Characteristics of Decametric Emission of Jupiter

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Received 20/10/2012 – Accepted 19/11/2013

الخلاصة

أجريت دراسة إحصائية لمعرفة مميزات الإشعاع الديكامتري المنبعث من كوكب المشتري.هذه المميزات هي الطبيعة المتقطعة والوقت والنوع والتردد. فترة من أحدى عشرة سنة أخذت لدراسة الميزة الأولى وبعدها أخذت سنة ٢٠٠٤ لدراسة الميزات الأخرى. زودت البيانات من مشروع الراديو جوفا، حيث يعطي معلومات عن موقع الراصد والتاريخ والوقت والنوع والتردد. النتائج قورنت مع نتائج الراديو جوفا وأشارت إن الإشعاع الديكامتري هو متقطع، وقت استمراره بين (٠٠:٠١-٠٥:٣١) ساعة ووجد إن (Io-B) هو أعلى من عدد.، اكبر عدد من الإشعاع الديكامتري حدث عند التردد (٢٠-٢١) ميكاهيرتز. النتائج قورنت مع نتائج برنامج الراديو جوفا وأشارت إن الإشعاع الديكامتري أشعاع متقطع زمن استمراره بين (٠٠:٠١-٠٥:٠٠) وتردده ٢١ ميكاهيرتز.

ABSTRACT

A statistical study was made to know the characteristics of Decametric (DAM) emission emitted from Jupiter's planet. These characteristics are the sporadic nature, time, type and the frequency. Period of 11 years was taken to study the first and year 2004 was taken to study the others. Data were provided from Radio Jove project, which gave information about the observer's location, date, time, type and the frequency. The results indicated that the DAM emission was sporadic, the time was between (00:01-05:31) hour, it was found that (Io-B) is the largest number, as compared with others, a large number emission occurred at frequency range (20-21) MHz. The results were compared with results of Radio Jove software, which indicated that the DAM emission is sporadic, the time is between (00:01-05:00) and the frequency is 21MHz.

Key words: DAM Emission, Acceleration of Particles, Radio Signals.

INTRODUCTION

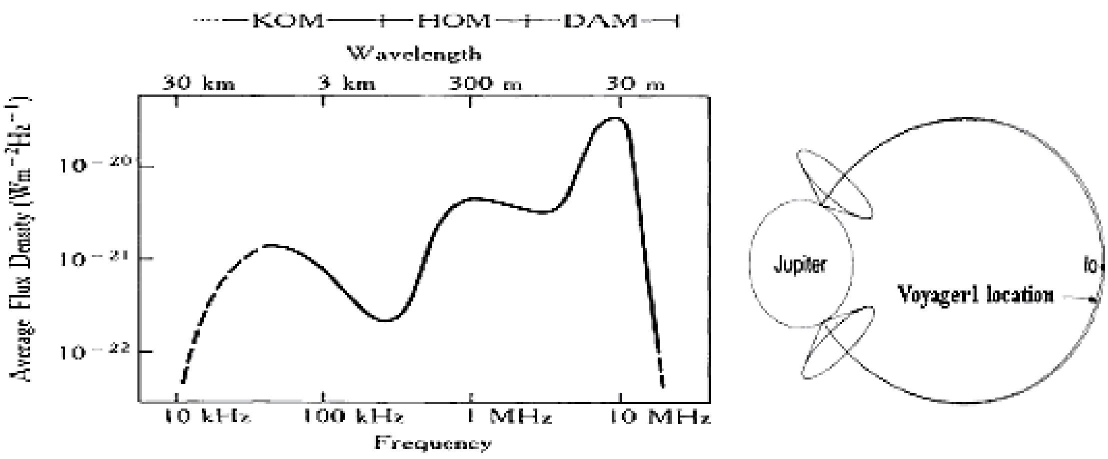
Early in 1955, Bernard Burke and Kenth Franklin of Carnegie Institute discovered, by accident, that Jupiter's planet emits strong short-wave radio signals. While testing a very directional radio astronomy antenna known as a" Mills Cross", they frequently received sporadic signals at frequency 22.2 MHz, that looked like interference[1,2]. After several months, it began to appear that the "interference" might be of a celestial origin and not simply the noisy ignition of a passing truck. Burke and Franklin were both amused by suggestion of Howard Tatel that the signals might be coming from the planet Jupiter. In order to disprove this suggestion, they made a plot of the celestial coordinates of all the interference events. To their amazement, Jupiter's location in the sky coincided with the direction of their antenna beam each time the interference signal was received[3].After the accidental discovery of this emission, scientists thought to understand what caused this radio emission. They started with careful observations, recording the times of hearing Jupiter and how intense Jupiter's emission. After collecting these radio data they compared it with other information they had about Jupiter[4,5].

