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IDENTIFYING MOVING RADIO SOURCES ASSOCIATED WITH SOLAR STORMS USING RADIO OBSERVATIONS AND MODELING OF MAGNETIC FIELDS

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Abstract

The techniques and instruments employed for receiving galactic radio signal at 1420 MHz at a tropical station Kalyani are described. The purpose and background of this type of observation and some early attempts for developing similar receiving equipments have first outlined. Some interesting characteristics obtained from the continuum observations as well as the spectrum observations are reported. An Interstellar Search System (ISS) is exceptionally vulnerable to interference by manmade coherent radiations and as a matter of fact the terrestrial radio spectrum is largely crowded. For this reason an extensive strategy is very much essential to hold interference up to a reasonable level. The terrestrial origin of an interfering signal can perhaps be recognized to a high level of certainty by making use of a properly operated ISS. A simultaneous study is essential to find the degree of using the ISS frequencies particularly where the signals are kept close to the surface of the Earth. In fact, any interstellar searching system is compatible with a large use of the same frequency band when its use is confined to the surfaceof the Earth. It may be pointed out that the present use of 1400 MHz to 1727 MHz band is more or less compatible with the operation of an ISS, in contrast to bands below 1400 MHz and above 1727 MHz, where powerful aircraft acquisition

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radars are in operation. There are physical and philosophical arguments which imply that the probability of finding signals from an extraterrestrial civilization is maximized in the frequency band between 1400 MHz and 1727 MHz. The 1400 to 1427 MHz band is of interest because interstellar transmissions may take place around the hydrogen line, while the 1427 to 1727 MHz band is located between the hydrogen and hydroxyl lines and lies near the minimum of the noise background. It is to be mentioned here that the 1400 MHz to 1427 MHz is currently allocated exclusively to the radio astronomy service while 1427 to 1727 MHz may be shared with other likely services where their use will not cause any recognized harmful interference during the operation of an ISS.Solar variability originates from the interior of the Sun. One very important aspect of solar variability is to link solar magnetic fields generated below the convective zone in the interior. The evolution of magnetic fields is responsible for variety of manifestations like the well known coronal mass ejections. Solar origin of variability, corresponding time-scale, and suggested possible climate changes are summarized. The shape of the corona depends on the distribution of the magnetic field lines and it is possible to study transient features due to large scale mass ejections through the corona. We have received radio signals from solar corona by using 406.7 MHz radio telescope in our observatory at Kalyani. The selection of the fixed frequency at 406.7 MHz of the receiver is to receive radio signal from the solar corona region. Radio signals owing to solar corona received at different dates when analyzed have shown interesting characteristic patterns with a variation in the signal levels. The varying nature of enhancement in the received radio signal may presumably be associated with the type of corona responsible for producing the characteristic patterns of the radio signal. The measurements of solar radio bursts as recorded by using log periodic dipole array over Kalyani, West Bengal, India have been presented.

Review of Earlier Works and Scope forPresent Investigation

1.1 Introduction

Scientists have recently discovered that sentient life may exist across the cosmos, and that we may not be the only civilisation in our galaxy. The study proposes a new search method based on sky noise windows that emphasises both the "water holes" and the wavelengths associated with them. It also implies that an all-sky search, rather than directing the antenna at known stars, might be more suitable for interstellar communication. The sun's many activity centres produce energy in both an impulsive and steady manner. The energy release mechanisms leave their mark in the form of radio

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frequency bursts. Solar radio bursts may span a wide bandwidth while also having a fine frequency structure, depending on the energy release and transmission mechanisms [1]. This page aims to provide information on the history of radio astronomy, its development, its relationship to solar studies, and the impact that spacecraft will have on this field's research. [2, 3].

1.2. Some Earlier Phenomenon at the Beginning of Radio Astronomy

It's almost difficult to portray the most significant events in radio astronomy history without giving a glimpse into how it all began, with the creation and knowledge of the electromagnetic spectrum.In 1960 James Clerk Maxwell developed his famous theoryrelated to electro-magnetic radiation and shown that it is associated with electricity and magnetism, and could exist at any wavelength beyond the visible ray region. Scientists then used radio signals in spite of optical signals for detecting solar signals because optical signals may plagued by clouds and dusts present in earth"s atmosphere. Radio signals have become one of themost important tools of astronomical observations [4, 5]. The earliest experiments in radio astronomy were not successful, mostly due to technical limitations of the instruments as well as lack of knowledge of the nature of radio emissions from celestial objects. Several attempts were made to detect radio emission from the Sun by experimenters of Oliver Lodge, Nikola Tesla and Thomas Edison but unfortunately they were not successful [6, 7].

