

# Study of Sky Radio Frequency Interference Background Level Behavior During the Partial Solar Eclips on 25 Oct. 2022 at The Baghdad University Location

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## Abstract

Radiofrequency interference (RFI) describes the weakening of radio astronomy transmissions caused by man-made radio signal noise in radio telescope observation indicates the level of radio frequency noise in the sky at all times, regardless of any astronomical sources. This noise is affected by various sources, including Earth's atmosphere or solar activity and all communications equipment operating near the radio telescope. In this study, the background noise which includes RFI was measured using HSA2000 series receiver spectrum analyzer, which connected with two dipole antennas in different frequency bands (15-80 MHz) low band antenna, and (110-240 MHz) high band antenna during the partial solar eclipse in Baghdad on October 25, 2022, at (12:00-15:00), as a simple radio telescope to observe the radio astronomical background level in the sky. It is clear that the average amount of RFI level during a partial solar eclipse (-83.249 dBm for LBA decreased by about (0.93) from the value on a normal day (-77.495 dBm). And For HBA -84.711 dBm decreased by about (0.85) from the value on a normal day (-72.784 dBm). Also, it was noticed that these amounts are approximately equal to the RFI level at night (-82.352 dBm for LBA and -82.739 dBm for HBA). It is (0.98) for LBA and (0.97) for HBA, respectively. This research confirms that despite the short duration of the partial eclipse, the average value during the partial eclipse period is close to the average values during the night period due to the decrease in the electronic density of the ionosphere, especially at low frequencies, and the FRI of ground disturbances as a result of the activities of human from the surrounding the monitoring area. also, found that at the monitoring point, there is a good relationship between the time of the maximum partial eclipse and the peaks of signal gain strength.

**Keywords:** Radio frequency interference; solar eclipsing; dipole antenna; radio telescope.

## الخلاصة

تداخل الترددات الراديوية يمثل الضعف في استلام الإشارة الراديوية الفضائية و تكون هذه التداخلات ناتجة عن صنع الانسان حيث تعمل على تقليل جوده استلام الإشارة الفضائية والتي تتأثر بالغلاف الجوي الاثmosphير والنشاط الشمسي وكل النشاطات القريبة من التلسكوب. في هذه الدراسة تم رصد ظاهرة الكسوف الجزئي في العاصمة بغداد باستخدام الجهاز HSA2000 series receiver spectrum analyzer والمربوط مع هوائي ثنائي القطب ضمن الترددات المنخفضة (15-80 MHz) والتردد العالي (110-240 MHz) والتي صممت في مختبر الفلك الراديوي للدراسات العليا في قسم الفلك والفضاء بجامعة بغداد حيث تم مقارنة هذه القراءات مع الأيام الاعتيادية حيث وجد ان نسبة الضوضاء في يوم الكسوف الى يوم اعتيادي في نفس وقت الرصد يساري (0.93) للتردد المنخفض و (0.85) للتردد العالي، وكذلك وجد تقارب كبير بين معدل الإشارة المرصوده خلال الكسوف الجزئي و معدل القيم المرصوده خلال فترة الليل والتي تفسر بسبب نقصان الكثافة الالكترونية لايونوسفير وكذلك الضوضاء الناتجة من النشاط البشري في منطقة الرصد. حيث كانت النسبة (0.98) و (0.97) للترددات المنخفضة والعالية على التوالي. حيث يعمل الكسوف على تقليل الضوضاء بالرغم من القرة القصيرة لكسوف الشمس ووجد علاقة وثيقة بين ذروة الكسوف الجزئي مع قوة الإشارة المستلمة.

