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Revealing Variety of Comets by Long-Term Monitoring Observation with a 50-cm Telescope

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Abstract. We have been monitoring comets using the 50-cm telescope at the Mitaka campus of the National Astronomical Observatory, Japan since 1996. Over 20 comets, including bright ones such as comet C/1995 O1(Hale-Bopp), have been observed over long-term periods, namely over large heliocentric distance scales. Our samples show variety of comets in terms of both morphological and temporal variations. Several typical examples of various morphology, probably due to dust, are shown to emphasize the importance of long-term monitoring of comets.

1. Introduction

Comets are the representative solar system objects which often show drastic time variations in both brightness and morphology. As most of the readers of these proceedings recognize, small telescopes are quite appropriate to monitor such time-variable objects, mainly because we can get access to plenty of time without heavy discussion with the time allocation committee. Moreover, recent developments of high efficient detectors such as the CCD made it possible to see fainter objects than before. Since 1995, we have started a long-term monitoring program of comets, simultaneously targeting as many comets as possible, which indicate the existence of a variety of cometary activities at a wide range of heliocentric distances. Some typical examples are introduced in this paper.

2. Observations

Our image monitoring has been carried out using the 50-cm telescope at the Mitaka campus of the National Astronomical Observatory of Japan, located near Tokyo, Japan (35.66°N, 139.55°E, H=59m). A liquid-nitrogen cooled CCD camera (Astromed Type 3200) is attached to the cassegrain focus(f/12) of the telescope, giving a field of view of 14.8×9.9 arcmin^2. We use another portable telescope in order to complement the observations in case of severe observational conditions. The installed CCD is EEV type P88231, which has 770×1152 pixels. The pixel size is 22.5×22.5 μm. In order to reduce the background sky level from the severe light pollution, and to study dust activity of the coma, R-band or I-band filters are usually applied. The telescope is tracked by following the apparent motion of the comet. Table 1 lists the comets observed to the end

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of 2000. Most of the observed images have been released on our web page at http://www.nao.ac.jp/pio/Comets/.

Table 1. Comets monitored up to the end of 2000

C/1995O1(Hale-Bopp)	C/1996B2(Hyakutake)	C/1998M5 (LINEAR)
21P/Giacobini-Zinner	C/1998K5 (LINEAR)	52P/Harrington-Abell
C/1998T1 (LINEAR)	C/1999S4 (LINEAR)	C/1999L3 (LINEAR)
C/1999E1 (Li)	P/2000B3 (LINEAR)	C/1999J2 (Skiff)
C/1999H3 (LINEAR)	C/1999T2 (LINEAR)	29P/Schwassmann-Wachmann 1
C/1999Y1 (LINEAR)	P/2000S1 (Skiff)	C/2000W1(Utsunomiya-Jones)

3. Comet C/1995 O1(Hale-Bopp) – Activity at Large Heliocentric Distances

The first example is comet C/1995 O1(Hale-Bopp), which was one of the intrinsically brightest comets in the last millennium. The apparent magnitude of this comet reached -1 when the geocentric distance was about 1 A.U. The orbit of this comet was close to the Earth's orbit, so there was a chance of a close encounter. If this comet had come four months earlier, its apparent magnitude would have been about -6. It is interesting to monitor such a bright comet at large heliocentric distances. The results of our image monitoring before the perihelion passage are shown in Figure 1; one can see the gradual and steady evolution of the cometary activity with its approach. Many straight jet-like structures are interpreted as the edges of cones produced by dust jets from the rapidly rotating nucleus.

After the perihelion passage, we detected several eruptive ejections of huge dust clouds from the nucleus as shown in Figure 2 (Yamamoto & Watanabe, 1997).

4. Comet C/1996 Q1(Tabur) and C/1999S4(LINEAR) – Complete Disruption of Nuclei?

The next example is comet C/1996 Q1(Tabur). This comet appeared to be normal until the end of October 1996, when the central part of the coma started to elongate, and began to fade-out. In November we could see only a faint, diffuse cloud of dust tail as shown in Figure 3.

