Abstract. Continuous radio-wave monitoring of the Geminid activity in December 1992 and 1993 by using a forward scatter (FS) bistatic radar over the Bologna-Lecce baseline (700 km) in Italy, reveals peculiar structural aspects of the stream in terms of signal amplitude-rate and duration-rate dependence. The observational results of the Geminid display obtained in the two consecutive years with differentiated peak levels of transmitted power, exhibit different time distributions of underdense meteors against the signal received power. Both sets of the data relative to the peak activity in December 12-14, show reflection properties of Geminids which are atypical if compared with echoes from cometary-type showers, with really high echo counts at mid-upper levels of the peak received power. An assymmetric curve of activity of the Geminids complex is evidenced, with the peak flux of smaller particles occurring earlier than that of larger ones.

1. Introduction

The short-period Geminids are one of the richest regular meteor shower particularly active on December 12-14. The discovery of the Apollo-type object 1983 TB (the asteroid 3200 Phaeton), moving in the mean orbit of the Geminid meteor stream, has suggested that Phaeton is the missing compact parent body no longer able to eject fresh meteoroids to complement the meteor stream. The stream is revolving in smallest orbit with the period of revolution of 1.5 years and the Earth crosses it in about 10 days, but the maximum is relatively narrow, lasting 2-3 days (Williams and Wu, 1993; Porubčan and Cevolani, 1994).

2. Equipment and observations

A forward scatter (FS) continuous wave (CW) meteor radar over a long baseline Bologna-Lecce in Italy, has been recently developed for the study of the upper atmosphere and meteor physics/astronomy, with applications to engineering communication when investigating meteor burst (MB) propagation (Cevolani and Hajduk, 1993; Cevolani et al., 1993). The transmitting section placed at Budrio ($\phi_B = 44.6^\circ$ N; $\lambda_B = 11.3^\circ$ E), near Bologna and the receiving one at Lecce ($\phi_L = 40.3^\circ$ N; $\lambda_L = 18.2^\circ$ E) in Southern Italy, utilises a continuous wave...
frequency at 42.7 MHz with a fixed modulating tone at 1 kHz. The Bologna-
Lecce baseline has an azimuth $A = 137^\circ$ and the FS transmitting and receiving
antennas at the two separated places are horizontally and vertically polarised
with an elevation angle of about 15°. Only results from the records collected
using the horizontal antennas are presented here.

The peak received signal power due to an underdense trail at $t = 0$ is (Sugar,
1964):

$$P_R = \frac{P_T G_T G_R \lambda^3 \sigma_e}{64 \pi^3 \frac{q^2 \sin^2 \gamma}{R_1 R_2 (R_1 + R_2)(1 - \sin^2 \phi \cos^2 \beta)}}$$

(1)

where $P_T$ is the transmitter power, $G_T$ and $G_R$, the transmitter and receiver
antenna gain; $R_1$ and $R_2$, the distance (m) from the transmitter and receiver
to the trail; $\lambda$, the wavelength (m); $q$, the electron line density (electrons/m);
$\sigma_e$, the classic cross section of an electron; $\gamma$, the angle between the incident
and received electric field vectors; $\phi$, the propagation angle formed by vectors
$R_1$ and $R_2$; $\beta$, the angle of the trail relative to the plane formed by $R_1$ and $R_2$.
The equation (1) reduces to the backscatter case, when $R_1 = R_2$, $\phi = 0^\circ$, $\beta =
90^\circ$ and $\gamma = 90^\circ$.

A simple calculation of the peak received power from a typical FS meteor
echo is given in Table 1; an electron line density $q = 5 \times 10^{12}$ el/m has been
assumed. To discover the significance of the received power calculated in Table
1 we must evaluate the likely noise power level $N$.

Table 1. Peak received power from a typical FS meteor echo (an electron line density
$q = 5 \times 10^{12}$ el/m has been assumed)

<table>
<thead>
<tr>
<th>parameter</th>
<th>value</th>
<th>units</th>
<th>comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_T$</td>
<td>+31.0</td>
<td>dBw</td>
<td>1 kw peak power</td>
</tr>
<tr>
<td>$G_T G_R$</td>
<td>+22.0</td>
<td>dB</td>
<td>11 dB gain antennas</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>+25.4</td>
<td>dBm$^3$</td>
<td>frequency: 42.7 MHz</td>
</tr>
<tr>
<td>$\sigma_e$</td>
<td>-280.1</td>
<td>dBm$^2$</td>
<td>radius electron: $2.8 \times 10^{-15}$</td>
</tr>
<tr>
<td>$q^2$</td>
<td>+247.0</td>
<td>dBm$^{-2}$</td>
<td>$q = 5 \times 10^{12}$ el/m</td>
</tr>
<tr>
<td>$\sin^2 \gamma$</td>
<td>0.0</td>
<td>dB</td>
<td>$\sin \gamma = 1$ at the &quot;hot spots&quot;*</td>
</tr>
<tr>
<td>$1/R_1 R_2 (R_1 + R_2)$</td>
<td>-170.0</td>
<td>dBm$^{-3}$</td>
<td>$R_1 = R_2 = 400$ km</td>
</tr>
<tr>
<td>$(1 - \sin^2 \phi \cos^2 \beta)^{-1}$</td>
<td>+2.7</td>
<td>dB</td>
<td>typical values: $\phi = 75^\circ$, $\beta = 45^\circ$</td>
</tr>
<tr>
<td>$P_R$</td>
<td>-155.0</td>
<td>dBw</td>
<td></td>
</tr>
</tbody>
</table>

* relatively small regions of the sky where the meteors contributing to propagation over
a particular path occur. For the longer transmission paths this region is near the path
midpoint.

The noise power level $N$ is given by Kingsley and Quegan (1992):

$$N = N_{int} + N_{ext} + MF + BW[dBw]$$

(2)

where:

$N_{int} = \text{internal thermal noise power} = -204$ dBw Hz$^{-1}$;
$N_{ext} = \text{excess of external noise over interval} = 20$ dB at 42.7 MHz;
$MF = \text{noise figure of the receiver} = 3$ dB;
$BW = \text{final bandwidth of the radar} = 300$ Hz = 24.8 dB.