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GIADA characterises 67P/Churyumov-Gerasimenko Dust Environment

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Abstract

GIADA (Grain Impact Analyzer and Dust Accumulator) flying on-board Rosetta is devoted to study the cometary dust environment of 67P/Churiumov-Gerasimenko (hereafter 67P). GIADA is composed of 3 sub-systems: the GDS (Grain Detection System), based on grain detection through light scattering; an IS (Impact Sensor), giving momentum measurement detecting the impact on a sensed plate connected with 5 piezoelectric sensors; the MBS (MicroBalances System), constituted of 5 Quartz Crystal Microbalances (QCMs), giving cumulative deposited dust mass by measuring the variations of the sensors' frequency [1]. The combination of the measurements performed by these 3 subsystems provides: the number, the mass, the momentum and the velocity distribution of dust particlesemitted from the cometary nucleus. No prior in situ dust dynamical measurements at these close distances from the nucleus and starting from such large heliocentric distances are available up to date.

1. Results

We report on the dust spatial distribution in the 67P coma as well as its dynamical and physical properties with the final goal of studying the ejection process and the dust environment evolution. GIADA could disentangle two different types of particles in the 67P coma: compact particles [2] and fluffy porous aggregates of grains of about 0.1 micron in size.[3]. The detections of the first type of particles are mainly concentrated within at latitudes and longitudes such that the spacecraft was in view of the 'neck' of 67P. We registered an increase of the compact particles from 3.36 to 2.43 AU heliocentric distances. The speed of these particles, having masses ranging from 1x10^{-10} to 3.9 x 10^{-7} kg, resulted to vary from 0.3 to 12.2 m s^{-1}. Measuring the particles velocity distribution allowed us to constrain the acceleration region to distances from the nucleus > 30 km. The dynamics of the fluffy aggregates, whose detection is not localized as for the compact particles, is found to be biased by electrostatic interactions with the spacecraft. The electrostatic interaction results in the fragmentation and deceleration of the fluffy aggregates that have speeds < 1 m s^{-1}, i.e. much lower than the compact ones.

The density of the two types of particles was constrained [2,3]. The influence of solar radiation pressure on the nanogram particle fluxes was studied. The results confirm a strong anisotropy in the dust flux: the integrated flux of nanogram particles coming from the Sun direction is about 3 times larger than the flux coming directly from the comet nucleus. The integrated flux of nanogram particles coming from the Sun direction (particles reflected back by the solar radiation pressure), is larger than the flux coming directly from the nucleus. We estimated the ratio of these dust fluxes, sub-solar areas versus terminator areas. taking into account the different flight time of reflected versus direct particles. Since the received dust flux scales accordingly to the square of the dust flight time, we conclude that terminator areas eject a flux of nanogram dust a factor < 15% than the nucleus areas characterized by a sun-zenith angle < 50○.

2. Discussion

Comet 67P showed a quite localized gas activity especially when studying the water vapour emission in the view of the neck region [4,5]. These findings seem to be somehow related with what we find for compact particles emission. Fluffy low density aggregates are highly dispersed over the longitude/latitude map of detections. This could suggest that the emission mechanism for these particles could be different from the emission mechanism of the compact particles. An over-simplified interpretation would lead to a connection between the fluffy aggregates and the CO2 emission. The data show quite a strong dependence of compact particle velocity as a function of particle mass as $v \propto m^{-0.29}$. However, in [2] this was not the case. This could be either connected to the different heliocentric distance at which these measurements were performed, [2] referred to very far (3.4-3.7 AU) heliocentric distances, or to the quite large distance of the spacecraft, i.e. the distance of detected dust particles, from the comet nucleus.

3. Conclusion and Future work

GIADA was able to characterise the coma dust environment of an awakening comet describing the dust spatial distribution and measuring speed and mass of individual particles, for the first time in cometary space exploration. GIADA is continuing monitoring the dust environment while 67P is increasing its activity approaching the perihelion (August 2015). GIADA will improve the dust dynamic characterization and reevaluate the dust to gas ratio determined at high heliocentric distances (from 3.6 to 3.4 AU) [2].

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