Observations of Comet C/LINEAR (2004B1) between 2 and 3 AU heliocentric distance*

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Abstract. We present R-band observations of comet C2004B1 obtained in the period June, 21 - August 20, 2006. The data have been reduced to surface brightness maps, light curves, and mean radial profiles of the coma. In two cases a decrease of the brightness was recorded, which lasted for several days. The brightness decrease was accompanied by morphological changes in the coma.

Key words: comet 2004B1 coma brightness

Наблюдения на кометата C/LINEAR (2004B1) между 2 и 3 а.е. хелиоцентрично разстояние

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Представени са наблюдения на кометата C2004B1, получени в R филтър, в периода 21 юни - 20 август 2006 г. Данните са обработени до карти на повърхностната яркост, криви на блясъка и средни радиални профили на комата. В два случая е регистирано намаляване на интегралния блясък на кометата, продължило няколко дни. Намаляването на блясъка бе придружено от промени в морфологията на комата.

1 Introduction

On January 29.16 the Lincoln Laboratory Near-Earth Asteroid Research project (LINEAR) discovered a faint distant comet. The new comet was named C/LINEAR (2004B1). For shortness, we will refer to it as C2004B1. The orbit of the comet is slightly hyperbolic (eccentricity = 1.001), and its perihelion was on 2006, Feb 7.9.

2 Observations

We observed the comet on its outbound orbit, between 2.4 and 2.9 AU heliocentric distance. Our observing campaign started on June 21, 2006, and lasted until August, 20. The observations were carried out with the Schmidt telescope of the National Astronomical Observatory. The images were obtained in the R-band with a CCD camera ST-8. Parameters of the camera can be found in Kostov et al. [2007]. Details for the observations are given in table 1. Visit http://www.astro.bas.bg/solsys/C2004B1/ to see all the images.

* Based on observations obtained in the Rozhen National Astronomical Observatory

Table 1. Data for the observations

Month of 2006	Day	Days after perihelion	heliocentric distance	geocentric distance	Phase angle
June	21	133	2.363	1.650	21.1
	22	134	2.372	1.668	21.2
	29	141	2.436	1.803	21.9
July	7	149	2.509	1.974	22.4
	8	150	2.519	1.996	22.4
	9	151	2.528	2.018	22.5
	13	155	2.565	2.109	22.5
	14	156	2.574	2.132	22.5
	16	158	2.593	2.178	22.5
	27	169	2.697	2.438	22.1
	29	171	2.715	2.486	21.9
August	2	175	2.753	2.581	21.6
	3	176	2.763	2.604	21.5
	4	177	2.772	2.628	21.4
	5	178	2.782	2.652	21.3
	9	182	2.820	2.746	20.9
	11	184	2.839	2.793	20.7
	12	185	2.849	2.816	20.6
	13	186	2.858	2.840	20.5
	14	187	2.868	2.863	20.4
	15	188	2.877	2.886	20.2
	16	189	2.887	2.909	20.1
	17	190	2.896	2.932	20.0
	18	191	2.906	2.955	19.9
	19	192	2.915	2.978	19.7
	20	193	2.925	3.001	19.6

3 Surface brightness distribution

The images were converted to surface brightness by using standard stars in the field. We used the R-magnitudes of these stars given in the USNO (United States Naval Observatory)[4] catalogue for photometric calibration. Examples of surface brightness maps are shown in figure 1. The 6 images shown are not a randomly selected sample. Their purpose is to illustrate how the coma morphology changes with variations of the total comet magnitude. The maps in the middle panels are derived from the images obtained at the two instants of reduced brightness, described in the next section.

4 Light curves

Figure 2 shows the light curves of comet C2004B1. They are compared to ephemeris calculated at two different epochs by HORIZONS (http://ssd.jpl.nasa.gov/horizons.cgi). The first one (dotted line) is from Nov 8, 2006 and is based on 1521 observations from the period 2004 - 2006. This ephemeris gives also the brightness of the comet nucleus, shown with dashed-dotted line in figure 2. The second ephemeris data (dashed-double dot line) in the same figure, are from April 1, 2007, and are based on 1576 observations from the period 2004 - 2007. Five months after perihelion the brightness of comet C2004B1 was substantially reduced in comparison to the first ephemeris, but about one magnitude above the values from the second one. In most cases the total brightness of the comet was comparable with the predicted brightness of the bare nucleus given by the first ephemeris. In two cases, on July 7,8,9 and around Aug 9, the brightness of the comet dropped more than 1 magnitude below the mean level.

