Light Curves of Comets in 2004

March 19 and 20, 2005　35th Comet Conference

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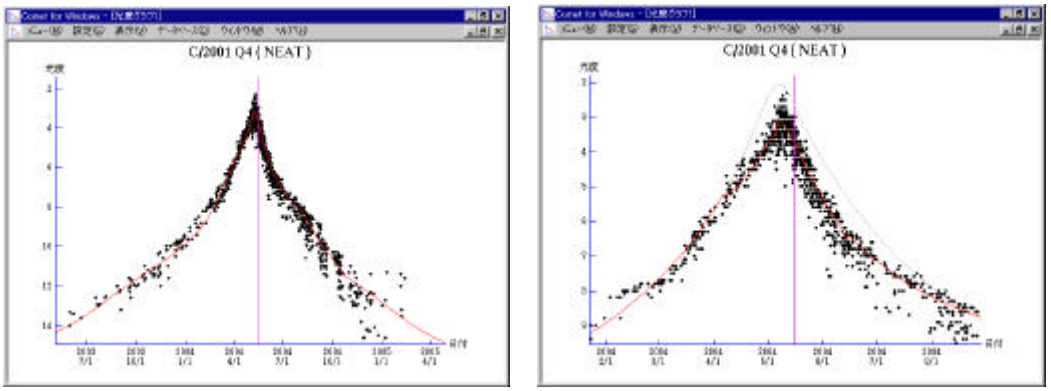
1. Overview

In this paper, I introduce the light curves of comets, bright comets or interesting comets with peculiar light curves, observed during a year between 2004 March and 2005 February.

My web page "Comet Catalog" also introduces the light curves of comets, including ones not described in this paper.

2. Bright Comets

2-1. C/2001 Q4 (NEAT)



It brightened well along the formula of 8.6 log r for about one year, from 2003 spring when it began to be observed visually, to around 2004 April 10 when about 40 days before the perihelion passage.

Because the perihelion distance is 0.96 A.U., not so close to the sun, the light curve seemed stable. It was expected to keep brightening well and reach to 2.0 mag at best in May.

However, the brightening evidently slowed down after April 10. It was just before the perihelion passage, and the heliocentric distance did not change at that time. That means the activity of the comet declined.

Actually, it reached to 3.0 mag at best, fainter than expected by 1.0 mag.

The absolute magnitude of this comet is bright as about 4 mag. And the perihelion distance is large. Therefore the decline of the brightness is very unusual.

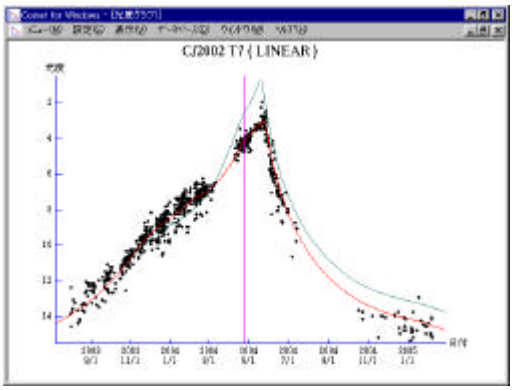
The light curve after the perihelion passage is also interesting. It had been fading normally along the formula of 10 log r for about one month after the perihelion passage. However, it

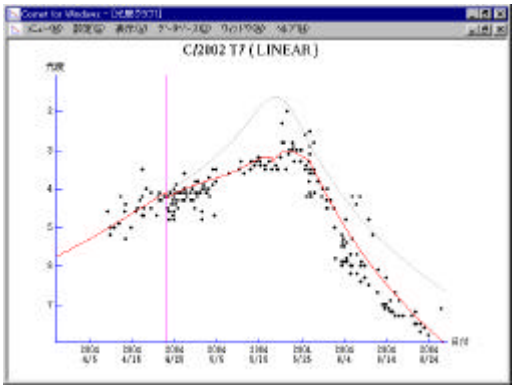
suddenly stopped fading in June, and kept the brightness for two months until August.

After August, reported magnitude began scattering among observers. For example, it was reported from 8.8 mag to 11.1 mag visually in early September, the difference was so large as 2.3 mag. Still in early February, it was reported from 11.4 to 13.5 mag, therefore the scattering is still large.

Now it is still bright visually, however, it is already very faint by CCD observations. In 2005 January, the CCD magnitude faded down to 15 mag, and the difference from the visual magnitude became very large. In addition, the diameter looked very large as 1-2 arcmin visually, however, it looked very small as 0.3-0.5 arcmin by CCD observations. Therefore the difference of diameter between visual and CCD observations is also very large.

2-2. C/2002 T7 (LINEAR)





It brightened well along the formula of 10 log r after its discovery until 2003 October when about a half of a year before the perihelion passage.

However, it brightened rather rapidly after 2003 November, and became brighter than predicted by 1 mag in 2004 January. The heliocentric distance was around 3.0 A.U. when the rapid brightening began.

After February, when the heliocentric distance reduced to 1.5 A.U., the brightening turned to slow down. Then it kept slowly brightening along the formula of 5 log r, and reached to 4 mag around the perihelion passage in late April.

The perihelion distance of this comet is small as 0.61 A.U. It is common that brightening of a comet with a small perihelion distance slows down around the perihelion passage.

The comet approached to the earth rapidly after that, and it was expected to reach to 1.5 mag at best in May. It becomes bright as it becomes close to the earth. So it was confidentially predicted to be 1-2 mag.

But actually, the comet did not brighten as expected at all. Finally it reached to 3.0 mag at best.

Some thought at first, it means the activity of the comet declined rapidly. However, the unexpected fading of this comet is probably not due to the decline of the activity.

After passing near by the earth in mid May, it was expected to be fading while it became far from the earth. But actually, it brightened slowly. Finally in early June, the brightness

recovered to the original.

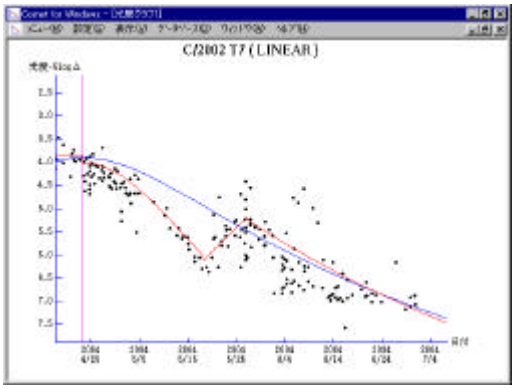
It is hard to consider that the activity of the comet declined temporarily when it became closest to the early by chance, and recovered soon after the temporary fading of 1.5 mag.

