Scattering properties of dust in C/2011 KP36 (Spacewatch)

Olexnadra Ivanova\textsuperscript{1,2,3}, Ludmilla Kolokolova\textsuperscript{4}, Igor Luk’yanyk\textsuperscript{3}, Valery Kreshenok\textsuperscript{2}, Vera Rosenbush\textsuperscript{2,3}, Nikolai Kiselev\textsuperscript{2,5}, Viktor Afanasiev\textsuperscript{6}, and Zachary Kirk\textsuperscript{4}

\textsuperscript{1}Astronomical Institute of the Slovak Academy of Sciences, Slovakia
\textsuperscript{2}Main Astronomical Observatory of the National Academy of Sciences of Ukraine, Kyiv, Ukraine
\textsuperscript{3}Astronomical Observatory of Taras Shevchenko National University, Kyiv, Ukraine
\textsuperscript{4}University of Maryland, College Park, MD, USA
\textsuperscript{5}Crimean Astrophysical Observatory, Nauchnij, Crimea
\textsuperscript{6}Special Astrophysical Observatory of the Russian Academy of Sciences, Russia

Long-periodic comet C/2011 KP36 (Spacewatch), defined by Bauer et al. 2013 (Aph. J. 773:22) as a Scattered Disc Object, has a period of around 238 years and perihelion distance \( q = 4.88 \) au. Its semi-major axis \((a=38.41 \) au\) is larger than aphelion distance of Neptune \((a_{N}=30.07\) au\). Comprehensive observations of the comet were carried out at the 6-m BTA telescope of the Special Astrophysical Observatory (Russia) with the multimode focal reducer SCORPIO-2.

Long-slit spectra in the visible and photometric and linear polarimetric images with the g-sdss and r-sdss filters were obtained on November 25, 2016, after perihelion passage, when heliocentric and geocentric distances of the comet were 5.06 au and 4.47 au, respectively. The observations were done at the phase angle 9.57 deg. Two strong jet-like structures in solar and antisolar directions and two short and narrow jet features in a direction almost perpendicular to the Sun–comet direction were revealed in the coma. The cometary activity was characterized by \( A \rho \) values of \( 10^{65} \pm 11 \text{ cm} \) in the g-sdss filter and \( 1264 \pm 17 \text{ cm} \) in the r-sdss filter.

The spectrum of comet C/2011 KP36(Spacewatch) we observed shows emissions from the ion \( \text{CO}^+ \). It is second comet, for which we detected emissions at large heliocentric distances more 4 au.

In the near-nucleus coma, the polarization is about 5\% (in absolute value), then it decreases, reaching the minimal values about 2\% in the region of 10000–20000 km. The polarization increases up to 3.7–5\% at the distance of 25000–45000 km, and then the degree of polarization changes with wave-like variations up to 1–4\%, depending on the cut direction, with increasing distance up to \(~10^5\) km. See Figure 1 for details.

On average, the \((g-r)\) color index of the dust varies with increasing distance from the nucleus. In the near-nucleus region, the color index is about 0.7\text{ m}. At distances from about 10000 to 20000 km from the photocenter, dust color is bluer \((~0.33\text{ m})\) in comparison with the Sun color \((\text{color indices (g–r) for the Sun is 0.44 m})\).

To characterize the dust in this comet, we modeled both polarization and color in the directions of all jets as well as for the regular coma. We considered a variety of materials typical for cometary dust and Centaurs (including porous particles) and their mixtures and modeled the dust as ensembles of
rough spheroids of a variety of obliquity and size. Our modeling allowed us to reproduce not only specific values of color and polarization but also their change with the distance from the nucleus using realistic ideas about possible changes in particle size and composition as they move through the coma and also to compare the dust in different cometary features.

**Figure 1** A spatial distribution of polarization degree in comet C/2011KP36 (Spacewatch) in the r-sdss filter obtained at the phase angle 9.6 deg. The left image shows the polarization map for the whole coma with its associated scale bar in percentage on the top of the image, while the image on the right displays the coma area around the nucleus in an enlarged scale. The location of the optocenter is marked with a black cross, and jets with black lines. The arrows point in the direction to the Sun, North (N), East (E), and negative velocity vector of the comet as seen in the observer’s plane of sky (V). Negative distance is in the solar direction.