"Radio observations of Meteor and Meteor Showers"

Project report submitted to:
Kishore Vaigyanik Protsahan Yojana(KVPY)2004,
Bangalore.

From:
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Background and Origin:

'Meteor' is the scientific word for the phenomenon called 'Shooting Star'. Meteors are the dust particles left behind by the parent comet. When the Earth enters in the dust cloud of the comets orbit, these particles enter into the earth's atmosphere and burn due to friction. We can see it as a light streak in the night sky. They also produce a trail of ions, which reflects radio waves.

Many meteor showers like Leonids, Geminids, Lyrids, Quadrantids, Eta-Aquarids, Taurids, Orionids, Perseids, Ursids etc. were observed by visual method earlier for the last five years(Please refer to Annexure 1,2 and 3). The observations were sent to the institutes like 'International Meteor Organization (IMO), 'North American Meteor Network (NAMN), 'American Meteor Society (AMS) etc. But for the KVPY it was thought to use an innovative way i.e. 'the radio observation method' for meteor showers. As KVPY project had to be submitted by 1st October, the meteor shower available was only Perseid meteor shower on 12-13th August 2004 [1]. Monitoring meteor activity by radio got its start right after the 2nd world war. The types of radio observations are- 1) HAM radio observations (HRO) 2) FM radio observations (FRO) 3) RADAR observations. [2]

During recent years, however few amateurs in the following countries have been recording meteor reflections: Austria, Belgium, Denmark, Germany, Finland, Japan, UK, and US [3]. But there are no radio observers in India to observe meteor activity on regular basis. Hence by carrying out this project, it was thought of to setup a proper Radio observing system. This set up further can be used to collect a large and continuous data on meteor activity over the Indian sub continental region. This data can be used for further research in this area.

Objectives of the Project:

It was proposed to observe and record the 'Perseid meteor Shower', 12-13 August 2004 by FM radio observation method using 91 MHz frequency. It was also proposed to observe the same meteor shower activity simultaneously by visual observation method for comparison, as there is a fairly simple relation between the visual magnitude of a meteor and the duration of the radio reflection.

Also it is proposed to study the effect of 1) Sun spot cycle 2) Daily variations 3) annual variation on average number of meteors per hour observed by radio method. Also it is thought to observe the same meteor activity through different observing locations, to triangulate for the meteor to calculate its altitude.

Radio Observation Method (Mechanism) and advantages:

When the meteor burns in the atmosphere it produces a trail of ions, which is able to reflect a band of radio frequencies. At low frequencies (<50 MHz), the ionosphere reflects the radio waves without meteor trails. At high frequencies (>150 MHz) the radio waves are scattered for too short period of time (< 1 sec.). The FM radio band (88- 108 MHz) falls within this frequency range.

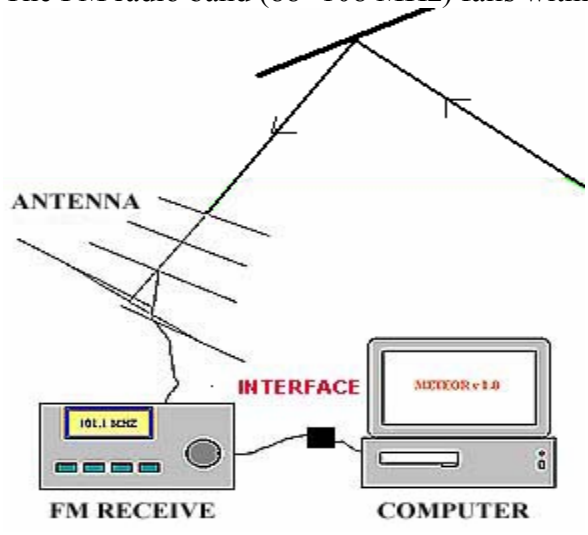


FIGURE 1: Reflection of radio waves by ionized meteor trail.

