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Analysis of photometric, spectroscopic, and polarimetric observations of five distant comets

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Abstract

Photometric, polarimetric, and spectroscopic observations of five nearly parabolic comets at heliocentric distances greater than 4 AU were performed. No molecular emission was observed for any studied comet and the entire cometary activity in all cases was attributed to dust production. Upper limits of the gas production rates for the main neutral molecules in the cometary comae were calculated. The derived values of dust apparent magnitudes were used to estimate the upper limit of the geometric cross-section of cometary nuclei. The maps of intensity and linear polarization over the coma are derived. The linear polarization of distant comets with a high level of activity is the first ever measured at the heliocentric distances larger than 4 AU.

Introduction

Physical nature of comets is known mainly from the observations of bright comets close to the Earth and the Sun (typically 1−2 AU). A few of the Jupiter, Neptune family comets and Kuiper-Belt objects have been investigated with space experiments, while observations at large heliocentric distances (more than 4 AU) are still scarce and episodic, thereby not covering very important stage of the development of cometary activity.

The reasons for the activity of distant comets can not be interpreted by the available theory of the origin of the comets, there is no generally recognized explanation for this phenomenon. Sublimation of more volatiles than water ice, for example, CO, CO_2, N_2, can serve as a probable explanation of the problem. Condensation of these gases on dust grains, or by their capture by condensed molecules of water, is possible only at temperature of an environment which does not exceed 25-30 K. Such temperature conditions could be realized or in an interstellar cloud from which the Solar system was originated, or at early stage of the Solar System formation.

1. Observations

We have started a comprehensive program of polarimetric, photometric, and spectral investigations of active distant comets (or without noticeable activity) with the focal reducer SCORPIO-2 [1] attached at prime focus of 6-m telescope BTA (Special Astrophysical Observatory, Russia). We performed broad-band photometry, polarimetric imaging and long-slit spectroscopy of C/2011 S1 (LINEAR), C/2011 R1 (LINEAR), C/2014 A4 (SONEAR), C/2013 V4 (Catalina), and C/2011 KP36 (Spacewatch) in the visible wavelength range at phase angle from 4.9° to 14°, when the comets were at the heliocentric distances from 3.2 to 6 au.

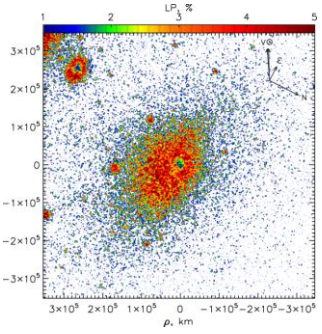

Figure 1: Polarization map of comet C/2011 KP36 (Spacewatch) on November 25, 20165. The arrows show the directions to the Sun, North, East, and motion of the comet. The heliocentric distance off the comet r=5.06 au and phase angle α=9.5°

Our observations of comets at large heliocentric distances revealed the occurrence of a well-observable dust cloud near the cometary nuclei, but we did not detect any gas. The results of photometry

investigation of five distant comets presented here show activity properties that are typical for new comets. The Afρ value obtained and the dust production for our objects are of the same order as those measured for most of dynamically new and long period comets.

Summary and Conclusions

Distant comets show considerable levels of activity not only within a zone of water sublimation (up to 3 AU) but also at heliocentric distances far exceeding this limit. Molecular emissions are not detected in the observed cometary spectra. The cometary comae display the degree of linear polarization within the range of about (−2 ÷ −2.5)% and (−2.5 ÷ −3.5)%, respectively. These values are higher (in absolute value) than that (about −1.5%) typical of close to the Sun comets.

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