Physics, Chemistry, and Dynamics of Interplanetary Dust
ASP Conference Series, Vol. 104, 1996
Bo A. S. Gustafson and Martha S. Hanner (eds.)

The First in a New Series of Leonid Outbursts

P. Jenniskens

NASA/Ames Research Center, Mail Stop 239-4, Moffett Field, CA 94035-1000 (peter@max.arc.nasa.gov)

Abstract. The Leonids returned with higher than usual rates in November 1994. From an analysis of the available visual and radio forward meteor scatter observations, it is found that the meteor stream activity curve and the magnitude distribution index are similar to those of the outbursts in 1961 and 1965 during the previous return of the parent comet. It is possible that the outburst was due to the same dust component or dust with a similar stream evolution history.

Meteor outbursts are significant enhancements of meteor activity over the normal annual activity. Intense meteor outbursts are called meteor storms, the most intense of which are currently the Leonid storms. Enhanced Leonid activity has always been associated with the return of the parent comet P/Tempel-Tuttle to perihelion (Kazimircak-Polonskaya 1968). In November of 1994, the first in a new series of Leonid outbursts was observed associated with the upcoming perihelion passage of February 1998. The event was observed by a number of visual observers, in spite of a full moon, and recorded by two automatic meteor monitoring systems using radio forward meteor scatter (MS).

The visual observations of six observers have recently been analyzed in Jenniskens (1996). These include a total of 219 Leonids and 82 sporadic meteors that were seen in 25 hours of net observing time. It was found that the effective cross section of the outburst, i.e. between activity levels of 1/e times peak activity, was 18±5 hours and the stream peaked at solar longitude 235.2±0.1 (Eq. 1950.0) on 1994 November 18 10±3 UT. The peak rate was ZHR = 75±15 Leonids per hour, which came on top of the normal annual Leonid activity of about 10 Leonids per hour. The meteors were bright on average, with a magnitude distribution index of χ = n(m+1)/n(m) = 2.1±0.3. The annual activity peaks at solar longitude 234.9 (Eq. 1950.0) with an effective duration of 4.4 days (main peak) and for which χ = 3.0±0.4.

Figure 1 shows the combined meteor activity of annual and outburst Leonids and sporadic meteors in the period 1994 November 14-23 as recorded by radio forward meteor scattering systems of I. Yrjölä from Kuusankoski, Finland (solid line), and M. De Meyere from Deurle, Belgium (open circles - Steyaert 1994). Leonid rates were significantly above sporadic background activity on the three consecutive nights from Nov. 17 until Nov. 19. Most, if not all, of this activity was from the Leonid outburst. The annual activity is only barely detected by the meteor scatter systems. Almost no increase of activity above sporadic rates (dashed line) was observed in 1993.

