Amateur Radio Astronomy

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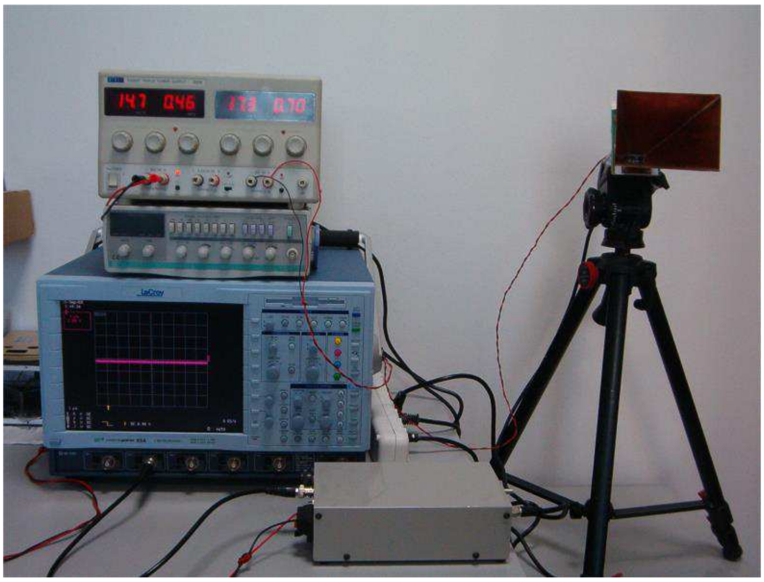


After a brief introduction on the theoretical and technical principles of radioastronomy, the author proposes to link the concepts of the discipline with the activity of amateur research. They will discuss some areas of work truly accessible to amateur experimenters, and the possible outcomes within the description of feasible projects, together with the analysis of the equipment and the necessary instruments to conduct a successful amateur observations (antennas, receivers, acquisition and automatic data logging). The observations range from receiving very low frequency (lower spectrum) of electromagnetic phenomena induced by the ionosphere and linked to local natural events (Schumann resonances, atmospheric electrical phenomena, electrical activity in the earth's crust, ...), to phenomena induced by astronomical events (activities meteoric and solar interference), to the description of receiving systems capable of monitoring the powerful and sporadic emissions that occur at wavelengths decametric of Jupiter and the Sun. Interesting is the construction of microwave radiometers that measure the thermal component of solar radiation or other important radio sources.

Finally, some electronic modules are described, equipped with the necessary software, developed for amateur radio astronomy applications: using such devices any investigator will be able to approach the radio astronomy building instruments operating in various frequency bands, with different performance and cost. This material, available in kit form or as a complete instrument ready for use, it should contribute to the diffusion of this fascinating discipline and allow the creation of a network of amateur radio astronomy stations with characteristics comparable and repeatable.

Introduction.

The astrophysical observations collect and classify information from cosmic objects in order to understand the physics and make predictions about their evolution. These data allow scientists to develop models and theories suitable to describe the phenomena studied. Astronomy experimental traditional "carriers" of information are the photons (which encompass the entire electromagnetic spectrum): the type of photons produced depends on physical conditions prevailing of sources, from the nature of the particles responsible for the radiation and by a series of variables (temperature and pressure), as well as by their dynamic and by the presence of magnetic fields. Each natural phenomenon manifests peculiar spectral characteristics, focusing on the production of energy in specific frequency bands: some celestial objects are studied more easily in certain wavelengths, although there is no, in fact, a single spectral range can fully characterize a phenomenon. Although the detection techniques are very different in the various ranges of the electromagnetic spectrum, the data acquired globally lead to results physically consistent and complementary.

Radioastronomy, powerful media and fruitful results, studies the celestial bodies by analyzing the electromagnetic radiation emitted by these in the spectral range of radio waves (frequency range between about 20 MHz and 300 GHz) using the radiotelescopes. A *radiotelescope* is a complex measuring instrument that includes an antenna system connected to the receiving equipment and automatic data logging. The analysis of the received signals is to determine the intensity of cosmic radiation captured by the different directions of space and for different wavelengths, in addition to their degree of polarization. A further area of investigation involves the analysis of the spectral characteristics of the received signals to obtain important information about the objects that emit radio waves.

It seems obvious the function performed by a radiotelescope: Collect the weak electromagnetic energy coming from outer space and amplify it in sufficient quantity to allow proper measurement. It is equipped with a radioantenna sufficiently directive that measures the equivalent noise temperature associated with the emission of radio-energy coming from cosmic objects. The instrument behaves as an optical telescope even if, in the case of radioastronomy, the collection surface of the antenna may require very large areas. This surface is imposed by the requirements in sensitivity of the instrument and, above all, by the need to reach an adequate resolving power, ie the ability to distinguish (resolve) the two sources are very close or details of a radiosource extended. This performance require the antenna system size proportional to the operating wavelength: given that the wavelengths belonging to the radio spectrum are greater than those in the optical band from one hundred thousand to ten million times, for radiotelescopes will have heavy restrictions from constructive and economic point of view, also to achieve decisive powers much lower than those commonly in use in astronomy optics. These are precisely the characteristics that differentiate and specialize instruments used in radioastronomy than those used in optics.

The history.

Radio astronomy was born by chance in 1931 by K. Jansky, a radio engineer engaged (on behalf of Bell Telephone Co.) in the study of natural and man-made noise which limited the reliability of the first commercial radio communications. Working with a receiving apparatus (at a frequency of 20.5 MHz) specifically built and connected to a rotatable antenna system of moderate directivity (Fig. 1), he recorded a "noise" constant of natural origin that seemed to come from the direction of the galactic center (constellation of Sagittarius - Fig. 2): it was the radio emission of the first cosmic source.

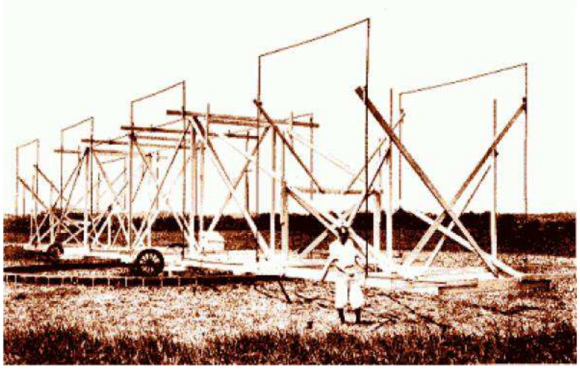


Fig. 1: The first, historical, radio astronomy antenna (1931), the famous " Jansky carousel". The structure, able to rotate 360°, was organized as an array of square loop connected to a receiver custom built.

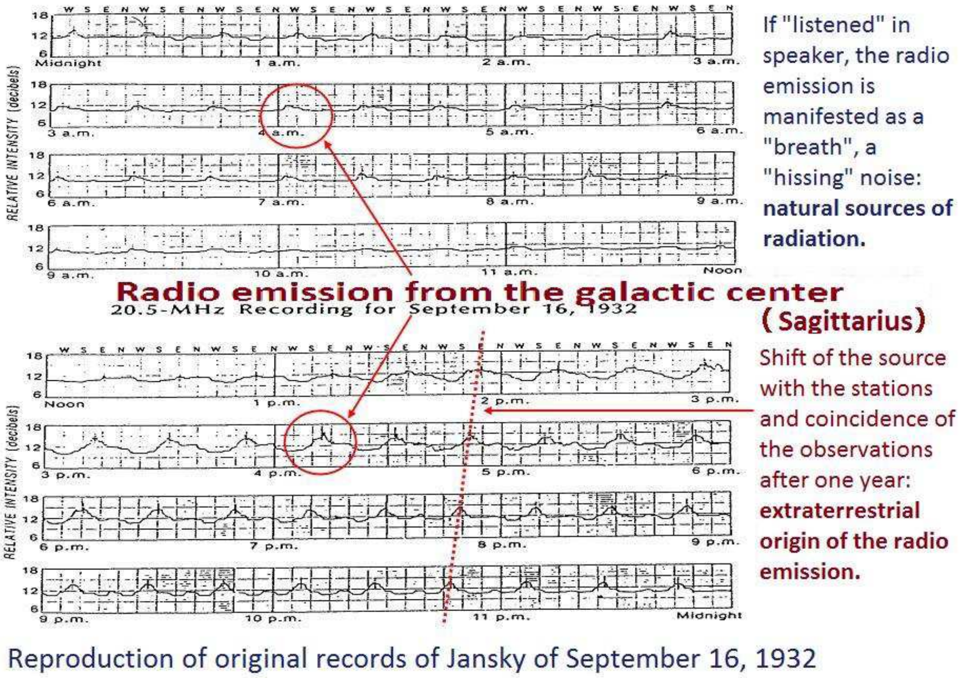


Fig. 2: The first radio astronomical data recorded by Jansky.

