Orbits and Microphysics of Dust Particles Ejected from Comet 29P/Schwassmann-Wachmann

T. Nozdrachev[1,2], A. Kochergin[1,2], E. Zubko[3], and G. Videen[3,4]

[1] Far Eastern Federal University, Vladivostok, Russia
[2] Institute of Applied Astronomy, Russian Academy of Sciences, Saint Petersburg, Russia
[3] Humanitas College, Kyung Hee University, Yongin-si, Republic of Korea
[4] Space Science Institute, Boulder Suite, USA

Abstract. Using time-domain simulation, we study the motion of small dust particles ejected from the nucleus of Comet 29P/Schwassmann–Wachmann at its perihelion and aphelion. We infer the β parameter of dust particles that are capable of remaining in an elliptical orbit around the Sun, which appear in good quantitative agreement with theory, validating our simulation.

Keywords: comets: individual: 29P/Schwassmann-Wachmann
DOI:10.26119/978-5-6045062-0-2_2020_330

1 Introduction

Zodiacal Light reveals the presence of interplanetary dust in the Solar System. The light-scattering response from IDPs is predominantly governed by submicron and micron-sized particles (Zubko et al. 2020). While some studies suggest more than half of IDPs originated from asteroids, other works suggest they are mainly of cometary origin (Nesvorný et al. 2010). This latter conclusion would imply, however, that the phenomenon of Zodiacal Light is almost entirely caused by dust freshly ejected from comets as submicron and micron-sized particles cannot settle in an elliptical orbit due to the effect of solar-radiation pressure (Burns et al. 1979). The effect of radiation pressure is quantified through the ratio of the force of solar-radiation pressure to the solar-gravitation force, and $\beta < 1$ is necessary to keep the particle bound to the Solar System. However, such a constraint on the β parameter is somewhat stricter if the particle is ejected from the parent body on its perihelion passage (Burns et al. 1979):

$\beta < (1{-}\epsilon)/2$, where ϵ is the orbit eccentricity. For instance, a particle ejected from Comet 29P/Schwassmann-Wachmann ($\epsilon = 0.04475$) near perihelion must have $\beta < 0.478$. On the other hand, ejection near aphelion relaxes the constraint on the β parameter (Burns et al. 1979): $\beta < (1 + \epsilon)/2$, yielding $\beta < 0.522$. Therefore, particles ejected near aphelion have a better chance of survival in the Solar System. We aim to investigate the migration of IDPs throughout the Solar System and are developing a numerical model that will be capable of such simulations.

2 Results and Discussion

We model the motion of particles ejected from a parent body using an iterative time-domain approach, taking into account rigorously for three forces acting on a small dust particle: gravity of the parent body, gravity of the Sun, and solar-radiation pressure. Our model is validated versus two other similar codes (Kochergin et al. 2019; Zubko et al. 2015). We simulate the motion of dust particles ejected from the nucleus of comet 29P/Schwassmann-Wachmann at two points of its orbit, perihelion and aphelion. We analyze emanation of dust with the β parameter spanning the range from 0.01 to 0.99 with an increment of 0.01. Our simulations show that dust particles emanating from the comet continue to orbit the Sun if their $\beta \leq 0.47$ (perihelion) and $\beta \leq 0.52$ (aphelion). These reconstructions appear to be in good quantitative agreement with constraints in Burns et al. (1979), validating the accuracy of our numerical model. It is worth noting that this comet remains almost permanently active over the entire period of observations since its discovery in 1927 (Miles et al. 2016). Finally, the orbits of the ejected dust particles can be enormously large. Dust particles ejected on the 29P/Schwassmann–Wachmann perihelion passage can have semi-major axis of their orbit of $\sim$ 192 au. Dust particles ejected on the aphelion passage have a semi-major axis of $\sim$ 766 au. This suggests a long journey for these dust particles before they can settle in the inner solar system.

Bibliography

Burns et al. 1979, Icarus, 40, 1
Kochergin et al. 2019, Res. Notes Am. Astron. Soc., 3, 152
Miles et al. 2016, Icarus, 272, 327
Nesvorný et al. . 2010, Astrophys. J., 713, 816
Zubko et al. 2015, Planetary and Space Science, 118, 138
Zubko et al. 2020, Astrophys. J., 895, 110