Characterization of Recent Activity from Visual Observations of the 2002 Perseids Meteor Shower

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Abstract

The visual observations of the 2002 Perseids meteor shower were obtained by 9 observers in 17.4 hours on 12 and 13 August 2002. The observations were made at Owghol Beyg, Zanjan, Iran and the number and magnitude distributions are analyzed using the IMO method. The maximal Zenithal Hourly Rate (ZHR) equal to 86 ± 8 were noted on August 13 (λ_{sun}= 140.081), and the minimum of a population index value, r=2.0±0.2, occurs at sol=140.121. Our observations suggest that 2002 Perseids activity was weaker than the previous years.

1. Introduction

The earliest record of Perseids meteor shower activity appears in the Chinese annals, in 36 AD, but the credit for discovery of the shower's annual appearance is given to Quételet (1835).
The J2000 coordinates for the radiant of this shower are: R.A. = $02^h37^m26^s$, Dec. = +60°05'18", respectively.
The observations by many observers around the world continued almost annually, with maximum rates typically falling between 37 and 88 per hour through 1858. Interestingly, the rates jumped to between 78 and 102 in 1861, according to estimates by four different observers. In 1863, three observers reported rates of 109 to 215 per hour.
The shower's primary maximum has produced rates of 400 in 1991 and 1992 (Koschack *et. al*), around 300 in 1993 (Rendtel), 220 in 1994 (Rendtel) and about 160 in 1995 (Rendtel and Arlt).
Since 2000 the Perseids have appeared to be returned to normal appearance, after they had shown an additional peak prior to traditional maximum in 1988-1999. Moreover the traditional maximum varies somewhat in time.
Computations of the Perseids orbit between 1864 and 1866 by G. V. Schiaparelli revealed a very strong resemblance to periodic comet Swift-Tuttle (1862 III) with a period of about 120 years. This was the first time that a meteor shower had been positively identified with a comet.
In this study, we analyzed our number and magnitude distributions using IMO method, and the parameters derived from observed distributions are compared with the previous studies.

2. Observations

A total number of 430 Perseids were carried out during 17.4 hours observing time on 12 and 13 August 2002, by 9 observers at the Owghol Beyg, Zanjan, Iran.
In our method, the observers were divided into 6 groups while each group only observed his observing field, independently from the others.

The complete records of our observations include the meteor list with time labels, start, end and break times, the meteors magnitudes, and information about clouds or blockages and limiting magnitudes.
The meteors magnitudes were estimated by comparing them with the brightness of the nearby stars we memorized at the beginning of the watch.
And also, the limiting magnitudes were calculated by comparing them with some stars in Cepheus constellation for each observer every 2 hours.
Because of the probability of detecting a meteor is extremely low near the limiting magnitude, the faintest magnitude class carried 2mag brighter than the limiting magnitude.
Figure 1 and 2 represent the number and magnitude distributions derived from our observations. The magnitude distribution percentage is also shown in Figure 3.
All times are converted to solar longitudes, a precise measure of the Earth's position on its orbit which is not dependent on the vagaries of the calendar. All lambdas are given for equinox J2000.0.
Additionally the phases of the Moon were almost ideal with 3 days after New Moon on August 12.
All observers were the students of the Farzanegan high school as a meteor observing group as listed below;
M. Bazrafshan, M. Farahbod, S. Feyzbakhsh, A. Gharavi, T. Kadkhodayan, S. Karami, F. Mosanen zadeh, A. Rezayi, S. Zavarei.

