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Charged nanodust from comets: an application to comet 67P/CG

K. Szego(1), A. Juhasz (1) and Z. Bebesi (1)
Wigner Research Center for Physics, Budapest, Hungary (szego.karoly@wigner.mta.hu)

1. Introduction

The existence of tiny (nanometer-sized) dust particles has been known from observations of the interstellar medium for a long time and several in-situ measurements have revealed that nanodust particles exist in the solar system also.

During its first Jupiter flyby in 1992 the Ulysess spacecraft discovered a high speed (~ *100* km/s) dust stream consisting of particles with sizes *5-15* nm that were originated from the volcanically active moon Io [*Gruen et al., 1993*]. When Cassini approached Saturn in 2004 the CDA dust analyzer discovered a stream of fast (*50 − 200* km/s) nanometer sized ($a = 2 - 8$ nm) dust particles [*Kempf et al., 2005, Hsu et al., 2011*] that originated from the inner Saturnian system. The Cassini Plasma Spectrometer (CAPS) detected singly-charged nanodust particles erupted from the south-pole plumes of Saturn's geologically active moon Enceladus [*Hill et al., 2012*]. The STEREO wave instrument measures a large number of intense pulses that were interpreted as nanodust impacts and was suggested that the small particles originated from the vicinity of the Sun [*Meyer-Vernet et al., 2009*]. In 1986 at large distances from the nucleus of comet Halley the presence of a high number of tiny dust grains ($m \sim 10^{-18}$ g) was interpreted from the signals of the particle-impact ion mass spectrometers on the Giotto and Vega spacecrafts [*Utterback and Kissel, 1990*]. Electrostatic dust lifting and levitation on the lunar surface have extensively been examined for a long time and was suggested to play role on the surfaces of other celestial bodies (comets and asteroids) too [*Mendis et al., 1981*]

Here we explore the possibility whether an inactive cometary nucleus can be a source of nanodust particles and whether such nano-particles could be detected by some instruments onboard the Rosetta spacecraft that is planned to orbit the comet 67P/CG in 2014.

2. Basic Concept, Nanodust dynamics

The basic concept of our model can be summarized as follows. We assume, that the gas production due-to cometary activity is low enough to be neglected. The surface of the comet nucleus (like other bodies in space) is subject to different charging currents (photoelectric current is dominating) and it collect charges. The resulting electric potential of the surface will be positive ($\Phi \simeq +4$ V) and a few meters (~*10* m) thick photoelectron sheet will form above the surface. The electric field strength at the surface is about *1* V/m, so it is capable to produce a large electric force on nano-sized dust particles (that have only *+1e* extra charge) and lift them with high velocities from the surface (we neglect the adhesion). The flight time of the dust particles inside the photoelectron sheet is only a fraction of a second, so they can not accumulate negative charges from the sheet and they will be ejected from the cometary surface. We give an (upper limit) estimate for the escape flux of nanodust grains and discuss their detection possibility by the charged particle detectors onboard the Rosetta spacecraft in case of comet 67P/CG. The charged dust will be picked up by the interplanetary magnetic field. We consider also the possibility that charged nanodust could be detected after one gyroperiod, during the approach phase.

Charged nanodust dynamics. In the few km vicinity of the nucleus the dynamics of the singly charged nanodust particles is governed by the the electrostatic force $F_e = eE$ and gravity $F_g = GM\,m/R^2$ where G is the gravitational constant, M and m are the mass of the nucleus and the particle, respectively and R is the nucleus (assumed to be spherical) radius. Other forces (radiation pressure, gas drag) are negligible. For the nucleus we assumed a radius of R

= 2 km, a density of ρ = 0.5 g/cm and for the dust grain we set ρ = 1 g/cm^3. As can be seen, for an a=1 nm sized dust particle the acceleration is very high and the electric force is about 8 orders of magnitudes larger than the gravity. These grains will be lifted and blown off the nucleus surface. With such a large acceleration an a =1 nm sized dust particle acquires a relatively large velocity $v \simeq$ 600 m/s within a percent of a second so there is no chance for them to collect charges from the photoelectron sheet. For larger grain with radius a=10 nm the velocity is v=15 m/s only. The electric and gravitational forces equal (F_e /F_g=1) if a_c = 50 nm, this sets the limit for the largest size that can be lifted from the surface by the electric force. Similar model has been worked out for P/Wirtanen [*Juhasz and Szego*, 1998].

The effect of cohesion will be discussed as well, high cohesion force might hamper charged nanodust to be lift off from the surface.

References

Gruen, E. et al., Discovery of Jovian dust streams and interstellar grains by the Ulysses spacecraft, Nature, 362 428-430, 1993.

Hill, T.W., et al., Charged nanograins in the Enceladus plume, J. Geophys. Res., 117, A05209, doi:10.1029/2011JA017218, 2012.

Hsu, H.-W. et al., Stream particles as the probe of the dust-plasma-magnetosphere interaction at Saturn, J. Geophys. Res., 116, A09215, doi:10.1029/2011JA016488, 2011.

Juhasz,A. and K. Szego, Charged dust dynamics above the surface of a comet far from the Sun, J. Geophys. Res., 103, 12015-12022, 1998.

Kempf,S., et al., High velocity streams of dust originating from Saturn, Nature, 433, 289-291, 2005.

Mendis,D.A., et al., On the electrostatic charging of the cometary nucleus, The Astrophysical J., 249, 787-797, 1991.

Meyer-Vernet,N., et al., Dust detection by the wave instrument on STEREO: nanoparticles picked up by the solar wind? Solar Phys., 256, 463-474, 2009.

Utterback, N.G. and J. Kissel, Attogram dust cloud a million kilometers from comet Halley, The Astronomical J., 100, 1315-1322,1990.