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# The daytime Taurid complex meteor streams: Activity and mass distribution

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**Summary.** — The activity and mass distribution of the summer daytime Taurid meteor complex streams Zeta Perseids and Beta Taurids in 1997-2004 is analysed and discussed. The results are based on radio observations obtained by the BLM forward-scatter system (Italy-Slovakia) and by the Ondřejov backscatter meteor radar (Czech Republic). The observed positions of maxima of the streams are in a general agreement with previous analysis. The observations indicate a filamentary structure of the streams, the existence of which is supported also by the mass exponent values.

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## 1. – Introduction

The spring/summer daytime meteor streams Zeta Perseids and Beta Taurids are postperihelion continuation of the autumn Taurid stream and were first recorded by radio observations at Jodrell Bank in 1947 [1]. From continuing observations in 1949 and 1950 the activity period of the Zeta Perseids was found to be June 1-16 with the shower radiant at right ascension $\alpha = 62^\circ$ and declination $\delta = +24^\circ$ and the Beta Taurids were observed on June 26-July 4, 1950 with the radiant at $\alpha = 86^\circ$, $\delta = +19^\circ$ [2]. In 1960's the streams were observed by several radio equipments, however, most compact data were obtained from the Harvard-Smithsonian Radio Meteor Project in 1961-1965 [3]

 

and in 1969 [4]. A suggestion that the Beta Taurids are closely related to the Taurids of October and November was first made in 1951 by Almond and later supported by Nilsson, Sekanina and others [5], but already in 1940 Whipple [6] noted that the Taurids might produce a stream observable during daylight hours in summer. Based on results obtained from the Southern Hemisphere in 1969 (radio equipment of the University of Adelaide) Gartrell and Elford showed that the Zeta Perseids are probably the twin of the Southern Taurids [7]. The annual activity of both streams is low and Sekanina [3] based on Radio Meteor Project has derived the period of activity and maximum of the Zeta Perseids, May 20-June 21, June 8 and for the Beta Taurids, June 12-July 6, June 26. Cook [8] gives the activity periods and maxima for both streams June 1-17, June 7 and June 24-July 6, June 29, respectively.

In the present paper the radio observations of both stream by the BLM forward-scatter system (Italy-Slovakia) and by the Ondřejov backscatter meteor radar (Czech Republic) in the period 1997-2004 are presented and discussed.

## 2. – Equipments and observations

The BLM (Budrio-Lecce-Modra) forward-scatter system for meteor observations has been transmitting a radio signal along two mutually almost rectangular baselines. The transmitter is located at Budrio near Bologna (44.6°N; 11.5°E, Italy) and receivers are located at Lecce (40.3°N; 18.2°E, Italy) and Modra (48.4°N; 17.3°E, Slovakia). The equipment utilizes a continuous wave transmitting frequency at 42.7 MHz, a fixed modulating tone at 1 kHz and 0.25 kW mean power transmitted in the direction of both receiving stations. The baseline distances between the transmitter and receivers are: Bologna-Lecce of 700 km (azimuth 307°) and Bologna-Modra of 590 km (azimuth 224°). Details about the equipment published Cevolani *et al.* [9].

The Ondřejov radar operates at 37.5 MHz, with a peak power of 10 kW, a pulse repetition frequency of 500 Hz. The equipment utilizes a steerable antenna in azimuth but fixed in elevation at 45°. Detailed description of the radar and its operation can be found elsewhere [10].

The BLM equipment is operating in the frame of coordinated observations during selected periods of the year, which cover partially also the periods of activity of the summer Taurid complex streams, Zeta Perseids and Beta Taurids. Therefore, each year another of the streams was observed. In this campaign, the Zeta Perseids were observed in 2000, 2001 and 2002, and Beta Taurids in 1997, 1999 and 2004. Due to reconstruction of the equipment there are missing observations of the streams in 2003.

The Ondřejov meteor radar started regular observations of the Zeta Perseids and Beta Taurids in 2003 and the first results concerning the activity and mass distribution of particles in the streams in 2003 have already been analysed and published [11].