DAM Emission

The word Decametric (DAM) in terms of wavelength means tens of meters and frequency range (10-40)MHz, the observer on the ground detects this emission at specific frequency, the studies of the Jovian emission show, in particular, its great variability. No other planets in the solar system emit this type of emission[6,7], as shown in Figure-1a. The observation of Jovian DAM emission is the only one that can be observed from Earth. In 1964, Bigg pointed out that Io the inner most of Jupiter's satellite, affects the Jovian DAM emission[8]. There are three major factors not related to observing conditions on Earth which have been identified to affect the probability of hearing Jupiter's DAM emission at any given time: longitude of system three (L_{III}) of Jupiter that faces to Earth, the position of Io's (γ_{Io}) satellite in its orbit around Jupiter, and the Jovicentric declination of the Earth (D_E). The DAM emission divided into two types Io-related (Io-A,B and C) and non-Io-related (non-Io-A,B and C)[7,10,11].

Generation of DAM Emission:

When charged particles move through a magnetic field their paths are changed. The particles are accelerated and start to move in spirals around magnetic field lines towards either the south or the north pole[12]. The DAM emission is emitted in a thin hollow cone, the radiation can only be detected at Earth, if the thin walls of the cone intersect the direction of Earth, as shown in Figure-1b. The opening angle of the hollow cone seems to be around (70-80)º[11,13].



a b

Figure-1: a: The range of frequency and wavelength[9], b: The emission cones[14].

DATA AND RESULTS

• The Sporadic Nature

The DAM emission is described as a complex, organized, variable, sporadic and detected at specific frequency. During the emission, the Sun, Earth and Jupiter, must be at a straight line, otherwise the emission will not occur, as shown in figure-2. Table-1 explains the data from the Radio Jove project, which describes different characteristics for the DAM emission such as observer's name, observer's location, date,time,type and the frequency, at which point the observer detects the radio signal. Receiving DAM emission depends on two parameters: longitude of system three of Jupiter and phase of Io's satellite. According to these two parameters the emission is determined, but this type of emission is not continues, it is received sporadically, in one day the observer on Earth can detect one emission, more than one or can not detect any emission depending on the motion of Jupiter around itself and the rotation of Io's satellite around Jupiter in the solar system, at the point which the emission was formed. The number of DAM emissions in one day does not give a good explanation to describe the sporadic nature, so the number of DAM emissions was taken for each month within 11 year, from (2000-2011), which is approximately the period that requires for Jupiter's planet to complete approximately one cycle around the Sun, as shown in figure-3. The average was calculated for each year to know how does the emission changes. Figure-3 was compared with figure-4, which indicated that the number of DAM emissions for year 1989 was distributed randomly, a highest column was within October, this matches our results, but for different months of the emission occurrence. Table-2 and figure-5 explained the average.

Table-1: Data from Radio Jove project.

