

STEREO/WAVES Science Nugget
2012-Oct-25

STEREO Dust Observations

Shortly after the launch of the STEREO mission, the WAVES Time Domain Sampler (TDS) as well as the high and low frequency radio receivers (HFR/LFR) began observing sharp voltage spikes. Many of these spikes show amplitudes exceeding the TDS saturation level of ~ 200 mV/m.

Similar spikes have been observed on previous missions. Voyager and Cassini observed such spikes in conjunction with passage through the rings of Saturn [Gurnett et al., 1983; Wang et al., 2006] and in conjunction with Jovian dust streams [Zook et al., 1996; Meyer-Vernet et al., 2009b]. The Deep Space 1 and Vega spacecraft recorded voltage spikes in the dust tails of comets Borrelly and Halley [Tsurutani et al., 2003; Laakso et al., 1989]. Similar spikes observed by the Wind/WAVES electric field instrument have fluxes and impact direction variation consistent with a mix of interplanetary and interstellar micron-sized dust particles [Malaspina et al. 2013 (in prep)]. Given this prior experience, it is most likely that the STEREO spikes are also due to the impact of high velocity dust on the spacecraft.

Subsequent investigation produced correlations between the strongest voltage spikes and STEREO/SECCHI images contaminated by streaks consistent with debris close to the spacecraft [St Cyr et al., 2009]. This work further supports the dust interpretation for particles in the ~ 10 micron range.

However, the flux of dust on STEREO was found to be many orders of magnitude higher than could be explained by the impact of micron-sized dust. To resolve this inconsistency, it was suggested that STEREO/WAVES observes the impact of nano-sized dust particles [Meyer-Vernet et al., 2009a] that are picked up by the solar wind close to the Sun, much like massive pickup ions. Detailed analysis of TDS waveforms offers support to this suggestion [Zaslavsky et al., 2012].

Today, members of the space dust community generally accept that electric field antennas do observe the plasma generated by the impact of high velocity dust particles under some circumstances. While there is general acceptance of micron-sized dust impact observations by electric field antennas, considerable skepticism exists regarding the detection of nano-dust by STEREO. This skepticism is fueled by several observational inconsistencies.

First, flux comparisons between dedicated dust detectors and electric field antennas yield very different results, in general because the collecting area and sensitivity of electric field antennas to dust detection is only roughly estimated rather than known. For example, Cassini measurements of the thickness of Saturn's ring plane by the Radio Waves and Plasma Science (RWPS) electric field instrument differ from those made by the dedicated and well calibrated Cosmic Dust Analyzer (CDA) instrument by up to 50%

[Kempf et al., 2008; Kurth et al., 2006].

Second, and more critically, the nano-dust particles were not observed at 1 AU by Cassini's CDA, an instrument that detected/discovered streams of nano-size dust particles both at Saturn and Jupiter. These open questions are being addressed by researchers both external to and within the SWAVES team.

STEREO Dust Measurements

Dust Size	Mass	Rate	Comments	Technique	Location	Reference
~10 nm	~10 ⁻²⁰ kg [virus size]	[A]&[B] ~0.1-10x per second [A] ~3x[B] [A]&[B] TDS-LWS bursts of 1,500 per second	Sporadic w/bursts on [A] & [B], lasting months then disappearing Speed ~350 km/s, similar to pick-up ions	SWAVES single antenna [TDS and LFR] [A] 26x more singles than triples [B] 11x more singles than triples	S/C body strike near an antenna	Meyer-Vernet <i>et al.</i> (2009); Zaslavsky <i>et al.</i> (2012); Meyer-Vernet & Zaslavsky (2012); Le Chat <i>et al.</i> (2012); Pantellini <i>et al.</i> (2012)
0.1-0.3 micron	~10 ⁻¹⁷ kg	[A]&[B] ~10x per day	-“beta-meteoroids” are spiraling outward [50-80 km/s, accelerated by radiation pressure] -“interstellar” component is modulated by longitude [26 km/s motion through galaxy]	SWAVES 3-antenna (non-saturating) [TDS]	S/C body strike	Zaslavsky <i>et al.</i> (2012); Belheouane <i>et al.</i> (2012)
~0.1 micron		[A] & [B]	~10% images [B] ~1% images [A]	SECCHI HI offpoints	HI strike	Davis <i>et al.</i> (2012)
~1 micron	~10 ⁻¹⁶ kg [E-coli size]	~4x per day		SWAVES 3-antenna (saturating)	S/C body strike	Mentioned in St.Cyr <i>et al.</i> (2009)
~10 micron	~10 ⁻¹² kg	[A]~1x per 7 days [B]~1x per 27 days	-Likely Keplerian orbits(?)	SECCHI HI MLI storms; Subset of SWAVES 3-antenna (saturating); HI cosmic ray counter	Sunward face of S/C strike	St.Cyr <i>et al.</i> (2009)

St. Cyr -- Version 2012-09-21

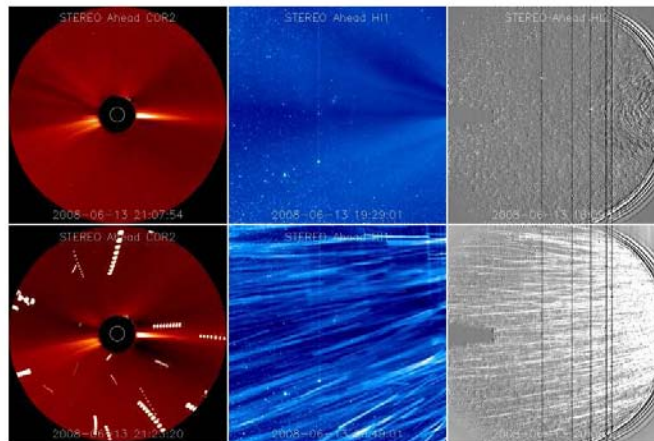


Figure 1: STEREO-A images from COR2, HI1, and HI2 immediately before (top panel) and during (bottom panel) the dust storm on 13 Jun 2008. Times of each image are shown, and the degradation to the specific quality is evident. The COR2 images were not affected during this storm. The size and location of the Sun are shown as a white circle in the COR2 image, the Sun is to the right of the HI1 and HI2 images.

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