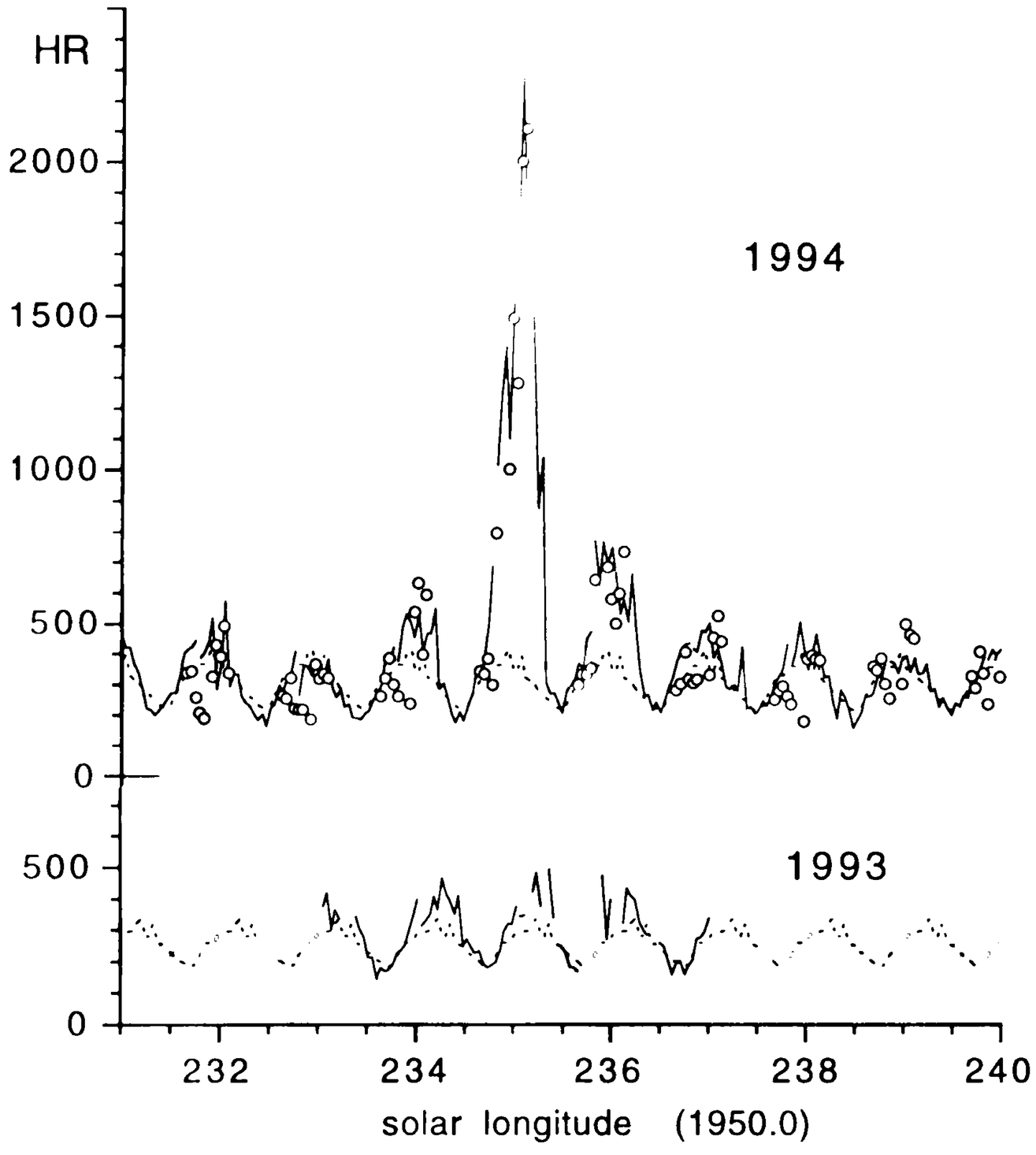

Figure 1. Hourly count of radio meteor-scatter reflections (HR) for the period November 14-23 in 1993 and 1994. The number of occasions that the output signal passed a trigger level is plotted versus time in terms of solar longitude. The conspicuous increase of rates in 1994 is due to the Leonid stream. The typical radio Leonid is approximately magnitude +3. Dashed lines show the mean (sporadic) rates in the days before and after the event. (Data: I. Yrjölä (—) and M. De Meyere (o)).

Similar long lasting outbursts of bright meteors ($\chi \sim 2$) were recorded in 1961 and 1965 by radar (McIntosh & Millman 1970) and it is possible that they were due to the same dust component. The event in 1994 occurred 1198 days before comet passage of perihelion, while the event in 1961 occurred 1260 days before.

The 1965 radar data contain both a broad component of bright meteors ($\chi = 1.7$) and a narrow component of faint meteors ($\chi \sim 3$). This narrow component of faint meteors is probably associated with the Leonid meteor storms. The storms are typically of shorter duration and richer in faint meteors, with $\chi = 3.0$. Past activity curves of the Leonid storms have both a main peak and a broader background component (Jenniskens 1995). That brings the number of distinct features in Leonid outburst activity profiles to three. A forecast of near-future Leonid returns is given in Jenniskens (1996) based on the assumption that previously observed patterns in the manifestation of these dust components are repeated.