Observer's Name	Observer's Location	Date	UT (HH:MM)	Type of DAM Emission	Frequency (MHz)
Ruggero Ulivastro	NICEro	31/12/2003	05:54-06:02	Io-A	20.2
Jim Sky	NASA/GSFC	21/12/2003	14:35-15:41	Io-B	20.1
Richard Flagg	UFRO	01/08/2004	09:07-09:17	Io-B	18-28
John H. Thomas	W3FAF_Radio Observatory	23/02/2005	07:00 -10:00	Non-Io-B	20.99
Jim Brown	NJ3B Radio Observatory	22/07/2006	11:59- 13:29	Io-C	20.1
Wesley Greenman	University of Florida	24/02/2007	13:00-13:10	Io-C	15-30
Bernardin Marker	Franciscan Gymnasium Kreuzburg	04/09/2008	05:09-05:10	Non-Io-C	20.1
Jim Brown	Hawk's Nest Radio Astronomy Observatory	21/06/2009	08:10- 09:40	Io-B	20.1
Wesley Greenman	University of Florida	22/05/2011	01:00-02:00	Io-A	19.9

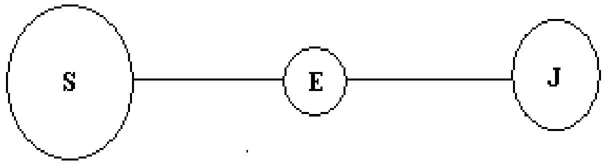


Figure-2: The Geometry of the emission[16].