We do not know what happened in this comet. Fulle et al (1998) analyzed this fade-out and suggested a sudden cessation of evaporation from the nucleus, but nobody knows the truth. Four years later, another comet C/1999 S4(LINEAR) played an important role in solving the nature of such behaviour. This comet also seemed to be normal until mid-July 2000, then showed quite a similar morphological variation together with a brightness change at the end of July. One thing that differed from comet C/1996Q1(Tabur) was that Comet C/1999S4(LINEAR) was bright enough, that many large telescopes, including HST and VLT, could observe it, and witnessed the complete disruption of the nucleus. This lends strong support to a complete disruption of the nucleus of

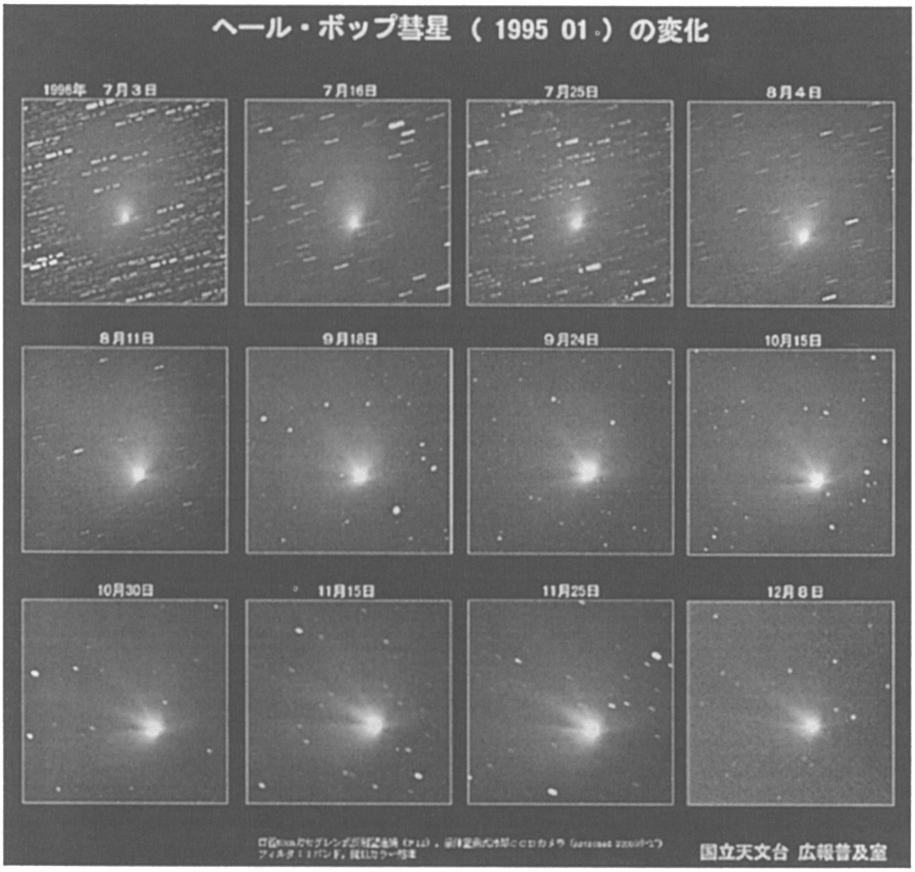

Figure 1. The I-band images of Comet C/1995 O1(Hale-Bopp) from July 3 through December 8, 1996.