If we have a transmitter between 50-150 MHz, and the receiver placed at a distance (between 200-2000 Km) for which the transmitter will be below it horizon and no direct signals will be received. As shown in figure1 if a meteor appears at a particular angle in between the sky of the two stations, the transmitted waves get reflected by ionized trail of the meteor and could be received at the receiving station [2].

Advantages of radio observations:

1) Meteor can be detected both during day and nighttime also when there is a bright moon.
2) It does not get affected by any weather condition (i.e. cloudy and rainy weather).
3) We can detect the meteor up to 8 magnitude (i.e. almost 100 times fainter than by visual).
4) We can monitor the activity continuosly for several hours by using computers.

Methodology:

For this project, FM Radio observation method was carried out, because there are many commercial FM transmitters available in Indian [5]. The transmitter 'Radio City, Mumbai' 91 MHz was chosen for the following reasons:

1) The transmitter is a high power and 24 hours transmission type.
2) 91 MHz is one of the lower clear frequencies so that the meteor scatter will be longer.

For receiving the signals, the receiving station was Manmad (Lat 20.15N Long 74.29E) (Near Nasik, Maharashtra) and not from Pune because:

1) As Pune (18.55N, 72.54E) is at 150km from Mumbai where the direct signals could be received.
2) The distance between the transmitter and receiver was 280km where we can expect meteor scatter signal.

Construction of Yagi Antenna:

A 3-element Yagi type-high gain directional antenna was constructed for 91 MHz frequency, to reduce the reception of local interference and to increase intensity of meteor scatter signal. Cutting the aluminum pipes of inner diameter 6mm and outer diameter 6.5mm made the antenna. The lengths of the director, dipole, element 1, element 2 and boom and calculated by using formula: (As shown in figure2) are164.83cm, 157.14cm, 151.64cm, 147.25cm and 148.35cm respectively. The separation of each of the above elements on the length of the boom is 49.45cm. As the making of the dipole of length 157.14cm was a difficult part, two small (ready made) diploes were cut in such a way and connected again by giving extension of the other aluminum pipes. But because of the breaking and rejoining of the pipes, the impedance of the antenna was changed, hence to achieve the impedance of the antenna to 75 ohms, small aluminum pipe was cut along the length were put up on each joint and were fixed by small nut bolts (of diameter 3mm) [6][7].

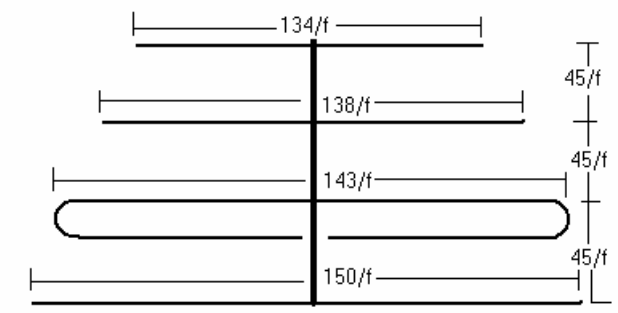


FIGURE 2: Dimensions of Yagi Antenna

The antenna was mounted at some height on the roof as shown in plate 1. A compass and a map were used to point the antenna towards the direction of Mumbai City (Maharashtra). It was firstly tilted at 90^{o} and towards Mumbai. But some faint 'direct' signals were received after sometime it was directed to Delhi's direction (air distance 600km from Manmad having a transmitter at 91 MHz), and was tilted at 10^{o} – 15^{o}

PLATE 1: The Yagi Antenna

The antenna was connected to a '2 in 1' (FM Radio cum cassette recorder) radio receiver (National RX-CS700 with manual FM tuner) by using 75 ohms co-axial cable. This receiver was used because of its good quality and the '2 in 1' facility. A radio-computer interface circuit was made to feed the observed signals to computer for further analysis [6]. The signals were recorded on high quality blank cassettes (SONY 90HF). Then the recorded signals were played and the signals were given to software called 'METEOR v8.2' (which works on DOS platform). The observational setup is as show in figure 1.

