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Observation of a faint glow of scattered sunlight from the dust trail of the Leonid parent comet 55P/Tempel-Tuttle

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Abstract: The faint glow at the direction of the dust trail of comet 55P/Tempel-Tuttle was discovered during the Leonid meteor shower in 1998 ($\Delta MA = 0.136$) by the photometric observations at Mauna Kea, Hawaii (Nakamura et al. (2000)). This is considered as the scattered sunlight by the sub-millimeter size dust particles located along the orbit of 55P/Tempel-Tuttle. To examine the orbital distribution of the dust particles, we observed the direction of the dust trail on 2001 November 19 ($\Delta MA = 0.705$), at Akeno Observatory (138d30m(E), 35d47m(N), 900m, Institute for Cosmic Ray Research, University of Tokyo, Japan). The instruments were the same one as Nakamura et al. (2000) used. From our data, there is no prominent evidence detected at that direction. Based on these two data obtained in 1998 and 2001, we discuss the spatial distribution of the dust material observed as the dust tube in visible wavelength.

1. INTRODUCTION

The dust trail is not the dust "tail", which consists of small sub-micron size dust particles which are blown out by the solar radiation pressure forces. On the other hand, the dust trail consists of sub-millimeter size dust particles, which are poorly coupled with the cometary gasflow and the solar radiation pressure, and which spread out along the orbit of the parent comet and formed a tubular structure. The meteor shower occurs when the earth enters into a dust trail. In order to consider the three-dimensional structure, dynamical evolution of the dust trail, and the interaction with the cometary gas outflow, it is important to know the orbital distribution of the dust trail.

The dust trail is too faint and difficult to be observed from ground-based observatory. It is, however, a good opportunity to observe the dust trail as the meteoric cloud during the meteor shower because the column density along the line of sight in the dust trail increases. Here the meteoric cloud means the faint glow of sunlight scattered by dust particles in the dust trail.

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We expect to observe the dust tail as the meteoric cloud, a small patchy and a faint structure near the radiant point.

Nakamura et al. (2000) reported that they had discovered the meteoric cloud of 55P/Tempel-Tuttle by using a optical CCD camera at Mauna Kea, Hawaii (4200m), during the term of the Leonid meteor shower in 1998. Their observation was done when the observers were slightly out of the peak of the meteor shower (the peak time were 01:55 and 20:33 (UT), while their data was taken at 15:04 (UT) on 1998 November 17). Thanks to the accurate forecast of the meteor shower's time, we had a good opportunity to observe the dust trail from the center of trail in 2001. Therefore we observed the same direction by using the same instruments during the Leonid meteor shower in 2001.

2. OBSERVATION AND RESULTS

We tried to detect the meteoric cloud between 03:18 and 04:58 (JST) on 2001 November 19 at Akeno Observatory (138d30m(E), 35d47m(N), 900m, Institute for Cosmic Ray Research, University of Tokyo, Japan). This is almost the peak time of Leonid meteor shower. A broad peak of the activity was recognized at around 03:25 (JST) (Watanabe et al. (2002)).

We used an optical cooled CCD camera, Mutoh CV-16, with an airglow reduction filter and 24mm wide field lens (f = 24mm, F = 2.8). With a 2×2 binning, the angular resolution was 2'.5/pixel and the field-of-view was $32° \times 21°$. The temperature of the CCD chip was kept at $-30°$C. The airglow reduction filter is designed to agree with the broadest window of visible airglow and artificial sky lines between Hg at 435nm and OH at 557.7nm. These instruments were the same ones as Nakamura et al. (2000) used.

The exposure time was set to 3 minutes, and we obtained 13 exposure frames. Our best result is shown in Fig. 1, which was taken at 04:13 (JST) on 2001 November 19. We applied this frame for further analysis. In Fig. 1, the predicted position of the dust trail is also drawn. The radius of the dust trail is assumed as 0.01AU from the past shower durations. Therefore, the most brightness area as the appearance of the meteoric cloud would be located on the back of Leo.

After the removal of the point sources, Fig. 2 was obtained. The gradient all over the frame is owing to the morning zodiacal light, while the right edge of the frame almost corresponds to the ecliptic plane. In Fig. 3, the sky intensity was compared with the absolute brightness of the zodiacal light (Levasseur-Regourd & Dumont 1980). It is inferred that the photometric accuracy is at most 1% from the existence of the Themis-Koronis dust bands near the ecliptic and the non-existence of the Eos dust bands (typical brightness of each dust bands are $\sim 1.5\%$ and $\sim 0.8\%$ of smooth zodiacal light brightness, respectively (Ishiguro et al. 1999).