First Victory in Radio Astronomy

The earliest achievement was accidental! In 1932, physicist and radio engineer Karl Jansky was studying the origins of radio frequency interference for Bell Laboratories. The Bell Telephone Company was having problem with the working of their transatlantic service, because of static of some sort in the late 1930s. The company asked Karl Jansky to find such interference source [8]. He discovered a one type of interference signal (celestial in nature) with his Bell Laboratories ship, varying with the rise and set of constellations, coming from an unknown source in thecenter of our galaxy (Figure 1.1). He found "...a steady hiss type static of unknown origin", at a frequency of around 20 MHz which eventually he concluded had an extraterrestrial origin [9]. This was the first time that radio waves were detected from outer space. Eventually, through experimentation, he concluded that the signal received by him was not noise but was coming from the center of the Milky Way [10-12].

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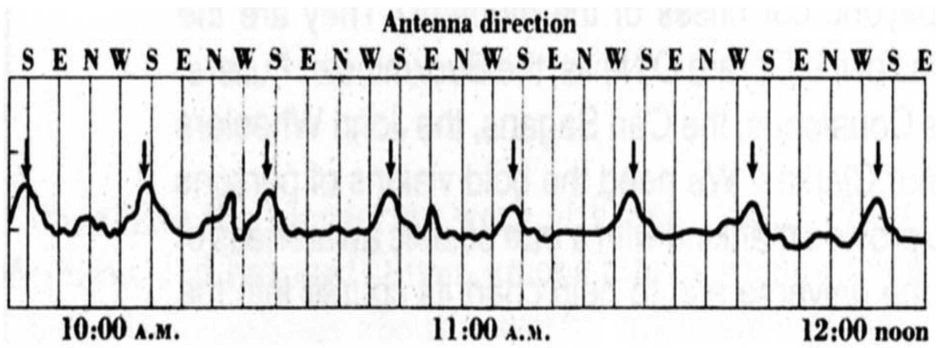

Figure 1.1 Karl Jansky detected radio waves coming from an unknown source in the center of our galaxy

The first radio telescope was constructed by Grote Reber in 1944. Grote Reber was motivated by Jansky‟s discovery. He was interested to find out the process that make the development of radio waves in space and verified whether the waves were coming from the different celestial objects. Bell Labs were not so successful at that time of great depression. Reber had the determination to achieve his goals, even if he did it all from his back yard. On his own investigation Reber constructed a telescope in 1937 which had a parabolic dish reflector and 3 receiving frequencies: 3300MHz, 900MHz and 160MHz [13]. Reber was one of the pioneers of modern radio astronomy. Depending on his work, after World War II, many scientists were able to build huge and better antennas or studying the universe [16].

Though Jansky and Reber published their findings in many appropriate journals, their findings were ignored initially many times. The interest is begun after World War II; when modern technology had been developed rapidly.

Radio Signals using Hydrogen Line Spectrometer

Strong Radio waves are emitted from Astronomical radio sources, which are universe [20-21]. In the 1970s, it is discovered that there are some stars in our galaxy, which emit strong radio waves, one of the recent years, radio communication has been attempted by considering the sky noise windows of the atmosphere [39-41]. If the hydrogen line and the water line are taken into account one can find that the hydrogen (H) line is at 21 cm whereas the hydroxyl radical (OH) line is at 18 cm. When hydrogen is combined with hydroxyl radical, it produces water (H_2O) whose wavelength lies between 18 cm and 21 cm. The window between 18 cm and 21 cm is treated as the first „water hole‟ which when converted to frequency lies between 1420 MHz to 1666 MHz [42-44].