Result:

The FM Radio meteor observations of 'Perseid Meteor Shower' on 12th –13th of August 2004 were successfully recorded. As radio observations were supposed to be compared with the visual observations but the visual observations were not possible from India due to cloudy weather conditions.

When the signals were given to the software (METEOR v8.2) [6], it shows the signal in waveform and counts the meteors as the intensity of the signal peaks and crossed the given threshold. Please refer to plate 2.

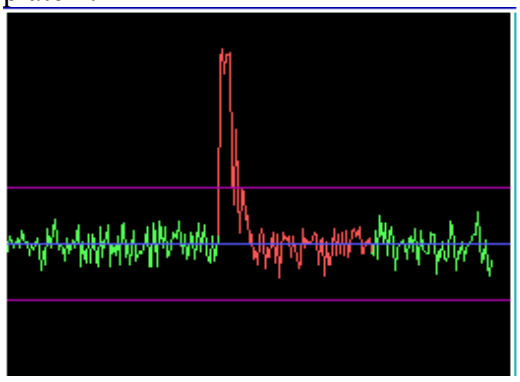
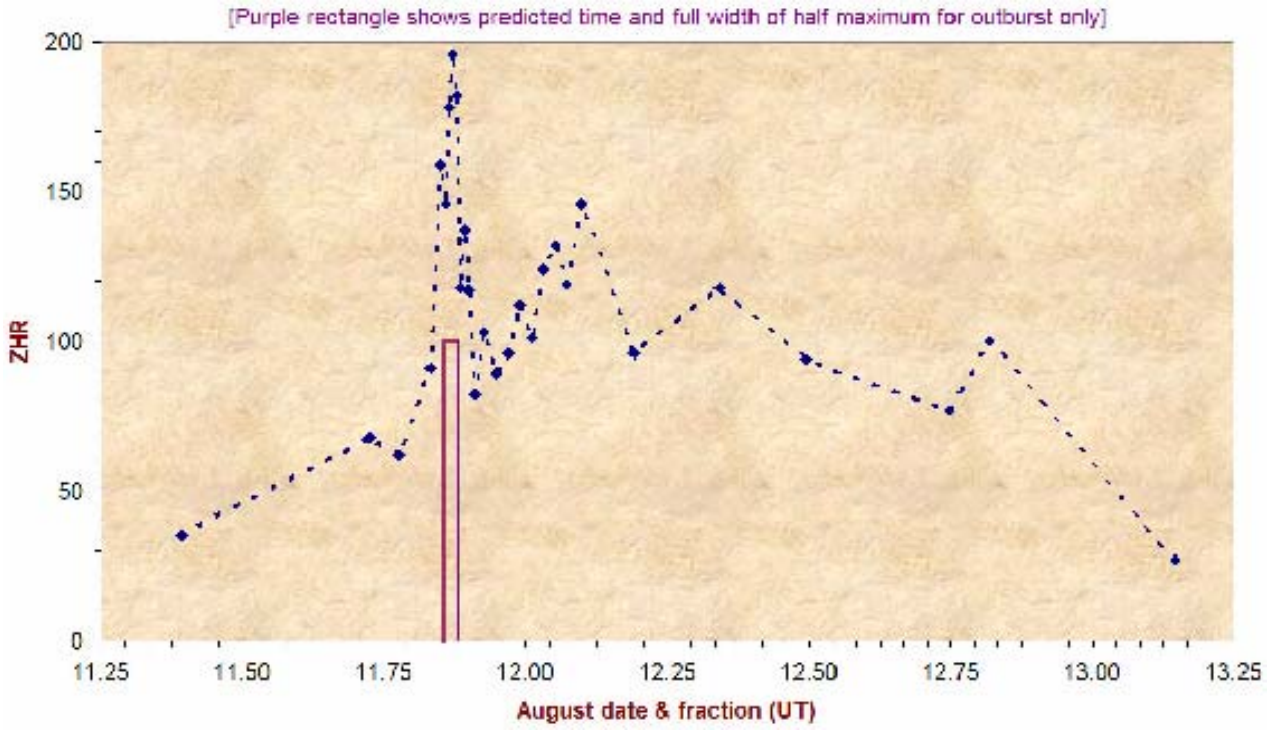


PLATE 2: Graph from Meteor v8.2 (software) – Meteor peak (in RED)

This software saves the data in different files in which the number of meteors and the length of echoes are also recorded along with UT.