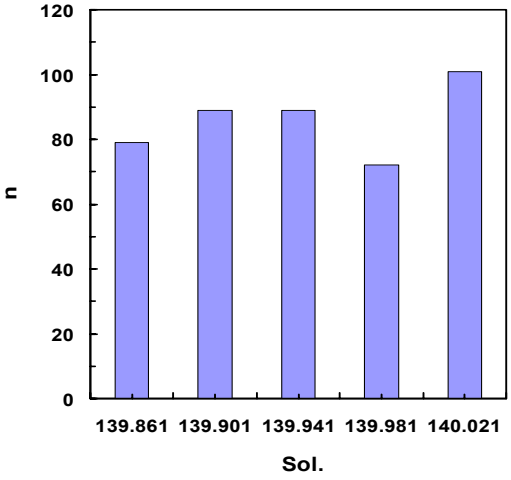

Figure 1 – The Number of total meteors in 5 intervals

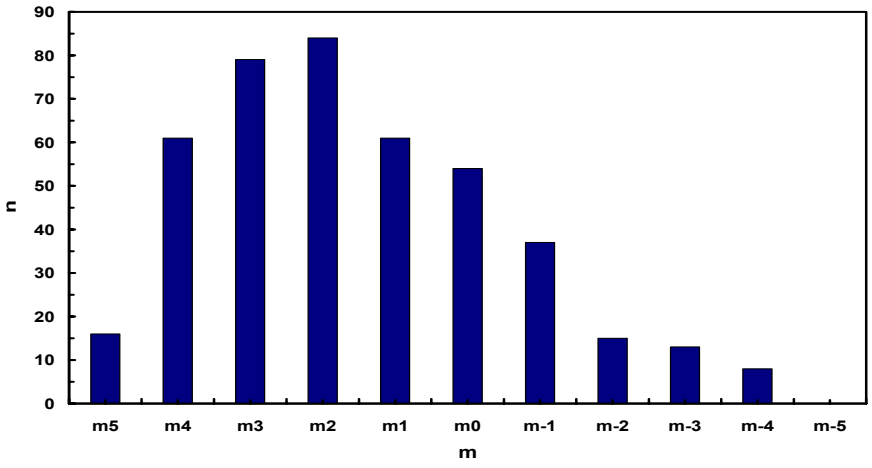

Figure 2 – Magnitude Distribution of the 2002 Perseids

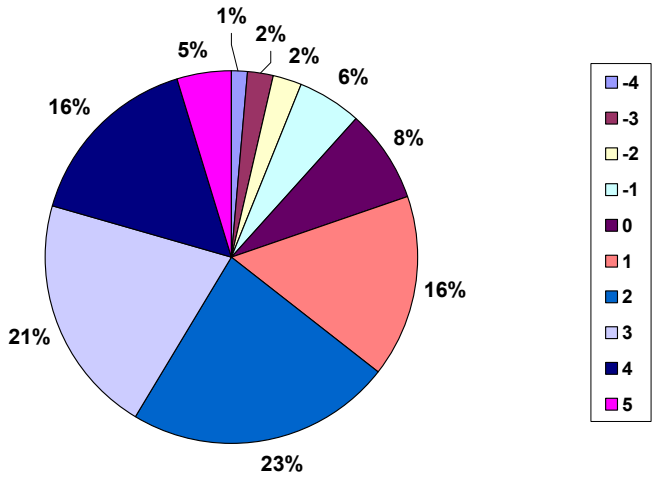

Figure 3 - Magnitude Distribution Percentage

3. Solution

The population index - The observed amount of data allowed the computation of a population index profile which is then used to calculate the individual zenithal hourly rates of each observing period. The population index *r* describes the increase of meteor numbers from a magnitude class to the next fainter one, and is needed to correct observations with the mean limiting magnitude (lm) of all observers at each time interval. The *r*-value of the Perseids was computed from the magnitude distribution when the perception probabilities for meteors of each magnitude are known from before observations.

The meteor numbers observed per magnitude are converted into true meteor numbers using the perception probabilities that given by Arlt (2002). The individual *r*-values are averaged for a population index profile.

The profile of the population index *r* derived from our 2002 Perseids observations is shown in Figure 4.

The lowest population index value, r=2.0±0.2, occurs at sol=140.121.

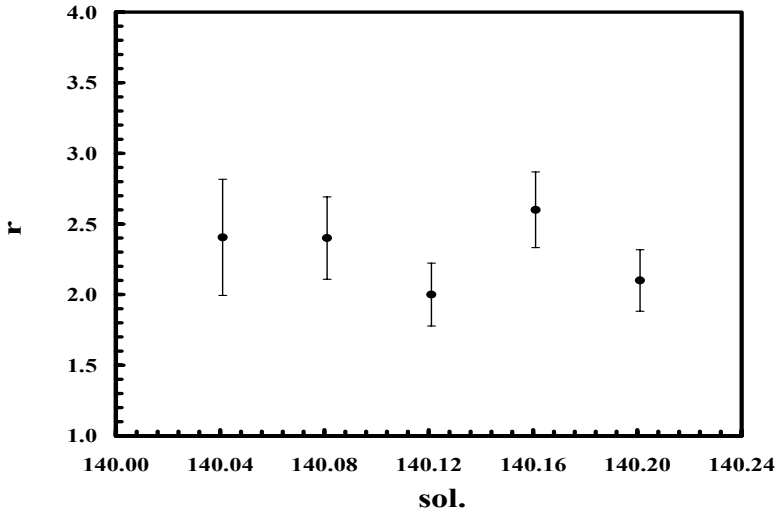

Figure 4 - Profile of the population index *r* of the 2002 Perseids

The Zenithal Hourly Rate - The ZHR (zenithal hourly rate) of a shower gives a measure of that shower's activity, and is the number of shower meteors an observer might count per hour if his limiting magnitude is 6.5mag under perfect sky conditions with the radiant in the zenith.
The ZHR is determined from the observations by correcting the observational parameters to the "ideal" conditions.
We used some factors based on the number of meteors missed as being proportional to the field fraction obscured.
The Zenithal Hourly Rate (ZHR) of a meteor shower at a certain time is calculated by

