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The Exogenous Dust Populations in the Saturnian's System: a CDA Inventory

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Abstract

The analysis of different CDA subsystems data, acquired since SOI, reveals that the Saturnian system is permanently crossed by dust grains originating from the Interplanetary medium, as well as from the neighboring interstellar medium surrounding the Solar System. We observe two main types of particles: on the one hand, those with low injection velocity with respect to Saturn, and whose flux is significantly enhanced by gravitation focusing. On the other hand, particles with fast injection velocities, essentially unperturbed by gravitation focusing. In the slow category, we use our data to test the hypothesis that the Kuiper Belt or TNOs/Centaurs are sources of the detected dust grains. As for the main component of the 'fast population' our data suggest interstellar dust (ISD), with grains also possibly released by Oort Cloud type comets.

1. Introduction

We report in this paper on the analysis of 7 first years of Cassini-Cosmic Dust Analyser (CDA) data obtained in the Saturn's system. We are looking specifically for the presence in our data set of dust particles originating from the outside the Saturnian system, called hereafter exogenous dust. The main focus of this work is therefore to answer the following questions: can we find signatures of exogenous dust in the Saturnian System ? If yes, can we constrain its origin ?

2. Data analysis

The major difficulty we are facing is the identification of comparatively very rare exogenous particles in an environment dominated by E ring particles, making our study similar to ' looking for a needle in a hay stack'. In the densest regions of the E ring, the CDA instrument is saturated by E ring impactors, therefore 'masking' contributions from other sources. Fortunately, the Cassini spacecraft has been flying on orbits for a wide range of inclinations and eccentricities while touring Saturn during the past seven years such that regions with reduced E ring contribution can be exploited for our study. Regions more favorable for the search of exogenous particles are typically as far as possible from Saturn, or, 'far enough' from the equatorial plane of Saturn, in order to avoid the bulk of the E ring particles. Having measured nearly continuously for over 7 years provides enough integration time in these regions for our study to be done with reliability. We use in this paper the data of the CDA EG, IID and CAT detectors.

3. Results and Discussion

We find the signature of exogenous dust in all CDA subsystem data set. This fact by itself is an important result that will constrain evolutionary processes in the Saturnian System, like, for example, the compositional evolution of atmosphere-less icy surfaces (icy moons and Saturn's main ring system).

Our data suggest two main dynamical types of exogenous particles crossing the Saturnian system: the 'slow' and 'fast' populations, in term of relative velocity with Saturn at 'infinity', that is, beyond the gravitational sphere of influence of Saturn. The fast populations contains ISD sub-micron grain candidates, as observed by the Ulysses mission as they cross the solar system on hyperbolic orbits. These grains could be identified by their directionality and impact speed derived from CAT time-of-flight spectra signals. The chemical composition appear to be consistent with silicates-magnesium-iron signature. A second component of the fast exogenous population,

identified in the EG data appears to consist of grains on nearly parabolic, prograde and retrograde solar orbits. However, such grains are rare in the EG data compared to heliocentric bound particles, a result also suggested by our modeling of the CDA-IID data. We also find the signature of an exogenous grain population at Saturn that must have a low injection velocity (a few kms^{-1}) in order to explain the radial distribution of the CDA-IID impacts. Remarkably, this low velocity with respect to Saturn of grains, obtained by statistical means from the CDA-IID data is consistent with the ones directly computed from the possible trajectory solutions of individual exogenous grains detected by the CDA-EG data. Three main known types of grains in the outer Solar System were discussed to explain our observations. We find that JFC comet cannot be a dominant source for the dust that CDA measures at Saturn. In turn, our measurements appear in good qualitative and quantitative agreement with the dynamical signature of KBO dust expected at Saturn that can explain the bulk of our 'slow' population. We find, however, that KBO dust cannot be distinguished at Saturn dynamically from particles released by Centaurs/TNOs, whose cometary-like activity at large heliocentric distances has been recently discovered.