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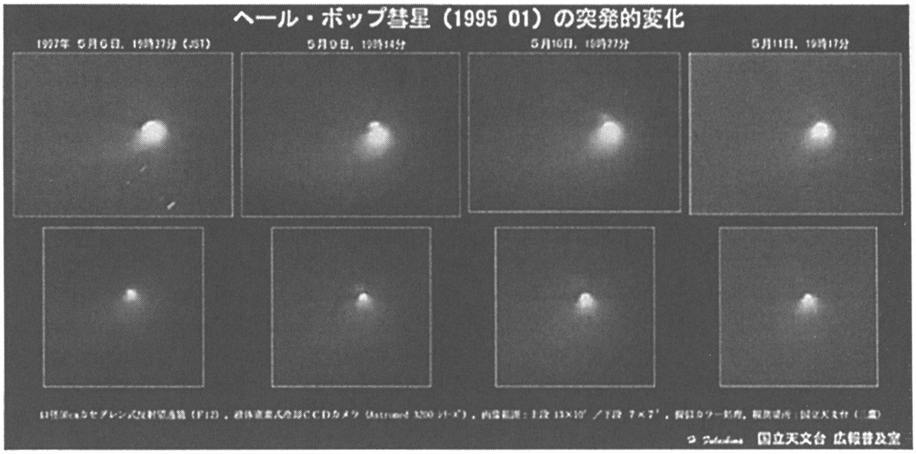

Figure 2. Time variation of the huge dust cloud of Comet C/1995(Hale-Bopp) on May 9-11 1997. An eruptive ejection of the dust cloud can be recognized as a knot just above the central condensation in the image of May 9 (second panel from the left). The field of view of is 13'x10' for the top panels and 7'x7' for the bottom panels.

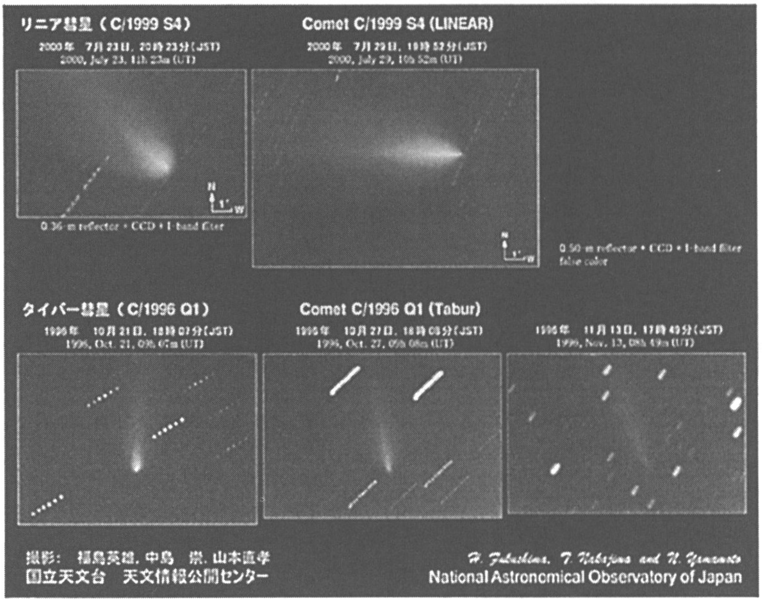

Figure 3. Morphological variation of Comet C/1996 Q1(Tabur) and C/1999S4(LINEAR)

