α Monocerotids 1995 – a search for non-random pairing of particles in the stream

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Received: November 12, 1996

Abstract. The enhanced activity of the α Monocerotids in 1995 provided a possibility to make a search for non-random distribution of particles in the stream. The analysis is based on the Poisson distribution, the time distribution and correlation between successive time intervals. Visual observations of the shower at the peak activity (November 22, 01:11 - 01:50 UT) suggest a possible non-random clustering of meteors in the densest part of the stream.

Key words: meteor showers – α Monocerotids

1. Introduction

Visual observers have often the impression that meteors in meteor showers tend to appear in close-spaced pairs or clusters more frequently than would be expected from random distribution. The problem was studied by more authors predominantly on the basis of radar observations yielding comprehensive data (Bowden and Davies 1957, McCrosky 1957, Poole 1965, Porubčan 1968). Porubčan (1979) has shown that while there is no non-random clustering of meteors in permanent showers, this may appear in relatively young streams generated from the parent comets more recently which are characterized by a narrow width and a preponderance of small particles.

The α Monocerotids rank among unusual showers exhibiting sudden outburts in activity and are known since 1925 only (Kronk 1988). The last higher activity burst was observed in 1985 and the following, based on a presumed 10 year periodicity, was predicted for 1995 (Kresák 1993). The burst in 1995 was widely observed in Europe in the early morning hours on November 22 (Rendtel et al. 1996). This spectacular phenomenon was recorded also by a group of visual observers at Kojšovská hoľa (48.8°N, 21.0°E, 1246 m), Slovakia (Rapavý and Gerboš 1996) keeping a precise time record of each meteor. This record of the shower having appropriate characteristics of a young meteoroid stream pro-

Contrib. Astron. Obs. Skalnaté Pleso **27**, (1997), 21– 24.

vided a possibility to analyze the stream for a possible non-random clustering of meteors.

2. Search for non-random pairing

Three methods of analysis were applied to the observational data. The observed meteor rates were compared with a Poisson distribution and the time intervals between successive shower meteors were compared with an exponential distribution. The third analysis was based on correlation between successive time intervals.

If meteors occur at random, the distribution of rates within a sampling time interval will satisfy the Poisson relation

$$n_i = n \, \frac{x^i}{i\,!} \, exp(-x), \tag{1}$$

where n_i is the expected number of sampling intervals containing i meteors, n is the total number of intervals and x is the mean number of meteors in a unit sampling interval.

Similarly, a random frequency distribution of the time intervals between successive meteors is given by the exponential law

$$n_t = n \, \frac{dt}{T} \, exp\left(-\frac{t}{T}\right), \tag{2}$$

where n_t is the expected number of intervals between t and t+dt, n is the total number of intervals and T is the mean interval. Integration of relation (2) yields the number of echoes in any time interval.

Both the distributions should be applied only to the events which are approximately homogeneous in frequency as any rapid and systematic changes in frequency can generate spurious deviations from randomness. In order to avoid this possibility, the search was made in shorter discrete periods dividing the observations into several sets.

The correlation coefficient between successive time intervals is given by the formula

$$\rho = \frac{\sum_n t_n t_{n+1} - NT^2}{\sum_n t_n^2 - NT^2} \pm \frac{1}{\sqrt{N}} \tag{3}$$

where t_n, t_{n+1} are successive time intervals, T and N stand for the mean interval and number of intervals as before. The correlation coefficient is expected to be zero for a random distribution of meteors.

3. Results

The 1995 maximum of Monocerotids was pronounced and very narrow lasting less than one hour. The search for possible non-random pairing was made in a 40 minute period about the peak (Nov. 22, 01:11 - 01:50 UT, Fig.1) and the period was divided into four separate 10 minute sets (Table 1). If any real grouping of echoes above a random level does exist, it should appear as an excess of observed counts over the theoretical values in the wings of the fitted distributions. Differences between the observed and expected Poisson and time distributions were evaluated by the chi-squared test.