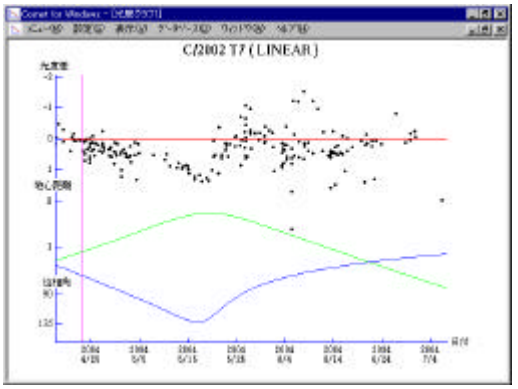
After June, it has been fading normally along the formula of 10 log r until early 2005. So, it is hard to consider the activity of the comet significantly and temporarily declined.

We think the fading in May was due to the effect of phase angle.

The left graph below shows the visual observations of the comet for 70 days after the perihelion passage when the comet approached to the earth. Apparent effect due to the geocentric distance is deducted in this graph. Two curves are drawn, approximate curve of actual brightness (red) and theoretical magnitude without fading (blue). The blue lines means the formula of m1 = 5.7 + 5 log(delta) + 8.5 log r.

The right graph below shows the difference between the observed magnitude and the theoretical magnitude, the geocentric distance (green), and the phase angle (blue).

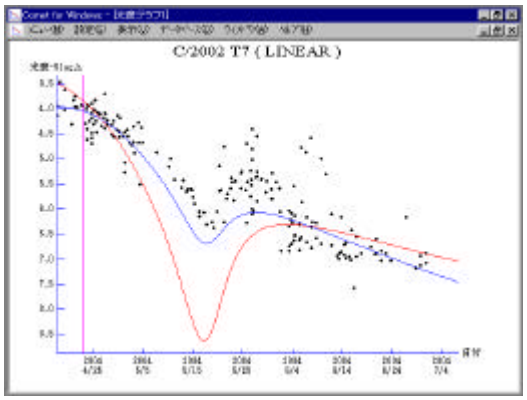




This graph suggests the fading in May was related to the phase angle, was not the apparent effect due to the geocentric distance.

The following graph shows the visual observations where apparent effect due to the geocentric distance is deducted, and the theoretical curves including the effect of phase angle. Two curves are drawn, the theoretical magnitude assuming it fades as an asteroid (red), and considering the ratio of bright hemisphere visible on the earth (blue).

Although the theoretical curves do not completely coincide with the observations, the trend of the fading and recovering is similar.



2-3. C/2003 K4 (LINEAR)

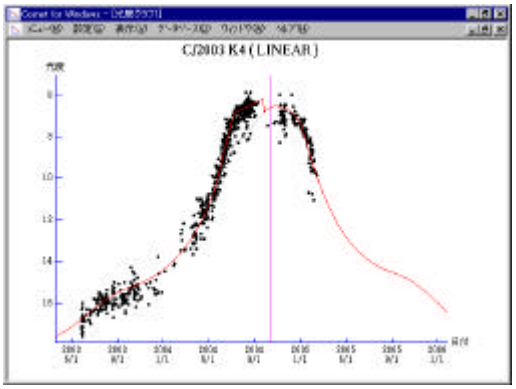
The perihelion distance is 1.02 A.U., not so close to the sun, but it showed an interesting behavior.

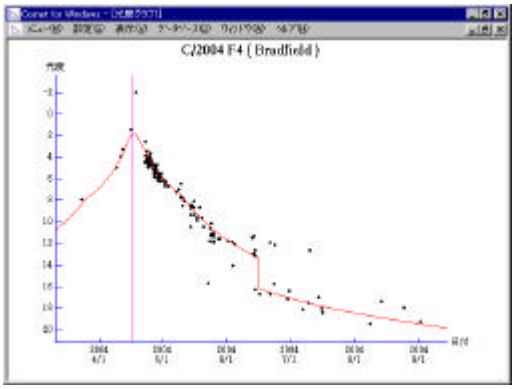
It brightened rapidly for about 50 days from mid May to early July. As a result, it became brighter than predicted by 1.5 mag. The heliocentric distance reduced from 2.5 to 1.9 A.U. in this period. The comet was still very far from the sun.

However, the brightening suddenly stopped in July. In addition, in autumn when it appeared again after the perihelion passage, it became fainter than predicted based on the observations before the perihelion passage by 1.0 mag.

The brightness after the perihelion passage was H10=5.0 mag, that is, the brightness returned to the value before the rapid brightening in May.

Then it keeps fading normally along the formula of 10 log r.





2-4. C/2004 F4 (Bradfield)

The brightening was rather slow along the formula of 7.3 log rbefore the perihelion passage, from March 23 when Bradfield discovered it in the evening very low sky at 8 mag, to April 12 when confirmed at 3.3 mag.

Because the perihelion distance is very small as 0.17 A.U., and the absolute magnitude was rather faint as H10=8.0 mag, it could vanish at the perihelion passage. But actually, it became a great comet with a long tail.

At the perihelion passage, it brightened due to the forward scattering, and reached to –2 mag in the SOHO/LASCO images.

After the perihelion passage, it faded completely along the same formula as before the perihelion passage. That means the comet was not influenced at all after passing very close by the sun.

Because it was not visible in the SWAN images in early March, it probably brightened rapidly until late March.

When three weeks passed after the perihelion passage, it suddenly began fading rapidly along the formula of 16.5 log r. The comet was 0.7 A.U. from the sun at that time. The comet reached to the same distance from the sun before the perihelion passage in late March. That means the turning point of slow and fast brightening or fading was also symmetric around

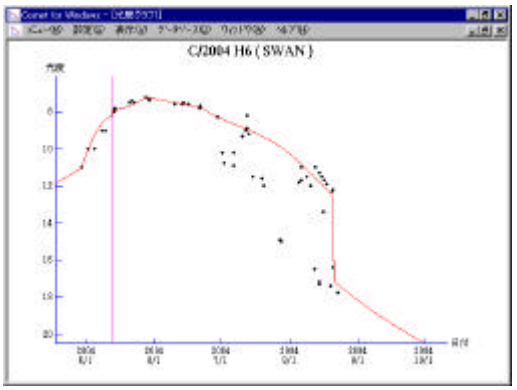
the perihelion passage.