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1.3 The Solar Variability

Solar variability originates from the interior of the Sun. One very important responsible for variety of manifestations like the well known coronal mass ejections. Solar activity changes on time-scales from hours to years. Broadly one can classify the two distinct types of emissions from the Sun as (i) continuous emission and (ii) solar cycle dependent emission.

Electromagnetic radiation, solar wind and solar magnetic field are the continuous emissions, whereas coronal mass ejection, energetic particle emission are related to solar cycle dependent emission. The continuous emissions are caused of climate, structure of the atmosphere, magnetosphere. The solar cycle dependent emissions are the cause of geomagnetic activity and it interacts with upper polar atmosphere.

One very important aspect of solar variability is linked to solar magnetic fields generated below the convective zone in the interior. The evolution of magnetic fields is responsible for variety of manifestations such as the well-known coronal mass ejections and solar wind structures. Though the influences from the variation of the electromagnetic radiation have considered widely and largely available in literature [104-106], a changing solar wind and energetic particles have got less priority, perhaps due to its very complex scenario, which can also influence Earth either directly or indirectly through modulating the cosmic ray flux.

1.3.1 Variations in Solar Activity

Variation of solar activity directly interacts with earth‟s atmosphere and also effect the climate of the earth. A block diagram (Figure 1.4) is shown the interaction between solar activities with earth‟s climate.

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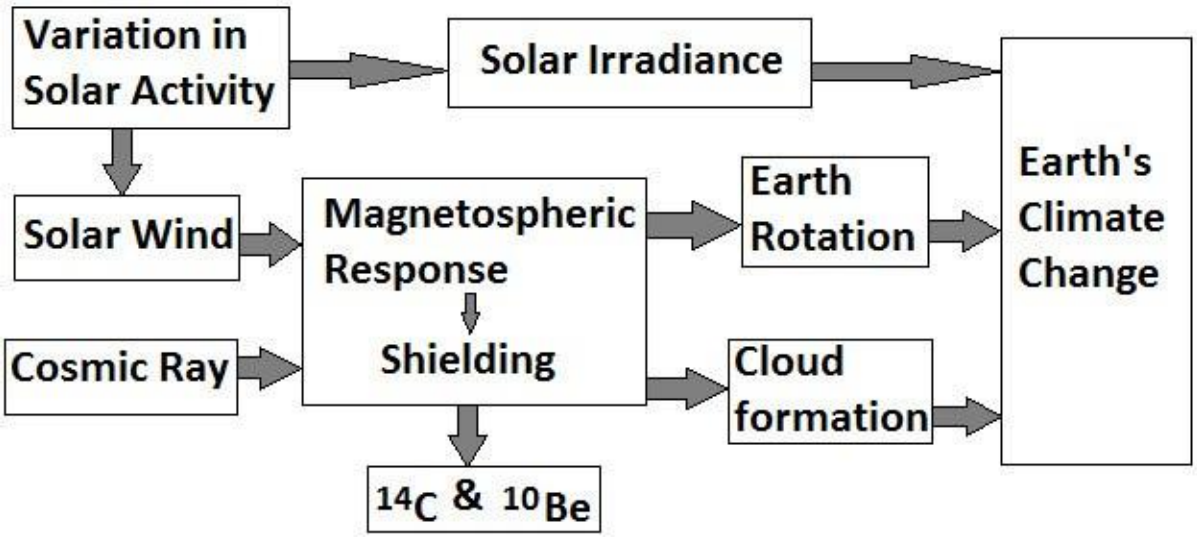

Figure 1.4 Change of Earth‟s climate with solar activity variation.

1.4 Variation in Earth's Geomagnetic Field

Most of the geomagnetic field observed on the ground was of internal origin (About 99%) and a very small portion was of external origin. These external origins are known as transient variations. There is much kind of transient variations e. g. solar and lunar daily variations, magnetic storm, solar flare effects and solar coronal mass ejections (energetic charge particles). The primary cause of these variations is external to the earth. When we observed the geomagnetic variations, the variation is contained a part of internal origin, which is the secondary effect of the primary causes of same order of magnitude [124].

