CNRS & Observatoire de Laurent Pagani Paris-PSL



















interferometers? Which images show







Answer on overleaf







Some radio telescopes have receivers with

camera, but without spectral resolution. These receivers are called 'bolometers';

the frequency is too high to be amplified directly, the frequency is changed first,

to a lower value, before being amplified.

This is the so-called heterodyne

technique.

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to be finally analyzed by a computer. If

frequency range

signal is then amplified and filtered in a

mirror and then to a detector. The reflects the signal to a secondary primary mirror, metallic and large,

they are useful for observing cold interstellar dust that emits high-

frequency radio waves.

hundreds to thousands of pixels, like a



Quiz

movements in the clouds where stars are

possible to measure very small

and filters

Schematic of a radio telescope. The

Amplifier

concave metallic Primary mirror (parabolic) Cable formed and to identify hundreds of

different interstellarmolecules.

point. These points are then assembled to Single-dish radio telescopes often observe obtain an image or map'. On the other hand, only one point in the sky at a time (called a sensor. To obtain an image, the telescope theirreceivers can detect a wide range of frequencies at the same time with a very pixel") because their receiver has only one high 'spectral resolution'. This makes it must scan the entire surface point by

The Universe in my pocket

Radio telescopes

Computer and

Radio wave coming from the sky

(IRAM - J. Boissier)

diameter each observe the same

theEarth in orbit around RadioAstron telescope The 10 m Russian radio

substantial, limiting the resolving

Because λ is large, diffraction is

is in arc minutes.

the diameter of the telescope, and θ

 $\lambda/D/O.OOO3$; λ is the wavelength, D page). The angular resolution is $\theta \approx 1.2$

perceptible (see figure on the opposite

exist in radio and diffraction is turbulence. This problem does not telescopes is limited by atmospheric For visible light, the resolution of

Size and resolution

FAST, in China, 500 m in diameter, is the

largest fixed radio telescope in the world.

The Green Bank

approximately 100 m,

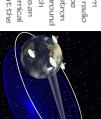
telescope in the world. is the largest mobile with a diameter of Telescope, in the USA,

anthropogenic emissions by the frequencies are protected from interference. Certain radio factories that produce electrical to electrical interference. They are large antennas that are very sensitive this, radio astronomers use extremely power of radio telescopes. To mitigate

located far from urban centers and

International Telecommunication

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same time source at the astronomical observes an

resolution is that of an equivalent radio as the telescopes on the ground. The

disperses in various the wave that arrives Diffraction pattern: on the obstacle directions.

meter (IRAM). 12 antennas of 15 m NOEMA, the Plateau de Bure interfero-

astronomical source simultaneously

remains very small, so only very bright objects can be observed. 12in blue in the figure) but the collecting surface telescope larger than the Earth (represented

Radio technique

come to us from the Universe. capture the very weak signals that antennas pointed towards the sky to techniques associated with large Radio astronomy uses all the radio radio wave in reception, or creating sensitive to the electric field of the structure of conductive metal, magnetic part. It is emitted or itself. Rather, it interacts as a wave, TUIMP 43) does not generally manifest corpuscular nature of radio light (see Because of its low energy, the Note that radio telescopes can this electric field in transmission. received with an antenna - generally a composed of an electrical part and a

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observe both day and night, because

the sky does not emit in radio waves

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See the illustrations on page 12.

The resolution of an interferometer is most-distant antennas. Such a large telescope with a diameter equal to the separation between the two similar to that of a single-dish single-dish telescope would be

The distances between the antennas 10m Russian RadioAstron telescope. the Earth, or even more if one of the antennas is placed in orbit, as is the can be enormous, up to the size of

Interferometers

Radio telescopes can also be made by putting several antennas into service

1 arcminute

After initial unsuccessful attempts to

detect radio waves from the Sun

between 1896 and 1901, it was Karl

Jansky who made the first discovery

emitted by the center of the Milky

Way, in 1932.

of extraterrestrial radio waves,

footballs side-by-side at 1 km distance The eye has a resolution of one arc

mixed or 'interfered' with each other.

coming from all the antennas are

interferometry' because the signals

simultaneously. This is called 'radio

and combining their signals

minute, thus one could distinguish 2

An optical telescope has a resolution of one arc second. This is 60 times better FAST has even less resolution than the up to 60 km away or 2 dice at 1 km.

separate the 2 balls at 300 m (less Radio interferometers can see tiny eye: three arc minutes. It can only than the size of the antenna!).

could see a ping-pong ball on the Moon.

than the eye, so it can distinguish 2 balls Some examples of angular resolution:

From then on, radio astronomy made

science and very complementary to

rapid progress to become a rich

traditional optical astronomy (see

ruimp 46).

second. At this extreme resolution, they thousandths or even millionths of an arc details. Their resolution is measured in

neterodyne detection (measuring the

(measuring the signal energy) or

detection of light, as in optics

incident electric field), which allows amplifying the signal and filtering it

with high precision thanks to radio

frequency electronics.

Radio astronomy can perform direct

totally transparent from 3 cm to 20 m and partially blocked by water vapor which is high altitudes to improve the transmission advantageous to locate radio telescopes at 0.3mm. At short wavelengths it is partially transparent between 3 cm and 1 mm to tens of km in wavelength. The sky is wavelength. Radio waves cover from about Transparency of the sky as a function of mostly present at lower eleva capture a radio wave same principle: they work on the All these devices or an image. demodulate to deliver as sound which they amplify and several always composed of antennas. Interferometers are (radio telescope) Nobeyama Antenna



The Universe in my pocket no 45





de Paris and Stan Kurtz from IRyA Grażyna Stasińska of the Observatoire Paris and the CNRS and reviewed by Laurent Pagani of the Observatoire de This booklet was written in 2025 by



Jodrell Bank



telescopes: MEERKAT

(Unless otherwise specified, general credits: <u>Cover image:</u> one of the latest radio

Wikipedia)



Answer







radioheliograph



TUIMP Creative Commons franslation: Otan Kurtz



impossible to build. because the Allies knew that their planes, were reused after WWII to make the first The Sun's emission was first detected in These German radars (called Würzburg) 1942 by the British physicist James if they had the sun behind them, would Hey. This discovery remained secret not be detected by German radars. steps in radio astronomy in Europe.

Antenna of a Würzburg radar



Introduction

captured by the eye (the so-called talkies, cellular phones and radars. therefore a very low frequency (\vee) thousand to billions of times longer) and compared to visible light (from a These waves have a length (λ) very long discovered at the very end of the is light, of which only a small part can be TUIMP 43). The best-known messenger capture the messages it sends us (see such as radio or television sets, walkie: to transmit and receive radio waves, We have been able to build many devices $(c = \lambda \times v)$, where c is the speed of light). used ever since: radio waves. 19th century and has been widely types of light, one of which was the rainbow). But there are many other visible light, consisting of the colors of To observe the cosmos, we must