## INTRODUCTION

When the Moon and the Sun are in direct line with the Earth, a partial eclipse will arise, allowing us to measure the impact of eclipsing on the received radio signal. From a huge area of Earth beyond the path of a complete eclipse or an annular eclipse, you may see this event [1][2]. A partial solar eclipse happens when the moon does not completely hide the surface of the sun or the photosphere so that some direct sunlight can reach the observer [3]. However, the eclipses (25 October 2022) just a partial eclipse is seen since the moon doesn't completely cover the sun and the umbra never reaches Earth's surface [4]. Partial eclipse is practically unnoticeable at the Sun's brightness, as it is taking a good coverage area over 46.3% in Baghdad [5]. When the eclipsed shadow crosses the propagation channels, there is a noticeable decrease in signal strength, as measured by monitoring radio signals given by different radio stations at different frequencies and received at a specific observation point. It is an acronym for a specific range of electromagnetic energy frequencies used to transmit data [6]. The important applications of this spectrum in various fields, including radio and television broadcasting, civil aviation, defense, emergency services and satellites, depend on specific assignments of radio frequencies at eclipsing the radio radiation of the spectrum, the radio flux (density) from the sun photosphere layer is no longer dominant. the basic element of most solar symbols is the circular solar disk. This allows the investigation of the solar disk and the structures in the solar atmosphere throughout the eclipse [7]. In solar radio astronomy relevant observations may be long out for several hours between the start and the end contact. The main aim is that the time change of the received radio flux is related to the spatial distribution of Low-Frequency Array (LOFAR) to observed radio sources [8]. Radio observations allow studying the sun layers from the corona to the chromosphere. The frequency of the emitted radio radiation, whether at the plasma frequency or its harmonics, depends on the height above the photosphere layer, where was generated [9]. The LOFAR telescope large number of antennas also enables it to achieve unparalleled sensitivity and angular resolution in the low-frequency radio regime designed as a large radio telescope operating in the low frequency range from 10-240 MHz (wavelength of 30.0 - 1.2 m) contains two dipole antenna fields: LBA (Low

Band Antennas) and HBA (High Band Antennas) [10].

The LBA work in the frequency range 15-80 MHz and HBA antennas the frequency range 110-240 MHz for observed background noise include radio frequency interference (RFI) as more devices connect to the network, the radio frequency spectrum becomes so crowded that frequency bands often overlap [11]. Other wireless devices that use the same frequency as Wi-Fi can also interfere with your network connection, as can nearby debris and other types of equipment. However, background noise in radio astronomy refers to any unwanted signal that interferes with the detection of the desired radio signals from celestial [12]. Dipole antennas are used because they are able to receive signals of varying frequencies in a balanced manner. It also aids the device in resolving reception issues brought on by competing signals [13]. Radio astronomy signals travel through the air in a straight line, are reflected from layers of the ionosphere or clouds, or are relayed by satellites in space are weak of man-made radio signal noise, or a sign that interferes with blocking radio astronomers' astronomical signals is called radio frequency interference (RFI) [14]. Radio astronomy signals travel through the air in a straight line, are reflected from layers of the ionosphere or clouds, or are relayed by satellites in space are weak of man-made radio signal noise, or a sign that interferes with blocking radio astronomers' astronomical signals RFI [15]. The ionosphere is significantly impacted by solar radiation, and the ionosphere's ions and electrons are generated by the energy of the sun [16]. The ionospheric electric conductivity and electric field distribution can be modified by eclipse-induced electron density changes, which can further affect the ionospheric electron density perturbations. Therefore, the effect of an eclipse on radio signals received depends on the frequency of the radio waves and the location of the receiver [17]. The ionospheric electric conductivity and electric field distribution can be modified by eclipse-induced electron density changes, which can further affect the ionospheric electron density perturbations [18]. the dynamics of ionospheric plasma changes significantly, wave disturbances are generated, and the interaction between subsystems in the Earth-atmosphere-ionosphere-magnetosphere system increases during a solar eclipse [19]. There is limit research about the effect of eclipsing by using

LOFAR telescope such as Ryan *et al.*, 2021 The search results show that LOFAR was used for observing the solar corona at 20 March 2015 during solar eclipse where the effect of angular broadening is observed at metric and decametric wavelengths. However, the search results do not get any information on the specific effects of eclipsing on LOFAR [20].

## MATERIALS AND METHODS

### Design of half wave dipole antenna

To observe the spectrum of radio signal for studying the effect of partial eclipsing on received of background radio signal over Baghdad, Iraq. The first presses are design dipole antenna which includes two conductive elements like wires and rods or wires, an antenna section is the two halves of the conducting element of an antenna that are separated by an insulator [21]. The feeding gap between the two arms of a half-wave dipole antenna is where the coaxial cable or feeder connects to the antenna. The dimension of an antenna frequency ( $f$ ), for low band 20.1 MHz and high band 110 MHz has been chosen. Here, the radiation resistance of the half-wave dipole is  $\approx 50$  Ohm, which matches the line impedance by using the fundamental equations for design antenna the wavelength ( $\lambda$ ) of dipole can be calculate by using (1) equation depending on radio signal frequency [22]:

$$\lambda = \frac{c}{f} \quad (1)$$

Also, the length of the dipole antenna has been found from the equation (2):

$$L = \frac{\lambda}{2} \quad (2)$$

$\lambda$ : the wavelength for low and high band antenna in (m)

$c$ : the speed of light in space (m/sec).

