Optical and Near-Infrared Polarimetry for a Highly Dormant Comet 209P/LINEAR

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The linear polarization of light scattered by airless solar system objects (i.e. comets and asteroids) is a useful tool for investigating the physical properties of their surfaces. The phase-polarization curves display a common behaviour, having a negative polarization branch at $0 < \alpha \leq 20°$, positive branch at $\alpha \geq 20°$ and maximum polarization around $\alpha = 90°–100°$, where α denotes the solar phase angle (i.e. Sun-object-observer's angle). The phase-polarization curves of asteroids, usually observed in the main-belt at a low phase angle ($\alpha < 30°$), provide information about composition (i.e. taxonomic type), optical properties, porosity of the surface regolith layers, and so on (see [1,2,3]). In contrast, comets, which are usually enclosed in a dust coma plus gas contamination, have been observed with polarimeters at a wide range of phase angles, providing the composition, size and structure (fluffy or compact) of dust grains in comae [4,5].

Although several near-Earth asteroids and active comets were observed at large phase angles, little is known about the polarimetric properties of bare comet nuclei at large phase angles. Whenever comets are observed at large phase angles (i.e. $\alpha > 90°$), their nuclei are supposed to shrouded in thick cometary comae, because comets are located within 1 AU in the geometry where they are heated up, creating outflow of dust particles and sublimating ice.

In this work [6], we attempted to obtain unique data of the linear polarization degree, P, for a bare cometary nucleus as well as dust particles of the highly dormant Jupiter-Family Comet, 209P/LINEAR (hereafter 209P). Optical and near-infrared polarimetric observations of 209P were conducted for five nights in 2014 April-May using two telescopes: the Hiroshima Optical and Near-InfraRed camera (HONIR) on the 1.5-m Kanata telescope at the Higashi-Hiroshima Astronomical Observatory, Hiroshima, and the visible Multi-Spectral Imager (MSI) on the 1.6-m Pirka telescope at Hokkaido University's Nayoro Observatory in Hokkaido, Japan.

Our results suggested that no significant difference was found in R_c- and J-band. Because of its low activity, we were able to determine the linear polarization degrees of the coma dust particles and nucleus independently, that is $P_n = 30.3^{+1.3}_{-0.9}$ % at $\alpha = 92.2°$ and $P_n = 31.0^{+1.0}_{-0.7}$ % at $\alpha = 99.5°$ for the nucleus, and $P_c = 28.8^{+0.4}_{-0.4}$ % at $\alpha = 92.2°$ and $29.6^{+0.3}_{-0.3}$ % at $\alpha = 99.5°$ for the coma. By fitting with the Lumme and Muinonen function [7,8], we deduced the maximum polarization Pmax = 30.8 % (nucleus) and 29.6 % (coma), respectively.

High $P_{\max}$ value of the dust coma is consistent with a polarization classification scheme described by [9]. We employed an empirical function for relating $P_{\max}$ of the nucleus to the albedo [10] , and found that we obtained a good estimate of the albedo when we assumed the effective size of the regolith particles of ≈1–100 μm.

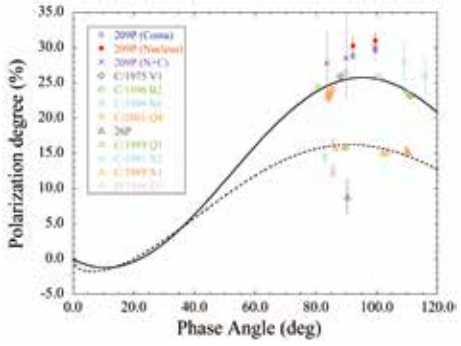

Figure 1: Phase angle dependence of polarization for 209P nucleus (filled circles) and coma (open circles) taken with MSI. Regarding data taken with HONIR (indicated by crosses), we adopted blended signals of nucleus and coma with relatively large aperture (3 × FWHM) due to inadequate tracking of the telescope. For comparison, we show polarization degrees of other comets in the R-band region (about 650 ± 50 nm), which are mostly attributed to light scattered by dust particles in comae. Two fit lines with the Lumme and Muinonen function [7,8], high $P_{\max}$ (solid line and open diamonds) and low $P_{\max}$ (dashed line and open triangles) comprise the PDS archive [11].

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