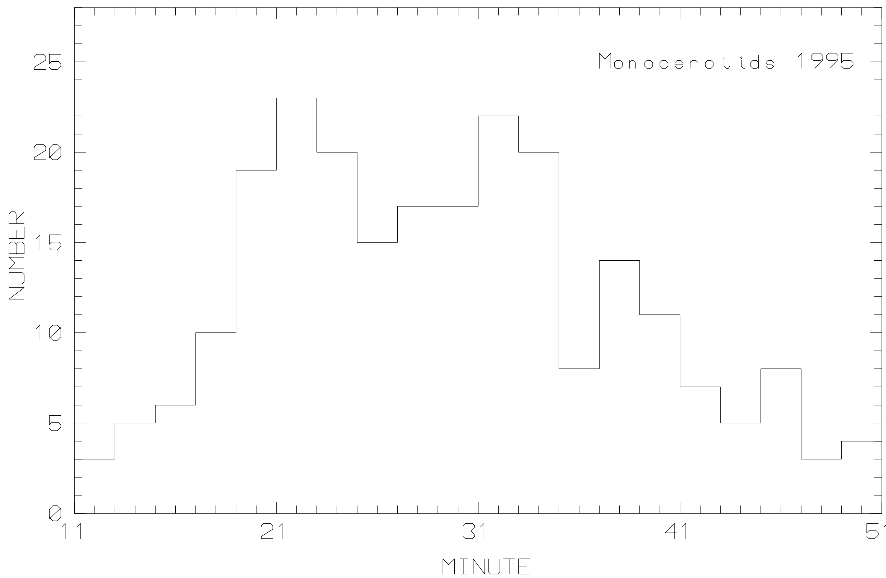

Figure 1. The counts of α Monocerotids observed at Kojšovská hoľa (Slovakia) during the peak of the shower enhanced activity in 1995, November 22, 01:11 - 01:51 UT.

Results of the analysis are summarized in Table 1, where the columns 1 through 5 list, respectively, the analyzed period, the observed number of Monocerotids in the period and probabilities resulting from the chi-squared test for both - the Poisson distribution tested in 10-second sampling intervals and time interval distribution - while the last column presents the correlation coefficient found from equation (3).

The last row of Table 1 presents the results for a set consisting of all subsets and comprising the entire period. Although the low probabilities being well bellow the 5% level of significance indicate a high probability of a non-random clustering of meteoroids in the period, the result cannot be taken for conclusive and may illustrate a spurious pairing due to systematic changes in the rates. Therefore, more conclusive are the results obtained for individual 10-minute sets.

The probabilities resulting for the exponential law of time intervals as well as Poisson distribution for 10-second sampling intervals indicate a real non-random

Table 1. Testing the enhanced α Monocerotid activity for a non-random clustering of meteors. The columns 3 and 4 list probabilities resulting from the chi-squared test for the Poisson distribution tested in 10-second sampling intervals and time interval distribution, the last column gives the correlation coefficient.

Interval UT	Number of meteors	Poisson distr.	Time distr.	Correlation coeff.
01:11 - 01:20	43	< 0.005	<0.005	0.38 ± 0.16
01:21 - 01:30	92	0.005	<0.005	0.08 ± 0.10
01:31 - 01:40	75	0.10	<0.001	0.11 ± 0.12
01:41 - 01:50	27	0.60	0.025	-0.11 ± 0.19
01:11 - 01:50	237	<0.001	<0.001	-0.16 ± 0.07

clustering of meteoroids in the first three sub-sets (01:11-01:40 UT), i.e. in the densest part of the 1995 Monocerotid stream. The largest group of meteors observed in a 10-second sampling interval consisted of seven Monocerotids and appeared at 01:22:50-01:23:00 UT.

The correlation coefficients do not disprove the above inference unambiguously and thus a non-random clustering of meteors in the 1995 Monocerotids is probable. Though the result should need an independent confirmation, in particular from radar observations with an accurate timing, the phenomenon appeared again only in the densest part of a meteoroid stream, in a relatively young concentration similar to those found in the Leonids and Giacobinids (Porubčan 1979) and could indicate a progressive disintegration of meteoroids in space.

Acknowledgements. The authors acknowledge support from the Slovak Grant Agency for Science, Grant No. 2002/96.

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