Although the characteristics of the instrument of Jansky were not too good compared to the apparatuses of today, he was able to reveal the emission of the Galaxy due to its efficiency as a "radio transmitter" in the band of wavelengths decametric (the so-called *short wave*). The full development of radioastronomy came after World War II, stimulated by the growing availability of sophisticated and sensitive electronic equipment born with radar techniques. The first real radiotelescope, designed and built "ad hoc", was a system of G. Reber (American amateur and very skilled technician): the instrument (Fig. 3) was composed of a parabolic reflector antenna of about 9 meters in diameter, built in the garden of the house with a wooden structure covered with wire mesh from stables meshed, connected to a receiver and a chart recorder placed in the laboratory in the cellar. With this tool, working at a frequency of 160 MHz, along with admirable patience and tenacity, Reber compiled and presented to the scientific community the first radio-map of our Galaxy: the lines were drawn at constant flow in a cartographic representation of galactic coordinates (Fig . 3). It is shown, for the first time, the structure of the Galaxy to radio frequencies, with emission peaks located in the region of Sagittarius (the galactic center), Cygnus and Cassiopeia (two of the most intense radiosources in the sky). This scenario corresponds to what we would see if our eyes were sensitive to radio waves with frequency around 160 MHz, rather than the light.

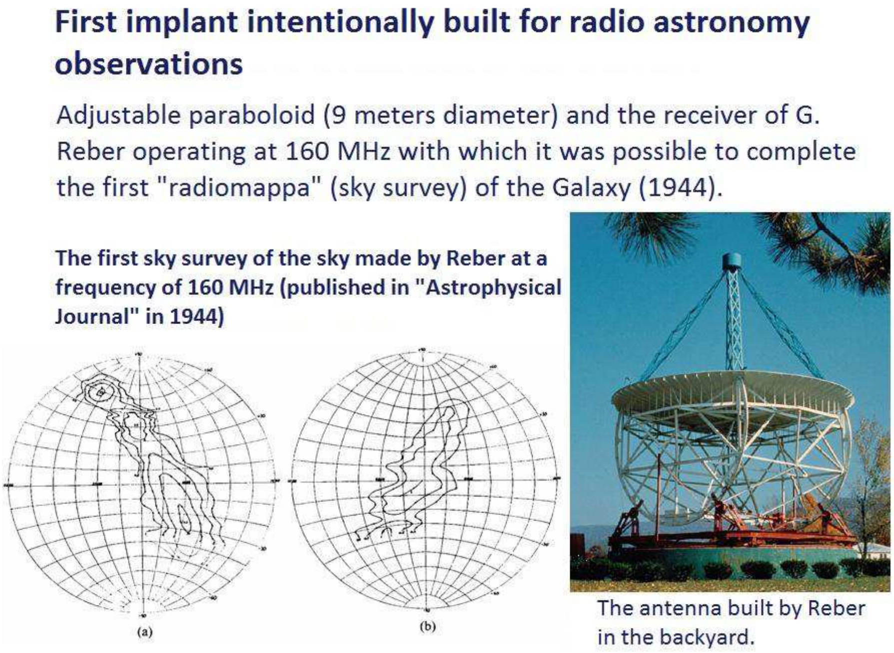


Fig. 3: The first radio-sky map compiled by G. Reber with his instrument, considered the prototype of the modern radio telescope.

Solicited the attention of the scientific world to this new and effective observational methodology, rapid has been the development of radioastronomy, dotted with countless discoveries of fundamental interest in astrophysics and cosmology (the discovery of the neutron stars, *pulsars*, the fossil radiation at 3 K, the distant objects *quasars*, the emission line to 1420 MHz neutral hydrogen clouds of interstellar and numerous organic molecules). The latest and most advanced radioastronomy techniques include the development of *radio-interferometry* (traditional and long baseline - VLBI), and radioastronomy in space. The future of radioastronomy involves improvement of interferometric techniques with very high resolution from ground-based instruments and instruments aboard satellites, the installation of radiotelescopes on the far side of the Moon, the development of systems SKA (Square Kilometer Array).

It is interesting to note that the birth of radioastronomy and some of its milestones are due to random findings of experts in radio technology but not astronomy, engaged in the study of technical issues related to radio communications.

The instrumental technique.

It's called radio telescope the instrument that measures and records the flow of radio waves produced by natural celestial sources (radio sources). In its simplest form is composed of an antenna (or a system of antennas), a transmission line, a radio receiver and devices for processing and recording the acquired

data. This also includes any pointing and control organs. A telescope is not, conceptually, too different from a normal radio receiver.
The "observation window" is that of radio waves, bounded below by the known effects of shielding of the Earth's ionosphere, above the phenomena of molecular absorption mainly due to water vapor (with absorption peaks at frequencies of about 22 GHz and 184 GHz) and oxygen (with absorption peaks at about 60 GHz and 118 GHz). A representation of the atmospheric transparency at various frequencies is shown in Fig 4, 5 and 6. The extension of the "radio window", considerably wider than the optical (more than 10 octaves in the spectrum), can greatly enrich the wealth of physical information obtained from the analysis of the electromagnetic radiation received at the earth from the celestial bodies, making observations peculiar possible only in this frequency range. Figure 6 shows the frequencies used for radio astronomy observations from the ground and summarizes the selective causes of attenuation of cosmic radio waves.

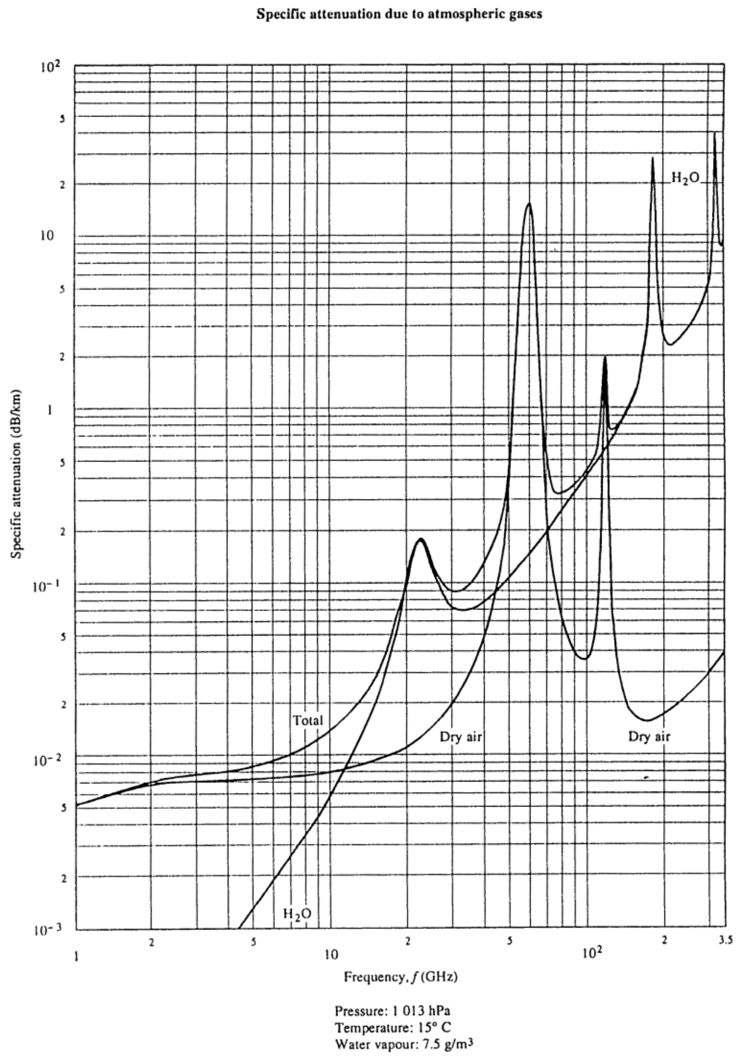


Fig. 4: Attenuation due to the absorption properties of the gas present in the atmosphere.