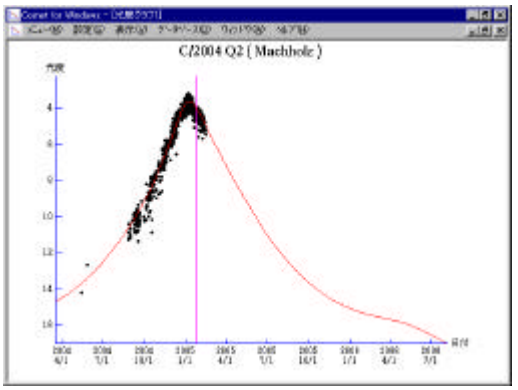
2-5. C/2004 H6 (SWAN)

It brightened rapidly from 11 mag to 7 mag in the SWAN images only within two weeks before the perihelion passage. Unusual brightening continued for more two weeks after the perihelion passage. This suggests an outburst of a small comet passing near by the sun.

It kept bright for about one month after that, then faded and became diffused rapidly.

The difference between visual and CCD magnitude became very large, as is often the case of a diffused comet. In August, it was 12 mag visually, however, so faint as 17-18 mag by CCD observations. The difference was so large as 5-6 mag. Therefore, when it became too faint to see visually, it also became too faint to catch using CCD cameras despite of the good condition.





2-6. C/2004 Q2 (Machholz)

It was discovered in August, but Michael Jager and Vello Tabur reported pre-discovery images in May.

Because the perihelion distance is 1.21 A.U., far from the sun, it showed a normal light curve along the formula of 10 log r without any unexpected events.

However, the tail was unusual. The direction of the dust tail was completely different from the calculation.

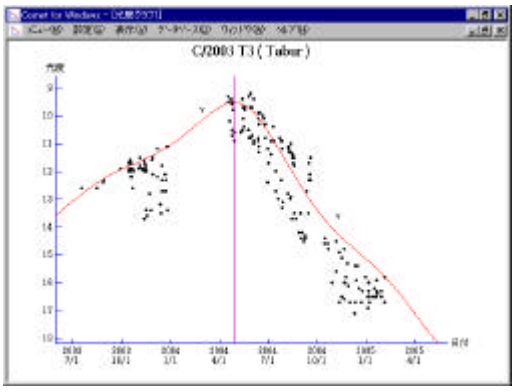
But no unusual events were found on the light curve.

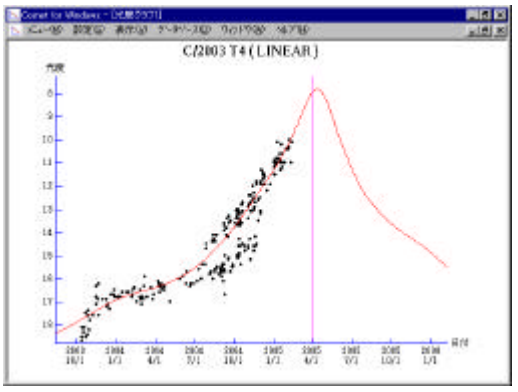
3. Visual Comets

3-1. C/2003 T3 (Tabur)

Brightening before the perihelion passage was very slow along the formula of 6.5 log r.

On the other hand, fading after the perihelion passage was very rapid along the formula of 14.0 log r.





3-2. C/2003 T4 (LINEAR)

It keeps brightening very slowly along the formula of 7.0 log r for about one and a half years after its discovery.

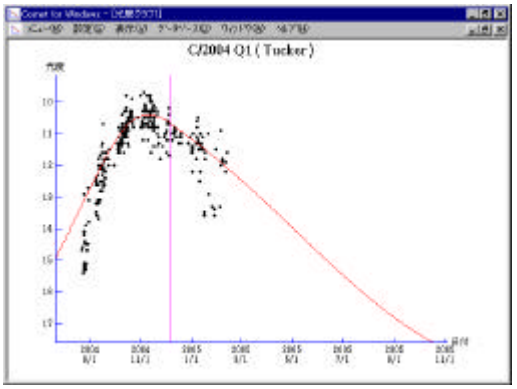
The slow brightening did not change all over the period, while the heliocentric distance reduced from 6.5 A.U. to 1.0 A.U.

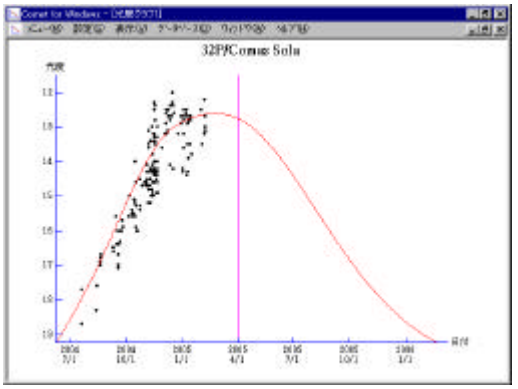
In general, a comet discovered very far from the sun brightens along the formula of 10 log r. The trend of this comet is unusual.

3-3. C/2004 Q1 (Tucker)

Although the perihelion distance is 2.05 A.U. far from the sun, it brightened more rapidly than expected and reached to 10 mag.

After the perihelion passage, it is fading rather faster than a typical comet. But the pace became slower than that of brightening before the perihelion passage.





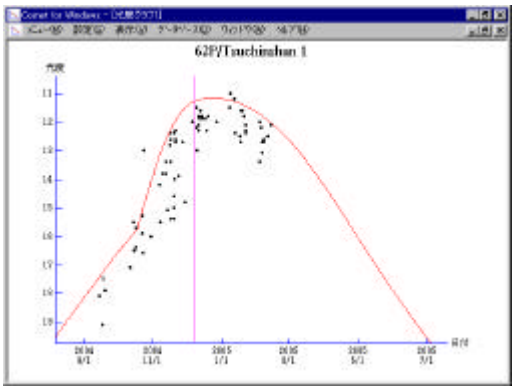
3-4. 32P/Comas Sola

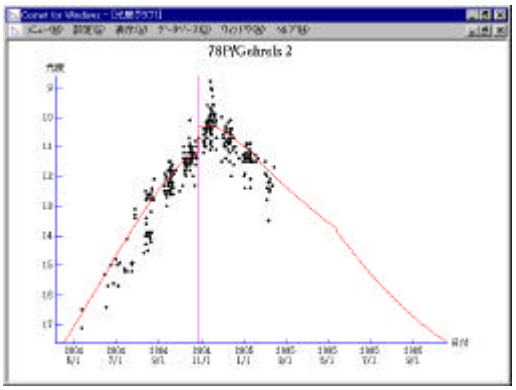
It brightened completely as expected from its last appearance.

