Microphysics of Dust in Disintegrating Comet C/2019 Y4 (Atlas)

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Abstract. We observe Comet C/2019 Y4 (ATLAS) before and after its disintegration while making polarimetric measurements over a wide range of phase angles. The disintegration event was marked with a dramatic growth of the positive polarization branch that is consistent with a large relative abundance of absorbing material of up to (96.5 ± 3.4)%.

Keywords: comets: individual: C/2019 Y4 (Atlas)

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1 Introduction

Comets are believed to be remnants of planetesimals from the time of Solar System formation. Therefore, they are considered as reservoirs of material of Solar-System formation in its least processed form. However, comets may also experience numerous close approaches to the Sun that allow the development of a refractory surface layer under repeated exposure to the solar radiation, solar wind, and meteoroid bombardment. Relative contribution of the crust particles gets reduced in disintegrating comets because a disruption causes a nearly instant release of significant quantity of pristine material from the inner part of the nucleus.

2 Observations

We started observations of Comet ATLAS on March 15 of 2020, several weeks before disintegration. We were lucky, therefore, to measure the polarization prior and after Comet ATLAS's disintegration, which allows us to compare the materials of the processed crust with the pristine interior materials released by its subsequent disintegration. The observations continued until May 6.

We measured the degree of linear polarization of Comet ATLAS using a 0.5-m telescope (F = 1.62 m) of the Ussuriysk Astrophysical Observatory, a division of the Institute of Applied Astronomy of RAS (code C15; Russia). This telescope is equipped with a commercially available CCD detector SBIG STX-16803, the V filter of standard Johnson photometric system, and a dichroic polarization filter (analyzer). The analyzer is rotated through three fixed position.

3 Results and Discussion

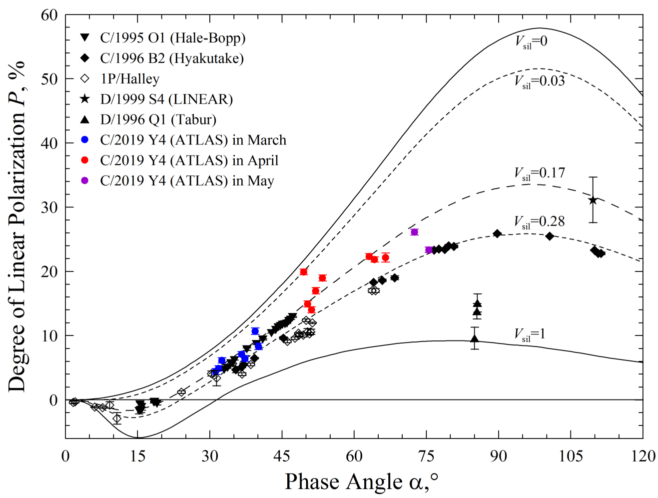

Fig. 1. Polarization P as a function of phase angle α in Comet ATLAS and five other comets.

Fig. 1 shows the polarimetric response of Comet ATLAS measured through a circular aperture with radius of 6000 km versus polarization measured with the blue and green continuum filters in five other comets (Kikuchi 2006; Kikuchi et al. 1987; Velichko 2010). Prior to disintegration (blue points), the polarization of Comet ATLAS closely matches what was found in Comet Hale-Bopp (C/1995 O1).

Interestingly, shortly after disintegration at $\alpha = 49.5^o$, the polarization of Comet ATLAS was even larger than in Comet Hale-Bopp. Nevertheless, later on in April (red symbols), the polarization of Comet ATLAS was tending to converge to the Hale-Bopp. However, on the last epoch of May 6, 2020, polarization of Comet ATLAS was dampened to the Comet-Hyakutake level.

The angular profile of polarization of various comets can be reproduced using a mixture of weakly absorbing Mg-rich silicate particles and highly absorbing carbonaceous particles (Zubko et al. 2016). One can explain the dispersion of P_{max} in comets through different volume fractions of their silicate and carbonaceous particles, V_{sil} and $V_{car} = 1-V_{sil}$. The two solid lines of Fig. 1 shows the angular profile of polarization in silicate particles ($V_{sil} = 1$) and carbonaceous particles ($V_{sil} = 0$). Within this paradigm, the intermediate volume fraction of silicate particles $V_{sil} = 0.17$ corresponds to Comet Hale-Bopp; whereas, $V_{sil} = 0.28$ corresponds to Comet Hyakutake. However, the strong polarization in Comet ATLAS shortly after disintegration suggests an extremely low relative abundance of silicates in its coma, $V_{sil} = 0.03$. It implies that the primordial dust particles are highly enriched in carbonaceous materials and, simultaneously, poor in silicate materials. More details on this research can be found in Zubko et al. (2020).

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