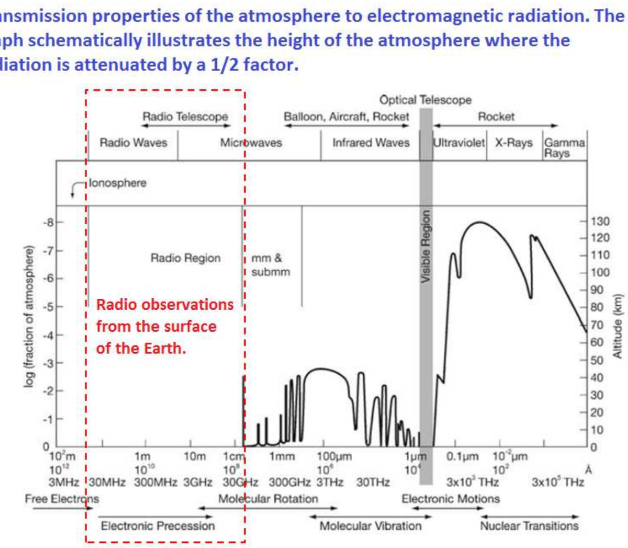


Fig. 5: Schematic of the atmospheric transparency to the cosmic radio waves.

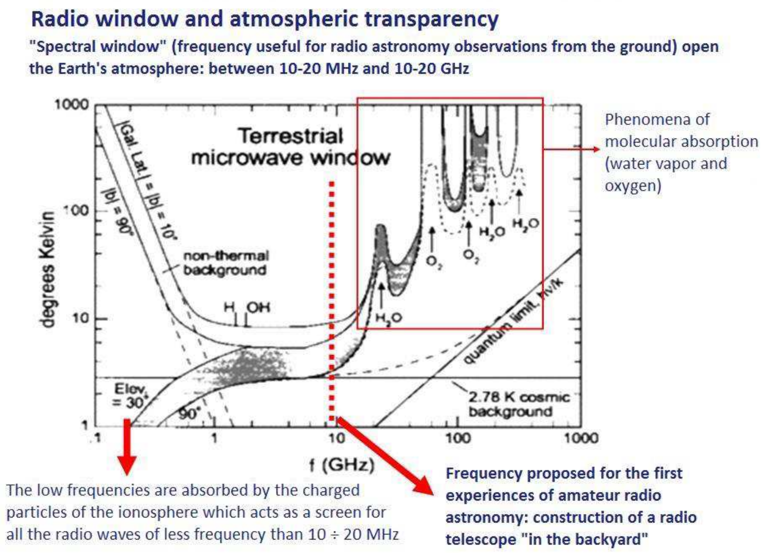


Fig. 6: Usable frequencies for radio astronomy observations from the ground.

With the generic term *radio source* refers to any celestial object responsible for measurable broadcasting. These bodies, in function of their mechanism of specific radiation, prevalent exhibit very different chemical-physical characteristics from one another. For our purposes, we can simply group the radiative types of celestial sources into two broad categories:

1. *thermal radiation*, with a trend of increasing flow with frequency;

2. *non-thermal radiation*, with a trend of decreasing flow with frequency.

The radio sources that emit thermal radiation behave, at least in a certain range of frequencies, approximately as a *black body*. This type of radiation (Planck's law) is originated by thermal agitation of the molecules that constitute the object and is proportional to its absolute temperature, with a law

increasing with the frequency. Examples of celestial objects considered thermal radio sources are the quiet Sun (in the absence of centers activity on the surface), the Moon and the clouds of rarefied gas (hydrogen) located in the vicinity of the stars with high surface temperature.
To justify the intensity of the radio waves emitted by non-thermal sources (the majority), we should admit a temperature to prohibitive values, unacceptable from a physical standpoint. These mechanisms, the object of study of astrophysics, were, for the majority of the celestial bodies, explained on the basis of synchrotron emission and exhibit a spectrum decreasing with frequency.
Especially in the case of amateur radio astronomy experiments, it is appropriate to choose the frequency of work according to the type of radio source to be studied, taking into account that the flux values for the particular reception used frequency, as inferred from Fig 7, establish the design parameters of receiving facility. Should take into account also the possible technical and economic difficulties imposed by the operating band, as regards mainly the complexity of the antennas and electronic circuits of the receiver. As you will see, there are other parameters that guide the choice, however, at first sight, we understand how the section most critical and demanding in terms of technical and economic, which requires the availability of wide space for the installation, undoubtedly the antenna of the radio telescope: in the case of amateur instruments, the greater will be its effective area, the more numerous will be the radio sources that our tool will be able to reveal.

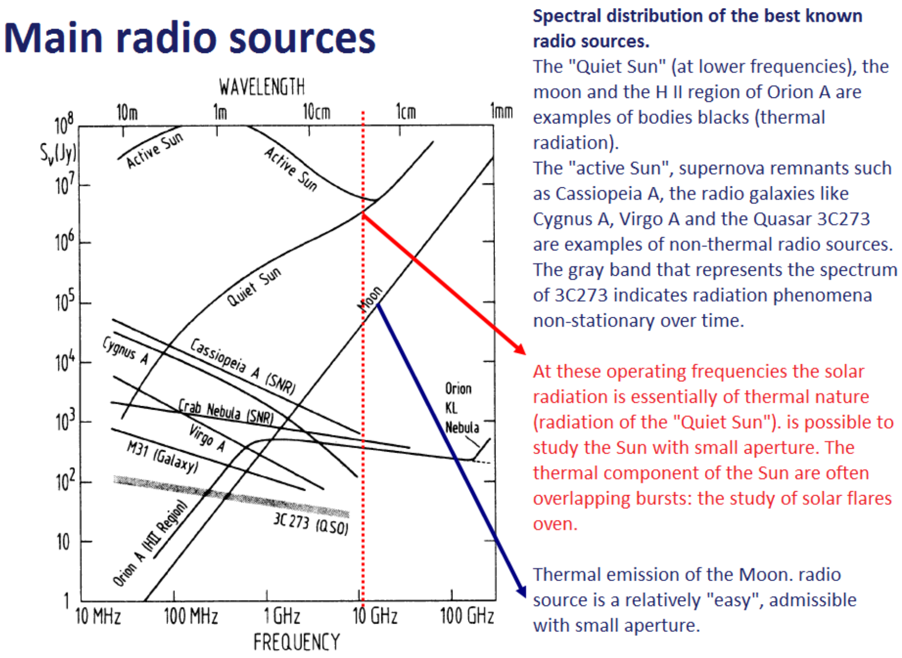


Fig. 7: Main radio sources available to the amateur tools.

