EPSC Abstracts
Vol. 7 EPSC2012-315 2012
European Planetary Science Congress 2012

The real dispersion of orbital elements in meteor streams obtained from the photographic catalogues of the IAU Meteor Data Center

M. Hajdukova Jr.
Astronomical Institute of the Slovak Academy of Sciences, Bratislava, Slovakia (Maria.Hajdukova@savba.sk)

Abstract

The present paper, based on a statistical analysis of photographic meteor orbits from the IAU Meteor Data Center [4], shows the dispersion of orbital elements within the meteor streams. The contribution of the real orbital dispersion was deduced from a comparison of the observed dispersions in different lists of orbits, where the observational errors should be different, as well as from the long-period orbits, where an excess over the parabolic value can be regarded as entirely due to measuring errors. Four meteor showers, with high heliocentric velocities, were selected for this analysis, based on the dispersion of their reciprocal semimajor axes.

1. Introduction

A thorough analysis of a large set of precisely-determined meteor orbits enables the real dispersion of reciprocal semimajor axes within meteor streams to be estimated, even if the observational errors considerably exceed the real deviations from the parent comet's orbit. A complete study of the real dispersion of orbital periods in meteor streams was made by Kresák and Kresáková [5]. It showed that the observed dispersion of the semimajor axes involves the real orbital dispersion plus errors, which are greater by a factor of 10^4 for the orbits of the meteoroids than in the case of well-determined cometary orbits. Their analysis of 308 photographic orbits showed that the real dispersion of the Perseids is at least eight times smaller than that indicated by observation. Porubčan [7], in his study of the dispersion of the orbital elements of meteor orbits, analysing 295 photographic Perseids, showed that there are considerable differences in the dispersion among different catalogues, and the spread of the orbits obtained even from the most accurate catalogues is very large indeed.

2. The accuracy of semimajor axes of meteor orbits

Error in the heliocentric velocity is a significant source of uncertainty in semimajor axes determination. In the IAU MDC catalogues, the errors in velocity determination can reach the value Δv_H ~10 kms^{-1}. The errors differ both for individual catalogues and for individual meteor showers. The largest spread was found for the Perseids from catalogues with a lower precision, reaching values of 10 – 15 kms^{-1} [1, 2]. Therefore, in analyzing the error function, it is convenient to use a median absolute deviation [6]. The median a_M is the most representative value of semimajor axis a because the arithmetic mean value a is strongly affected by extreme deviations caused by gross errors. The dispersion of the semimajor axis within the meteor stream is described by the median absolute deviation Δ_M in terms of $1/a$: $\Delta_M(1/a) =|(1/a)_{1/2} - (1/a)_M|$, where $(1/a)_{1/2}$ are limiting values of the interval, which includes 50 percent of all orbits. The probable range of uncertainty is determined by $\pm\ n^{-1/2}\ \Delta_M\ (1/a)$, where n is the number of the meteor orbits used for the median determination $(1/a)_M$. For the sake of comparison, we also derived the deviation of the median $1/a$ from the parent body: $\Delta(1/a)_C = |(1/a)_M - (1/a)_C|$, where the $(1/a)_C$ is the reciprocal semimajor axis of a parent comet.

3. Dispersion of orbital elements in individual streams

To find the most probable values of semimajor axes and to compare the observed dispersion in different lists of orbits, shower meteor data from the photographic catalogues of the IAU Meteor Data Center [4] were divided into two samples, of higher and lower precision. The sample of 812 Perseids allowed us to determine the resulting value of median

a_M = 8.98 AU with an uncertainty of only 0.002. The dispersion for the Perseids, described by the median absolute deviation in terms of 1/*a*, is ±0.05 AU^{-1}. The median absolute deviation obtained from the orbits of higher precision $\Delta_M(1/a)$ is 0.032 in comparison with the value of 0,053 obtained from the catalogues of lower precision. The median from 71 photographic Orionids is a_M = 7.49 AU and the absolute median deviation ±0.052 AU^{-1}. For this meteor stream, a considerable influence of the dispersion on the quality of orbits is visible. The dispersion of meteor orbits obtained from catalogues of lower precision ($\Delta_M(1/a)$ = 0.078) is much larger than that obtained using the orbits with a higher accuracy (Δ_M $(1/a)$ = 0.027). A more detailed description dealing with this analysis was made in our previous paper [3].