However, no significant features exist around the expected position of the dust trail.

3. DISCUSSION

In 1998, Nakamura et al. (2000) reported that they detected the meteoric cloud at $4.5 S_{10\odot}$, where $S_{10\odot}$ is the traditional unit of the zodiacal light brightness. On the other hand, in 2001, we could not detect the sign of the dust trail within the $2.5 S_{10\odot}$ in uppermost.

We need to consider some possibilities of the reasons why the meteoric cloud disappears. Of course, we cannot dismiss the problem with the observational instruments and the weather conditions in 2001. But we used the same set as Nakamura et al. (2000) used. Furthermore, we could detect the zodiacal dust band in data of 2001, the weather of that night was considered

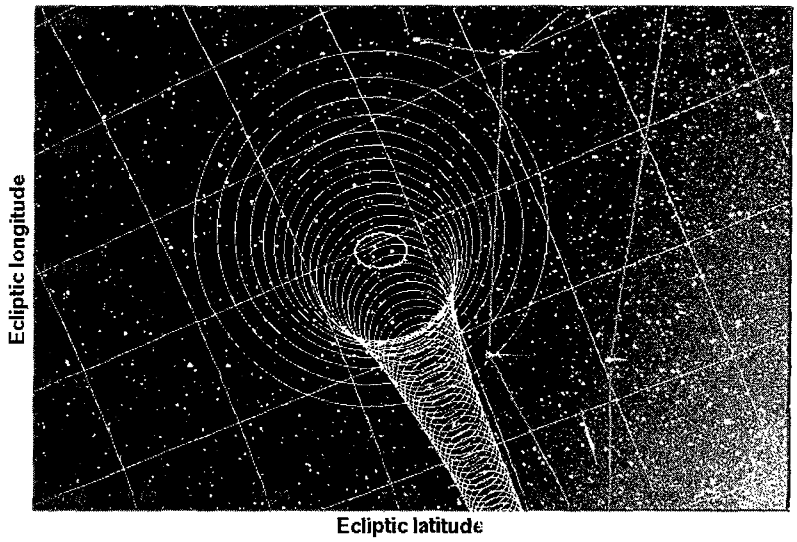

Fig. 1: Sky image taken at 04:13:51 (JST) on 2001 November 19 at Akeno Observatory. Model dust trail of β (the ratio of the solar radiation pressure to the solar gravity on the dust particle) = 0 is also shown, which is assumed to be a cylindrical tube with a radius of 0.01AU along the orbit of comet 55P/Tempel-Tuttle. The most brightness area of the meteoric cloud would appear on the back of Leo.

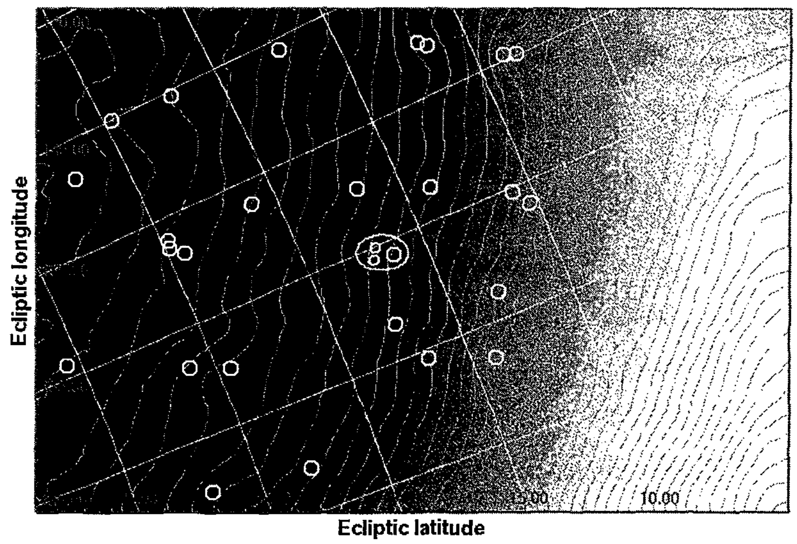

Fig. 2: Same as Fig.1 but after removal of the point sources. The gradient of the sky is owing to the morning zodiacal light. Circles denote the positions of the bright point sources.

