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Improvements of GIADA measurements by means of re-analysis of old calibration data and newly obtained ones

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Abstract

GIADA (Grain Impact Analyzer and Dust Accumulator) is an in-situ instrument devoted to measure the dynamical and optical properties of the dust grains emitted by the nucleus of comet 67P. An Extended Calibration activity using the GIADA Flight Spare Model (PFM) has been carried out taking into account the knowledge gained with the analyses of IDPs and cometary samples returned from comet 81P/Wild 2 [1]. The re-analyses of the on ground calibration data collected during the instrument qualification campaign (performed on the GIADA in-Flight and PFM), coupled with the new data-set we obtained recently on the GIADA PFM and the data from the cruise phase [2] allowed us to extend and improve GIADA capabilities. In addition, we are able to rescale the Extended Calibration data to GIADA in-Flight mounted on board the Rosetta S/C. The calibration curves coupled with the GIADA telemetries collected during the Rosetta Cruise phase constitute a large database of sensors responses that will support the scientific data interpretation.

1. GIADA

GIADA consists of three measurement subsystems:

- GDS (Grain Detection System), an optical device measuring the optical cross-section for individual dust grains. It detects the transit of each single grain entering GIADA; GDS sub-system consists of a laser curtain with an area of 10x10 cm and 3 mm thick formed by 4 laser diodes (λ =900 nm) and 2 optical receivers. The receivers are mounted beside the laser curtain with the cones optical axes at 90° with respect to the direction of the laser light beam.
- IS (Impact Sensor) an aluminum plate connected to 5 piezo-sensors measuring the momentum of impacting single dust grains;
- MBS (Micro Balance System), 5 Quartz Micro Balances (QCM) pointing towards different space directions measuring the cumulative deposition in time of dust grains smaller than 10 µm.

GIADA performances, measured physical quantities and sensitivities are summarized in Table 1.

Table 1: GIADA measurements performances.

Phys. Quant.	Direct Measur.	Derived Measur	Range and Sensitivity
Speed	x		1-300 [m/s]
Momentum	x		$6.5\ 10^{-10}$- $4\ 10^{-4}$ [kg*m/s]
Fluence of dust grains	x		$1.9\ 10^{-9} – 2.9\ 10^{-4}$ [g/cm^2]
Optical Cross section	x		Function of optical properties of dust grains
Mass		x	$2.12\ 10^{-12}$ - $4\ 10^{-4}$ [kg]
Flux		x	$6\ 10^{-12}$ [g*cm^{-2}*s^{-1}]

2. GIADA characterization

An in-depth analysis on calibration data acquired during the pre-launch campaign and those we recently acquired on the GIADA PFM was carried out. The results of this analysis allowed us to completely revise and understand GDS and IS performances and capabilities. GIADA characterization activities have been focused on three main aims: a) to find a correlation between the 2 GIADA Models (PFM and In-Flight Model on-board ROSETTA); b) to achieve a complete analysis of measurement sub-systems features (signal elaboration, sensitivities, space environment effects); c) to perform new calibration measurements to obtain the related curves by means of the PFM using realistic cometary dust analogues.

2.1 Correlation between 2 GIADA models

To find the "transfer function" between the two GIADA models (in-Flight and PFM) the complete datasets collected during pre-launch on the 2 models and those collected during the Rosetta cruise phase on the in-Flight Model were reconsidered. Data acquired with the 2 GIADA Models both by each sub-system reading proximity and by the complete acquisition analog to digital chain have been considered. Two "sensitivity translation maps" have been obtained for the GDS and IS. These maps will be used to apply the calibration curves obtained with the PFM to the measurements that will be collected by the GIADA in-Flight Model.

2.2 GDS analyses

Starting from the signal elaboration performed by the GDS proximity electronics and looking at the recorded signals we characterised the non-uniformity of the laser curtain. This characterization allows us to revert a GDS weakness into an advantage. Now we have the possibility to identify the laser curtain crossing position and to improve the accuracy in the optical cross-section measurement (**Figure 1**).

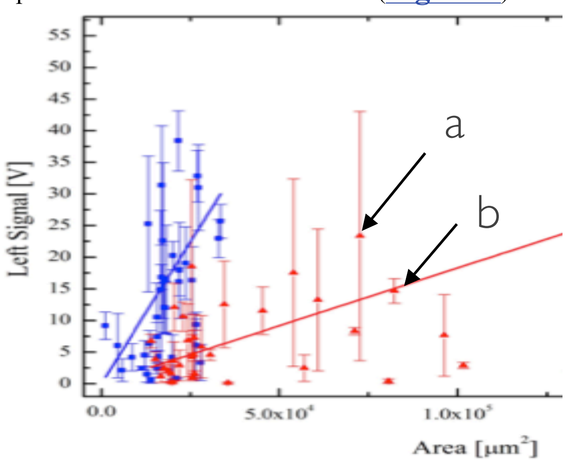

Figure 1 GDS optical cross section measurement: a) measurements and error bar obtained following the old data treatment; b) Measurement and error bar obtained following the new approach.

2.3 IS analyses

The analyses of the IS data show that some unexpected coupling among the signal of the PZTs affect the subsystem. This effect decrease the reliability of the impact position reconstruction. A new algorithm, for the position reconstruction, that take into account this effect allows a remarkable improvement of the dust grain momentum measurement. With this new algorithm we increased the accuracy of the impact reconstruction of a factor of about 3.

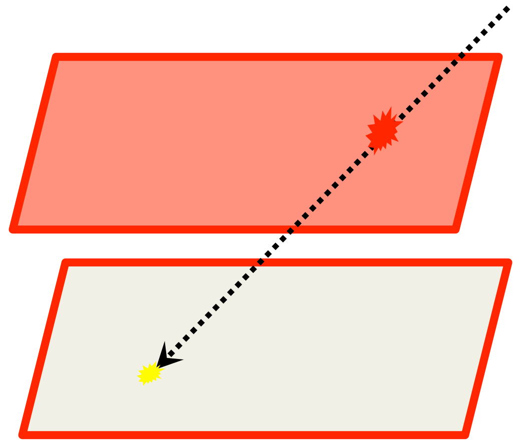

Figure 2 Identification of the velocity vector of a dust grain entering GIADA.

The possibility of reconstruct the position of a dust grain both on the GDS and IS allow us to identify its velocity vector (Figure 2).

6. Summary and Conclusions

Our activities during Rosetta hibernation phase, allowed us to be ready for the operational phase of the mission. The results we obtained made possible a considerable improvement of the GIADA measurements, significantly increasing their accuracy. The performed in-depth analysis of the measurement systems behaviour will allow to fully characterize the dynamic parameters of the dust particles, including the evaluation of the velocity vector for a subset of measured dust grains.

Acknowledgements

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