It is important to understand the type of signals detected by a radio telescope. This is the natural electromagnetic radiation emitted by celestial bodies stimulated by specific physical mechanisms. As with any natural phenomenon of electromagnetic emission, the radio signal resulting random incoherent, in the sense that it is composed of innumerable primary radiation that can be considered independent, with each frequency and phase random, generally random polarization and intensity distribution that follows a statistical Gaussian. This signal is substantially identical to the thermal noise produced by a resistor placed at a certain temperature (law of Nyquist): daily experimentable are the effects of such noise being, this, the predominant component of the background noise that is observed in the electronic receivers apparatuses tuned in an area free from the band transmitters.

Some problems are not easy to overcome, for the correct measurement of the cosmic noise, are those related to its low intensity, lower than the own noise of the apparatus. The spectral and temporal characteristics of the cosmic noise are also similar to the unwanted signals are always present in a receiver being indistinguishable from each other, is not easy to discriminate the "useful" signal than disturbing. for this reason in a radio astronomy receiver are not applicable traditional filtering techniques present in ordinary radio systems, the techniques to separate and extract the useful signal (generally with shape and amplitude of the spectrum are clearly distinguishable with respect to the spectrum of the uniform thermal noise) from the diffuse noise of the equipment.

The sky is characterized by a continuous distribution of brightness (magnitude that quantifies the radiative properties of the observed area) with discrete sources of radiation, more or less extensive, they stand out compared to the diffuse background. Since the radio signal cosmic and the thermal noise of the resistors are of the same nature, is always possible (and convenient) to imagine that the receiving antenna of a radio telescope is replaced by a resistor of value identical to the radiation resistance of the antenna, located a temperature such that the power of thermal noise produced by the equivalent resistance is equal to the power of cosmic radiation. This temperature, named noise temperature of the antenna, is the combination of all the contributions associated with the signals received by the antenna receiver, coming from all directions of the space, including the land. When the main lobe of the antenna intercepts the radiation emitted by a radio source, one observes an increase in the temperature at the receiver antenna which provides a power of measurable signal. The output of the radio telescope also includes the contribution of noise disturbing the receiver due to the amplifiers and to the transmission lines. Considering the low level of cosmic radio signals, there is the problem of finding an efficient way to measure with enough, reliability and repeatability, precision small changes in signal-to-background level relatively constant and with high intensity. As the variations of the signal to be measured are very weak (speaking, on average, of power variations of the order of 10-18 W of a background noise with power less than 10-12 W), a receiver must be able to provide an high and stable amplification of the order of 80-100 dB: in these conditions, it is easy to imagine how the measure can be affected by significant errors if there is a spurious change, even minimal gain in the receiver chain. For this reason, the stability of a radio astronomy receiver is almost always more important than its sensitivity.

The main enemy of radio astronomy electromagnetic pollution is artificial, more and more widespread and uncontrollable in urban residential and misappropriation, operated by commercial radio, the frequencies reserved for international agreement to radio astronomy research. The atmospheric disturbance and artificial are very important at low frequencies of the radio spectrum, as they become negligible in the microwave band: if, today, it is very difficult to plan observations amateur HF bands, VHF and UHF, especially in urban areas, a small radio telescope microwave can be installed successfully in the roof or in the garden.

It is possible the amateur radio astronomy?

Deal seriously with amateur radio astronomy means to set an experiment where individuals or groups of fans (amateurs, amateur, student groups, ...) can lead to interesting activity, including official research support. Must be clearly understood within the limits and stops the willingness to invest time and patience in the proper approach to a discipline that manifests itself in a very immediate and less "spectacular" than other observational techniques (such as, for example, optical astronomy) . We are not sensitive to radio waves: the "display" scenario and the "extraction" of information that comes from the observation is not immediate, serving tools (radio telescopes) can detect radio signals and convert them into usable information . These difficulties contribute to the eyes of the profane, radio astronomy much less

accessible and "dark" than optical astronomy.
Given the wavelength of visible radiation and the structure of our eyes, we are able to directly visualize the scenario observed in the form of a color image with a sufficient degree of detail for our needs of daily survival. The use of systems of optical amplification, together with appropriate opening geometries instrumental, allows to increase the sensitivity of our senses to better and farther observe. The wavelength much greater of radio waves, together with the need to use appropriate "transducers" that reveal the information coming from the scenario observed, makes it difficult and not immediate the formation of "radio images": complex tools are required, expensive to obtain data of "visual quality" comparable to optical. These difficulties are well-known to those involved in professional radio astronomy, are amplified when it comes to amateur radio astronomy. If the approach of the fan is made exclusively with the mentality acquired during the experience in optics, may be weak motivation to start and, more importantly, continue to a valid amateur radio astronomy experience.
The real possibilities available to an amateur radio astronomer depend on many factors interacting with each other: the skill and experience of the observer, the technical characteristics of the instrument used and the environmental characteristics of the place of observation which must be free from any kind of electromagnetic noise can drown out the weak cosmic signals. As just seen, the intensity of the artificial and natural disturbances, such as that of radio interference in general, increases as the operating frequency and with the height of the antenna system from the ground. This problem today is deeply felt due to the massive occupation of the radio spectrum, if not properly coped may invalidate or make impossible even radio astronomy observations.
The experimental character and charm inherent justify the interest shown by many amateur and amateur astronomers in this type of activity. It can not, or want not to take competitive positions with respect to the official radio astronomy research (Fig. 8): I think the radio astronomy amateur can take its place over the "academic" as well as the serious work of research of the optical astronomers amateurs (study and discovery of asteroids , variable stars, ...) arises in relation to astronomy professional optics. To avoid disappointment it is essential to identify projects accessible to their possibilities, together with the limits within which much depends, however, on the ability and competence to organize their work, the ability to work in groups.
The activity of the amateur radio astronomer appears to be technically difficult due to the technical complexity and the limited commercial availability of tools: being practically nothing, until today, the commercial availability of radio astronomy instrumentation, the fans build their own instruments, limiting, of Indeed, the spread of the discipline in those who had interest and expertise in electronics (like amateur radio). With rare exceptions, the activity amateur radio astronomy has emerged as an activity limited and sporadic. As a discipline that requires a minimum of knowledge in parallel fields such as physics and astrophysics, astronomy, electronics, mechanics and computer science, we understand that it is desirable to set the research activities in the style of work group. The complexity and cost of such an organization are directly proportional to the results you wish to achieve. And it is possible to direct gradually the issue, building to more ambitious and challenging the "building blocks" of the experience gained with the previous work that, in general, and especially in the beginning, they produce a certain number of failures, many doubts and some shy and exciting success.

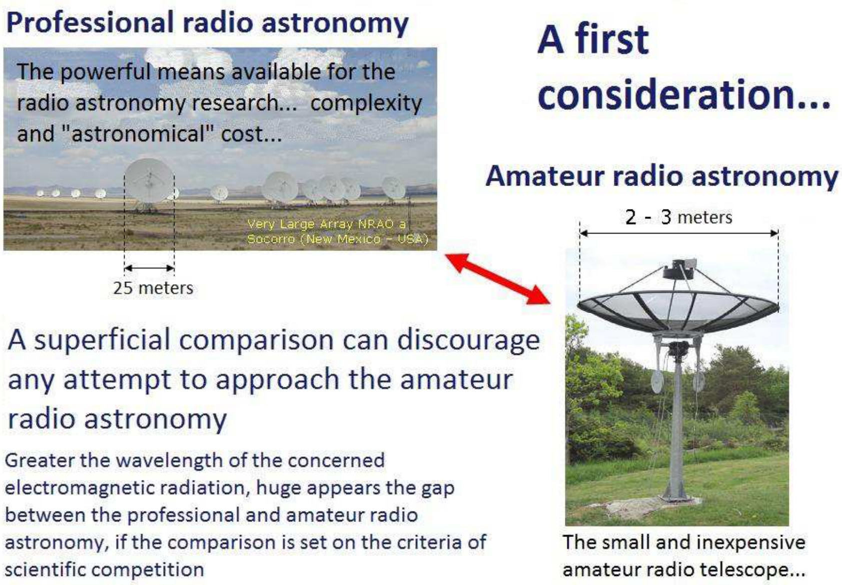
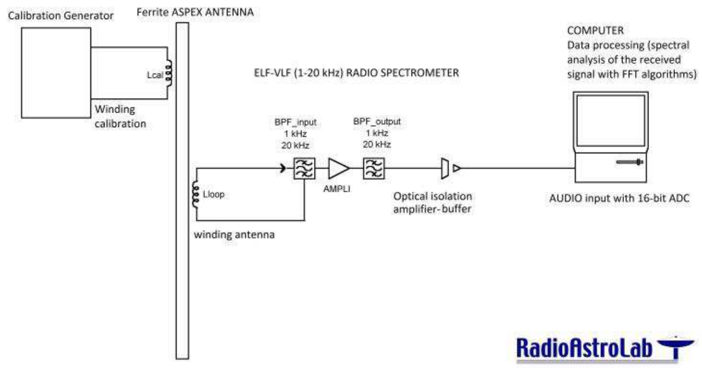


Fig. 8: "Cosmic" gap between professional and amateur astronomy.