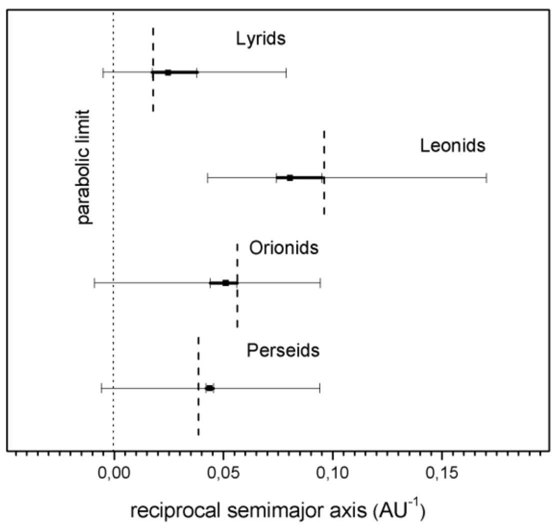

Figure 1: Observed dispersion of semimajor axes within the 4 investigated meteor showers. For each meteor stream plotted: Thin line – interval between two limiting values of $(1/a)_{1/2}$, which includes 50 percent of all orbits. Bold line – interval between two limiting values of the uncertainty $(1/a)_L$ of the resulting values of median a_M (square). Dotted vertical line - parabolic limit. Dashed vertical lines - parent comets.

3. Summary and Conclusions

Precisely-reduced meteor orbits from the photographic catalogues of the IAU Meteor Data Center have been analysed with the aim of determining the orbits' distribution in four chosen meteor streams with heliocentric velocities close to the parabolic limit. Taking into account the different observed dispersions in the different lists of orbits, as well as a large proportion of formally hyperbolic orbits in the analysed photographic observations, the upper limit of real dispersion for the Perseids was estimated to be at least one third of the observed value of 0.049AU^{-1}. The actual dispersion for the Orionids is slightly higher than one third of that determined from the observations. The dispersion for the other two streams, described by the median absolute deviation in terms of 1/*a*, is ±0.064AU^{-1} for the Leonids and ±0.042AU^{-1} for the Lyrids. The absolute value of the deviation of the median 1/a from the parent comet of $\Delta(1/a)_C$ is considerably smaller than the median absolute deviation $\Delta_M(1/a)$ for all four meteor streams. The semimajor axis of the associated comet is on the border of, or very close to, the range of uncertainty for all four meteor streams.

Acknowledgements

This work was supported by the Scientific Grant Agency VEGA, grant No 0636/09.

References

[1] Hajduková, M.: Meteors in the IAU Meteor Data Center on hyperbolic orbits, Earth, Moon, Planets, 102, pp. 1-4, 2008.

[2] Hajduková, M.: On the frequency of interstellar meteoroids, Astronomy and Astrophysis, 288, pp. 330-334, 1994.

[3] Hajduková, M.: The orbital dispersion in the long-period meteor streams, Contrib. Astron. Obs. Skalnate Pleso., 41, pp. 15-22, 2011.

[4] Lindblad, B., Neslušan, L., Porubčan, V., Svoreň, J.: IAU meteor database of photographic orbits – version 2003, Earth, Moon, Planets, 93, pp. 249-252, 2005.

[5] Kresák, L., Kresáková, M: The real dispersion of orbital periods in meteor streams, Bull. Astron. Inst. Czechosl., Vol. 28, No. 5, pp. 257-344, 1974.

[6] Kresáková, M.: On the accuracy of semimajor axes of meteor orbits, Bull. Astron. Inst. Czechosl., 25, No. 4, pp. 191-198, 1974.

[7] Porubčan, V.: Dispersion of orbital elements within the Perseid meteor stream, Bull. Astron. Inst. Czechosl., 28, No. 5, pp. 257-266, 1976.