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# Dust environment of distant comet C/2014 A4 (SONEAR)

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## Abstract

The results of imaging photometric, polarimetric, and long-slit spectroscopic observations of comet C/2014 A4 (SONEAR) in 2015 are presented. Possible explanation of the unusual polarimetric properties of the dust in this comet is provided.

## 1. Introduction

Cometary dust preserves the materials left from the early stages of the solar system formation. For those comets that reach close distances to the Sun, the dust does not represent the pristine materials due to sublimation of its volatiles and other changes caused by the solar radiation. However, there are some comets whose orbits keep them far away from the Sun. Some of them exhibit considerable activity at heliocentric distances much larger than 4 au and, thus, allow us to study the dust not notably modified by solar radiation. Since 2011, we are conducting a comprehensive program of polarimetric, photometric, and spectral investigations of active distant comets with the 6-m telescope BTA (SAO RAS).

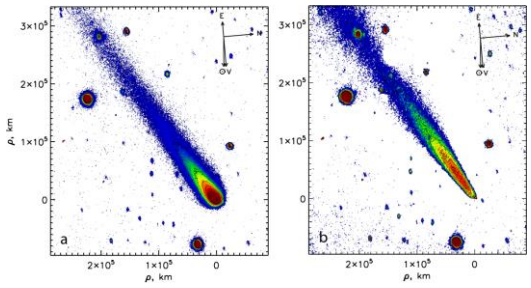


Figure 1: Intensity images of comet A4. The left panel (a) shows the direct images of the comet; the right panel (b) represents processed intensity images emphasizing structure of the coma.

In this work we study one of the distant comet C/2014 A4 (SONEAR), with perihelion distance $q$= 4.18 AU.

## 2. Observations

The observations of C/2014 A4 (SONEAR) (hereafter A4) were made with the 6-m telescope BTA SAO RAS on November 5, 2015, when heliocentric (r) and geocentric (Δ) distances of the comet were 4.21 and 3.28 au, and phase angle (α) was 3.8 degree, in both cases. Imaging polarimetric, photometric, and long-slit spectroscopic observations of comet A4 were performed. The observations were taken with a multimode focal reducer SCORPIO-2 of the SAO RAS. A 1024×1024 CCD with a full field of view of 6.1'×6.1' and a pixel scale of 0.18 arcsec/px was used as a detector. Observations were acquired using the broad-band filters.

## 3. Results

The analysis of spectra and the spatial distribution of intensity, color, and linear polarization over the coma revealed the following features.

### 3.1 Spectroscopy

No emission lines could be detected. Haser model [1] was used to derive the upper limits to the production rates. We determined upper limits to the emission fluxes of the main neutrals of comets and ion $CO^+$ and upper limits to the production rates of the molecules CN, $C_3$, $C_2$. We also used a polynomial fit to derive the reddening of the spectrum. The polynomial shows linear dependence on wavelengths 21.6 ± 0.2%/1000 Å within the 4650 ÷ 6200 Å wavelength region.

### 3.2 Image and polarization

The comet showed significant activity with some features in cometary coma and long dust tail at large heliocentric distances. To reveal the low-contrast structures in the cometary coma, we applied the available image enhancement techniques: division by azimuthal average, azimuthal renormalization [2], and rotational gradient method [3]. After processing the image, we revealed bright outflows in the cometary coma. Obtained structures correspond to the dust released from the nucleus, which then moved within the coma as the comet proceeded along its orbit. The dust production was estimated as $Af\rho$=361±1 cm in the r-sdss filter. The polarization images of the comet were taken in the r-sdss (λ6200/600 Å) filter. Polarization map, obtained at the heliocentric distance r = 4.2 au, shows spatial variations of polarization over the coma from about –2% near the nucleus to –5%.. Thus, the negative polarization is significantly greater than the typical polarization (~ 1.5%) observed for the dust of the comets close to the Sun. Based on the computer modeling of the dust as a polydisperse ensemble of multishaped rough spheroids [6], were provided the explanation of the unusual polarimetric properties of the dust in this comet.

## 4. Summary and Conclusions

The main aim of our observations of distant comets is to study properties of their dust. Most probably dust in distant comets is different than dust in short-period comets, the study of polarization of distant comets is very important for investigation of their physical properties. Photometric and polarimetric observations of distant active comets with specific features (such as long tails, jet structures, and asymmetric comae) are of particular interest. Our photometric and polarimetric observations of dynamically new comet C/ 2014 A4 (SONEAR) showed a considerable level of activity (extended dust coma and tail) at heliocentric distances of 4 au. Since molecular emissions were not detected in the spectra of this comet, it allowed us to study reflective dust properties without gas emission effect. It is known that the shape of the cometary coma as well as the distribution of the coma brightness tells us about the cometary activity, but detailed mechanisms of the activity of comets at large heliocentric distances are not well understood. Polarization map of comet A4 show spatial variations of the polarization. The obtained values of the degree of polarization are significantly higher in absolute values (of polarization over the coma from about –2% near the nucleus to –5%) than the typical value of polarization (~1.5%) observed for the whole coma of most comets closet to the Sun. Our modelling shows that the specifics of the dust in the distant comet A4 is presence of significant amount of ice and organics which likely sublimate at the smaller heliocentric distances.

## Acknowledgements

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## References

[1] Haser, L.: Distribution d'intensite dans la tete d'une cometes, Bull. Soc. R. Sci. Liege, Vol. 43, pp. 740–750, 1957.

[2] Samarasinha, N.H., Larson, S.M.: Image enhancement techniques for quantitative investigations of morphological features in cometary comae: a comparative study, Icarus Vol. 239, pp. 168–185, 2014.

[3] Larson, S., Sekanina, Z.: Coma morphology and dust-emission pattern of periodic comet Halley. I - High-resolution images taken at mount Wilson in 1910, Astron. J. Vol.89, pp. 571–578, 1984.

[4] Tozzi, G. P., Cimatti, A., di Serego Alighieri, S., Cellino, A.: Imaging polarimetry of comet C/1996 B2 (Hyakutake) at the perigee, Planet. Space Sci., Vol. 45, pp. 535–540, 1997.

[5] Farnham, T.: Radial surface brightness profiles as diagnostic tools in cometary dust comae, Bull. Am. Astron. Soc., Vol. 40, pp. 412, 2008.

[6] Kolokolova, L., Das, H.S., Dubovik, O., Lapyonok, T. and Yang, P., 2015. Polarization of cosmic dust simulated with the rough spheroid model. Planetary and Space Science, 116, pp.30-38.