1.10. Some Investigation of Extrasolar Planets

An extrasolar planet or exoplanet is a planet outside the solar system. Most of the exoplanets are massive giant planets similar to that of Jupiter. Strong Stellar Irradiation flux from the parent star interacts with all relevant depths of the planetary atmosphere with no need for a pre-assumed albedo. Rayleigh scattering increases the extrasolar giant planets flux by orders of magnitude short-ward of the Ca ii H and K doublet (3930A°), and the spectral features of the parent star are exactly reflected. Some kind of extrasolar giant planets of orbit within 0.05 AU of their primary stars, emit detectable infrared radiation [127-129].

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1.12 Scope of the Present Study

Chapter 1**:** In the early section of this chapter a brief review of the work done in this field is presented.

Chapter 2**:** The techniques and instruments developed for the study has been presented in this chapter.

Chapter 3**:** In this chapter we have proposed a new radio technique and the instruments required for the purpose of interstellar communication. Established methods for detecting exoplanets are discussed. Our approach is to receive and transmit radio signals by considering the two "water holes" and the associated frequencies. Under certain approximation the probable numbers of stars that can be covered by the proposed radio signal technique have been determined, pointing out the limitations.

Chapter 4**:** Some interesting characteristics obtained from interstellar radio signals of frequency 1420 MHz which received in Hydrogen line spectrometer receiver at Kalyani both in spectrum mode as well as in continuum mode of observations are reported in this chapter.

Chapter 5**:** Solar variability originates from the interior of the Sun. One very important aspect of solar variability is to link solar magnetic fields generated below the convective zone in the interior. Solar origin of variability, corresponding time-scale, and suggested possible climate changes are summarized first in the Chapter. The shape of the corona depends on the distributionof the magnetic field lines and it is possible to study transient features due to large scale mass ejections through the corona. We have received radio signals from solar corona by using 406.7 MHz radio telescope and also received some ordinary solar flare by using LPDA in our observatory at Kalyani (22.98°N, 88.46°E). The selection of the fixed frequency at 406.7 MHz ofthe receiver is to receive radio signal from the solar corona region. Radio signals owing to solar corona received at different dates when analyzed have shown interesting characteristic patterns with a variation in the signal levels. The amplitude of the signals received at 406.7 MHz is foundlarger than that the signal received through LPDA. The signal level of the surface effect of the Sun at the peak activity varies in amplitude from 0.06 volts to 0.1 volt while those related to the solar corona vary in between 7.0 to 7.2 volts. Both the solar wind velocity and proton density arefound to increase in the dates of severe bursts and there are sudden disturbances in the arrival direction of solar wind particles. Also the geomagnetic indices are enhanced at the time of solar bursts when the Disturbance Storm Time (DST) index

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reduces rapidly.

***Chapter 6*:** In this chapter we discussed various sources of VLF radio signals and their effect on earth‟s atmosphere including earth‟s Ionosphere propagation. Various effecting parameters on VLF signal also discussed. And finally we have tried to examine the interconnections of Solar and Extraterrestrial signals with VLF signals.

Techniques and Instrumentations

2.1 Introduction

Scientists have recently discovered that sentient life may exist across the cosmos, and that we may not be the only civilisation in our galaxy. The study proposes a new search method based on sky noise windows that emphasises both the "water holes" and the wavelengths associated with them. It also implies that an all-sky search, rather than directing the antenna at known stars, might be more suitable for interstellar communication. [1-3].

2.2 Established Methods for Detecting Extrasolar Planets

There are various methods to find the extrasolar planets. Out of many attempts so far thefollowing indirect methods have revealed successful results. Established detection methods are:
(i) Astrometric Method, (ii) Radial velocity methods and Doppler shift measurement, iii) Dynamical perturbations, (iv) Gravitational Microlensing, (v) Transit Method, (vi) Pulsar Timing Method, (vii) Circumstellar Disks Method, (viii) Direct Imaging Method, (ix) Observations from Space and (x) MOP and Phoenix. Some of these methods are discussed here [4-6].

2.2.1 Astrometric Method

Astrometry is the measurement of a star's location in the sky and the exact observation of how that position changes over time. This technique has the benefit of being very sensitive to planets with huge orbits. As a result, the astrometric technique is useful in conjunction with other methods that are more sensitive to planets with tiny orbits. Long periods of observation are needed, which may be years or even decades. [4, 7].

