THE JOVIAN DECAMETRIC EMISSION AND THE COLLISION OF COMET SHOEMAKER-LEVY 1993e.

The Jovian Decametric Emission.

The Jovian decametric emission was discovered in 1955 by B.F. Burke and K.L. Franklin at the frequency of 22.2 MHz. The emission has an upper cutoff frequency of 39.5 MHz. It can be detected from ground based stations from the upper cutoff frequency of the emission down to the cutoff frequency of the terrestrial ionosphere which is usually around 5 to 10 MHz. The peak of the intensity of the emission occurs at around 8 MHz. The emission occur in episodes called "storms". A storm can last from a few minutes to several hours. Two distinctive types of bursts can be received during a storm. The **L** bursts (L for Long) are bursts that vary slowly in intensity with time. They last from a few seconds to several tens of seconds and have instantaneous bandwidth of a few MHz. The **S** bursts (S for Short) are very short in duration, have instantaneous bandwidth of a few kHz to a few tens of kHz, and drift downward in frequency at a rate of typically -20 MHz/sec. They arrive at a rate of a few to several hundred bursts per second. In a 5 kHz bandwidth receiver they last only a few milliseconds. Sometimes both types of bursts can be heard simultaneously. The emission is believed to be beamed into a thin hollow cone with axis parallel to the direction of the magnetic field lines in the region where the emission originates (near the magnetic poles). The probabilities of detecting the emission depend **strongly** on the values of the Jovian central meridian longitude (**CML**), the **Io Phase**, and the Jovicentric declination of the Earth ($\mathbf{D_E}$). The CML is the value of the System III longitude of Jupiter facing the Earth. The Io Phase is the angle of Io, one of Jupiter's moons, with respect to superior geocentric conjunction. The regions in the CML-Io phase plane that have increased probabilities of emission are called sources. The sources are named **Io-A**, **Io-B**, and **Io-C** for the Io-controlled emission and **A**, **B**, and **C** for the Non-Io controlled emission.

Source	CML	Io Phase	Characteristics of emission
Io-related sources			
Io-A	200-290	195-265	RH polarized, mostly L bursts
Io-B	90-200	75-105	RH polarized, mostly S bursts
Io-C	290-10	225-250	LH polarized, L and S bursts
Non-Io related sources			
A	200-290		
B	90-200		
C	290-10		

The Collision of Comet Shoemaker-Levy 1993e and the Possible Effects on the Low Frequency Radio Emission.

Comet Shoemaker-Levy 1993e will impact Jupiter between July 16 and 22, 1994. Extreme tidal forces exerted by Jupiter broke the nucleus up into at least 21 fragments during a close pass

by the planet about two years ago. The largest of the fragments are about 2 to 4 km in diameter. Over a period of about six days, each fragment will penetrate Jupiter's magnetosphere and explode at about the cloud-top level of the atmosphere, creating a fireball that may rise to the altitude of Jupiter's ionosphere. Since the fireballs will occur just beyond Jupiter's limb as viewed from the Earth, they will not be visible unless they rise to unexpectedly great heights.

It is not known whether the passage of the fragments through the magnetosphere and their collision with Jupiter will create radio emissions that are detectable from Earth. An electric field will be induced in the nuclei as they pass through the Jovian magnetic field, an effect similar in nature to that experienced by the satellite Io. However the plasma density around the comet and the magnitude of the electric field induced may be too low and cause only weak radio emission (unless something unexpected happens that could suddenly increase the amount of ionized gas around the comet). Several suggestions has been made regarding the possibility of emission at different stages of the passage and entry into the jovian ionosphere and atmosphere. One suggestion is that the interaction of the fragments with the Jovian ionosphere may trigger decametric emission in the last 10-20 seconds before the explosion. Another suggestion is that low frequency electromagnetic radiation could be emitted by the plasma released during the fireball. In this case the emission may be in the form of short pulses of electromagnetic radiation. Another possibility is the stimulation of lighting discharges from lower altitudes after the fireballs have developed. This emission may be in the form of almost continuous noise originating in the possible large number of lightings discharges. Since the fireball will occur on the far side of the planet it is unlikely that direct radio emission could be detected from ground based observations. There have been suggestions that ducting of the radio emission in the layered ionosphere around the limb of the planet might make possible its detection from Earth. Apparently no estimates for the intensity of these types of emission are yet available.

Still one more possibility is that plasma released by the comet and plasma generated by the fireball may affect the well known decametric emission. If this plasma diffuses along lines of magnetic field and reaches the region where the decametric emission is generated, it may alter the probabilities of emission or it may have a quenching effect of the emission in particular at the low frequencies. These changes in the behavior of the decametric emission may not be easily detectable, at least for an occasional observer. It will be necessary to make systematic observation of the emission for several months prior to the collision in order to establish a baseline for the probabilities, the intensity, bandwidth, etc. of the emission. As was mentioned above, the decametric emission is sporadic but the probabilities of receiving the emission are larger for some particular configurations of central meridian longitude (CML) and Io phase. Careful radio observations will be made from various locations in an attempt to ascertain which of these situations prevail during the impacts. Whatever information can be determined in this way will be of great value in the investigation of the origins of Jupiter's radio emissions.