[4] http://www.usno.navy.mil/

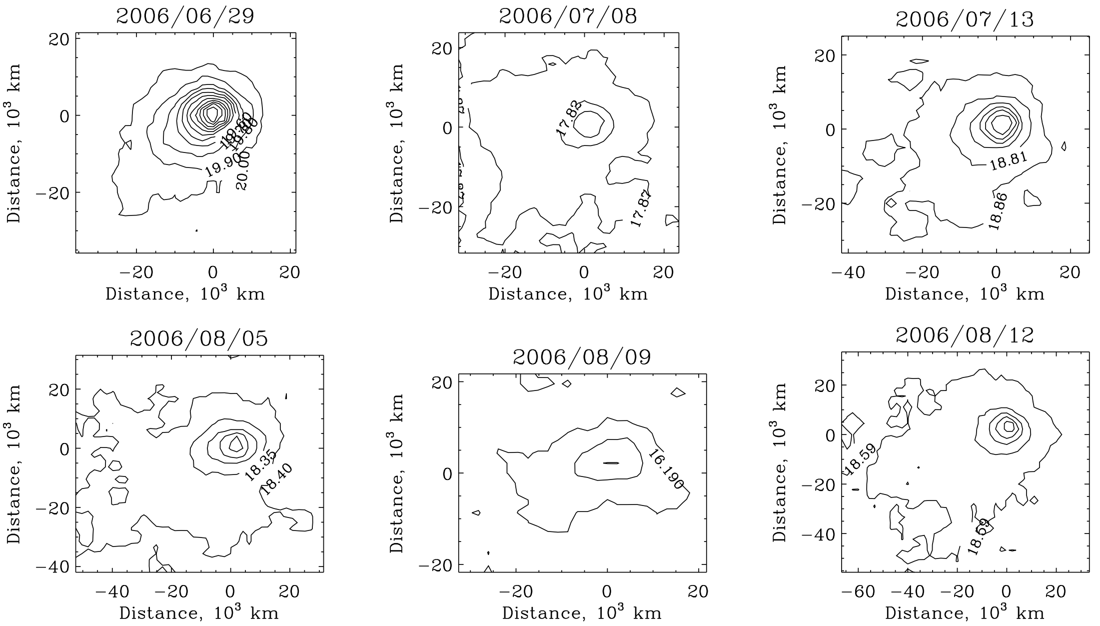

Fig. 1. Surface brightness of comet C2004B1 on 6 selected days. The isophote levels are in magnitudes/(arcsec)^2. Note, in both rows the morphology of the coma in the middle panel is different compared to the left and right images (see the text for more information).

5 Discussion

Figure 2 (right panel) shows that the activity of the comet is almost independent on its heliocentric distance. In their taxonomic study of 85 comets A'Hearn et al. [1995] found cases in which the dust production is even increasing with heliocentric distance. According to these authors flat slopes are characteristic for dynamically new comets before their perihelion passage. We remind that comet C2004B1 was observed several months after its perihelion.

The decreased total brightness of the comet at two occasions (see figure 2) is accompanied by morphological changes in the coma. Most remarkable is the faster decrease of the surface brightness in the outer coma, at distances $> 10''$. This is well seen in figure 3, where in the left panel the azimuthally averaged profiles of the images with reduced brightness are compared to those obtained several days before the brightness decrease and several days after that. The dotted line shows a ρ^{-1}- profile, the ideal case of an isotropic and stationary outflow. The full line is a fit to the data with a $\rho^{-1.35}$ - law. In the right panel of the same figure the corresponding $Af\rho$ profiles are shown ($Af\rho$ was introduced by A'Hearn et al. [1984] as a proxy for the dust production rate). Comparison of the profile from July 8 (a drop of brightness) with the profile from July 13 (almost a return to the total magnitude before the drop) shows comparable levels of the mean surface brightness at distances $< 10''$. This is an indication that most of the brightness reduction is due to losses in the outer coma, rather than to reduced activity of the nucleus. In the August event the reduction is again stronger in the outer coma but now it is accompanied by a decrease in the circumnuclear region. In this case both, reduction of the dust production from the nucleus and losses in the coma should be responsible for the total brightness decrease. The reduced brightness of the outer coma could be explained by sublimation of dust particles. Recently, Beer et al. [2006] have shown how sublimation of dirty icy grains can influence the particle size distribution in the coma and lead to a dominant role of large particles.