Data courtesy of Rainer Arit, International Meteor Organization

Discussion:

The "Perseid" meteor shower is associated with the parent comet 109P/Swift Tuttle passing perihelion in 1992 with an orbital period of about 130 years. The Perseids were one of the most exciting showers during the 1990's with outburst producing expected ZHR's of 400+. In 1991 and 1992, rates from these peaks decreased to 100-120 and since 2000, hardly any activity has been observed. Some researchers have commented that 2004 might see a return of the primary peak for a year or two [1]. As predicted before, the potential maxima would be best viewed from Eastern Europe and Eastern North Africa, East to Central Russia, India and West China (the additional August 11th, 21 h UT model prediction). The radio data of all over the world would naturally enable early confirmation or detection of perhaps otherwise unobserved maxima.

The radio observations taken under this project are the only observations for the Perseids 2004 showers amongst the Indian sub-continent. Hence for the global analysis of the activity, these observations recorded from Indian will contribute partially.

To observe a particular meteor shower activity, one has to continuously watch the skies throughout and simultaneously has to note down the observations. This method needs a lot of efforts and patience. The advantage of radio observations mentioned above is the activity need not be continuously monitored visually.

Conclusion:

The FM radio observations of Perseid meteor showers on 12-13th August 2004 were successfully recorded for the first time from India.

The 'Yagi Antenna' and the Radio-Computer interface circuit constructed for this project will further be used for other meteor shower observations like – Taurid, Orionid, Leonid, Geminid, Lyrid, Eta-Aquarid etc and will be sent to IMO, NAMN, JMS and AMS on regular basis.

References:

[1]: 'Meteor Shower Calendar 2004',International Meteor Organisation(IMO) website, edited by Jurgen Rendelt, Rainer Arlt and compiled Alastair.
[2]: George Zay, IMO member, Observing Techniques- Radio, Chapter V, NAMN and IMO notes.
[3]: Hiroshi Ogawa, Japanese Meteor Society, Participants of 'Radio Meteor Observation Project'.
[4]: 'Meteor Burst Communications', Jacob Z. Schanker.
[5]: All India Radio(AIR), FM radio stations in India, web page- www.asiawaves.net/sasfm.htm
[6]: 'American Meteor Society', web site- www.amsmeteors.org/radio
[7]: American Radio Relay League(ARRL) Hand book.

Annexure 1: NAMN Observations – December 2003
Annexure 2: NAMN Observations - November 2002 Final Leonid Summary
Annexure 3: International Meteor Organisation(IMO) Leonids- 2001, First profile.

NAMN Observations - November 2002 Final Leonid Summary
by Mark Davis

From: Mark Davis meteors@comcast.net
To: NAMN meteors@comcast.net
Subject: Final Leonid Summary
Date: Mon, 16 Dec 2002 15:06:56 -0500

Below is the final summary of observations covering the Leonids and the month of November. In the end, over 22,0000 Leonids were reported by observers. Thanks go to all of these observers!!

Happy Holidays!