## 3. – Analysis

From the studies of echo counts obtained by the BLM forward-scatter system it is evident that shower echoes can be clearly recognized from sporadic background echo counts only for long duration echoes [12]. Therefore, the activity curves from the BLM forward scatter were derived only for long duration echoes of $\geq 8$ s. Shower activity was obtained by subtracting sporadic background counts from all echo counts in corresponding hours. The activity curves represented by the hourly shower echo counts were derived, where possible, by combining the data from both receiving stations (Lecce and Modra).

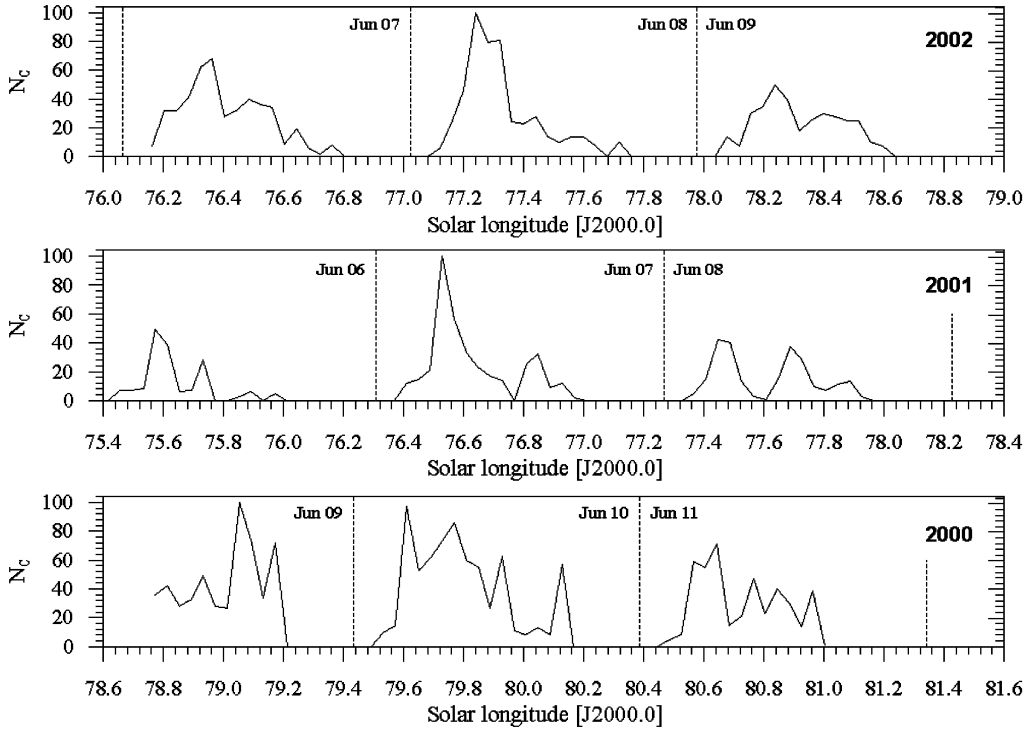


Fig. 1. – Counts of Zeta Perseid meteor shower echoes of duration $\geq$ 8 s in one hour intervals observed by the BLM forward-scatter radio system in 2000, 2001 and 2002. The curves represent the mean values of the data from Lecce and Modra. The counts are normalized to 100 echoes for the peak activity.

The activities of the Zeta Perseids and Beta Taurids for overdense echoes of duration $\geq$ 8 s in individual years, in three days around the maximum, acquired by the BLM system are shown in fig. 1 and fig. 2, respectively. The observed counts of echoes for which the radiant elevation $h$ was lower than 20° were eliminated from the analysis and all echo counts were corrected for the radiant elevation (reduced to the zenithal hourly rates).

The 2004 Ondřejov observations were carried out on May 30-31 together with June 18 in order to detect the sporadic background of the Zeta Perseids and June 6-12 to establish the core of the shower. The corresponding periods concerning the Beta Taurids were respectively June 19 and July 7-8 and June 25-July 1. The method of observations was the same as in 2003 [11].