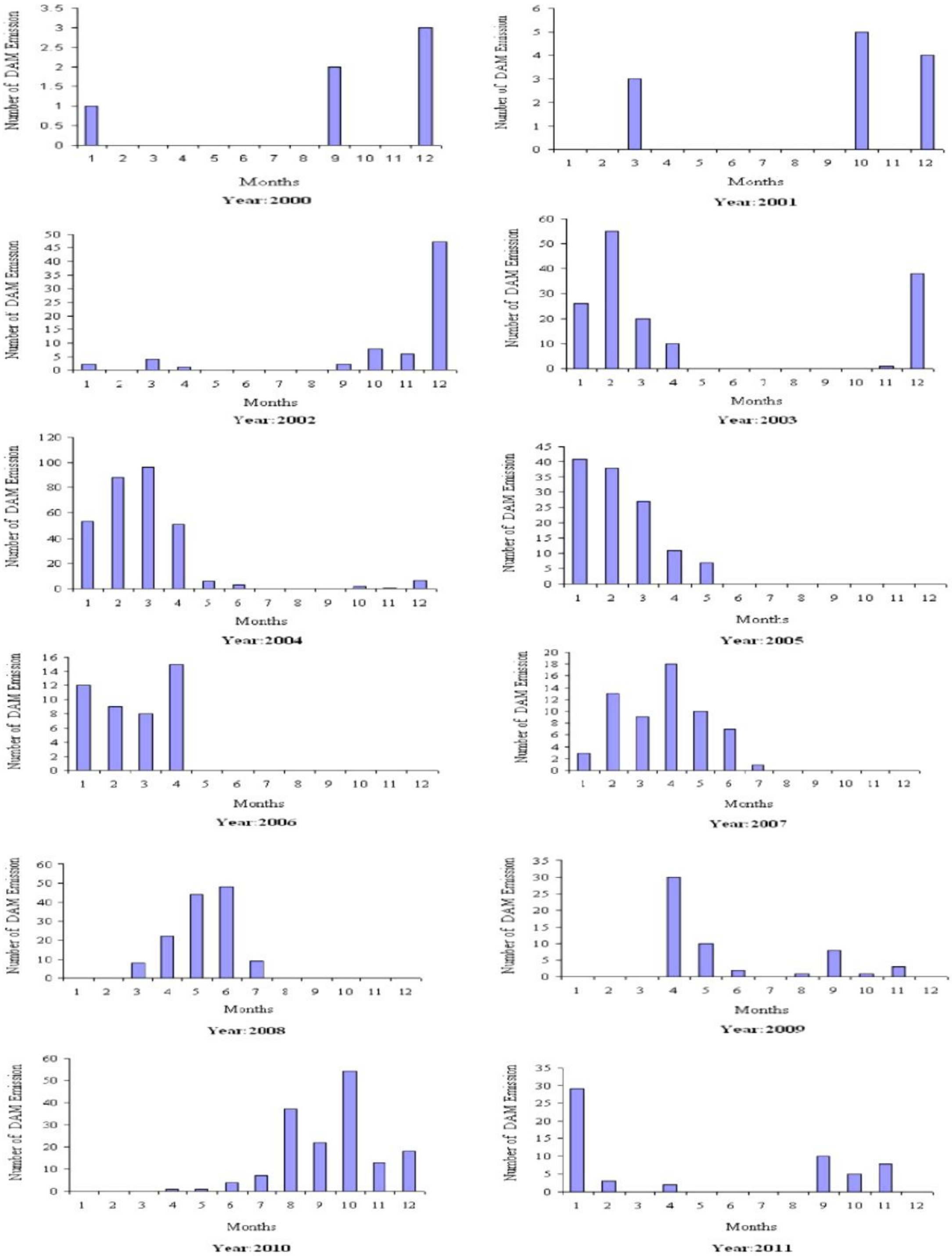


Figure-3: Number of DAM emissions for each month.

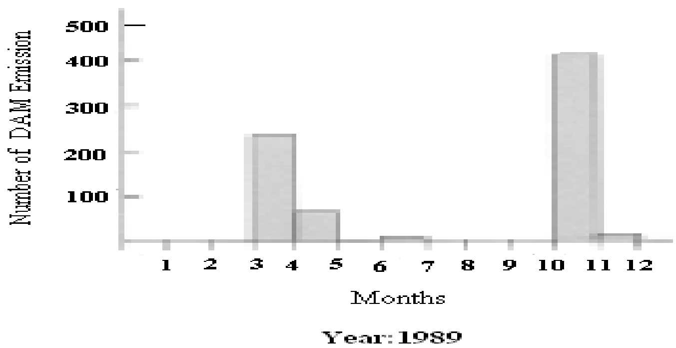


Figure-4: Number of DAM emissions for year 1989[16].

Table-2: Number of DAM emission within one cycle around the Sun.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Number of DAM Emission	6	12	73	52	311	127	44	61	131	55	157	57

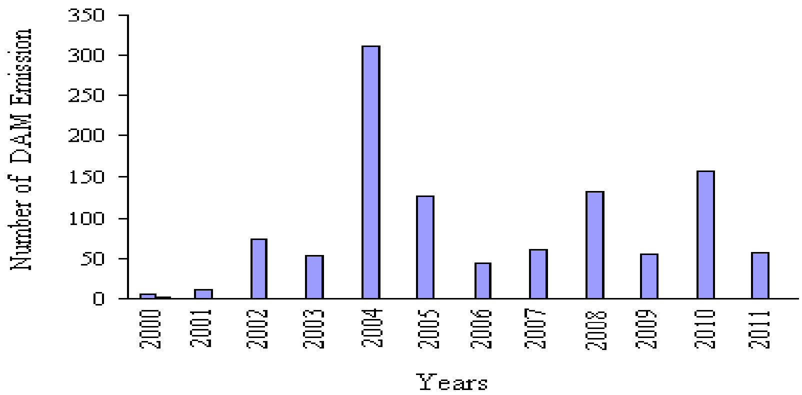


Figure-5: Number of emissions within one cycle around the Sun.

• **Time and Type**

The time required for DAM emission to cut off was different from each type to another. It was between few minutes to several hours, this depends on the rotation of Jupiter and Io. Table-1 indicates the differences in time. Because the number of DAM emission at year 2004 was the highest, so in our studying we depended on this year. The maximum and the minimum time were calculated to know the time continuity for DAM emission, as listed in table-3. The results indicated that the minimum time for DAM emission was 00:01, which was constant for all types of emission. The maximum time was different for each type, as figure-6a. The type of DAM emission was also depended on the motion of Jupiter and Io, (Io-B) type was the highest column, as shown in figure-6b.

Table-3: The maximum and the minimum time.