3-5. 62P/Tsuchinshan 1

In its last appearance, it began brightening rapidly about 50 days before the perihelion passage, and reached to 12 mag.

It brightened completely as expected from its last appearance, and reached to 11 mag.





3-6. 78P/Gehrels 2

It was predicted to brighten rapidly before the perihelion passage, and to fade slowly after the perihelion passage, based on its last appearance.

As expected, it brightened rapidly along the formula of 40 log r before the perihelion passage, and faded slowly along the formula of 10 log r after the perihelion passage.

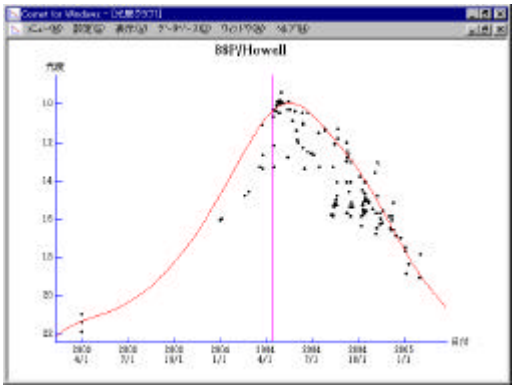
It suddenly brightened by 1 mag at the perihelion passage. So it reached to 10 mag, brighter than expected by 1 mag.

3-7. 88P/Howell

In its last appearance, it brightened and faded rapidly along the formula of 25 log r, and became brightest 33 days after the perihelion passage.

It brightened and faded completely as expected from its last appearance.

Because it was very diffused, the reported magnitude had large scattering among observers. This is also the same as its last appearance.



4. Comets which Brightened Rapidly

4-1. C/2003 H3 (NEAT)

It kept fading slowly along the formula of 8.0 log r until LINEAR's observation on October 5.

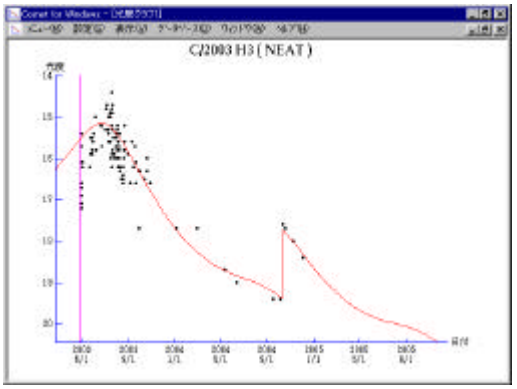
However, it suddenly became observed bright as 17.6 mag by Akimasa Nakamura on

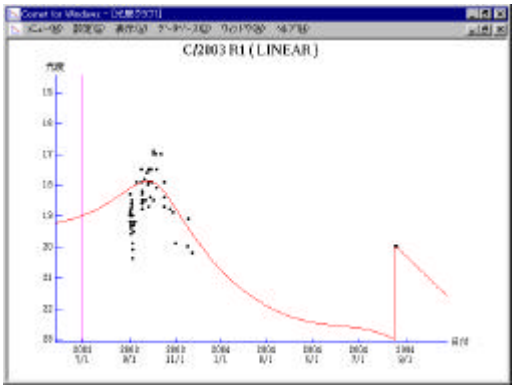
October 12, one week after that.

LINEAR's magnitude often much fainter than actual brightness, so the comet could be bright as 17-18 mag before October 5.

Based on the Nakamura's further observations, it faded along the formula of 10 log r. Therefore it is hard to consider the comet did not fade as expected after its discovery in 2003 and kept bright for a long time.

Anyway, a small outburst could occurred sometime before October 12.





4-2. C/2003 R1 (LINEAR)

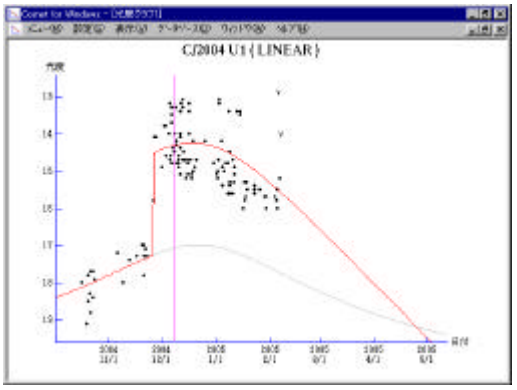
It was observed as 20 mag in September. The ephemeris says it must be fainter than 23 mag at that time, so an outburst must have occurred sometime before that.

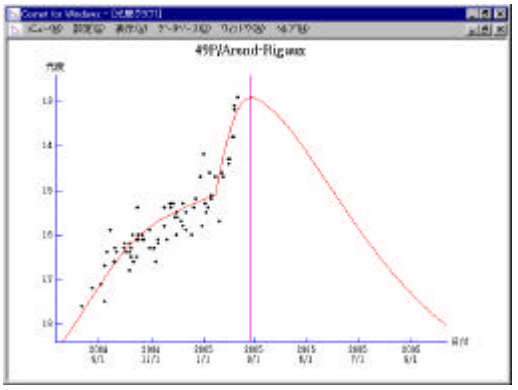
4-3. C/2004 U1 (LINEAR)

Although it kept so faint as 17-18 mag for about one month after its discovery, it suddenly brightened up to 14 mag in late November.

The outburst occurred before the perihelion passage. It kept bright for about one month around the perihelion passage. A comet after outburst often begins fading rapidly soon even before the perihelion passage, but this comet did not.

However, it began fading very rapidly along the formula of 60 log r after the perihelion passage.





4-4. 49P/Arend-Rigaux

It brightened slowly along the formula of 8 log r for a while. It looked almost stellar.

However, it suddenly brightened in 2005 January from 15 mag to 13 mag.