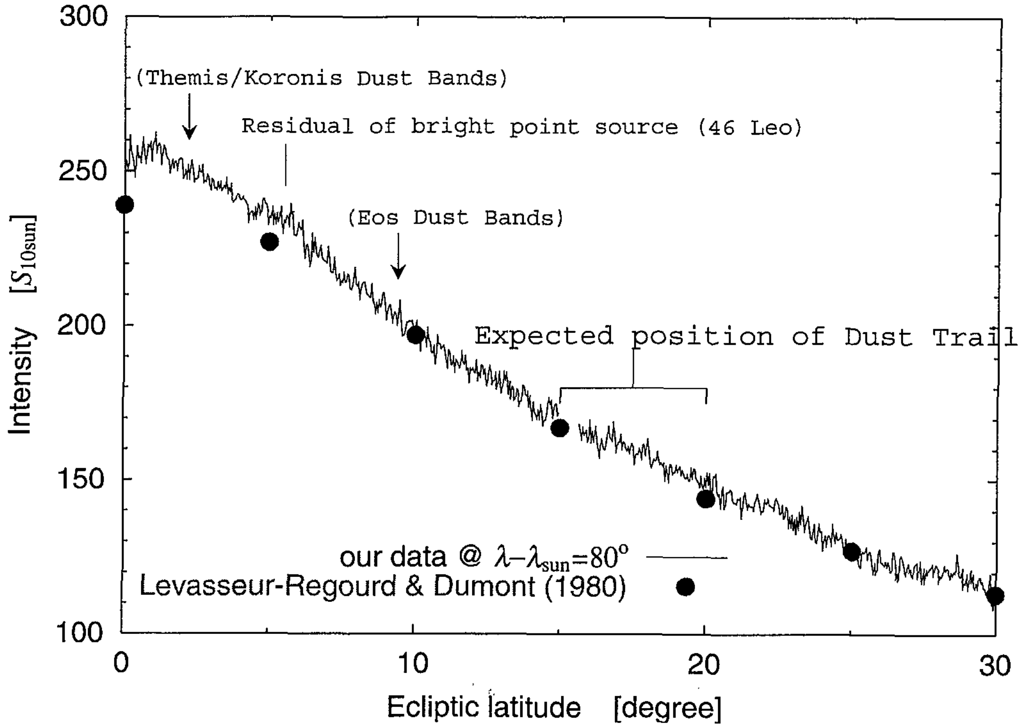

Fig. 3: The Sky intensity along $\lambda - \lambda_{\odot} = 80°$ is plotted against the ecliptic latitude. The absolute brightness of the zodiacal light (Levasseur-Regourd & Dumont (1980)) is also shown and predicted positions of the Themis/Koronis dust bands ($\beta = 2.2°$) and the Eos dust bands ($\beta = 9.4°$) (Reach (1992)) are denoted by arrows. Enhancement around $\beta = 5°$ is yielded by the bright star 46 Leo ($V_{mag} \sim 5.46$).

Table 1: Summary of the meteoric cloud observation during the Leonid meteor shower.

Year	Observation site	Results
1998 $t - t_d = 262_{[day]}$ $\Delta MA = 0.136$ (Nakamura et al. 2000)	Mauna Kea, Hawaii (4200m)	**Detected** ($4.5S_{10\odot}$ at peak)
2001 $t - t_d = 1360_{[day]}$ $\Delta MA = 0.705$ (This work)	Akeno, Yamanashi (900m)	**NOT Detected** ($< 2.5S_{10\odot}$)

as pretty good.

If this disappearance is considered as a real feature of the dust trail, the optical depth of the dust trail decreases for some reason. For example, the sublimation of the volatile in the dust particles due to the solar radiation pressure and the solar wind (Mukai & Yamamoto (1982)) or the dust-dust collision reproduces smaller grains, which are easy to remove by solar radiation pressure. Consequently, the dust trail becomes wider and fainter as the distance from the parent comet increases. Similar observational results were reported from the observation of comet 22P/Kopff (Figure 3 in Ishiguro et al. 2002).

4. SUMMARY

We observed the night sky at the direction of the dust trail of comet 55P/Tempel-Tuttle in optical wavelength during the Leonid meteor shower in 2001 but no significant enhancements could be detected, while Nakamura et al. (2000) reported the discovery of the meteoric cloud in 1998 by using the same instruments of our observation. From the fact of this "disappearance", we know the spatial distribution of the dust trail, that is, the dust trail becomes wider and fainter as the distance from the parent comet increases. Further observations and model calculations are expected.

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