Available online at www.sciencedirect.com
ScienceDirect
Advances in Space Research 55 (2015) 303–310
ADVANCES IN SPACE RESEARCH
(a COSPAR publication)
www.elsevier.com/locate/asr

Counter data of the Cosmic Dust Analyzer aboard the *Cassini* spacecraft and possible "dust clouds" at Saturn

Emil Khalisi [a,*], Ralf Srama [b], Eberhard Grün [a]

[a] *Max-Planck-Institute for Nuclear Physics, Saupfercheckweg 1, D–69117 Heidelberg, Germany*
[b] *Institute for Space Systems, Pfaffenwaldring 29, D–70569 Stuttgart, Germany*

Received 16 October 2013; received in revised form 5 August 2014; accepted 1 September 2014
Available online 16 September 2014

Abstract

We present the impact rates of dust particles recorded by the Cosmic Dust Analyzer (CDA) aboard the *Cassini* spacecraft. The "dust counters" evaluate the quality of an impact and give rise to the apparent density of dust particles in space.

The raw data is pre-selected and refined to a new structure that serves to a better investigation of densities, flows, and properties of interplanetary dust grains. Our data is corrected for the dead time of the instrument and corresponds to an assumed Kepler orbit (pointing of the sensitive area). The processed data are published on the website for the Magnetosphere and Plasma Science (MAPSview), where it can be correlated with other *Cassini* instruments.

A sample is presented for the Titan flyby on DOY 250/2006. We find that the dust density peaks at two times, at least, in a void region between Titan and Rhea. Such features may point to extended clouds of small particles drifting slowly in space. These density clouds seem to be stable for as long as several months or few years before dispersing.

Keywords: Saturn; Cassini; Cosmic dust; CDA data analysis; dust clouds

1. Introduction

The Cosmic Dust Analyzer (CDA) aboard the *Cassini* spacecraft is an instrument to study the physical and chemical properties of dust particles in the interplanetary space (Srama et al., 2004). It consists of two subsystems working separately:

1. The main sensor is the Dust Analyzer (DA) designed to analyse the particles according to their speed, mass, charge, chemistry, and impact direction. It deploys a time-of-flight mass spectrometer. The sensitive area of the Impact Ionisation Detector (IID) is 0.0825 m^2, and Chemical Analyzer Target (CAT) is 0.0073 m^2.
2. The High-Rate Detector (HRD) only counts the number of impacts with a frequency of up to 10,000 counts per second. It is a simple impact trigger with an area of 60 cm^2.

The general purpose is to quantify the dust density in the interplanetary space during the spacecraft cruise as well as the dust environment at Saturn. A permanent mapping of all directions is not possible because of the fixed position of the CDA on a 3-axis stabilised spacecraft. However, a designated turntable of the CDA allows some re-directioning of the boresight (aperture axis).

We introduce the "dust counters" that serve to investigate local densities, particle flows, and their properties measured along the *Cassini* trajectory (Khalisi and Srama, 2012). The original data (raw data) of the CDA is stored in a MySQL database on a computer server at the

* Corresponding author.
E-mail address: emil.khalisi@mpi-hd.mpg.de (E. Khalisi).

http://dx.doi.org/10.1016/j.asr.2014.09.002
0273-1177/

Max-Planck-Institute for Nuclear Physics in Heidelberg, Germany, and Institute for Space Systems at the University of Stuttgart.

We wrote an IDL code that unites similar features in the pristine data. Additionally, the code returns useful graphics or correlates various physical parameters about the distribution of dust. Our code does not dispense the original data but serves as a helping tool if a more concise format is desired, e.g. for comparison with other instruments on *Cassini*. That pre-processed data can be accessed in the MAPSview database (Magnetosphere and Plasma Science) at http://mapsview.engin.umich.edu/.

2. Description of the impact counters

The "dust counters" are an array of 27 enumerators for certain impact properties valid after DOY 150/2005. Each event is analysed by the onboard flight software immediately after its occurrence. A dust grain hitting the sensitive area of the detector will produce various signals that are subject to a classification (Srama et al. 2006). For example, the QI-signal approximately indicates the impact energy as returned by the ion multiplier, while attributes like "charge" and "velocity" are exploited by the QP-signal at the entrance grid (Fig. 1). When spectral lines are present, the impact is supposed to have hit the CAT rather than the IID.

