Puerto Rico
(resolution – 2.4 arcminutes)



10 Antennas of the Very Long Baseline Array
(resolution – 5 milli-arcseconds)

Tools of Radio Astronomy

- Your FM radio is an example of a simple antenna and receiver
- Radio waves actually cause free electrons in metals to oscillate!
- Radio receivers amplify these oscillations, so, radio telescopes measure the voltage on the sky

Radio Astronomy Instruments

- Parabolic reflector
  - From a few meters to over 300m!
- Focal-plane antenna at focus of reflector
  - Waveguide
  - Dipole
  - Various
- One or more **L**ow **N**oise **A**mplifiers
  - Professional instruments chill the amplifiers in liquid Helium to reduce inherent electronic noise
  - Amateurs don't (usually) have that option
    - Use the best amplifiers they can afford
    - Sometimes chill with dry ice

Radio Astronomy instruments cont…

- Receiver chain
  - Spectral
  - Total-power
  - Pulsar
- Back-end data processing
  - Pulsar processing can require enormous computer power
  - Total-power and spectral can require large amounts of storage space

Solar system objects

- Sun
  - Very strong microwave emitter
  - Makes daytime observing of weaker objects impossible
  - Upper solar atmosphere strong black-body emitter
- Moon
  - Black-body radiation with surface temperature around 200K
  - NOT reflection of solar microwave radiation!
- Jupiter/Io
  - Io plasma torus interacts with Jupiters magnetic field
  - Synchrotron emission peaked at 20-30MHz

New Radio Astronomy science

- Many "big science" RA projects underway
  - SKA Square Kilometer Array
    - Goal is to build a multi-dish telescope with an effective collecting area of 1km^2 or more!
  - ALMA Atacama Large Millimeter Array
    - 80 dish array, movable dishes
    - Located 5km up on the Atacama plain, Chile
    - Allows observing millimeter and submillimeter wavelengths
  - New CMB satellites: WMAP, PLANCK
    - More detailed maps of the CMB anisotropy

CONCLUSION

- The radio astronomy is use to information of universe and capture the image when he light has came or not seen
- A radio telescope uses a large concave dish a\t reflect radio wave to a focal point
- Radio telescope record signal from the sky
- A clever technology enables radio astronomers to produce resolution radio image the idea behind interferometry is to combine the data receiver simultaneously by two or more telescope

Abstract

- High angular resolution images of extragalactic radio sources are being made with the Highly Advanced Laboratory for Communications and Astronomy (HALCA) satellite and ground-based radio telescopes as part of the Very Long Baseline Interferometry (VLBI) Space Observatory Programme (VSOP). VSOP observations at 1.6 and 5 gigahertz of the milli–arc-second–scale structure of radio quasars enable the quasar core size and the corresponding brightness temperature to be determined, and they enable the motions of jet components that are close to the core to be studied. Here, VSOP images of the gamma-ray source 1156+295, the quasar 1548+056, the ultraluminous quasar 0014+813, and the superluminal quasar 0212+735 are presented and discussed.

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