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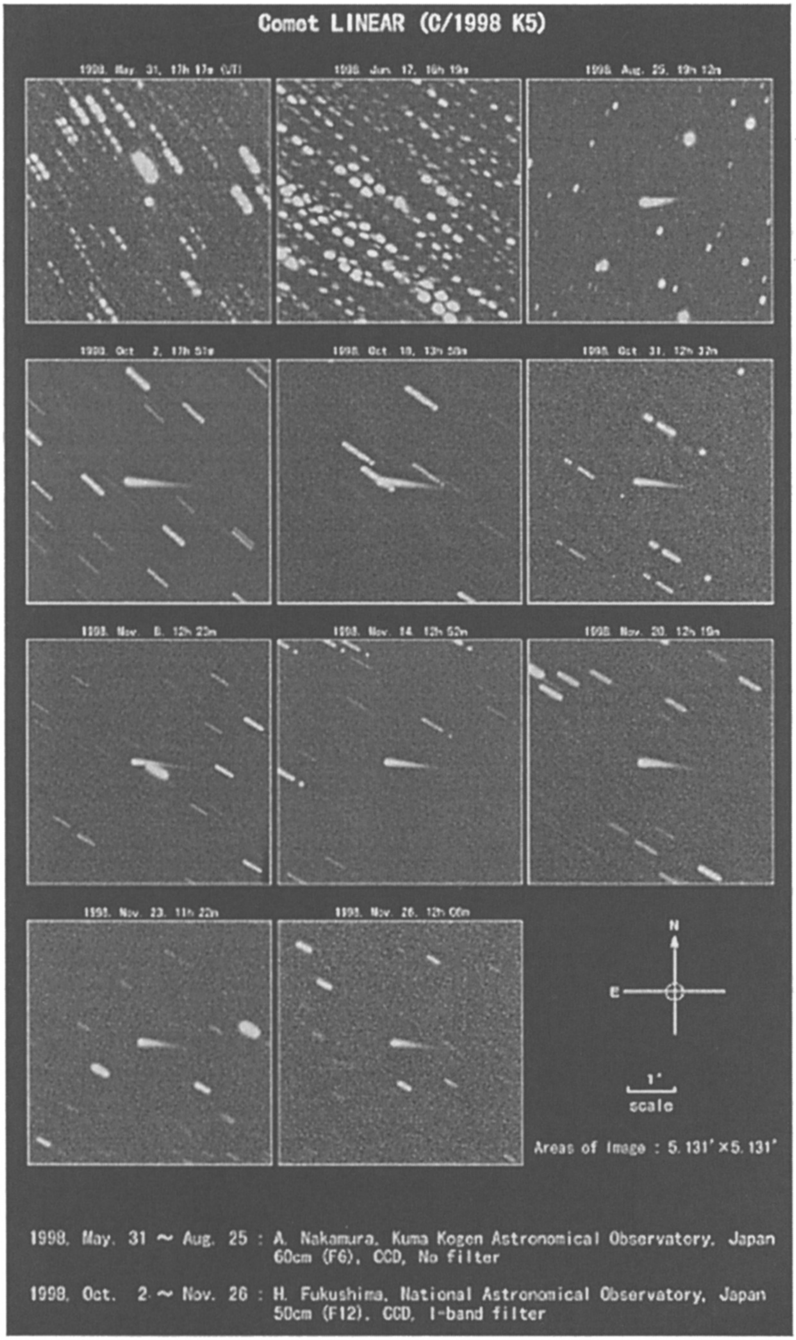

Figure 4. Morphological variation of Comet C/1998 K5(LINEAR) from May 31 through November 26 1998.

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comet C/1996Q1(Tabur) on the basis of the similarity in the time variations of both comets.

5. Comet C/1998 K5(LINEAR) – a Strange Tail?

The last example of an unusual feature revealed by our monitoring observations is comet C/1998 K5(LINEAR). Figure 4 shows the time variation of this comet; the spindle-like structure should be noted. Usually the dust tail of a comet of this brightness class should be faint and diffuse. The width of the dust tail should also be roughly proportional to the distance from the nucleus. However, the wedge-shaped tail of this comet was narrower with the distance. In order to determine the origin of this structure, information on time variation is important. Our long-term monitoring has indicated that this tail began to extend from July 1998, and interestingly, had been quite stable until the end of November. Although there is no space to describe in detail the possible origin here, from such time variation we can promptly eliminate the several possibilities including ion tail. The only solution to explain this structure is the dust tail formed by very limited large-size particles ejected at a certain epoch. We do not know why this happened. Could it be dust mantle peeling off the nucleus? Impacts of meteoroids? No clear explanation can be offered yet.

6. Conclusion

It is clear that long-term monitoring for many comets, which can be realized only by small telescopes, is important to delineate the nature of comets.

References

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