We will attempt to frame, divided by frequency band and complexity of construction, possible areas of research of interest to the amateur activities.

ELF-VLF band (0.3-30 kHz)
In this extreme region of the radio spectrum, cosmic radiation are not directly measurable, being shielded from the Earth's ionosphere. You can, however, program very interesting studies to reveal the ionospheric perturbations induced by astronomical events (meteor activity, impulsive transient phenomena caused by the sun). There are some interesting correlations with the research on Radio Nature involving the spectral monitoring of natural phenomena, low-frequency radio. The tools are cheap, easy to build and install. Figs 9 and 10 illustrate the realization of an amateur ELF-VLF receiver working in the frequency band from 1-13 kHz and an experimental recording.

HF band (3-30 MHz)
It is the classic band "shortwave": being not too far from the lower limit of the radio spectrum is subject to fluctuations notes linked to the activity of the ionosphere. Assuming they can find a clear frequency for radio-interference, the activity in this region of the spectrum is certainly very interesting for the study of radio storms of the Sun and Jupiter, as well as for the study of galactic radiation (Fig. 11) . Because of their emission mechanism, in this frequency band are particularly intense the non-thermal radio sources. The receivers are not too complicated to build, while the antenna systems are bulky and characterized by modest directivity. Overcome the problems associated with artificial disturbances and interference (particularly intense at these frequencies), questions requiring a deliberate choice on the installation site, one of the most interesting research that may be conducted at the amateur level concerns the monitoring of transient phenomena radio (radio -burst) produced and modulated by Jupiter and its satellite Io.



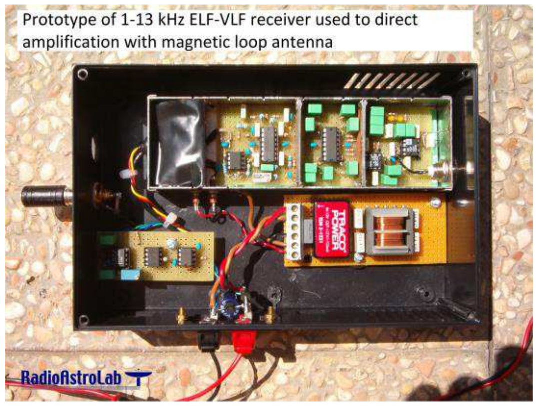


Fig. 9: Block Diagram and prototype of a ELF-VLF (1-13 kHz) receiver to direct amplification used to monitor atmospheric low-frequency electromagnetic phenomena induced by astronomical events. The apparatus is equipped with a magnetic loop antennas of generous proportions. These receiving systems, being very sensitive to electromagnetic interference industrial, must be installed in a "quiet" from the electromagnetic point of view.

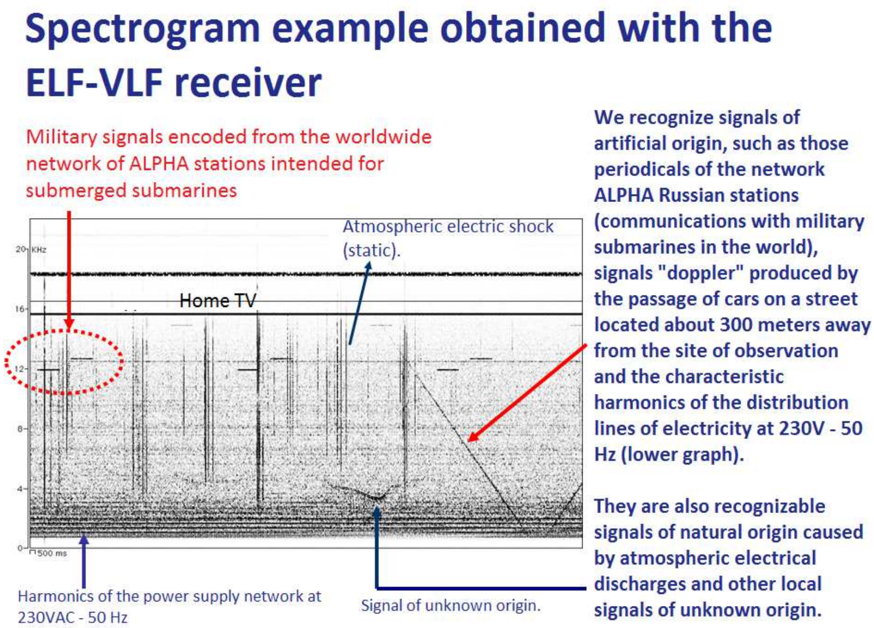


Fig. 10: Spectrogram example with the 1-13 kHz ELF-VLF receiver. A spectrogram allows the frequency analysis of the received signals: the temporal evolution of the spectral content of the signal is represented in a graph, which shows as ordinates the frequency axis, the abscissa and the time, while the intensity of the signal is represented with a gray scale (or color).

VHF band (30-300 MHz)

At these frequencies will be relatively simple receiving the galactic center of Cassiopeia A and Cygnus A. Installing a good antenna system coupled with a receiver sensitive enough it will record the pulsar more powerful that, because of their emission mechanism, have an emission maximum precisely in the VHF band. This research has, however, technically complex and requires considerable experience in radio astronomy observations and in the development of the equipment. It's interesting to note that, especially in the VHF range, the sources closest are not necessarily the most powerful: except the Sun and Cassiopeia A, the most intense radio sources in the sky are among the most distant objects in the universe. The most active extragalactic radio source Cygnus A is certainly, very distant galaxy that emits an extraordinary amount of energy apparently as a result of one or more explosions that have fundamentally altered the complex structure. The quasars and pulsars are objects inherently very powerful but almost certainly inaccessible to amateur instruments.