2.2.2 Direct Imaging Method

Current Telescopes are capable of directly imaging planets, e.g. the Gemini Telescope, the Subaru Telescope and the VLT etc. Direct imaging is possible when Observatory‟s very large telescope array in 2004 and 2005 and also in 2007 to produce images of exoplanets.

Future Detection Methods are: (i) Observations from space, (ii) Eclipsing binary minima timing,

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(iii) Orbital phase reflected light variations and (iv) Polarimetry.

2.2.3 Observations from Space

These space probes even have the capability of detecting planets similar to our Earth [4, 11-16]. NASA has cut funding for the Terrestrial Planet Finder in 2007 and the funding has gone towards the Kepler Mission. This is mainly because the transit method will be used by the Kepler Mission to scan a hundred thousandstars simultaneously and thus will be able to collect statistics on the numbers of planets around sun like stars [17].

2.2.4 MOP and Phoenix

The main objectives of the Microwave Observing Program [11, 18-19] abbreviated as MOP, were the followingµ (i) "Targeted Search" Program, (ii) 800 Specific nearby Stars & General Sky Survey, (iii) Radio Dishes associated with NASA and (iv) A 43-meter dish at Green Bank. Signals were to be analyzed by Spectrum Analyzers each with a capacity of 15 million Channels.

On the other hand, Project "Phoenix" (1λλ5) was largely engaged inµ (i) "Targeted Search" Program, (ii) Studying about 1000 nearby Sun-like Stars, (iii) Phoenix conducted observation at the 64-meter Parks Radio Telescope in Australia and (iv) A 140-ft Telescope of the National Radio Astronomy Observatory in West Virginia, USA. The project observed 800 Stars over the available channel in the frequency range from 1200 to 3000 MHz.

2.3 Recording Techniques

In our laboratory there are some radio receivers, which are 1420 MHz Hydrogen line Spctra- Cyber receiver, 406.7 MHz Solar Radio telescope, Log Periodic Dipole Array Antenna operates on 50 MHz to 300 MHz, 40 kHz VLF atmospheric Receiver and 92 MHz VHF receiver.

2.3.1 1420 MHz Hydrogen Line Spectra-Cyber

1420 MHz Hydrogen Line Spectra-Cyber receiver is used for receive a signal which coming from in the intergalactic space. The receiver is briefly discussed here.

2.3.1.1 Description of the Radio Telescope

The Radio Telescope is comprised of two units; one called the front end the other the backend. The front end contains the low noise amplifier and the Receiver Backend contains the converter and signal processing circuitry. Both are powered by +12 Vdc, which is supplied by the backend and the external power supply. This low noise system is constructed with the latest, microwave component technology and, is state of the art for amateur radio astronomy. The 1420 MHz converter is a dual

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conversion unit, which converts the 1420 MHz. hydrogen region down to the 70MHz. IF frequency. The backend contains a high gain IF amplifier, square law diode detector, computer controlled DC amplifier, programmable integration control, adjustable offset, and a 12 bit A/D converter, power supply, all controlled by a Basic Stamp II micro computer! Interface to the outside world is by RS-232 link to an IBM compatible computer on com port #1 or #2. Presently, no other com ports are supported [20-22].

Radio Sources Associated with solar storms

3.1 Introduction

An extrasolar planet or exoplanet is a planet outside the solar system. Most of the exoplanets are massive giant planets similar to that of Jupiter [1-3]. For this limitation only a very few extrasolar planets have been detected directly [4-8]. Generally the life, which originatesoutside the earth, signified as extraterrestrial life. Tentative types of extraterrestrial life are in the range between sapient beings to bacterial life. Since convincing evidence of life is not extensively acknowledged by the scientific community, its existence is still hypothetical. The purpose of this chapter is to present a method of new radio technique and an outline of the instruments required for the purpose that can be implemented for interstellar studies.

3.2 Early Searches

At N.R.A.O., Green Bank, with a radio telescope (diameter of antenna 26 m) Drake [10] took first attempt to search extraterrestrial life. At Ohio State University with 110 m radio telescope Dixon [11] continued observation for the same purpose while with 26 m radio telescope an ultra-narrowband multi-channel search was made by Horowitz and Forster [12]. The summary of all these early attempts are presented in Table 3.1.

