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Meteroid collisions as a cause of turbulence in the solar wind

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The solar wind is a collisionless plasma, but the neutral matter in the solar system is in constant danger of collisions with small bodies in danger of disruption. Large bodies such as the Earth are immune to this collisional hazard, because any collision with the Earth at the 20km/s average collisional speed at 1 AU will not destroy it unless that body is at least 10-6 of the mass of the Earth or 0.01 of its radius. There is not much matter of that size near 1 AU other than the Earth. However, at smaller scale objects are being destroyed continuously, producing nanoscale dust that in turn becomes immediately charged by sunlight and accelerated by the solar wind motional electric field. This acceleration cannot overcome the Sun's gravitational attraction for particles above the micron scale, but dominates the dynamics of particles at the nanoscale. We have monitored the magnetic disturbances we believe to be associated with these fine-scale dust-producing collisions for over forty years. Magnetic structures, characterized by enhanced field strength and central current sheets, arise as the charged dust is being accelerated and the surrounding magnetically connected plasma decelerated. When the dust reaches the solar wind speed, the field enhancement signature disappears as the charged dust and the solar wind are moving at the same speed. The current sheets can remain as tangential (non-propagating) discontinuities. The observational rate of such events at any one spacecraft is small, about once a month in the solar wind, controlled by both the collision rate and the lifetime of the magnetic enhancement. However, recently, with the launch of the Magnetospheric Multiscale satellites, we received a surprise. Short (less than 1 minute) and more frequent events, with similar magnetic signatures as those in the solar wind with durations greater than 10m, were seen in the Earth's magnetosheath. The charged dust responsible for these events had no signature in the solar wind, because it had been rapidly accelerated to travel with the speed of the solar wind. However, when the solar wind plasma slowed down at the Earth's bow shock, the dust did not, and the velocity difference produced a signature similar to that seen under acceleration in the solar wind. This larger occurrence rate of charged-dust-produced twisted fields raises the possibility that the solar wind turbulence is produced at least in part by the pick-up of collisionally-produced charged-dust clouds.