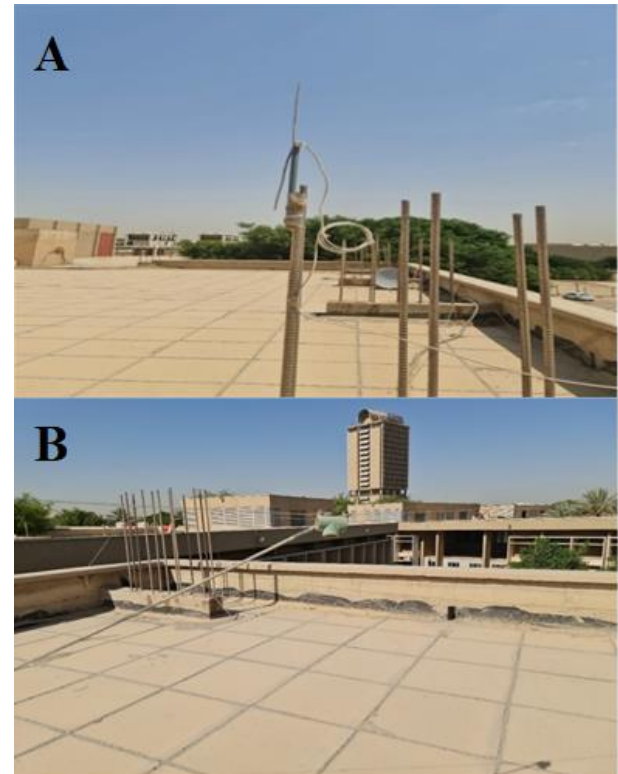
$L$ : the total length of the dipole antenna in meters.in our design, the length of wire that we used is less than the obtain length for both LBA and HBA because of the resistance of the wire used in the manufacture of the antenna, which affects the inductive current

The feeding gap ( $g$ ) and wire radius ( $r$ ) were calculated from equations (3) and (4), respectively [23]

$$g = \frac{L}{200} \quad (3)$$

$$r = \frac{D}{2} \quad (4)$$

Figure 1 presented the actual our dipole antenna design.



**Figure 1.** Actual designing for our antenna A) low band antenna (LBA) B) high band antenna (HBA).

The main parameter of design dipole antenna for received background noise depend on frequency of signal which calculate wavelength, average impedance, length of dipole, radius of wire. As shown in Table 1.

**Table 1.** Design Parameters of the Antenna.

Parameter	Value of LBA	Value of HBA	Unit
Frequency ( $f$ )	20	110	MHz
Wavelength ( $\lambda$ )	15	2.7	m
Average Impedance	50	49	Ohm
Length of the dipole (L)	7.5	1.36	m
Radius of the dipole (R)	1.5	2.5	mm

By connecting our design of antennas with a device HSA2000 series spectrum analyzer to measure the power of spectrum background noise which are small, light, and cost-effective, are portable spectrum analyzers designed with a frequency range: of 9 kHz to 3.2 GHz, Optimal sensitivity: -

161dBm, it can show the density of field strength or power (gain) where the electromagnetic wave flowing over the dipole antenna at the receiver section will induce a small voltage. As a result, the antenna will become the signal source for the receiver's input [24, 25].

**Interference radio signals testing in Baghdad**

To compare interference radio signals (RFI), during regular and eclipsing day we must test our both design of dipole antenna LBA and HBA to ensure it works properly by measure their impedance and stand wave ratio. Then we test the power of the signal at different days and times to study the normal behavior of background noise in a receiver depend on the frequency range in use.