3.3 Confirmed Extrasolar Planets

In 1995, the first exoplanets was detected. It is 51 Pegasi b, it is a hot Jupiter with a 4.2-day orbit revolution around the star 51 Pegasi [13]. A list of confirmed extrasolar planets as discovered during the last twenty five years is presented in Figure 3.1 in the form of histogram. In 2014, almost greater than 800 exoplanet have been discovered, out of which more than 720 planetshave been discovered through transit time method, while Table 3.2 provides the latest exoplanets discovered in 2015 (up to February).

Table 3.2 Exoplanets discovered in 2015 (up to February) [13]

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Star name	Planet name	Mass (Compared to Jupiter)	Radius (Compared to Jupiter)	orbital period (day)	Semi majoraxis	Eccentricity	Discovery year	Detection type
HD 145934	b	2.28		2730	4.6	0.053	2015	Radial Velocity
EPIC 201367065	b		0.191	10.05403	0.0769		2015	Transit
EPIC 201367065	c		0.153	24.6454	0.1399		2015	Transit
EPIC 201367065	d		0.136	44.5631	0.2076		2015	Transit
KOI-4427	01		0.164	147.6606	0.419	0.02	2015	Transit
KELT-7	b	1.28	1.533	2.734775	0.04415		2015	Transit
Kepler-436	b		0.244	64.00205	0.339	0.19	2015	Transit
Kepler-437	b		0.191	66.65062	0.288	0.02	2015	Transit
Kepler-438	b		0.0999	35.23319	0.166	0.03	2015	Transit
Kepler-439	b		0.2	178.1396	0.563	0.03	2015	Transit
Kepler-440	b		0.166	101.1114	0.242	0.34	2015	Transit

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Kepler-441	b		0.146	207.2482	0.64	0.1	2015	Transit
Kepler-442	b		0.12	112.3053	0.409	0.04	2015	Transit
Kepler-443	b		0.208	177.6693	0.495	0.11	2015	Transit
Kepler-444	b		0.036	3.600011	0.04178	0.16	2015	Transit
Kepler-444	c		0.0443	4.545884	0.04881	0.31	2015	Transit
Kepler-444	d		0.0473	6.189392	0.06	0.18	2015	Transit
Kepler-444	e		0.0487	7.743493	0.0696	0.1	2015	Transit
Kepler-444	f		0.0661	9.740486	0.0811	0.29	2015	Transit
Kepler-445	b	0.02	0.141	2.984151		0	2015	Transit
Kepler-445	c	0.027	0.224	4.871229		0	2015	Transit
Kepler-445	d	0.011	0.112	8.15275		0	2015	Transit
Kepler-446	b	0.014	0.134	1.565409		0	2015	Transit
Kepler-446	c	0.009	0.098	3.036179		0	2015	Transit
Kepler-446	d	0.01	0.12	5.148921		0	2015	Transit

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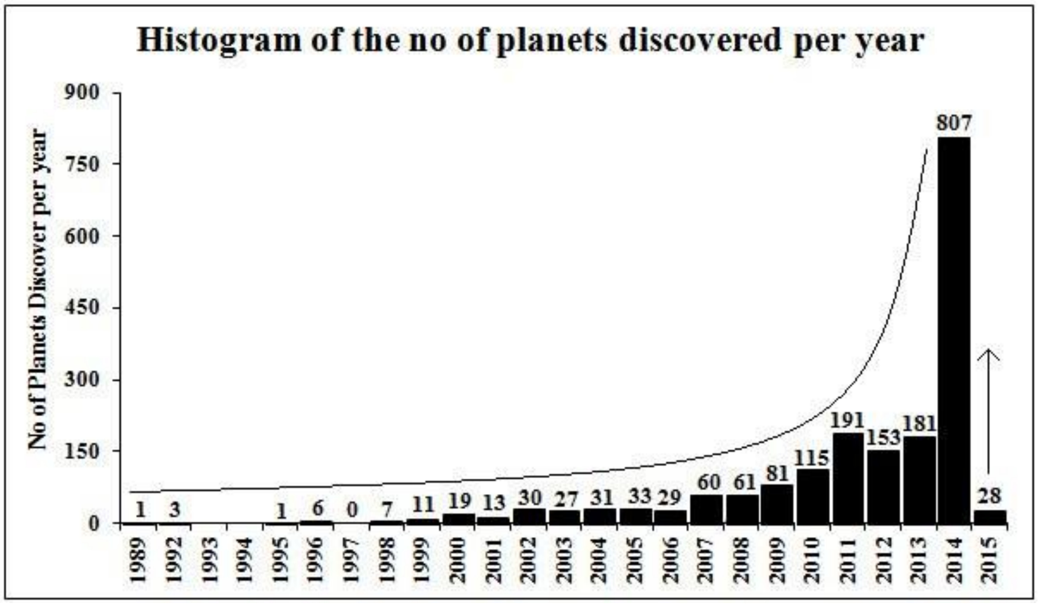