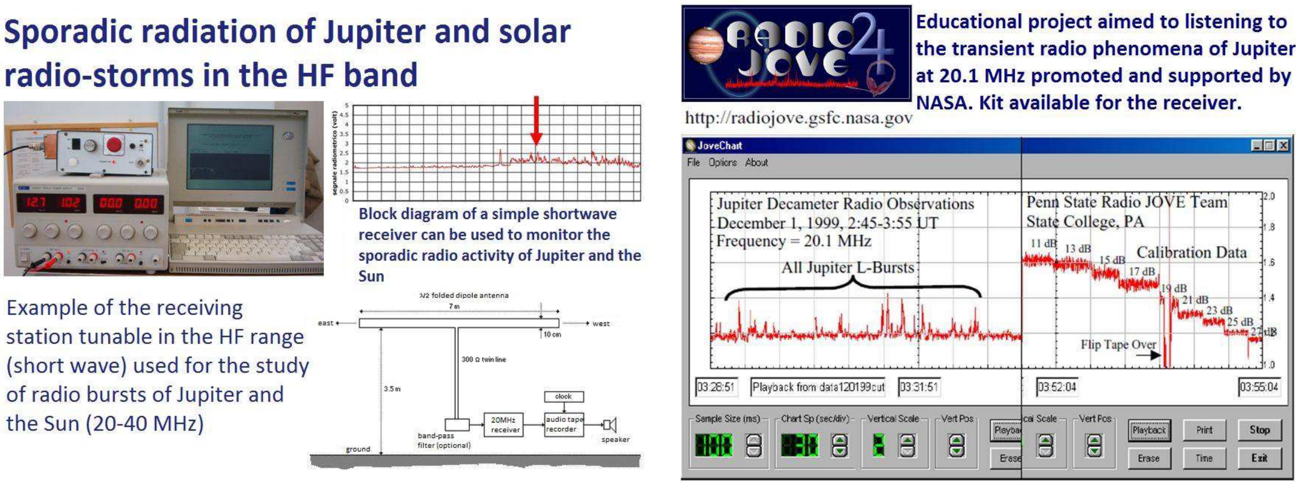


Fig. 11: Experimental facility for the reception of radio interference in the HF band of Jupiter and the Sun This is a classic, as well as fascinating area of research is particularly suitable for amateur radio astronomers.

UHF band (0.3-3 GHz)

These frequencies have been widely used by the research officer in the 1960-70 years: the first large radio telescopes were built just to operate in this band as tools for the discovery and classification of radio sources and pulsars. The amateur radio sources available to the media are not particularly intense and receivers are complex: for these reasons it seems advisable to study amateur radio astronomy in the UHF band, at least in the initial phase.

SHF band (3-30 GHz)

The observation microwave radio shows the thermal component of cosmic radiation and, using tools not too complicated, it is relatively easy to observe the Sun, the Moon and other radio sources (see Figure 7). The market penetration of satellite TV reception, GPS systems, and mobile products made available at very advantageous prices, electronic components and modules suitable for the construction of efficient microwave radiometers, along with a wide variety of satellite antennas (parabolic reflectors circular symmetrical or offset-like) operating in the 10-12 GHz band, complete with accessories for mounting and aiming. In Fig 12, 13 and 15 are shown examples of radio astronomy instrumentation utilizing these modules.
The SHF band, in particular the frequencies 10.7-11.7 GHz dedicated to the reception TV-SAT European, lend themselves to the development of interesting activities of amateur "radio browsing" of the sky. In addition, because of the availability of commercial components for easy installation, seems to be the best starting point for those who want to move, with success, the first approaches to the amateur radio astronomy activities. The advantages in the use of these frequencies are related, in addition to the commercial availability of components, the absence of noise and electromagnetic interference of artificial nature and the fact that, in these operating frequencies, the antennas exhibit good directivity (receive beams sufficiently tight) with dimensions. The drawbacks are related to the presence of geostationary satellites (which, however, being low on the horizon, in a fixed and known, not the very limited field of view) and to the fact that the emission of the main radio sources, characterized by radiative mechanisms of nature non-thermal, is not particularly intense in this region of the spectrum.

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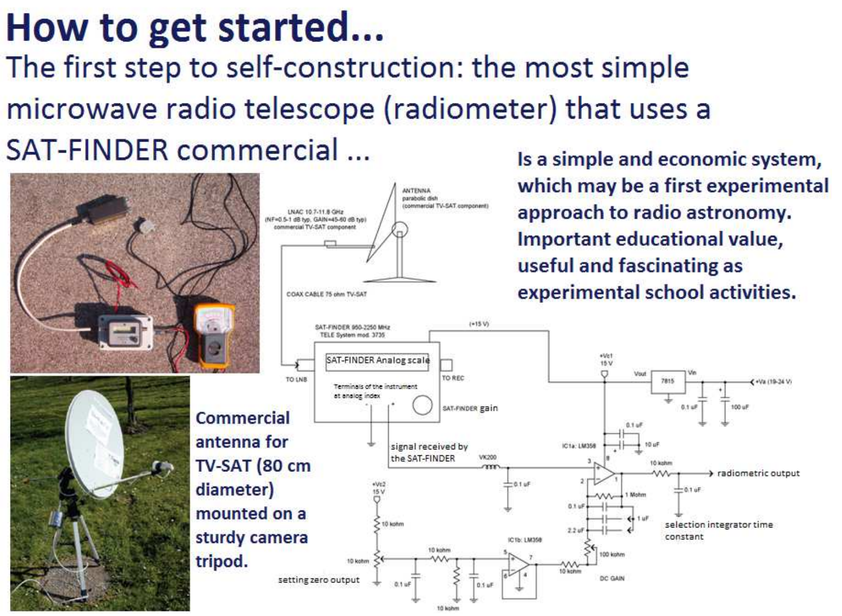

Fig. 12: Simple proposal for a DIY of a radio telescope at 10-12 GHz.

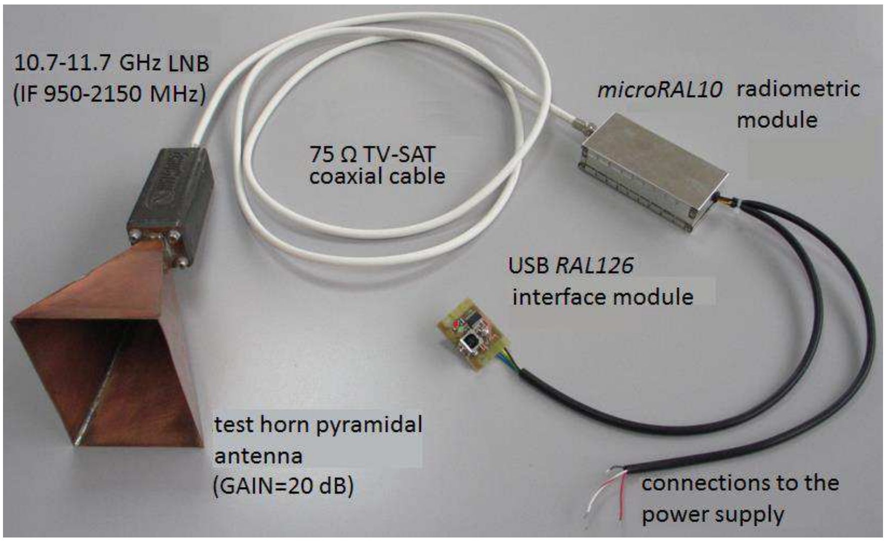

Fig. 13: A more advanced solution for experimenters: the microRAL10 + RAL126 KIT of RadioAstroLab that allows the construction of a sensitive radio Total-Power Microwave (10-12GHz).

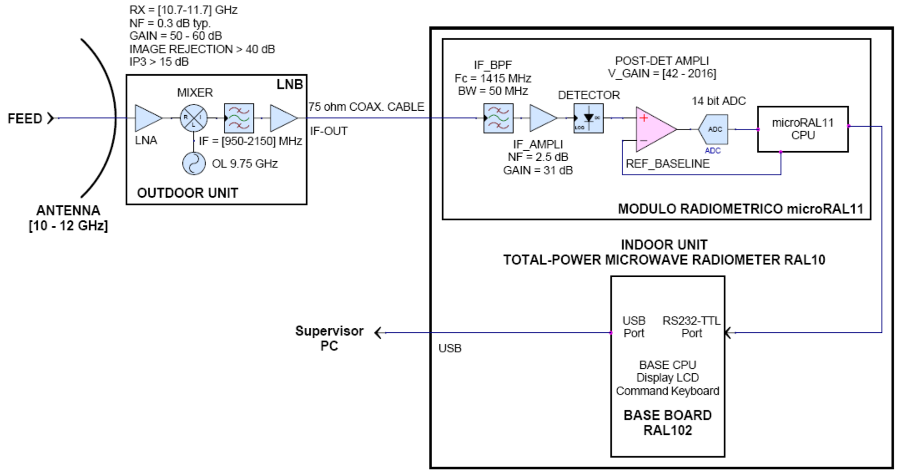

Fig. 14: Block diagram of the radio telescope achievable with microRAL10 + RAL126 KIT shown in the figure above. The LNB outdoor unit (with feed) is installed on the focus of the parabolic reflector: a coaxial cable TV-SAT from 75 Ω connects the outdoor unit with the microRAL10 module that communicates with the PC (on which you have installed the DataMicroRAL10 software) RAL126 through the interface and a USB standard port.