For both LBA and HBA measuring the radio spectrum presented the power obtained from background noise from the desired radio signal and undesired radio signal such as (radio stations, mobile, communication towers. etc.) and. The background noise is measured by unit dB<sub>m</sub>/Hz/s, which is calculated as a negative value according to the equation:

$$dBm = 10 \log \left( \frac{1}{power} \right) \quad (5)$$

where dB<sub>m</sub>=logarithm scale of power

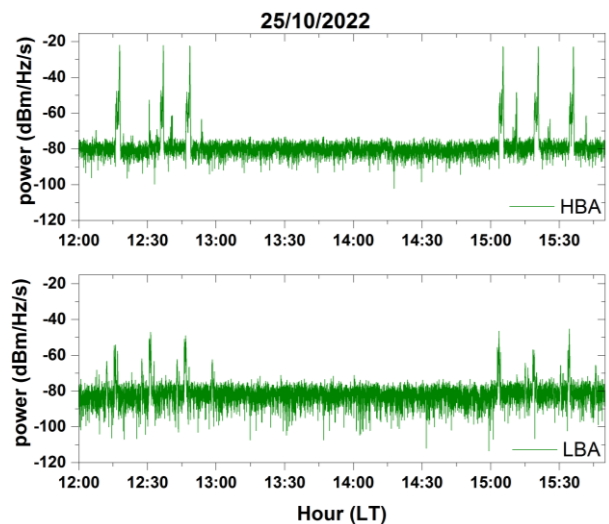
The device measured the power in this scale to receive a broad signal range, such as faint and robust signals, because it has high sensitivity and accuracy.

The RFI measured for different days before eclipsing in Baghdad on for both LBA and HBA by measuring the radio spectrum during the afternoon period (12:00-14:00) in LT (+3 GMT) at a rate of four observation per hour which contain 461data for each quarter of an hour during specific frequency.

**Eclipsing of Sun over Baghdad City**

During partial solar eclipse occurs on 25 October 2022 in Baghdad location. The Measures have been made by recording the power of background noise by using the HSA2000 series spectrum analyzers. The measurements were taken on 25 October 2022 from 12:00 LT to 15:00 LT through the eclipse day by identifying the variations of characteristic in strength of signal, caused by the phenomenon. Where the onset of the partial eclipse at Baghdad was at 13 hours 6 min 24 sec (LT), the solar maximum at 14 hours 23 min 31 sec (LT), and ended at 15 hours 35 min 2 sec (LT) with a total duration of 2 hours 28 min 38 sec.

The signal starts to fall down with the onset of a moon's shadow across the path of its. It was found through the observation results that the effect of the eclipse was more affected in the LBA than HBA. On hours without an eclipse, signal strength was greater by about -21 dBm for LBA and -11 dBm for HBA, as evident from Figure 2. There is a noticeable dip in signal strength across all the records just before the eclipse crosses the propagation path. This observational summation differs significantly from typical propagations, which experience only small changes in signal power. We have detected signal volatility during the solar eclipse, which is reflected in the characteristics. After the event has ended, the level of signal almost completely recovers to its pre-event level. A peak in signal intensity relative to the average level was also seen at that point of peak solar cover during the eclipse, and this peak was accompanied by a characteristic short-period fading.



**Figure 2.** The power radio signal (background noise) during afternoon in eclipsing event.

The addition from the observations appears to be a little different from transmitted or propagations in normal conditions when occurs a minimal change in signal strength. In the characteristics, we have noted signal change homogeneous in received signal during the solar eclipse. The signal gain returns to the average mount after the end of the eclipse. In addition, the increasing of the signal strength in the form of featured short-period founded was noted from the average peaking about the maximum solar time coverage of the eclipse. After passed the partial eclipse the signal level again decreased. The average value of background noise during the eclipsing for LBA

$$ave=-83.2493 \mp 0.4673$$

at HBA

$$\text{ave} = -84.7114 \mp 0.2263$$

We notice from the value of average at the eclipsing approach to the night observation. Despite the short time, this can be explained by the sun's influence. At the observation point there is a good correlation between the time of the eclipse maximum and the peaks of the noise strength will disappear. All the observations when plotted on the figure 2.

Also, a study was carried out for different day (11/9/2022) in the afternoon for LBA and HBA by measuring the radio spectrum at (12:00-14:30) LT (+3 GMT) at a rate of four observations per hour where the spectrum presented the power obtained from background noise as shown in Figure 3.