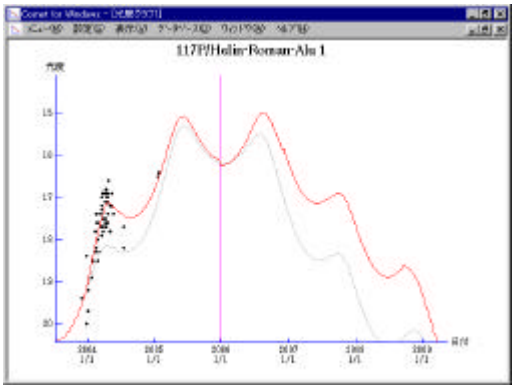
It must be a comet which brightens only near by the perihelion passage, and becomes almost stellar apart from the perihelion passage.

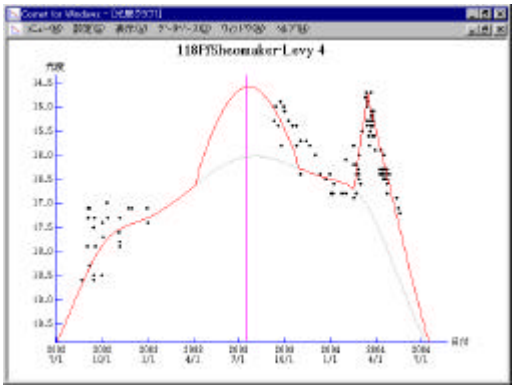
4-5. 117P/Helin-Roman-Alu 1

It brightened rapidly from 19 mag to 17 mag in a short time between late 2003 and 2004 April.

The perihelion distance reduced from 3.7 A.U. to 3.0 A.U. from its last appearance. Maybe that caused the sudden brightening. But it was still very far from the sun, further than 4.0 A.U.

The brightening and fading of this comet around the perihelion passage is very slow. On the other hand, it was observed so faint around the aphelion despite of the low eccentricity. That suggests there are some turning points where the comet suddenly brightens or fades. Maybe that was one of the turning points.





4-6. 118P/Sheomaker-Levy 4

It faded after the perihelion passage as expected, down to 16.5 mag in mid February. But it suddenly brightened after that, and reached to 14.5 mag in mid March. It brightened 2 mag within one month.

After mid March, it faded out very rapidly along the formula of 45 log r.

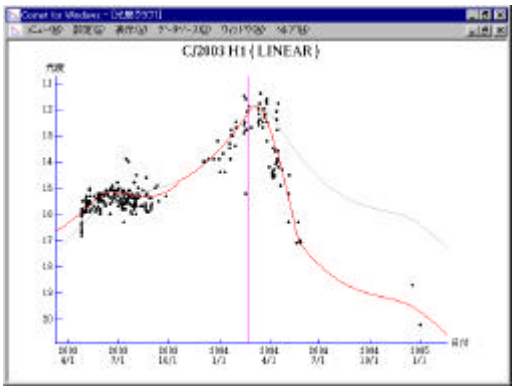
5. Comets which Faded Rapidly

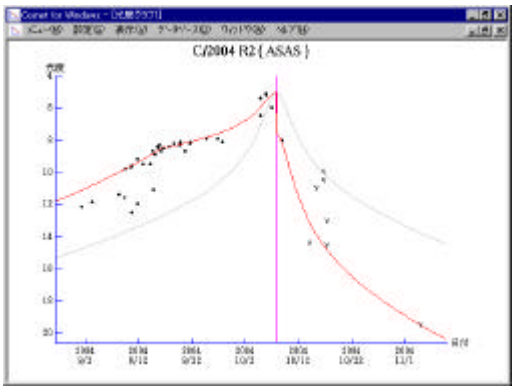
5-1. C/2003 H1 (LINEAR)

It reached to 11.5 mag and became bright visually in March. But it faded out very rapidly after that, and reached to 17 mag in late May. It must be bright as 13.5-14.0 mag still in late May in calculation.

However, it was observed as around 19 mag from 2004 December to 2005 January. This corresponds to the brightness along the formula of 10 log r based on the brightness in late May.

Therefore, this comet did not vanish in May. It just suddenly declined by3 mag.





5-2. C/2004 R2 (ASAS)

Because the absolute magnitude is faint as H10=10.0 mag, and it passes extremely close by the sun, only 0.11 A.U., it was predicted to vanish at the perihelion passage.

It brightened rapidly along the formula of 13.2 log r after its discovery until three weeks before the perihelion passage when it reached to 0.75 A.U. from the sun. Then it turned to brighten slowly along the formula of 5 log r.

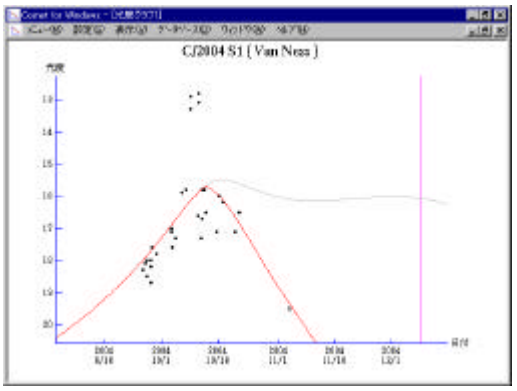
The comet reached to the perihelion without decline, however, it faded out rapidly just after the perihelion passage in the SOHO/LASCO images.

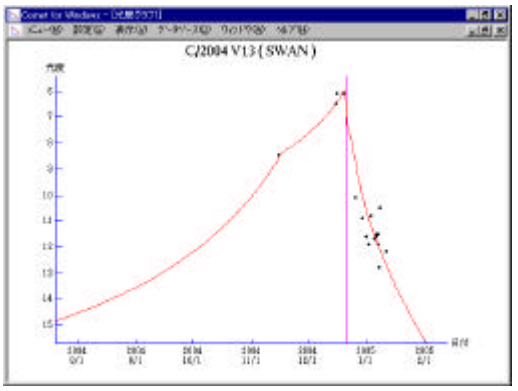
The comet was not observed in October when it appeared in the evening sky, so it must have vanished.

5-3. C/2004 S1 (Van Ness)

Because the absolute magnitude is extremely faint as H10=17.5 mag, and the perihelion distance is small as 0.68 A.U., it was predicted to vanish at the perihelion passage.

It was observed bright at 16.5 mag until October 21, however, it was not detected by Akimasa Nakamura on November 4. So it must have vanished.





5-4. C/2004 V13 (SWAN)

It was discovered from SWAN images at 8.5 mag in November. It was confirmed in the SOHO/LASCO images at 6 mag when passing the perihelion in December.