From the observed data also the mass distribution exponent showing information on size distribution of particles in the streams could be derived. The mass distribution exponent $s$ was found from the cumulative numbers of echo duration considering ambipolar diffusion for dominant process of an echo decay in the form [13]

$$\log N_{\mathrm{c}} = -\,(3/4)\,(s-1)\log T_{\mathrm{D}} + \mathrm{const}, \tag{1}$$

where $N_{\mathrm{c}}$ is the cumulative number of echoes with the duration in excess of $T_{\mathrm{D}}$.

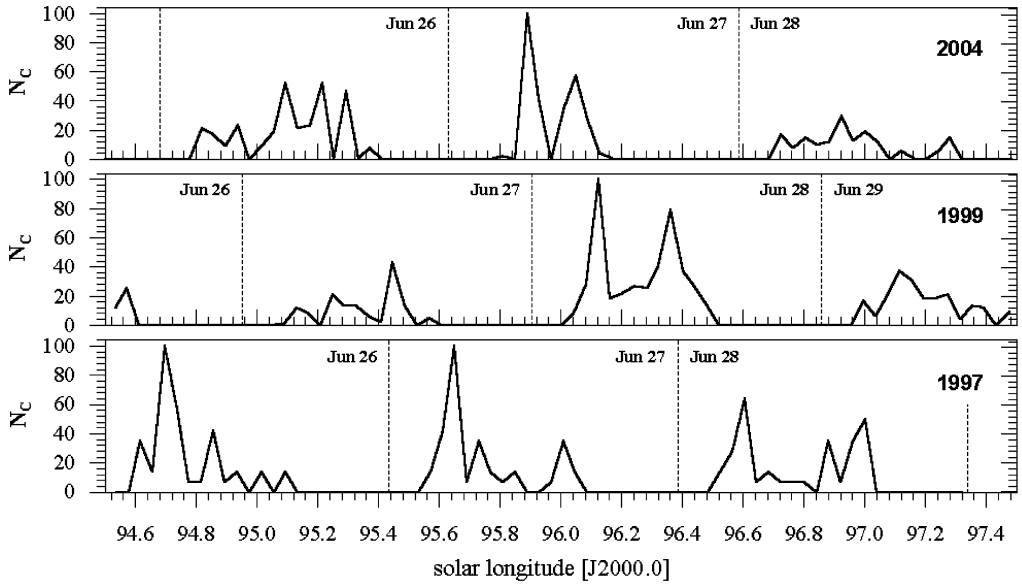


Fig. 2. – Counts of Beta Taurid meteor shower echoes of duration $\geq$ 8 s in one hour intervals observed by the BLM forward-scatter radio system in 1997, 1999 and 2004. The curves represent the mean values of the data from Lecce and Modra. The 1997 curve is from Modra only. The counts are normalized to 100 echoes for the peak activity.

The values of $s$ in individual years were obtained as the mean values from the period of the shower maximum (approximately 8 h) and corresponding sporadic background. The exponent values are together with the positions of activity maxima listed in table I.

**3**˙1. *Zeta Perseids*. – The stream is active in the first half of June with the radiant above horizon in the Northern mid-latitude sites for about 17 hours and culminates at 11 LT. The peak activity according to Cook [8] corresponds to solar longitude of 76.7° (eq. 2000). The BLM forward-scatter monitored the stream activity in 2000, 2001 and 2002, the Ondřejov radar in 2003 and 2004.

In 2000, the observations were carried out in June 9-16 and probably covered only the descending branch of activity. Thus the peak observed at solar longitude of 79.1° is probably not the main peak. Due to a high level of noise in Lecce, the mass exponent could be derived from the Modra data only and for the shower (June 9) and sporadic background (June 15) $s$ is 1.98 and 2.48, respectively. The value of 1.98 indicates that the stream was at the peak relatively rich in larger particles.

In 2001 observations (June 5-15) the peak was observed at solar longitude of 76.5° and was well defined at both stations (Lecce and Modra). The mass exponent derived for the shower meteors (June 7) $s = 2.24$ and for the background meteors (June 12) $s = 2.38$, which indicates that in 2001 return of the stream both populations were very similar.

