INTERACTION OF SATURNIAN DUST STREAMS WITH THE SOLAR WIND

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One of the major findings during the approach of the Cassini spacecraft to Saturn was the discovery of high velocity streams of nanometer-sized dust originating from the inner Saturnian system [4]. Until then, only the Jovian system was known to be a source of dust streams [1]. The dust stream phenomenon is of particular interest for a few reasons: (i) outside the planetary magnetosphere the stream particle dynamics is governed by the interaction with the solar wind plasma [2]; (ii) stream particles are the fastest solid bodies of the solar system known so far [6]; (iii) dust streams may transport material from areas which cannot be explored in-situ by space probes [4].

Numerical simulation by Zook et al. [6] proved that for the Jovian streams only grains of about 10 nm with speeds exceeding 200 km s⁻¹ reproduced the observations by Ulysses. Based on the impact signals caused by the Saturnian stream particles as well as by numerical simulations [3] those grains were found to have similar properties (radii ranging between 2 and 25 nm, speeds ≥ 100 km s⁻¹). Furthermore, the simulations indicated that particles detected at large distances from Saturn most probably originated from the outskirts of Saturn’s A ring. Surprisingly it was found that stream particles predominately consist of a silicon-bearing material [5] even though Saturn’s rings are composed of water ice. This proposes that stream particles are rather the impurities of the icy ring material than the ring material themselves.

Here we report on results based on one year of continuous monitoring of Saturnian stream particles by the Cosmic Dust Analyser (CDA) on the Cassini spacecraft. All dust bursts detected within 150 Saturnian radii so far clearly coincided with the spacecraft’s traversal through ‘co-rotating interaction regions’ (CIR) in the interplanetary magnetic field (IMF) – regions characterised by compressed plasma, increased solar wind speed, and enhanced magnetic field strength (Fig. 1). This finding together with our analysis demonstrates that the peculiar properties of dust streams can be explained by the interaction of the charged grains with the plasma inside the CIRs.

Figure 1: Impact rate and directionality of stream particles recorded during Cassini’s first revolution around Saturn outside Titan’s orbit spanning days 200 and 300 in 2004. The upper panel shows the angle between the CDA instrument normal and Saturn’s ring plane, the middle panel indicates the angle between the CDA and the Cassini-Saturn line of sight. The mean angle is plotted whenever more than 2 impacts within 4 hours were registered; the attached bars indicate the 1-σ deviation from the mean angle. The gray solid line marks the evolution of the CDA normal due to the varying spacecraft orientation. The lowermost panel shows the stream particles impact rate. The pronounced impact bursts around day 210 and around day 235 of 2004 coincide with Cassini’s traversal through co-rotating interaction regions in the solar wind. Note also that the directionality of the streams changed during these periods.

References