Because the absolute magnitude is faint as H10=7 mag, and it passes very close by the sun, only 0.18 A.U., it could vanish at the perihelion passage. The brightening from November to

December was very slow along the formula of 2 log r.

It was observed in the evening extremely low sky for two weeks from 2004 December 26 to 2005 January 11 as 10-13 mag. It was fainter than expected by only 1 mag based on the brightness at the perihelion passage and the formula of 10 log r. However, the brightness was fainter than the brightness in November by 7 mag.

However, after observed as 12.2 mag on January 11, nobody could observe it despite of the good condition. It was extremely diffused in early January. Therefore the comet must have vanished.

6. Comets which Brightened After the Perihelion Passage

Some periodic comets tend to become brightest some time after the perihelion passage.

Many of recent new periodic comets showed the trend. But it must be confirmed in its next appearance whether it shows such a trend in every appearance.

Most of such periodic comets brightened and faded rapidly.

6-1. P/2002 T6 (NEAT-LINEAR)

It became brightest 117 days after the perihelion passage, brightened and faded rapidly along the formula of 38.5 log r.

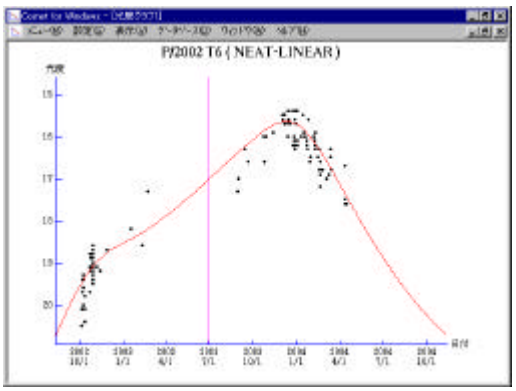
6-2. P/2003 A1 (LINEAR)

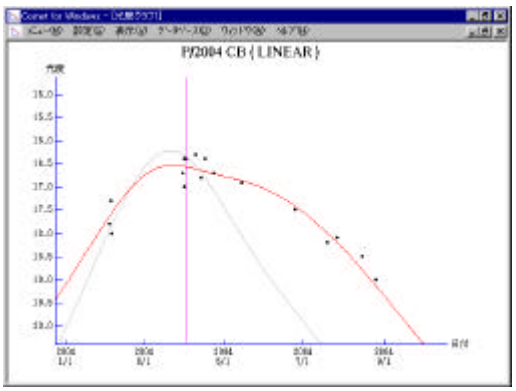
It became brightest about 100 days after the perihelion passage, brightened and faded rapidly along the formula of 30 log r.

6-3. P/2004 A1 (LONEOS)

The trend is hard to see when plotting all observations in M.P.E.C.s. But based on Akimasa Nakamura's observations, it became brightest after the perihelion passage. It was not discovered before 2004, which suggests the comet becomes brightest after the perihelion passage.

It became brightest about 200 days after the perihelion passage, brightened and faded rapidly along the formula of 20 log r.





6-4. P/2004 CB (LINEAR)

It became brightest 55 days after the perihelion passage. It brightened and faded very slowly along the formula of 5 log r.

6-5. P/2004 HC18 (LINEAR)

It became brightest about 65 days after the perihelion passage, brightened and faded rapidly along the formula of 55 log r.

6-6. P/2004 V1 (Skiff)

It became brightest 20 days after the perihelion passage, brightened and faded rapidly along the formula of 30 log r.

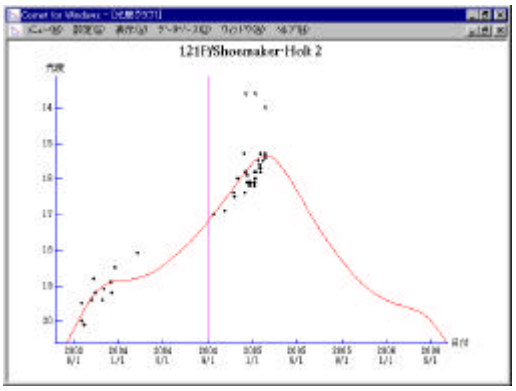
6-7. 120P/Mueller 1

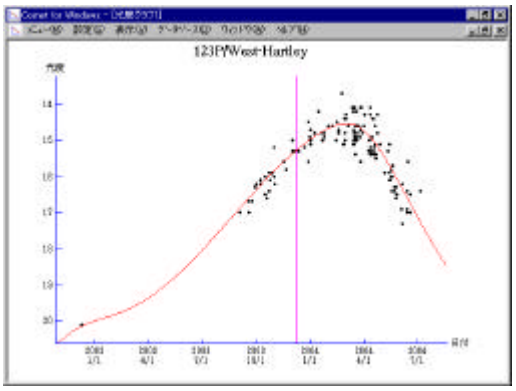
Observations in its last appearance and in this appearance suggest it becomes brightest 45 days after the perihelion passage, brightens and fades rapidly along the formula of 33 log r.

6-8. 121P/Shoemaker-Holt 2

In its last appearance, it became brightest 145 days after the perihelion passage, brightened and faded rapidly along the formula of 35 log r, and reached to 14 mag.

In this appearance, it became brightest 145 days after the perihelion passage, too. However, the brightening and fading was slower, along the formula of 25 log r. Therefore, the maximum brightness became fainter than its last appearance by 1.5 mag.





6-9. 123P/West-Hartley

In its last appearance, it continued brightening even after the perihelion passage. And the brightening was very rapid.

In this appearance, it became brightest 24 days after the perihelion passage, brightened and faded rapidly along the formula of 22 log r.

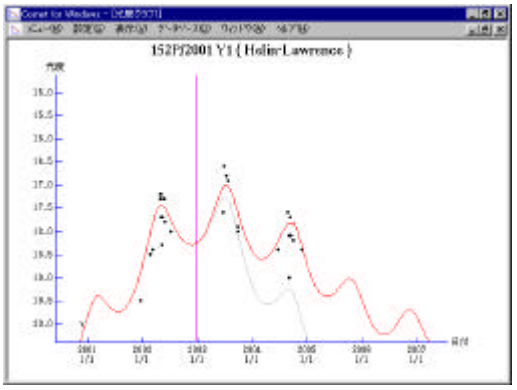
However, the parameters of the magnitude formula do not coincide between its last appearance and this appearance. So the maximum brightness may be different in each appearance.

