COLLISIONS IN SPACE: NANO-SCALE DUST PRODUCTION AND ITS DETECTION IN SPACE.
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Introduction: The solar system has evolved by gravitational and tidal interactions punctuated by collisions. These collisions produce ever smaller objects, and these objects are subject to ever more frequent collisions as they decrease in size. The orbits of these bodies evolve gravitationally, due to solar and thermal radiation, and if sufficiently small due to the electromagnetic interaction of the charged dust with the solar wind.

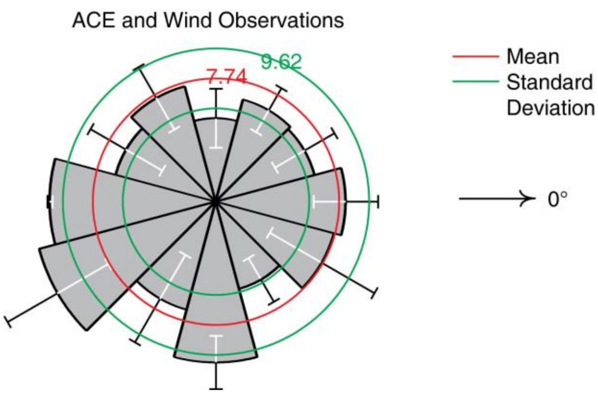

Figure 1. Longitude distribution of IFE encounters at 1AU seen by ACE and Wind.

A rule of thumb for a catastrophic collisions is that at the average collisionsal velocity at 1 AU of 20 km sec^{-1}, a 1 kg mass can destroy a 10^6 kg body, and a 1 mg particle can destroy that 1 kg mass. These collisional processes result in the distribution of collision rates versus size shown in Figure 1 that can be validated at 1 AU by observing the meteoric influx with optical and radar techniques.

Coherent pickup of nanoscale dust by the solar wind can be detected by interplanetary spacecraft equipped with magnetometers. The first such detection was of a very large event where the charged dust cloud took 12 hours to cross the observing spacecraft, the Pioneer Venus Orbiter, as shown in Figure 2. Shortly afterward, this cloud was also detected at Veneras 13 and 14 on their way to Venus.

While seldom are these magnetized dust clouds detected by multiple spacecraft, they have been seen many times on two nearly spacecraft and once on five spacecraft. The magnetic measurements for the five spacecraft detection are shown in Figure 3, as a function of time.

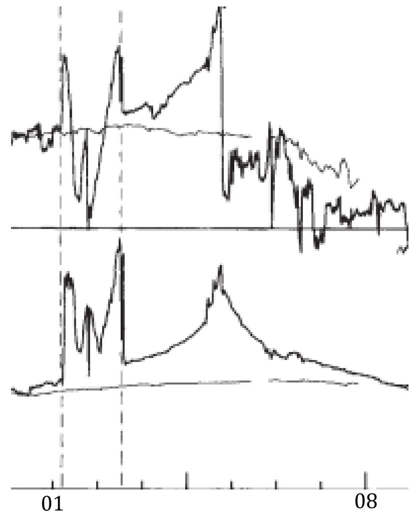

Figure 2. Discovery plot of the first Interplanetary Field Enhancement. This event lasted 12 hours as it moved by Venus observed by the PVO mission in orbit. Between dotted lines, PVO was in the Venus solar wind interaction region downstream of its bow shock.

Even more instructive is the sketch of the magnetic field lines derived from the measurements. The pattern is such as to pull the dust radially outward from the Sun. If the dust and solar wind were travelling at exactly the same speed, there would be no reason for this draped configuration. Hence the magnetic forces must be in the process of accelerating the dust from its initial slower orbital speed, and when observed, to a speed of hundreds of km/sec.

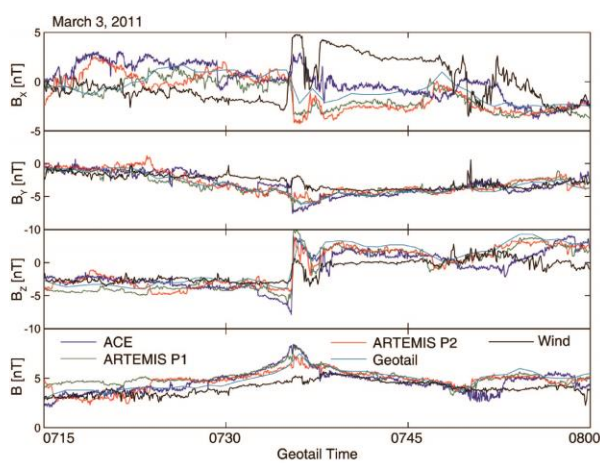

Figure 3. Plot of the magnetic field of an IFE at Earth obtained simultaneously by 5 spacecraft separated over a range fo 100 R_E.

In interplanetary space, we observe few events lasting 10m or less, perhaps because small events can be accelerated to the solar wind speed quickly, but recently we have found such short duration events downstream from the Earth bowshock when the solar wind was rapidly decreased in speed, thus reversing the forces quite rapidly necessitating the build-up in magnetic pressure to brake the flow of the dust entrained in the magnetized solar wind. This discovery was made with the four spacecraft MMS mission that has rapid sampling and precise magnetic measurements. Thus events lasting less than one minute are easily detected and characterized. Their rate of detection is surprisingly high, possibly because the rapid decrease in the solar wind speed at the shock reveals all such production in the solar wind all the way back to the Sun, whereas in the solar wind ahead of the shock, only recently produced charged dust clouds will have a magnetic envelope strong enough to be seen.

While the dust detectors on interplanetary spacecraft seem to generally be too insensitive to detect interplanetary dust, we recently have learned that one of our dust sources, the asteroid 138175 and its debris cloud that crosses the ecliptic plane twice inside the Earth's orbit has been "detected" by the Bright Source Faraday Cup on the Spekt-R spacecraft [1]. This study shows that despite their small size and the difficulty in their detection, it is possible to find the regions of collisional dust production in the inner solar system and identify their parent bodies.

References: Use the brief numbered style common in many abstracts, e.g., [1], [2], etc. References should then appear in numerical order in the reference list, and should use the following abbreviated style:

[1] Kociscak S., Pavlu S.J., Safrankova J., Nemecek Z., Prech L. (2017) *Planet. Space Sci.*, in press.