Distribution of semi-major axes of meteor streams observed in Kharkiv

Y.V. Cherkas, **S.V. Kolomiyets**, Y.I. Voloshchuk
Kharkiv National University of Radioelectronics, Ukraine (jura_cherkas@meta.ua)

Introduction

In Kharkiv since 1972 until 1978 were carried out radiolocation observations of meteors. It allowed registering and calculating of orbital parameters for about 160 thousands meteors. Cluster analysis of these orbits allowed detecting of 5160 meteor streams and associations that contain at least five registered meteor bodies [1].
Purpose of the study – investigate thin structure of Kharkiv meteor streams semi-major axes distribution.

Method of analyzing

Quantization of orbital space can be identified by examining of the distributions of semi-major axes of central body's satellites for the presence of periodic components. Such analysis was carried with using of frequency histograms, which show numbers of meteor streams in each range of semi-major axis. We are only interested in the relative variation of a number of orbits hitting a particular interval in relation to the trend. By removing the trend from histogram, we obtain series with a zero mean value. These series can be used for searching of supposed periodicity. Periodogram method was chosen as a frequency analysis method mostly because it does not require any a priory information about analyzed data and is one of the most robust methods of classical frequency analysis.
In general, the process of investigation can be summarized into following steps:
1) Orbits data transformation – building of frequency histograms.
2) Histogram trend estimation and its elimination.
3) Frequency analysis of result series.
As a result of investigation, representations of series in frequency domain will be obtain.

Results

Frequency histogram of meteor streams semi-major axes distribution is shown on fig. 1. The range of variation of a semi-major axis in fig. 1 is divided into $N = 200$ intervals. Analyzed range was restricted with following values $a_{\min} = 0.5$ a.u. and $a_{\max} = 3.5$ a.u. it reduced number of analyzed orbits to 4994 elements. Fifth degree polynomial spline was chosen as a method of trend estimation. On fig. 1 trend $u(a)$ were computed with using of spline which contains $l = 10$ knots.
After removing of the estimated trend from frequency histograms, we got series of meteor streams variation. These series can be used for further frequency analysis. Periodogram method was chosen for frequency analysis of result series.
The periodogram (fig. 2) contains level of significance p [2] for the most noticeable component. Level of significance shows a probability that a component with a given amplitude can be produced by noise.

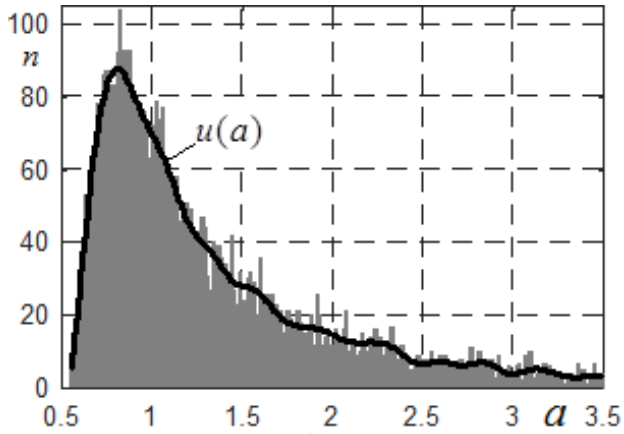

Fig 1 Frequency histogram of meteor streams semi-major axes distribution (*n* – number of orbits in histogram's bin; *a* – orbit's semi-major axis. [*a*] = 1a.u.)

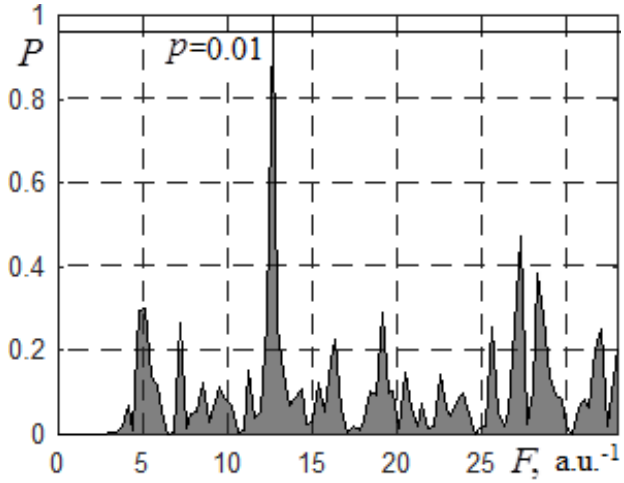

Fig 2 Periodogram of variation series of meteor streams semi-major axes distribution (*P* – normalized amplitude of power spectral density; *F* – frequency, [*F*] = 1a.u.$^{-1}$)

Discussion

Results of meteor streams orbits distributions fine structure investigation show that beside of systematic (trend) and sporadic (noise) components it contains periodical component. A harmonic on frequency $f \approx 12.6$ a.u.$^{-1}$ was detected with high level of significance. Analogous analysis was carried out for different numbers of histogram's intervals ($N = 100$, $N = 300$, $N = 400$, $N = 500$). All of obtained power spectral densities contain periodic component on the same frequency – $f \approx 12.6$ a.u.$^{-1}$.

References

[1] Voloshchuck, Y.I., Gorelov, D.Y. Meteor streams and associations that were detected by the results of many years of radar observations of meteors in Kharkiv, Kharkiv, NTMN, 383, 2011.
[2] Terebizh, V.Y. Time series analysis in astrophysics, Moscow, Nauka, 388, 1992.