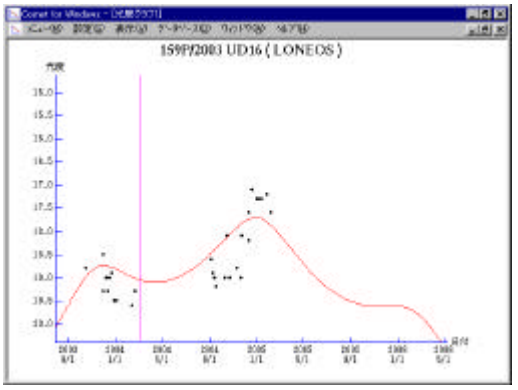
6-10. 152P/2001 Y1 (Helin-Lawrence)

It was not recovered two years before the perihelion passage, so it must have been fainter

than 20 mag. However, it was observed bright as 18 mag in late 2004, two years after the perihelion passage.

It must become brightest about one or two years after the perihelion passage. The brightening is normal along the formula of 10 log r.





6-11. 159P/2003 UD16 (LONEOS)

It has been brightening still in 2005, one year after the perihelion passage.

It must become brightest about one year or more after the perihelion passage. The brightening is rapid along the formula of 20 log r.

7. Comets which Brightened Before the Perihelion Passage

A few periodic comet become brightest before the perihelion passage.

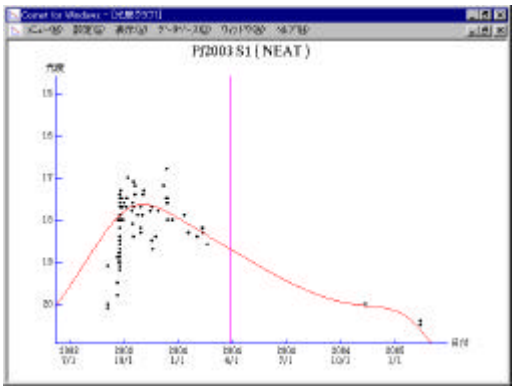
Three among recent new periodic comets showed the trend. But it must be confirmed in its next appearance whether it shows such a trend in every appearance.

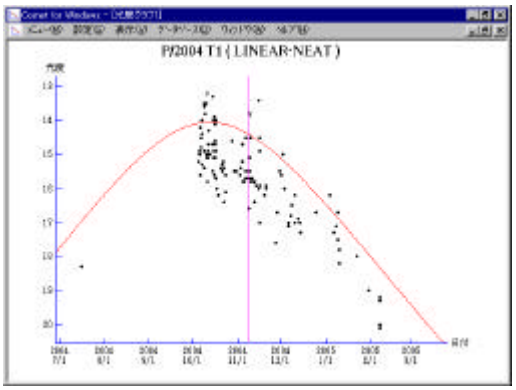
All of such periodic comets brightened and faded rapidly.

These comets could be discovered in outburst when they became bright temporarily, and they could fade out to the usual brightness.

7-1. P/2003 S1 (NEAT)

It became brightest 55 days before the perihelion passage, brightened and faded rapidly along the formula of 20 log r.





7-2. P/2004 T1 (LINEAR-NEAT)

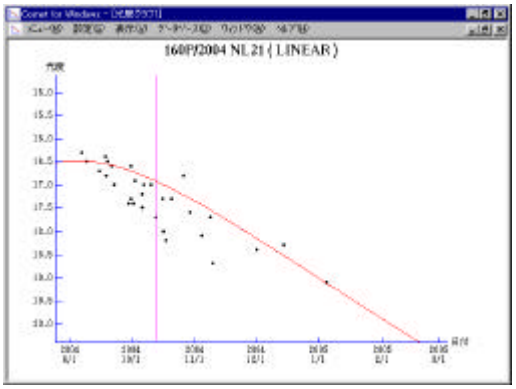
Bright new periodic comet observed visually as bright as 13-14 mag.

Although it was discovered before the perihelion passage, it began fading soon. It was brightest in October when discovered, then it faded rapidly along the formula of 35 log r.

Probably it was discovered in outburst when it became bright temporarily. So in its next return, it will not be as bright as in this appearance.

7-3. 160P/2004 NL21 (LINEAR)

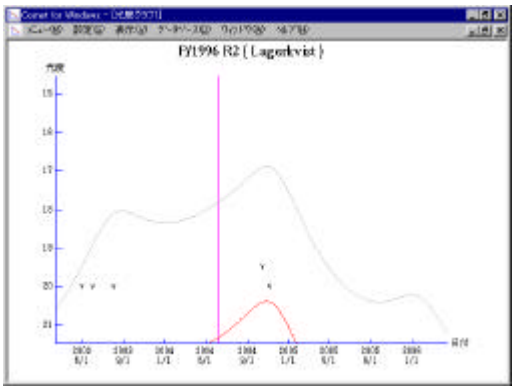
It became brightest 40 days before the perihelion passage, brightened and faded rapidly along the formula of 25 log r.

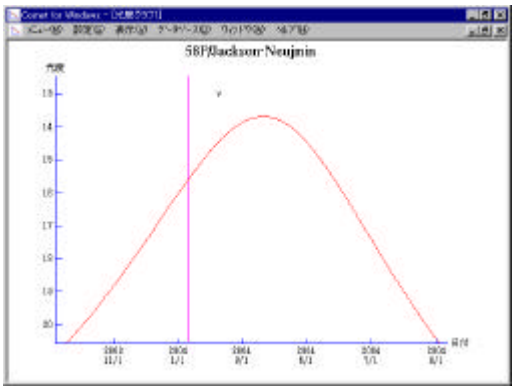


8. Comets Fainter Than Expected

8-1. P/1996 R2 (Lagerkvist)

It must have reach to 17 mag based on the brightness at the discovery. But actually, it was not recovered, fainter than 20 mag.





8-2. 58P/Jackson-Neujmin

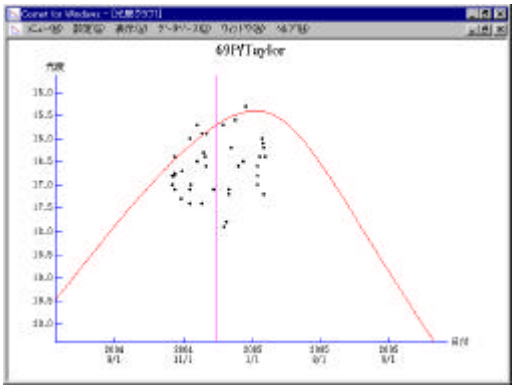
In its last appearance, it brightened after the perihelion passage and reached to 10 mag. The condition in this appearance was very bad, but it was expected to be 13.5 mag in the evening low sky.