In all cases, the advantages far outweigh the disadvantages and it is advisable to start the activity of amateur radio astronomy in SHF band. Examples of experimental observations later discussed confirm these claims.

The more easily admissible radiosource is the sun, to the point that even in Amateur Radio its emissions are often used to calibrate the antennas (determining their radiation diagram) and receivers as regards the noise figure (Fig. 16). Our star, because of its relative proximity, it emits a strong hertzian radiation, intensity widely varies in the range of wavelengths decametric (solar radio burst): these fluctuations are generally associated with emissive optical phenomena peculiar to the disc as stains and solar flares, along with other observable effects on Earth as the aurora borealis and the various disorders in short wave radio transmissions, well known to those involved in radio transmissions. Being linked to the cycle of solar activity, the different types of emissions rapidly variables have a very complex structure the physical origin of which can be found in any treaty of astrophysics. For our purposes (and the range of frequencies used by amateur instruments) is enough to differentiate the two key components in solar radio emissions, a stationary and a variable, called respectively the quiet Sun radiation and radiation of the Sun disturbed. Depending on the degree of activity of the star, the emission intensity (with variable duration between a few seconds and a few weeks) can go from a flow value of the order of 104 Jy (corresponding to 104 • 10-26 W / (m2 • Hz)), typical of the radiation of the quiet Sun, at amounts equal to almost 108 Jy relative to the radiation of the Sun disturbed (measured at a frequency of 100 MHz). Within this range of values occur all the complex radio emission of the star that is, without a doubt, one of celestial objects better suited to start the business of amateur radio astronomer, as well as to "cut their teeth" with the construction and development of the basic instrumentation: the constant study of the solar radio emission and its effects on the ionospheric layer and the complex phenomenon of radio propagation is a topic of great interest in astronomy, amateur radio and telecommunications in general.

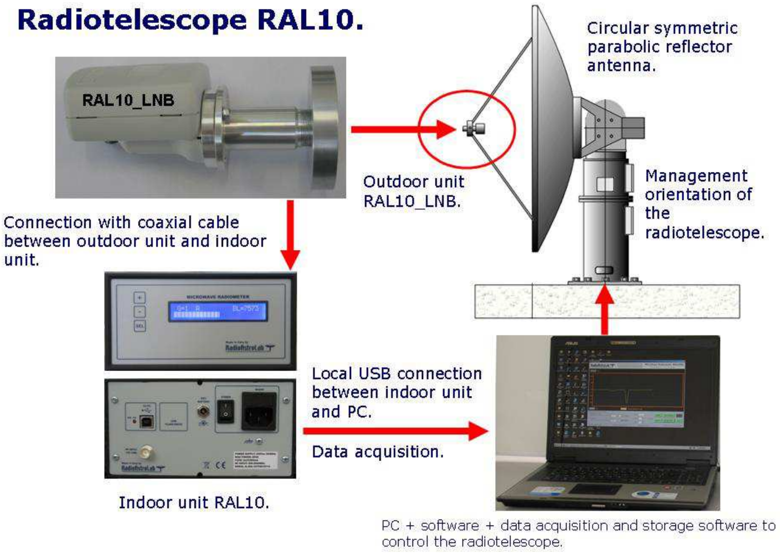

Fig. 15: Structure of a microwave radio telescope based on the RAL10 receiver of RadioAstroLab.

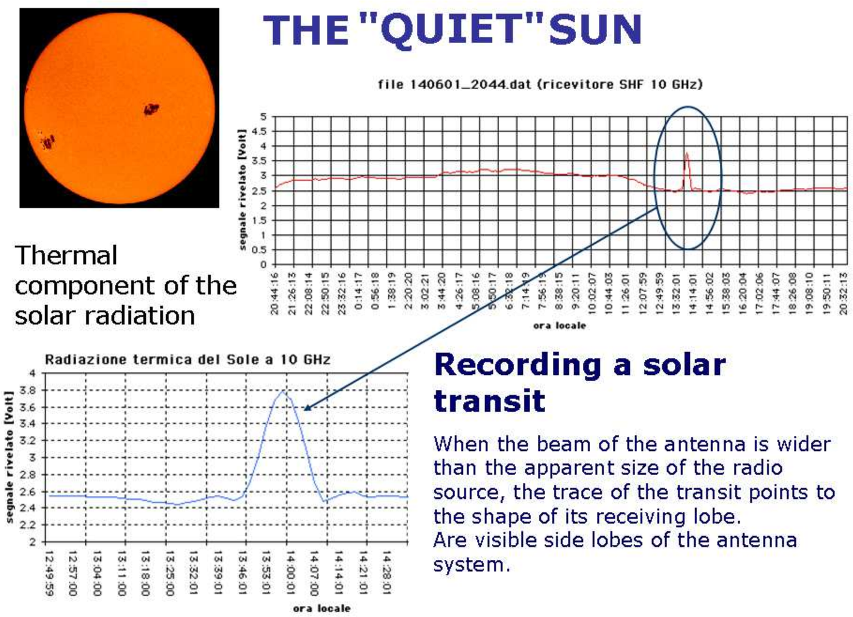

Fig. 16: Registrazione del transito solare.

The Moon is another interesting object: emits a flux density appreciable for the amateur equipment only at microwave frequencies (typically in the range of 10 GHz), with radiation of thermal origin characterized by increasing intensity with frequency. Interesting are the recordings of the phenomena of occultation and eclipse of the moon see it as the protagonist. In Figure 17 shows the recording of the transit of the lunar disk obtained with a small radio telescope (RAL10 of RadioAstrolab) equipped with a satellite dish for TV-SAT with a diameter of 1.5 meters.

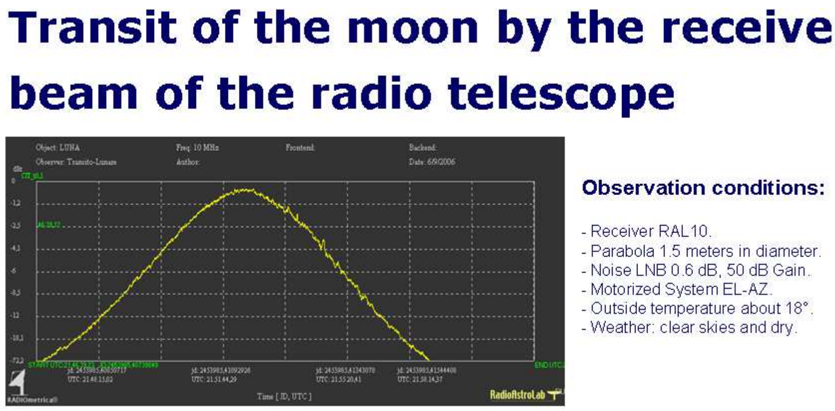

Fig. 17: Registering a lunar transit. The thermal radiation of the moon is visible: its emission is a result of the fact that the object emits approximately as a black body, characterized by a temperature of the order of 300 K. If the visible emission of the Moon is almost entirely due to the reflected light of the Sun, in the microwave there is an issue due to its temperature of the object that contrasts with that of the "cold" sky.