Type of DAM Emission	Time of Continuity for DAM Emission		Number of Each Type
	Maximum (HH:MM)	Minimum (HH:MM)	
Io-A	04:00	00:01	143
Io-B	03:37	00:01	322
Io-C	03:37	00:01	185
Non-Io-A	05:31	00:01	63
Non-Io-B	03:36	00:01	12
Non-Io-C	00:18	00:01	11

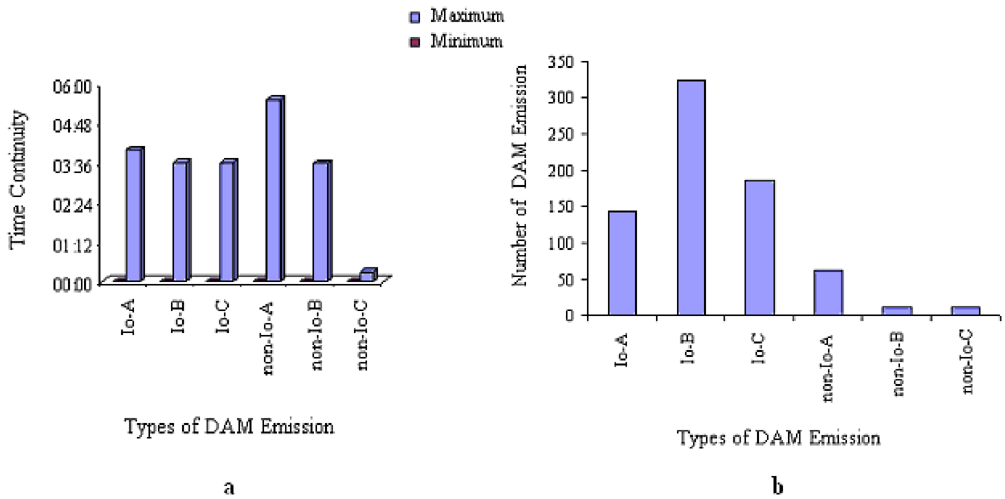


Figure-6:a: Time required for DAM emission, b: Types of DAM emission.

• The Frequency

All studies of the number of DAM emission indicated that emission from Jupiter at frequency of twentieth was larger as compared with other frequencies. The frequency range of DAM emission was between (10-40) MHz. The exact frequency depends on: solar activity, elevation angle of Jupiter above the horizon and time of night. Data collected from the Radio Jove project, as listed in table-1, showed that there were different values for the frequency, these differences were referred to as reasons that motioned previously and the setting of the receiver, which was picked up the frequency. Our results indicated that a large number of DAM emission occurred at frequency range (20-21), other columns were very low, as listed in table-4 and shown in figure-7.

Table-4: The frequency of DAM emission.

Frequency (MHz)	18.7	19.8	20-21	18-28	15-30
Number of DAM Emission	39	1	202	114	10

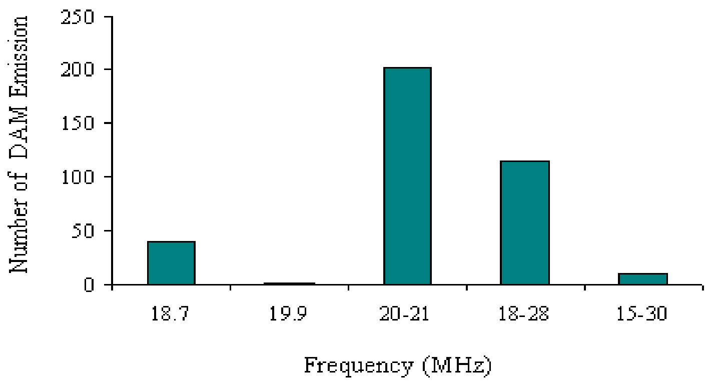


Figure-7: The maximum frequency at (20-21) MHz.

