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Calibration of the Grain Detection System and Impact Sensor of GIADA using cometary dust analogues

R. Sordini (1), M. Accolla (1,2), M. Ferrari (1,2), S. Ivanovski(3,1), V. Della Corte (1) and A. Rotundi (2,1)
(1) INAF- Istituto di Astrofisica e Planetologia Spaziali (IAPS), Via Fosso del Cavaliere 100, 00133, Roma, Italy;
(2) Università degli Studi di Napoli "Parthenope" – Dipartimento di Scienze e Tecnologie, Centro Direzionale Isola C4, 80143, Napoli, Italy; (3) INAF-Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, 80131 Napoli, Italy.

(roberto.sordini@iaps.inaf.it / Fax: +39-06-45488383)

Abstract

The Grain Impact Analyzer and Dust Accumulator – GIADA – is part of the payload onboard Rosetta Orbiter. GIADA's three detection sub-systems are able to measure the speed, the momentum, the mass, the optical equivalent size of single cometary grain and the dust flux ejected by the periodic comet 67P/Churyumov-Gerasimenko. In preparation of the scientific phase of the Rosetta mission, we have performed a dedicated extended calibration activity on two of the three GIADA sub-systems: the Grain Detection System (GDS) and the Impact Sensor (IS). This activity was performed shooting cometary dust analogues selected according to the results obtained by NASA/Stardust mission into the GIADA model installed in a clean room in our laboratory. We present the calibration activity performed on the GDS and IS and the obtained relative calibration curves.

1. GIADA

The Grain Impact Analyser and Dust Accumulator (GIADA) onboard the ESA/Rosetta mission will characterize the 67P/Churyumov-Gerasimenko (67P/CG) dust environment and its evolution. GIADA consists of three measurement sub-systems [1]:

1. Grain Detection System (GDS): a device detecting each incoming grain without affecting its dynamical properties. The GDS detects the grain providing its optical equivalent size and measuring the grain speed.
2. Impact Sensor (IS): it measures the momentum released from each grain that impacts its sensitive surface, an aluminium plate connected to five PZT sensors.
3. Micro Balance System (MBS): a network of five Quartz Micro Balances measuring the cumulative dust deposition from different space directions.

The coupled detection GDS+IS, providing the measure of speed and momentum of individual dust grains, allows to estimate the mass of each grain.
In preparation to the rendez-vous with the comet 67P/CG, an extended calibration activity was performed on the GIADA model hosted in a clean room in our laboratory (Figure 1). The calibration activity was performed on the GDS and IS sub-systems.

Figure 1: Set-up used for GIADA calibration using the cometary dust analogues.

2. Calibration of the GDS and IS

The extended calibration activity on the GDS and IS was done using a wide set of cometary dust analogues selected considering the results acquired by the NASA/Stardust mission on cometary dust. Taking into account the asteroid-like mineralogy recorded in Comet Wild 2 samples [e.g. 2, 3] a list of natural mineral has been selected [4] as cometary dust analogues of 67P/CG (Table 1).

Table 1: List of terrestrial materials used as cometary dust analogues during the extended calibration activity.

Material
Forsterite
Fayalite
Melilite
Enstatite
Alkali-feldspar
Anorthite
Serpentine
Talc
Kaolinite
Pyrrhotite
Corundum
Sodium hexafluorosilicate
Amorphous carbon

For each selected material, grains with sizes ranging from 20–500 μm in diameter were produced and characterized by FE-SEM/EDS and micro IR spectroscopy. About one hundred grains for each cometary analogue type were launched into GIADA, with velocities ranging from 1 to 100m/s. The velocity range is chosen considering: i) the expected velocities of the dust grains ejected from the cometary nucleus [5] and ii) the GIADA sensitivity velocity limits [1].
Each selected grain was photographed using an optical microscope equipped with a high-resolution camera (Figure 2). The dimensions of each chosen grain were measured using the microscope software prior to shooting it into GIADA.

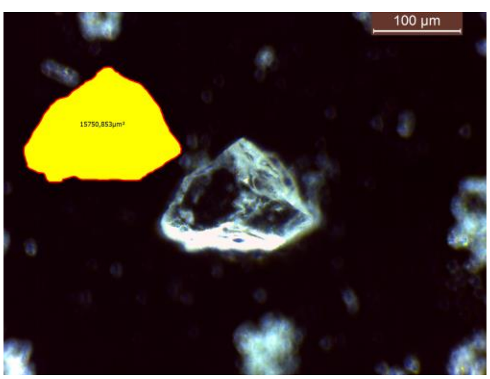

Figure 2: An image of an alkali-feldspar grain with the measured relative area.

The aim of this activity was to obtain a statistically meaningful number of measurements necessary to evaluate the calibration curves of the GDS and IS sub-systems. The response of the both sub-systems has been studied as a function of grain composition and size (Figure 3).

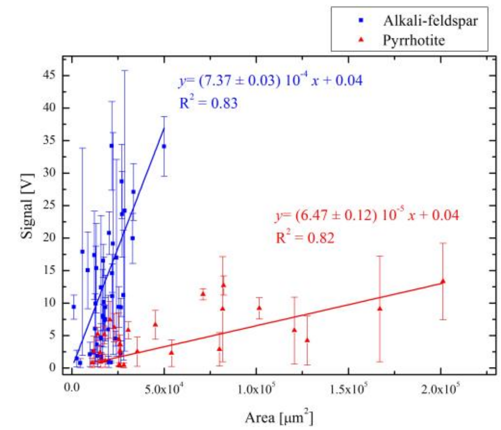

Figure 3: GDS signal vs area of the alkali-feldspar and pyrrhotite grains. The relative best fits are shown.

3. Conclusions

Our extended calibration activity was focused on the calibration of GDS and IS GIADA sub-systems using ad-hoc prepared cometary dust analogues grains (Table 1). The extended calibration campaign allowed us to improve the characterization of GIADA response with respect to more realistic cometary dust grains.

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