Characterizing Microphysics of Dust Particles in Comet 21P/Giacobini Zinner by Means of Their Stand-Off Distance

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Abstract. We measure the stand-off distance S of dust particles in comet 21P/Giacobini–Zinner in its 2018 apparition. We detect two fractions of dust particles, with $S = (8100 \pm 540)$ km and $(16,400 \pm 540)$ km and place constraints on their microphysics.

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1 Introduction

Comet 21P/Giacobini–Zinner (hereafter referred to as 21P/G-Z) is a short-period comet with relatively stable orbit belonging to the Jupiter-family. We measure the stand-off distance of dust particles emanating from the 21P/G-Z in its 2018 apparition, when it appeared at a phase angle of ~ 78 degree. Using this data and the chemical composition of dust in Comet 21P/G-Z inferred from polarimetry by Chornaya et al. (2020), we constrain the terminal velocity that dust particles were accelerated to by an expanding gas in the innermost coma of 21P/G-Z.

2 Observations and Data Reductions

On 2018 September 12, 19:15 UT, we obtained 40 images of comet 21P/Giacobini Zinner using the 65 cm telescope ($F = 1300$ cm) with a detector ProLine PL4301 of the Ussuriysk Astrophysical Observatory. The comet was at a heliocentric distance $r_h = 1.014$ au, geocentric distance $\delta = 0.393$ au, and a phase angle

$\alpha = 77.8°$. Images of the comet were processed using the IRAF software system, which includes basic programs for bias subtraction, removal of cosmic-ray events and flat-field correction.

The extent of the coma toward the Sun slightly exceeds the projected distance of 10,000 km. The boundary on the subsolar side of the coma appears somewhat sharper compared to the opposite, tailward side. While dust particles ejected from the 21P/G-Z nucleus move toward the Sun they are gradually decelerated by solar-radiation pressure. The velocity of dust particles is gets smaller until the particles come to a complete stop, and then get pushed back by solar-radiation pressure. The range that dust particles travel in the sunward direction is the *stand-off distance*, which is determined by the terminal velocity that the dust particles acquire in the innermost coma from an expanding gas and by the dust microphysical properties, predominantly size and refractive index, that determine the effect of solar-radiation pressure (Zubko et al. 2015).

The observation 21P/G-Z at $\alpha = 77.8°$ provide a rare opportunity to infer stand-off distance of its dust with great accuracy. We accomplish this goal with the *non-linear contrast stretches* using a logarithmic scale as suggested in Section 2.1 of Samarasinha et al. (2014). This technique makes it possible to identify cometary features, and reveals the presence of two regions in the 21P/G-Z coma having significantly brightness.

3 Conclusions

The approach described in Chornaya et al. (2020) and Kochergin et al. (2019) were used for determining the terminal velocities for two edges of the coma, that correspondingly suggests the presence of two types of dust particles. Our analysis of images of Comet 21P/G-Z at large phase angles reveal the presence of two edges in the coma in its subsolar point. They are presumably caused by Mg-rich silicate particles with $\beta = 0.54$ accelerated by an expanding gas to terminal velocity $V_0 = 220$ m/s and 320 m/s. Micron-sized amorphous-carbon particles previously detected in the 21P/G-Z coma would require a noticeably larger terminal velocity $V_0 = 450$ m/s and 620 m/s. Two edges in the 21P/G-Z coma suggest at least two active area on its nucleus with different gas-to-dust moment transfer efficiencies and different chemical composition of their dust.

Bibliography

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