Figure 3.1 Confirmed exoplanets during 1989 to 2015 (January) [13]

Except for four brown dwarfs found after 2009, this map (Figure 3.2) depicts all star systems within 14 light-years of the Sun (represented as Sol). Although "stacked" double and triple stars are shown, the actual location is the star closest to the centre plane. [14].

3.4 Present Approach and Theoretical Consideration

Sky noise windows have been suggested as a suitable alternative search method for interstellar communication [15, 16]. We propose a radio communication method here, taking into account the sky noise windows of the atmosphere. Figure 3.3 is a sky noise diagram that plots sky noise temperature versus frequency. The hydrogen (H) line is at 21 cm, whereas the hydroxyl radical (OH) line is at 18 cm when the hydrogen (H) line and the water line are combined. When hydrogen reacts with the hydroxyl radical, water (H2O) is formed with a wavelength of 18 to 21 cm. A fascinating quantum quirk in the behaviour of the electrons inside the hydrogen atom forms the 21cm line. A second water hole is provided by a 2 mm line from the commencement of the water molecule that extends up to a 14 mm line [17]. Table 3.3 depicts the interstellar components and their associated states, including fractional volume, density, and temperature.

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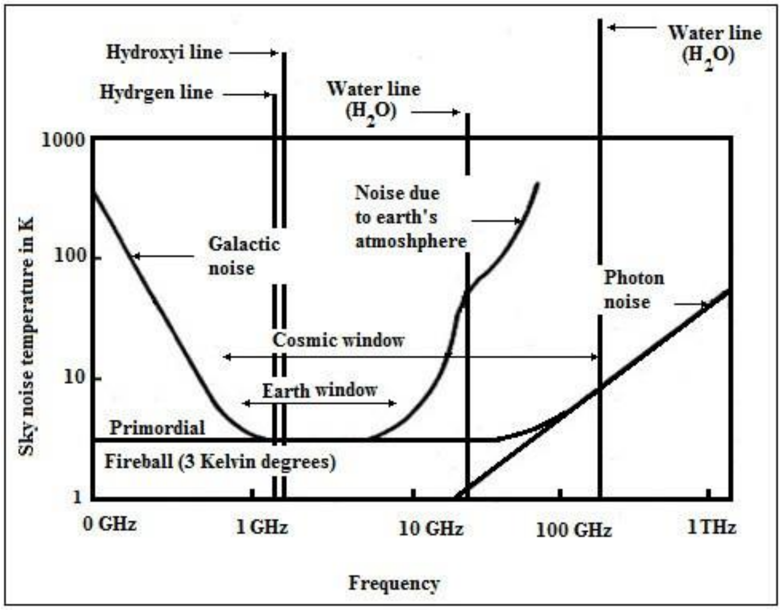

Figure 3.3 Sky noise windows ("water holes"), may be taken as most appropriate for interstellar
communications

This window is selected as the first water hole. To make radio link [18] this window can be exploited by galactic civilizations and also our own civilization with each other. Again there is a water molecule which starts from 2mm extend up to 14 mm line and this may be considered as a second "water hole".

3.5 Discussions

Photons (the building blocks of electromagnetic communication) move at the speed of light across the interstellar medium inside this so-called Microwave Window. Photons are the quickest spacecraft known to man since they travel at the fastest conceivable speed. As a result, the Microwave Window, where natural noise is low, is a popular location for radio astronomy study, including SETI [31, 32].