The planets, because of the low emission levels, are virtually inaccessible to amateur instruments, except Jupiter is, as previously stated, a radio source of extraordinary power at wavelengths metrics. Its emissions (radio-burst Jupiter) to appear the result of sporadic violent processes taking place in the atmosphere of the planet, connected (and modulated) to the motion of its moon Io. The power of Jupiter's decametric radiation is that (of the order of millions of Jy) can be proved without difficulty by ordinary plants for radio amateur: being sporadic however, may occur subsequent days of observation. Because of the particularity and emissions intensity, constant and systematic study of Jupiter's radio emissions in the frequency range from 10 MHz to about 40 MHz is one of the most accessible and fascinating for the amateur astronomer (Fig. 11). This is a classic example of amateur activities that, if carried out accurately and systematically, it is also of great interest for the radio astronomy professional research.

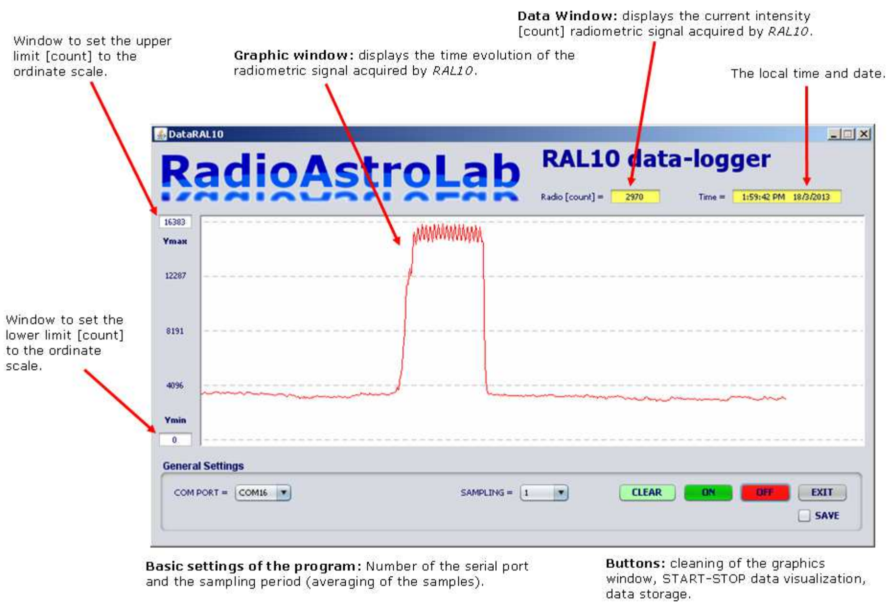

Fig. 18: Acquisition program and registration data for the DataRAL10 RAL10 receiver.

Disregarding the objects of small angular diameter named radio star (such as pulsars) probably too weak and distant to be detected with antennas "normal", it is worth mentioning the so-called supernova remnants, inherently very intense radio sources: the most powerful and source in the Crab Nebula (Taurus a), characterized by an intensity of flow, a 10 GHz, of the order of 500 Jy, detectable even by relatively simple tools (Fig. 19).

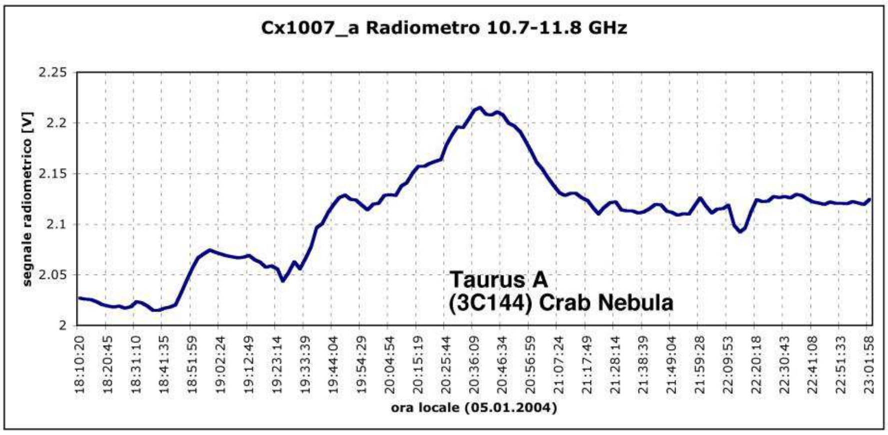

Fig. 19: Registering the transit of Taurus A radio source.

The most powerful radio source in the sky after the Sun is Cassiopeia A (17000 Jy at 100 MHz) for radiation, constant and intense, it is often used as a source of primary calibration to calibrate the instruments scale radio astronomy and is very useful as a reference for studies on the characteristics of variability of the Earth's ionosphere. The center of our galaxy, Sagittarius A, is a very powerful radio source (the order of 1000 Jy at 100 MHz), the first to be discovered by Jansky), relatively easy to capture with amateur equipment at wavelengths metrics.

It is interesting to conclude this overview of the possibilities of amateur radio astronomy mentioning the instrumentation actually available on the market. One of the comments most frequently asked by fans about the difficulty that many investigators in finding and equipping a radio astronomy station operating. Where to find the materials and information? It has been shown as one of the main obstacles to the spread of amateur radio astronomy is linked to the commercial availability of instrumentation and technical information. Up to now, an amateur radio astronomer necessarily had to build the antenna systems, receivers and data acquisition systems, or adapt apparatuses intended for other uses. For this reason, the first amateur radio astronomers have always been amateur radio or electronics technicians telecommunications experts with a passion to see the sky: many of the first experiments were started with amateur radio receivers adapted for radio astronomy uses. An indispensable virtue, to deal with the amateur astronomy successfully, seems to be the practice of electronic engineering. This results a significant limitations and "discrimination" of users: it is a fact of that these regulations have so far been excluded amateurs, enthusiasts who, possessing a thorough knowledge of the sky, they are certainly the best people to appreciate the extensions in the horizon of knowledge that radio astronomy can make to traditional optical astronomy.

After many requests, at least in part to overcome these difficulties, the company RadioAstroLab has developed a series of proposals dedicated to amateur radio astronomy, with the aim of spreading this discipline. For those who want to start the radio astronomy research can now:

- Acquire tools (hardware and software) specifically designed for radio astronomy applications.

- Obtain professional modules (assembled and tested) with which to build a receiver according to their needs and budgets. All the proposed systems are modular and can be expanded at a later time.

- Purchase KIT for DIY of small radio telescopes.

- Acquire information, documentation, application notes and examples of amateur achievements.

The figures above show examples of microwave radio telescopes with standard parts from the market TV-SAT and RAL10 Microwave Radiometer basic unit of RadioAstroLab, available commercially. For DIY lovers is available KIT that allows you to create, in a simple, cheap and "safe" in terms of reliability and repeatability of performance, a similar instrument. It is a Total Power receiver that measures the total power associated with the signal captured by the antenna and the power due to noise of the receiver (see, for more details, the block diagram shown in Fig 14). Using a differential circuit of post-detection, it is possible to measure only the changes in the signal due to the radiation coming from a radio source intercepted by the receive beam. The system is equipped with dedicated acquisition software. You buy it in any consumer electronics store (or at the most qualified TV-SAT installers), the satellite dish and, in the case of KIT, the external electronics (LNB + feed) and the coaxial cable, it is simple and immediately install a sensitive radio wave connecting the system to the USB port of a PC. The performance of the instrument will be influenced primarily by the size of the used antenna.

The RAL10 receiver has been designed to enable aspiring radio astronomers, amateur groups and schools to install an efficient microwave radio telescope at low cost, to collect and analyze the results of observations with standardized instrumentation and shared by other experimenters. An important advantage that comes to use standardized systems developed specifically for radio-astronomy, lies in the possibility of creating a network of amateur experimenters who, in groups or individually, plan scheduled observations with visual comparable and repeatable features. They are accessible on the web by discussion groups to explore issues of amateur radio astronomy, technical issues concerning the use and optimization of instrumentation and, ultimately, the opportunity to exchange experiences and compare data. In this perspective, it is conceivable the creation of a data bank of the observations amateur.

Doc. Vers. 1.0 del 18.04.2013

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