$$\mathbf{ZHR} = r^{(6.5-lm)}\, F\, n \,/\, (\sin h_R\, T_{eff})$$

where r is the population index, lm the limiting magnitude, F the correction factor for obstructions of the field of view (clouds), n the number of shower meteors, h_R the radiant elevation, and T_{eff} the effective observing time.
The zenith correction factor is $\sin^{gamma} h_R$ (Öpik, 1940), with gamma the so-called zenithal exponent. Bellot Rubio (1995) and Koschack (1994) showed that this exponent is close to 1.0 for visual Perseid data.
The F correction factor results from:

$$\mathbf{F} = \frac{1}{1-\mathbf{k}}$$

where k is the percent of blockage during T_{eff}.
The ZHR errors are derived from ZHR division by square root of total meteor numbers.
The maximum is found at λ_{sun}= 140.081 with a ZHR of 86 ± 8.
Finally, we observed a second slight increase of activity after the traditional maximum of the Perseids at sol=140.201°, reaching a ZHR of 59±5.
The ZHR-profile of the 2002 Perseids during the sol. 140.040 and 140.201 is shown in Figure 5.

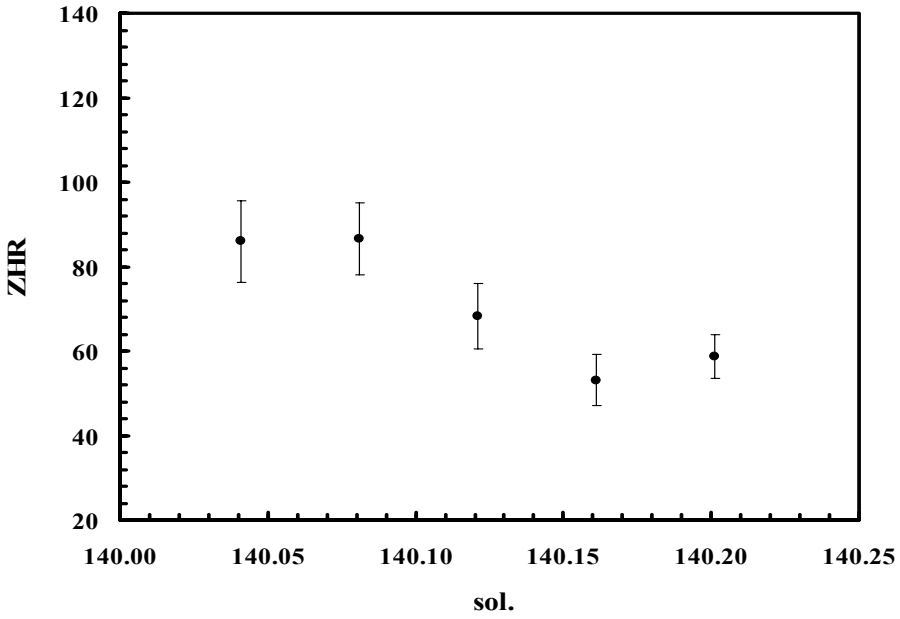

Figure 5 - ZHR-profile of the 2002 Perseids

4. Discussion

This result was quickly confirmed by Japanese radio observations (Kazuyuki *et. al*) as explain the 2002 Perseids activity weaker than the previous years.
Although the analysis of the 2002 Perseids return is based only on our observations as a part of the entire data, the results should be expected to be quite close to the final values that shows a maximum ZHR of 90 (Arlt and Buchmann, 2002). This is particularly valid for the peak period, although there may be some fine structures in this time interval which can be derived from a larger sample.
As shown in Table 1, the position of the peak varied from one return to the next. Some years ago, the changes in the position looked rather accidental, but according to the entire series given in Table 1, there seems to be a systematic decrease in the solar longitude from 139.78° in 1988 back to 139.48° in 1992, and a subsequent increase in the solar longitude of the peak arriving at 140.08° in 2002. The ascending node of the comet 109P/Swift-Tuttle is at 139.44°, hence the 1992 passage was the closest to the orbit of the Perseid parent comet.

Year	Sol.	r	ZHR(max)
1988	139.78	2.1	106
1989	139.56	2.1	94
1990	139.55	2.1	81
1991	139.55	2.1	97
1992	139.48	2.0	84
1993	139.53	1.9	98
1994	139.59	1.9	86
1995	139.62	2.1	65
1996	139.66	1.7	85
1997	139.64	1.9	162
2000	140.00	2.0	120
2001	140.00	2.0	130
Present Study	140.08	2.0	87

Table 1 – r, ZHR, and the position of the peak of Perseids, derived from activity analysis since 1988.

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