Galactic noise, mainly owing to synchrotron radiation, obstructs low frequencies, while quantum-effect emissions obstruct high frequencies, and the whole continuum suffers a 3 Kelvin background radiation level from the Big Bang's leftover radiation. Our capacity to identify artificial emissions is limited by these natural radiation sources. Furthermore, the Earth's own ocean of air produces spectral absorption and emission lines, drawing even another veil across our sky. However, the universe has a few reasonably clear windows. Our eyes have evolved to work in two of these windows. These windows will, ideally, enable us to view the stars and planets if the planned experiment is carried out with extreme caution. [1, 9, 23].

Some other data sheet is also present here by Figure 4.6 and Figure 4.7. The corresponding dates the data also indicated in the figurers. It very interesting to note that in all type of data sheet, the maximum pick voltages happened on 1420.2 MHz frequency.

Coronal holes closely communicate with high speed component of solar wind and these solar wind particles can interact with upper atmosphere and may influence the global electric circuit at high latitude. The signal strengths of the coronal effect in our observed data were very high compared to the surface effect of the Sun. In fact, the signal levelof surface effect of the Sun at the peak activity appears to vary in amplitude from 0.06 volts to

0.1 volt while those related to solar corona exhibit a change in between 7.0 to 7.2 volts. The solar wind also couples with magnetosphere and hence derives the ionosphere so that it again interacts with neutral atmosphere. These solar wind particles, i. e. the so called charged particles interacts with Earth"s magnetic field and influence the geomagnetic indices. Due to the active role of the charged particles, the geomagnetic indices are enhanced at the time of solar bursts when the DSTindex reduces rapidly.

Scope for Further Investigation

With a view to simplify the analyzing technique, we need to fine- tune the algorithm. This can help particularly when a large number of data is required to handle more systematically. In fact, a more appropriate solar burst identification strategy may be highly profitable at this time when the solar activity is picking up. Efforts are currently underway to calculate the response matrix for flare time intervals. In this regard, detailed spectral analysis andcross-calibration with other solar instruments are essential. We are planning to install on our server the response matrix software and generate response files for all flare time intervals. It isthe same date but with different time in IST, taken into consideration by us for illustrating our own data as a typical case and thus have used as a conclusive comparison.

A solar burst is a huge explosion in the Sun's atmosphere which affects different layers, particularly photosphere, chromospheres, and corona of the sun. It is responsible for heating plasma to very high temperature (~10^7 K) and accelerating nucleons and heavier ions to near the speed of light.

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peak Orionid meteor showers. When we compare on the same platform the characteristic variations of all the four magnetic parameters (viz. A_p, C_p, K_p and *AE* indices) we note a significant and very prominent changes during shower days with non-shower time. Our analysis indicates that the major meteor showers related to Orionids may be strong sources of geomagnetic disturbances. It was reported earlier that the auroral zone during geomagnetic storms of solar origin is subsequently redistributed to lower latitudes due to gravity waveperturbations. Present analysis reveals that the Orionid showers induce geomagnetic disturbancespresumably due to dumping of the ionized debris of meteors which eventually give rise to gravity waves during their propagation from polar to equatorial region and thereby to play an important role for redistributing the ionization in the appropriate height of the ionosphere which occurs at the path midpoint of the received signal. In fact, the greater number of occurrences of SF effects at night may be due to the reflection of signal at nighttime from a higher height (~90 km) and the probability of formation of an ionized meteor trail at such height with particle line density is sufficient to affect the 40 kHz VLF propagation. The photo-detachment process maybe operated in daytime to diminish the attachment coefficient, β_c. The higher value of β_c makes the duration of the observed SF effects greater at night due to the absence of photo-detachment process. The responses in the signal level due to Orionid meteor showers may also be governed by the time variation of the critical radius (r_c) under the combined influence of ambipolar diffusion, eddy diffusion and attachment but the contribution of r_c for Orionids should be examined elaborately for its model development and also to compare the time variation of r_c for other types of meteors like Leonids, etc. In addition, the spectrum monitoring stations could also be used for detecting radio transients and glowing radio sources in astronomy.

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