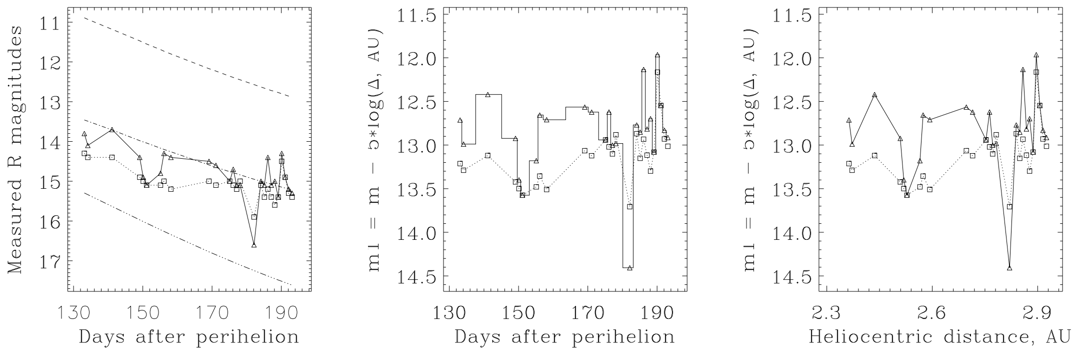

Fig. 2. Left: R magnitudes against time. Triangles and full line: total brightness. Squares and dotted line: Brightness in a circular aperture of radius 10″. Dashed line: Total brightness from old ephemeris (Nov 8, 2006). Dash-dot line: Brightness of the nucleus from this ephemeris. Dash-double dot line: Total brightness in new ephemeris (April 1, 2007). Middle: R magnitudes, corrected for geocentric distance, against time. Right: R magnitudes, corrected for geocentric distance, against heliocentric distance.

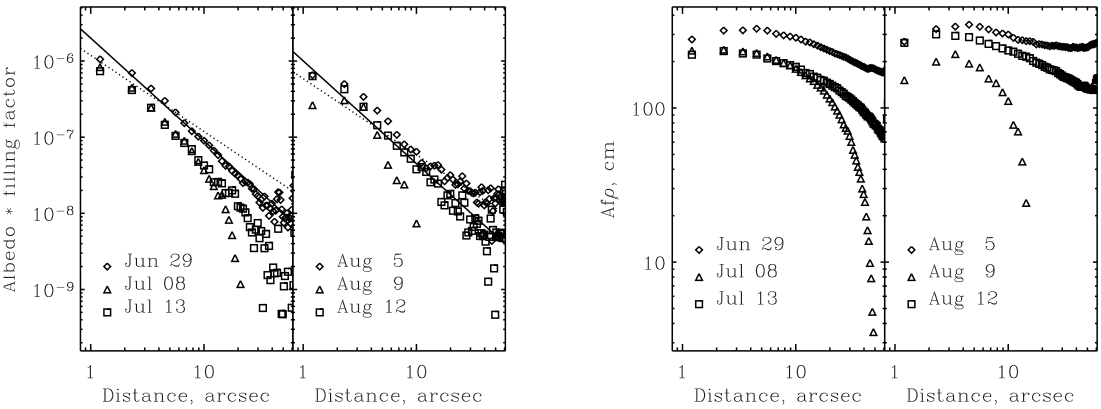

Fig. 3. Left: The two panels show azimuthally averaged profiles of the images obtained around periods of reduced brightness. Triangles denote the data at the minima, diamonds and squares stand for the days of normal activity before and after the minima. Right: The corresponding $Af\rho$ profiles.

Do large dust grains dominate the coma of comet C2004B1 on its outbound orbit between 2.4 AU and 2.9 AU perihelion distance? What are the reasons for the sudden drop of brightness? Answers to these questions could be given by comparison of our data with infrared observations

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[5] http://archive.eso.org/skycat/servers/usnoa