The University of Florida Radio Observatory (UFRO) has been observing the Jovian decametric emission since 1957. For the present apparition the UFRO started observing in January, 1994 at several frequencies between 18 to 32 MHz. The observations will be extended through at least August to be able to observe during the collision of comet Shoemaker-Levy 9 with Jupiter.

Observing the Jovian Decametric Emission.

There have been reports of detection of the Jovian decametric emission with simple half wavelength dipole antennas or low gain antennas such as the long-wire type or loop antennas. Such low gain antennas may allow the detection of only very strong bursts. Antennas with gains of 6-10 dB with respect to a half wavelength dipole are more suitable for detecting the emission. Yagi (5-elements) and log periodic antennas usually have gains in this range. These higher gain antennas connected to HF amateur radio receivers can easily detect most of the strong part of the Jovian decametric radio emission. It will be necessary for good reception of Jupiter that the antenna points towards the planet. This may be difficult since most amateur antennas only have azimuthal control. Most amateur HF radio receivers are suitable for detecting the emission since they have a relatively narrow passband and adequate noise figure. The relative narrow band of these receivers will help in tuning away from radio stations. It will be necessary to disable the AGC of the receiver otherwise the signal will be badly compressed. An observing frequency between 18-22 MHz is recommended. At frequencies below 18 MHz strong interference from stations and static is expected. At frequencies higher than 22 MHz, the probabilities of detecting the emission drop sharply because of the drop in intensity of the emission (see the histogram of occurrence probability, **hist.ps**). Although the low solar activity expected for this year is a favorable condition for detecting the emission during the period of the collision, the low value of D_E (around -3.4 degrees for July, 1994) reduces the probabilities of detection.

As a reference, the minimum detectable flux density (power per unit area per unit bandwidth) expected for an 8 dB gain linearly polarized antenna connected to a receiver having a 5 kHz bandwidth and an output time constant of 1 second is of the order of $5X10^{-22}$ $wm^{-2}Hz^{-1}$ at a frequency of 18 MHz. Jovian decametric radio emission with peak flux densities in the range of $10\text{-}100X10^{-22}$ $wm^{-2}Hz^{-1}$ are common. Expressing the flux densities in Jansky, a unit more commonly used in radio astronomy, these peak flux densities are 100,000 to 1,000,000 Jy (1 Jy= $1X10^{-26}wm^{-2}Hz^{-1}$). In terms of power and voltage at the input of a receiver, $10x10^{-22}$ wm^{-2} Hz^{-1} is equivalent to a power of $1x10^{-9}$ microwatt or 0.23 microvolt over 50 Ohms.

A few more additions need to be considered if the information gathered is to used for scientific purposes. A source of calibrated noise is necessary in order to calibrate the intensity of the signal. As an example, an HP 461A amplifier can be used as a noise source (with a variable attenuator), but the noise temperature of the amplifier must be calibrated against a standard noise source such as the type 5722 current-saturated noise diodes. Timing information is also an important consideration. WWV timing signals can provide adequate timing information. The ability to identify the Jovian emission and separate it from stations, statics, or other types of interference is also important. Recording of the receiver output in paper chart records provide a nice way of monitoring the emission. The chart records can be used for further data reduction and analysis, but their use is sometimes time consuming. A personal computer with an A/D converter will provide a better way to store, retrieve, and process the information (if further data reduction and analysis are to be made). Time constants of about 1 second are adequate for recording the envelope of the emission. Shorter time constants (10-20 milliseconds or shorter) are necessary to resolve the faster S bursts.

The University of Florida Radio Observatory (UFRO) has generated a listing of the prediction of the configurations of CML, Io Phase, the active sources, and the probabilities of emission at 26.3 MHz for the months of April, May, June, July, and August, 1994. The probabilities at 26.3 MHz are valid for an antenna of large collecting area (These probabilities

were obtained with the 640 dipoles of the UFRO 26.3 MHz Large Array), and are included as reference only. Probabilities at 18 MHz and other frequencies (obtained with Yagi antennas with gains around 8 dB) may be added later. For those having access to Internet, the files containing a short explanation and the predictions are accessible at the ftp site `astro.ufl.edu`; the files are in the `pub/jupiter` directory and are called README.DOC and `april94.txt`, `may94.txt`, `june94.txt`, `july94.txt`, and `aug94.txt`. Questions or comments regarding the predictions can be sent to L. Garcia at `garcia@astro.ufl.edu`.

Francisco Reyes
E-Mail:`reyes@astro.ufl.edu`
Phone: `(904) 392-7749`

Leonard Garcia
E-Mail:`garcia@astro.ufl.edu`
Phone: `(904) 392-0668`

Dept. of Astronomy. P.O. Box 112055
University of Florida
Gainesville, FL 32611-2055
Fax `(904) 392-5089`
`04/26/94`