The 2002 Zeta Perseids were observed over the period June 4-10. The peak activity appeared at 76.5° and the mass exponents for the shower (June 8) and sporadic (June 4) were 2.25 and 2.80, respectively.

The 2003 and 2004 Zeta Perseids were observed only at Ondřejov. The 2003 results

TABLE I. – *The maxima of activity and mass distribution exponent s derived for the Zeta Perseids and Beta Taurids observed by the BLM radio system in 1997-2004 and Ondřejov meteor radar in 2003-2004.*

| Year | Maximum (eq. 2000.0) | s-sh (shower) | s-sp (sporadic) | Observation (receiver) |
|---|---|---|---|---|
| Zeta Perseids | | | | |
| 2000 | 79.1° | 1.98 | 2.48 | combined |
| 2001 | 76.5° | 2.24 | 2.38 | combined |
| 2002 | 77.2° | 2.25 | 2.80 | combined |
| 2003 | 78.8° | 2.12 | 2.24 | Ondřejov [11] |
| 2004 | 81.5° | 2.28 | 2.50 | Ondřejov |
| Beta Taurids | | | | |
| 1997 | 95.7° | 2.37 | 2.23 | Modra |
| 1999 | 96.1° | 2.14 | 2.38 | combined |
| 2003 | 94.1° | 2.23 | 2.37 | Ondřejov [11] |
| 2004 | 95.9° | 2.10 | 2.38 | Lecce |
| | (95.8°) | - | 2.40 | Ondřejov |

were analysed elsewhere [11]. The 2003 peak of overdense echoes was recorded for solar longitude of 78.8° with the mass exponent of shower meteors $s = 2.12$. The 2004 peak was recorded for 81.5°. This value is exhibiting that the peak activity of the stream can change from one shower return to another also for a few degrees indicating a filamentary structure of the stream.

**3**˙2. *Beta Taurids*. – The Beta Taurids are active in the second half of June and beginning of July [8]. The shower radiant culminates at 11:15 LT and is above horizon for the Northern mid-latitude observations for about 16 hours. The peak of activity is generally posed on June 29 (solar longitude 76.7° (eq. 2000)) [8]. The shower activity was monitored by the BLM equipment in 1997, 1999 and 2004 and by the Ondřejov meteor radar in 2003 and 2004.

The 1997 Beta Taurids observation was carried out only in the direction to Modra (June 20-July 1) and due to a very low echo counts and shower activity, the curve in fig. 2 for 1997 depicts all echo counts (shower and sporadic). Two peaks at 94.7° and 95.6° are observed. The mass exponent derived from an interval of 8 hours about the peak at 95.6° (period the least contaminated by background) for all echo counts, is $s = 2.37$ and sporadic background value from the end of observations is $s = 2.23$.

In 1999 the transmission was made along both baselines in the period June 24-July 1 and the peak was observed for 96.1°, with mass exponent for the shower $s = 2.14$ and for sporadic background $s = 2.35$.

The 2003 shower was observed at Ondřejov [11] with the peak activity of overdense echoes at 94.1°.

The observations in 2004 were performed simultaneously by both radio equipments. Very low activity of the shower was detected in 2004 at Ondřejov. Thus the peak presented in table I (solar longitude of 95.8°) is very uncertain. The data from Modra were contaminated by strong interferences and spurious long duration echoes overlapping the standard shower echo activity and therefore only data from Lecce were used and the BLM data from Lecce gives the peak for 95.9°. The peaks obtained by both equipments are completely consistent.

## 4. – Conclusions

The activity of the spring/summer Taurid complex streams, the Zeta Perseids and Beta Taurids over the period 1997-2004 was studied by two different radio equipments applied for meteor observations: BLM forward-scatter system and Ondřejov backscatter meteor radar. The observed positions of maxima of the streams (table I) are in a general agreement with previous analysis. The observations indicate a filamentary structure of the streams, the existence of which is supported also by the mass exponent values found for individual returns of the streams.

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