DISCUSSION AND CONCLUSIONS

Jupiter emits intense DAM emission, and this emission depends on the longitude of system three of Jupiter and phase of Io's satellite. Eleven year were taken to know the sporadic nature of the emission, figure-3 indicated that there were months the observer on Earth can not detect any successive DAM emission; therefore one complete cycle of Jupiter around the Sun was plotted to describe the behavior of the emission. It was sporadically behavior, this refers to the motion of Jupiter and Io, which gave that behavior. Figure-5 gives us all the DAM emission that occurred along one cycle around the Sun. This means along this period, the observer on Earth receives the DAM emission, to study the fluctuation along all months and years to measure the number of DAM emission and the differences, we can notice the sporadic nature from the time occurrence. Figure-6 indicated that, the time continuity for DAM emission was different, this referrers to each type of DAM emission occurred at specific region within the rotation of Jupiter and Io. According to the motion of these two bodies, a region of strong and weak emission will occur, strong and weak emission determine the time of beginning and end of DAM emission. Figure-7 shows that the DAM emission occurred with different frequencies according to the setting of the receiver, that was used by the observer to pick up DAM emission, as shown in table-1. A large number of DAM emission was found at frequency range (20-21)MHz. In addition the Sun also emits multi types of radio signal at the same frequency, so the observer on Earth must be careful when detecting radio emission from Jupiter. The frequency of DAM emission does not depended on the longitude of system three and phase, but it depends on the time .The night time was better than the daylight.

REFERENCES

[1] 1.Burke B. and Franklin K., Journal of Geophysical Research,Vol.60,No.2,213-217(1955).
[2] 2.Bhattacharya A., Mondal S., Pandit J., Halder D., Sarkar A. and Raha B.,International Journal of Engineering Science and Technology,Vol.4,No.6,3029-3038(2012).
[3] 3.Flagg R..,Listening to Jupiter: A Guide for the Amateur Radio Astronomer, 1st edition,1-5,2002,Radio Sky Publishing,USA.
[4] 4.Hannu K., Pekka K., Heikki O., Markku P. and Kar J. D.,Fundamental Astronomy, 5th edition,330-340,2007,Springer Berlin Heidelberg,NY.
[5] 5.John D., Astronomy Journey to the Cosmic Forntier,4th edition,266-275,2006,MacGraw-Hill,USA.
[6] 6.Carr T., Desch M. and Alexander J. ,Physics of the Jovian Magnetosphere,3rdedition,226-284,1983,Cambridge University Press,UK.
[7] 7.Zaitsev V., Shaposhnikov V. and Rucker H., Astronomy and Astrophical Journal,Vol.454,669-676(2006).
[8] 8.Bigg E., Nature,Vol.203,1008-1010(1964).
[9] 9.Francoise G., Philippe Z. and Lecacheux A., Proceeding of the Workshop on Time-Variable Phenomena in the Jovian System, held at 25-27 August 1987, Lowell Observatory, Flagstaff, Arizona,156-174(1989).
[10] 10.Dessler A. and Hill T., Astrophysical Journal,Vol.227,664-675(1979).
[11] 11.Bose S., Sarkar S. and Bhattacharyya A. , Indian Journal of Radio and Space Physics,Vol.37,77-108(2008).
[12] 12.Diane F., Basics of Radio Astronomy for the Goldstone-Apple Valley Radio Telescope,1stedition,200-256,1998,California Institute of Technology,USA.
[13] 13.Hess S., Mottez F., Zarka P., and Chust T., Journal of Geophysical Research,Vol.113,No.(A03209),1-10(2007).
[14] 14.Melvyn L. and Goertz C.,Physics of the Jovian Magnetosphere, 3rdedition,317-352,1983,Cambridge University Press,UK.
[15] 15.Jim Th., Chuck H.,Leonard G.,Bill P.,Paul L.and Albie D., "Radio Educational Activities and Lesson Plans", 1stedition,5-9,2001,NASA,USA.
[16] 16.Akira M., Fuminori T., Yoshizumi M., Hiroaki M., Hiroshi O. and Kinji F., Earth Planets Space Journal,Vol.54,1277-1281(2002).