However, nobody succeeded to observe it because of the bad condition. It is uncertain whether it became as bright as its last appearance.

8-3. 69P/Taylor

In its last appearance, it bursted out after the perihelion passage and reached to 11 mag.

In this appearance, it did not behave unusually, and reached only to 15.5 mag at best.



9. Far Comets Observable Long Time

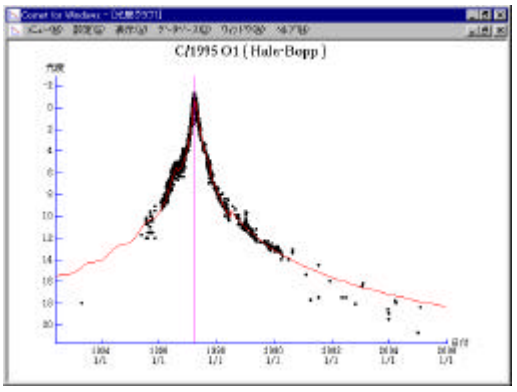
9-1. C/1995 O1 (Hale-Bopp)

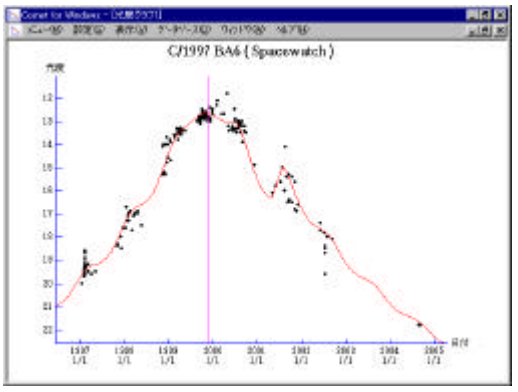
Mitsunori Tsumura observed it in 2005 February, when it was still bright as 18.4 mag. The heliocentric distance was 21 A.U.

The observation coincided with the brightness calculated by the formula of H10=2.0 mag. Tsumura observed its coma of 0.4 arcmin.

The 8.5 arcsec or longer tail was observed at the Magellan Observatory in 2005 January.

These suggest the comet is still active as a comet at the distance.





9-2. C/1997 BA6 (Spacewatch)

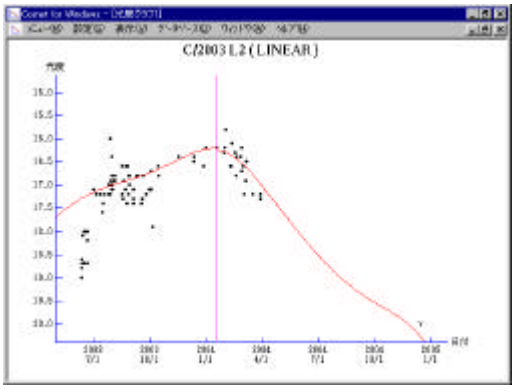
It was observed in September as 21.8 mag. The heliocentric distance was 13 A.U.

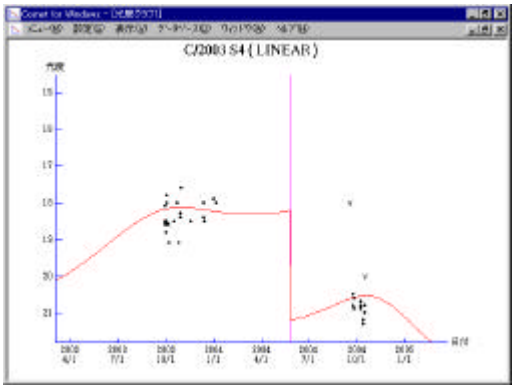
The observation coincided with the brightness calculated by the formula of 15 log r based on the observations in 2001 and 2002.

10. Other Comets

10-1. C/2003 L2 (LINEAR)

The brightening before the perihelion passage was very slow along the formula of 5.5 log r. On the other hand, the fading after the perihelion passage was rapid along the formula of 20 log r. This trend is same as the case of C/2003 T3 (Tabur).





10-2. C/2003 S4 (LINEAR)

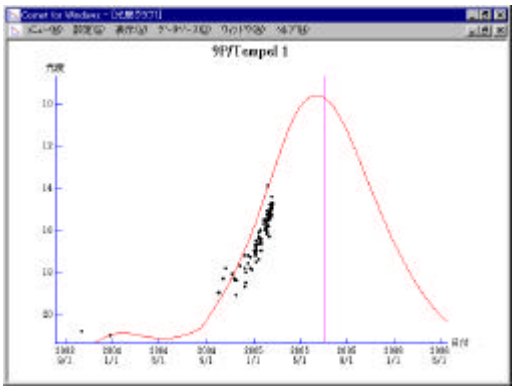
Rafael Ferrando discovered the split of nucleus in September.

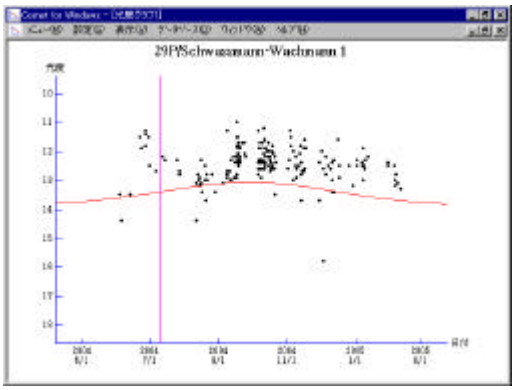
It was about 21 mag at that time, fainter than the brightness at the discovery in 2003 by 3 mag.

10-3. 9P/Tempel 1

It began brightening rapidly about one year before the perihelion passage as expected.

However, the brightening is evidently slower than expected. It must be along the formula of 25 log r, then it will be 10 mag at best. But actually, it is brightening along the formula of 10-15 log r, then it will be only 12.5 mag at best.





10-4. 29P/Schwassmann-Wachmann 1

It had been unusually active in 2004, brightest season in its history.

Several outbursts occurred continuously, and it kept bright as 12 mag almost all through the season. Especially, for a half of a year after September, it had been always in outburst.