The combined properties of all electronic signals are interpreted by a decision making algorithm as such that the counters act like "containers" or "categories" for some common characteristics among the various dust particles. The most important quantity for decision is the QI-signal as given in column 3 of Table 1 as an example.

The algorithm is priority-sequenced (last column of Table 1). For example, the first check is whether the necessary signals are present at all, otherwise the event will be classified as "QI-flare" (N1, see below). Afterwards, the criteria for strong impacts on the CAT are checked and whether a spectrum exists (A0 – A3). If not, then the event must have occurred elsewhere (Wall, IID, etc.) but on the chemical target. After having passed that onboard algorithm, each impact event is assigned to one of the 27 counters (column 2) and gets a qualitative name, e.g. "big" or "slow" (column 4). A "strong" event can be caused by a massive but slow particle as well as a small and very fast particle. If the essential conditions of a special counter are met, its value is enhanced by 1, and the search terminates. If not, the next criteria are checked unless an appropriate counter will be found. Each impact is assigned to one unique counter. The objective of that style is to accumulate the particles with special features in order to compare their frequency of occurrence.

The classification scheme follows a threefold pattern:

- A0 – A8: counter names for the CAT. These are signals showing mass lines on the multiplier (QM signal) with a corresponding signal on the Chemical Analyser (QC signal); the impacts are further divided into 9 sub-classes (0 to 8) for large, medium, small responses as well as the number of line peaks on QM.
- I0 – I7: counter names for impacts on the IID; further division into 8 sub-classes (0 to 7) for fast and slow entrance velocities (QP signal at the entrance grid).
- others: ten more counters are for putative noise records, impacts on the non-sensitive area ("wall"), test pulses, and control modes.

The thresholds for the registration of a particle were changed throughout the mission to adjust for the ambiences of a particular occasion: dense regions, ring plane crossings, flybys at moons etc. For example, when flying through a dense cloud, the number of very small particles is high, and large impacts are rarely triggered. Then, the threshold was raised which resulted in a mode of lower sensitivity of the CDA. Therefore, the counters are a *relative* measure at different environments. This kind of local customisation is the main bias that we have to be aware of when using the data.

The counters were originally not meant for scientific use, but rather to roughly prioritize the events for the data readout from the spacecraft's repository. The goal of altering thresholds was to select more important dust records for a transfer to Earth than noise events (Srama, 2009). The concept of the counters turned out to be

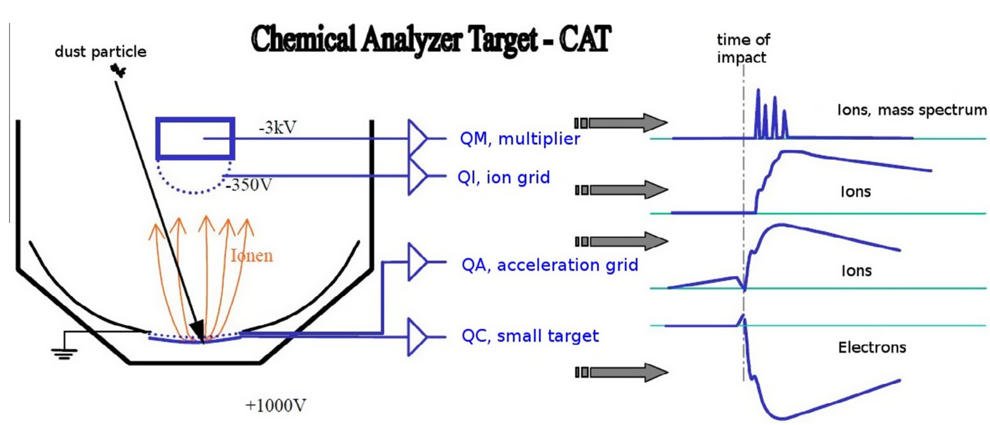

Fig. 1. The QM signal provides a fast changing current that is based on the arrival times of chemical compounds of different mass (Srama, 2000).