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NAMN Observations - November 2002

OBSERVERS
Ardalan Alizadeh, Iran; Ryan Altevogt, USA; Joseph Assmus, USA; Jure Atanackov, France; Zohre Barzegar, Iran; Jaydeep Belapure, India; Leslie Bell, USA; Lance Benner, USA; Supriya Bhate, India; Michael Boschat, Canada; Wayne Baumgartner, USA; Dustin Brown, USA; Bill Burton, USA; Ed Cannon, USA; Laverne Castillo, USA; Douglas Clayton, USA; Zolfaqar Daneshi, Iran; Luigi D'Argliano, Italy; Mark Davis, USA; Martin Galea De Giovanni, Malta; Farzad Falahati, Iran; Mark Fox, USA; Marie Francoise Gaboriau, France; Petros Georgopoulos, Greece; George Gliba, USA; Bill Godley, USA; Valentin Grigore, Romania; Mahmood Hajzaman, Iran; Amir Hassanzadeh, Iran; Robrto Haver, Italy; Kim Hay, Canada; Robert Hays, USA; Ken Hodonsky, USA; Chris Hully, USA; Terry Johnson, USA; Paul Jones, USA; Javor Kac, France; Slovenia; Richard Kramer, USA; Gary Kronk, USA; Jun Lao, USA; Ken Legal, USA; Mike Linnolt, USA; Xiaoyun Ma, China; Alan MacRobert, USA; Prajakta Mahajan, India; Grigoris Maravelias, Greece; Christophe Marlot, France; Felix Martinez, USA; Philippe Martin, France; Pierre Martin, USA; Bert Matous, USA; Marcel Meima, United Kingdom; Huan Meng, China; Thom Morgan, USA; Curt Nason, Canada; Emil Neata, Romania; Gregg Pasterick, USA; Gregg Patruno, USA; Francois Pineau, France; Maesoomeh Poorali, Iran; Mayuresh Prabhune, India; Ankur Puranik, India; Dave Radomski, USA; CJ Rainville, USA; Joseph Ross, USA; Leah Sapir, USA; Mazyar Seyyednezhad, Iran; Caroline Shelnut, USA; Brian Shulist, Canada; Manuel Solano Ruiz, Spain; Mark Stafford, USA; Chris Stephan, USA; David Stine, USA; Enrico Stomeo, Italy; Wes Stone, USA; Isabelle Struk, France; David Swann, USA; Richard Taibi, USA; Cristina Tinta, Romania; Marco Valois, Brazil; D.A.J. van Os, Spain; Jeremie Vaubaillon, France; Marco Valois, Brazil; Michel Vandeputte, Belgium; Harry Waldron, USA; Linjia Wang, China; Bill Watson, USA; Michael Wehner, USA; Gary White, USA; Kirby White, USA; Gary Wilson, United Kingdom; Stanley York, USA; Kim Youmans, USA; Joseph Zammit, Malta; Mengling Zhang, China; Zhilin Zhang, China

OBSERVING SUMMARIES
November 17:
Jaydeep Belapure (Teff=2.00, 7 LEO, 4 SPO)
Ken Hodonsky (Teff=1.03, 6 LEO, 1 TAU, 6 SPO)
Prajakta Mahajan (Teff=1.50, 11 LEO, 8 SPO)
Bert Matous (Teff=2.00, 2 AMO, 2 IAU, 11 LEO, 2 NTA, 4 STA, 19 SPO)

November 18:
Jaydeep Belapure (Teff=3.75, 13 LEO, 7 SPO)
Supriya Bhate (Teff=4.16, 6 LEO, 6 SPO)
Valentin Grigore (Teff=6.18, 22 LEO, 5 NTA, 4 STA, 16 SPO)
Paul Jones (Teff=0.50, 3 LEO, 3 SPO)
Prajakta Mahajan (Teff=3.33, 9 LEO, 7 SPO)
Felix Martinez (Teff=1.50, 15 LEO, 2 NTA, 7 SPO)
Mayuresh Prabhune (Teff=4.33, 8 LEO, 4 SPO)
Michel Vandeputte (Teff=7.50, 54 LEO, 3 TAU, 58 SPO)
D.A.J. van OS (Teff=2.06, 9 LEO, 2 TAU, 12 SPO)