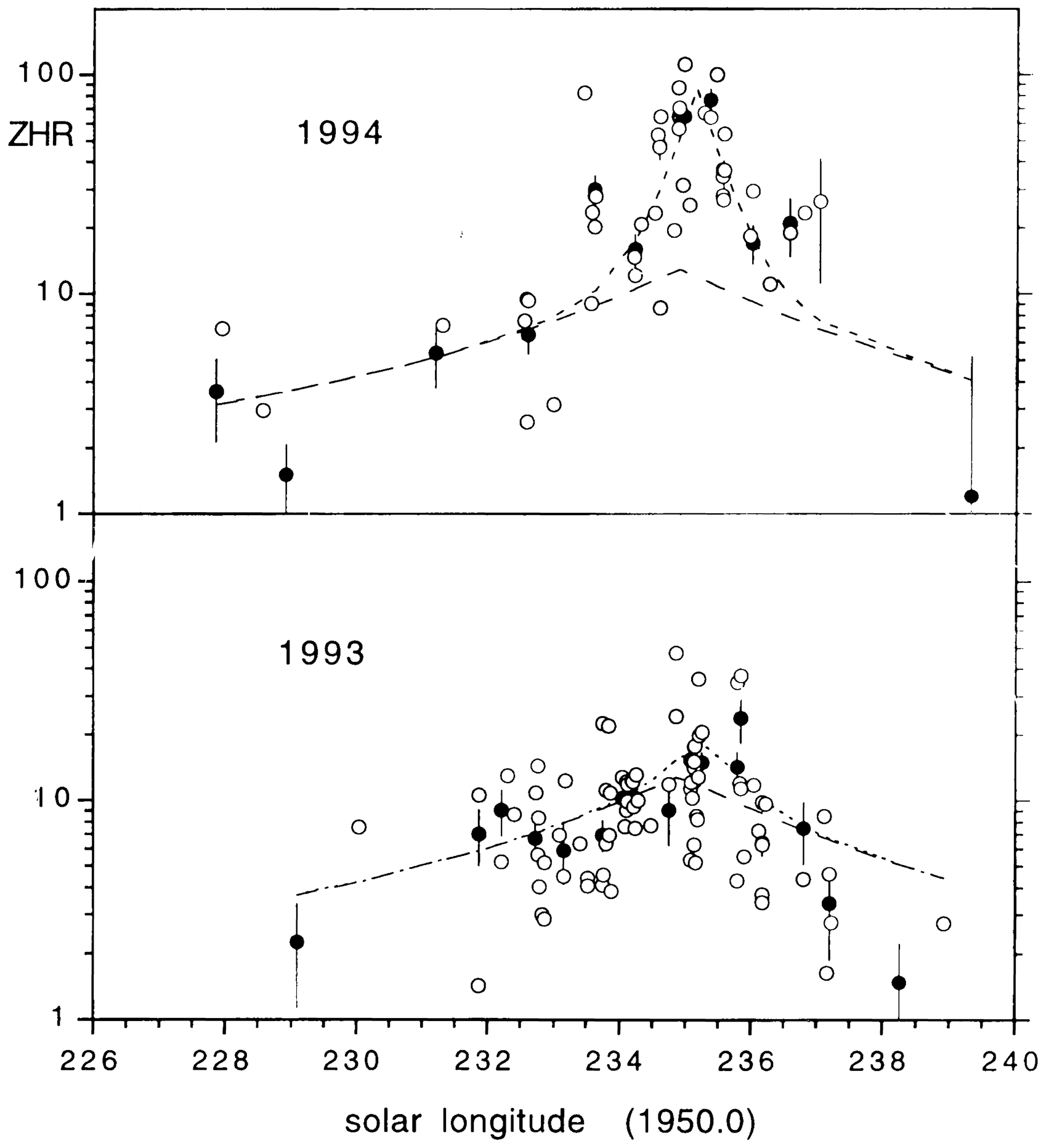

Figure 2. Visual data in the WGN Report Series of 1994 and 1993. Open circles show individual Zenith Hourly Rates per observer per time interval, closed circles give mean values. Dashed lines give annual Leonid rates (- - -) and (possible -1993) outburst (. . .) activity. The typical visual meteor is about magnitude +3 for annual Leonids and +2 for outburst Leonids.

https://doi.org/10.1017/S0252921100501389 Published online by Cambridge University Press

More visual observations of the 1994 Leonid outburst have become available recently. The results from 31 observers (77 hours of observing time in which 497 Leonids and 306 sporadic meteors were seen) have been gathered and published in the WGN Report Series of 1994 (P. Roggemans ed.). These observations are reduced in the same manner and are shown in the upper panel of Fig. 2. Open dots give individual ZHR values, while closed dots give mean values that include zero detections and are weighted proportional to the net observing time.

The new data are in good agreement and further strengthen the conclusions in Jenniskens (1996) regarding the shape and peak intensity of the activity curve of the 1994 Leonids when compared to the activity curve of the annual and outburst component.

Data from the year before are listed in the WGN Report Series of 1993. In 1993, a total of 726 Leonids and 1171 sporadic meteors were seen in 161 hours of net observing time by 49 observers. These data are reduced in the same manner and are shown in the lower panel of Fig. 2. I conclude that any enhancement of rates was less than one fifth that in 1994, in accordance with the radio meteor scatter counts of Fig. 1. The data do not support the early enhancement of Leonid rates suggested by Belkovich et al. (1995). This corroborates the behavior of Leonid activity during the previous return, when no enhanced rates were recorded in the years prior to 1961. The cause of the sudden enhancement of rates in 1961 and 1994 remains unknown. However, the return in 1994 holds great promise for good Leonid displays in the near future.

Acknowledgments. I thank the visual and MS observers for their contributions to this work. The WGN Report Series is published by the International Meteor Organisation. Part of this work was funded by a NASA/Ames Research Center - Director's Discretionary Fund.

References

Belkovich O., Ishmukhametova M., Suleymanov N. (1995) On when Leonids woke up, *WGN* 23, 117

Jenniskens P. (1995) Meteor stream activity. II. Meteor outbursts, *Astron. & Astrophys.* 295, 206

Jenniskens P. (1996) Meteor stream activity. III. Measurement of the first in a new series of Leonid outbursts, *Meteorit. & Planet. Sci.* 31, 177

Kazimircak-Polonskaja E.I., Beljaev N.A., Astapovic I.S., Terenteva A.K. (1968) Investigation of perturbed motion of the Leonid meteor stream, in: *Physics and Dynamics of Meteors*, Kresak L., Millman P. (eds.), 449

McIntosh B.A., Millman P.M. (1970) The Leonids by radar - 1957 to 1968, *Meteoritics* 5, 1

Steyaert C. (1994) *Radio Meteor Observation Bulletin* No. 16