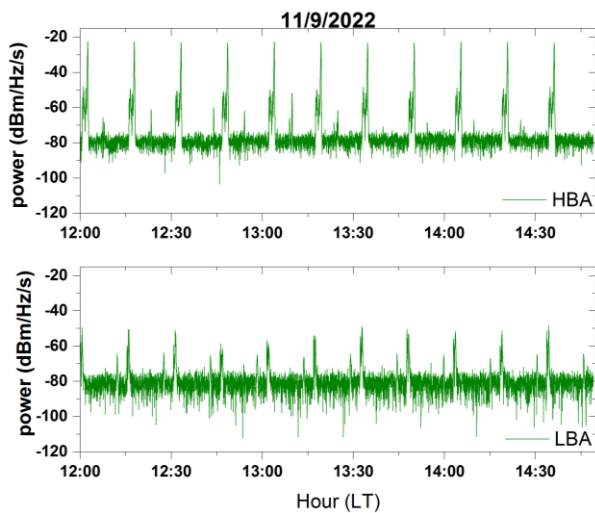
The power's behavior for all days is approximately symmetric for the afternoon in value and behavior.

The value in the afternoon for LBA:

$$\text{ave} = -77.4956 \mp 1.06541$$

The value in the afternoon for HBA:

$$\text{ave} = -72.7847 \mp 1.1583$$



**Figure 3.** The power radio signal (background noise) during afternoon.

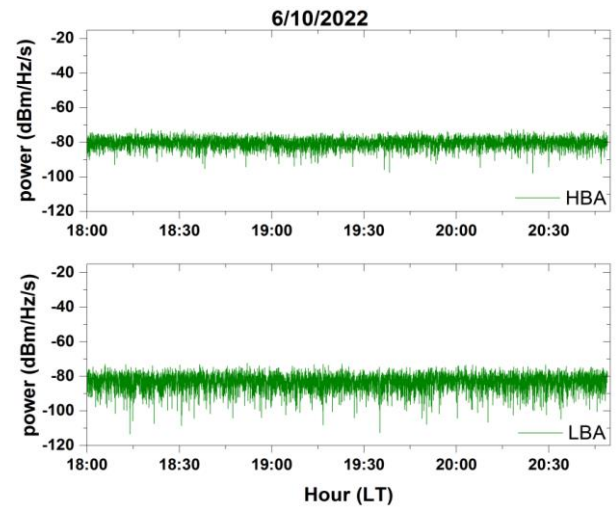
Also, an Interference Radio signals test was carried out for different days in Baghdad on (6/10/2022) for both LBA and HBA by measuring the radio spectrum during the night time (18:00-20:30) in local time (+3 GMT) at a rate of four observations per hour which contain 461 data for each quarter of an hour during specific frequency (Figure 4).

The value at night for LBA:

$$\text{ave} = -82.352 \mp 0.5066$$

The value at night for HBA:

$$\text{ave} = -82.7397 \mp 0.4997$$



**Figure 4.** The power radio signal (background noise) during night.

## RESULTS AND DISCUSSION

LOFAR is a new and innovative radio telescope designed for measuring the lower frequency radio system to a wide range of astrophysics studies capable of operating in the 10-240 MHz by designing two dipole antennas to measure background noise included RFI during eclipsing on 25 October 2022 then compare it with measured in a regular day during afternoon and night. During a solar partial eclipse, the ionosphere significant drops in electron density, which can affect radio wave propagation. This decrease of electrons in the ionosphere during a solar eclipse is due to the temporary blockage of incoming sunlight from reaching the Earth. Which causes decrease the plasma density in the ionospheric of layers E and F1 regions caused by the loss of solar ionization rate although the short time of eclipsing.

However, in the night observed as shows Figure 4 there is a smooth behavior for both LBA and HBA, where the reason could be the ionosphere electron density a decrease at all altitudes because the production of ions is significantly attenuated. In contrast, recombination rates of electrons and ions remain high, especially at low altitudes where the recombination process is fast.

## CONCLUSIONS

In this study, the level of the radio background was measured during the partial eclipse period in Baghdad, where it was found that the noise level associated with the signal was lower than its level in normal days and became approximately to the night period, which has radio calm. And there is a

good relationship between the peak of the eclipse and the amount of the signal received. Also, the received power of backscattered signals decreases during an eclipse.

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