DUST PARTICLES DETECTED IN THE OUTER SOLAR SYSTEM BY VOYAGER 1 AND 2.

D. A. Gurnett, Z. Z. Wang, A. M. Persoon, and W. S. Kurth (University of Iowa, Dept. of Physics and Astronomy, Iowa City, IA 52242, USA; donald-gurnett@uiowa.edu)

In this paper we report PWS observation of dust impacts detected in the outer solar system by the Voyager 1 and 2 plasma wave instruments. During the Voyager 1 and 2 flybys of the outer planets, it was discovered that the plasma wave (PWS) instrument could detect small micron-sized particles striking the spacecraft. When a small particle strikes the spacecraft at a high velocity, the particle is instantly vaporized and heated to a very high temperature, typically 10^4 K, or more. At this high temperature a substantial fraction of the gas is ionized. As the resulting plasma cloud sweeps over the PWS electric antenna, it produces a voltage pulse on the antenna. By counting the number of pulses per unit time, the impact rate can be determined.

An example of a dust impact detected by Voyager 2 at a heliocentric radial distance of 53.62 AU (Astronomical Units) is shown in Figure 1. Typically the voltage pulse detected on the antenna consists of an abrupt step with a rise time of a few tens of microseconds followed by complicated recovery waveform lasting several milliseconds.

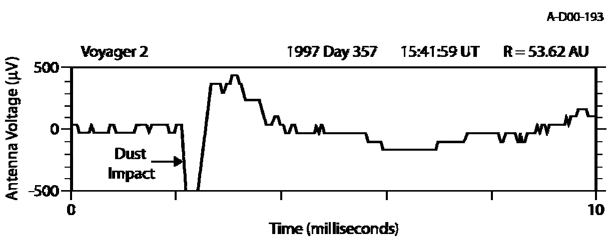

Figure 1. A dust impact detected by the Voyager 1 plasma wave instrument at a heliocentric radial distance of 53.62 AU.

The waveforms detected in interplanetary space are very similar to the waveforms detected at the Saturn ring plane crossings, which are believed to be due to micron-sized particles. After eliminating dust impacts detected during the flybys of the outer planets, the impact rates detected by Voyagers 1 and 2 are found to be nearly constant, approximately 4 impacts per hour for Voyager 1, and 5 impacts per hour for Voyager 2, after correcting for the observation duty cycle. Plots of the impact rates detected by Voyagers 1 and 2 are shown in Figures 2 and 3, respectively.

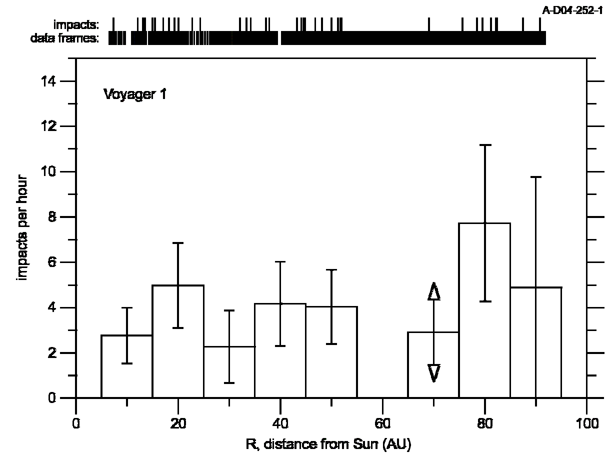

Figure 2. The dust impact rate detected by the plasma wave instrument on Voyager 1.

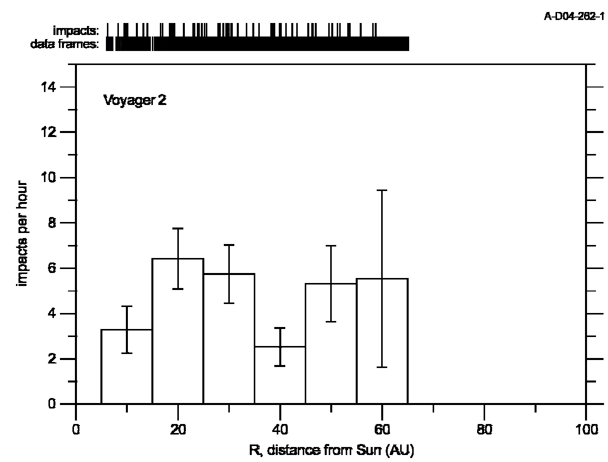

Figure 3. The dust impact rate detected by the plasma wave instrument on Voyager 2.

The impact rates shown in Figures 2 and 3 appear to be completely independent of the heliocentric radial distance of the spacecraft. Voyager 1 is currently at a heliocentric radial distance of 96.1 AU, and Voyager 2 is at 77.0 AU. Because of a failure of the wideband receiver on Voyager 2, the ability to measure dust impacts on that spacecraft ended at a distance of about 64 AU. The impact rates also do not depend on ecliptic latitude or longitude, although the data coverage for these two parameters is much more limited than for heliocentric radial distance.

If we assume that the spacecraft is effectively sweeping up the particles, we can make a rough estimate of the number density of the impacting particles by using the formula n = R/UA, where R is the impact rate, A is the cross-sectional area of the spacecraft, and U is the heliocentric speed of the spacecraft. Using A = 1.66 m^2, which is our best estimate of the effective area of the spacecraft for detecting dust impacts, and U = 18 km s^{-1}, which is a typical spacecraft velocity, the average number density works out to be about 4 x 10^{-8} m^3. The mass of the impacting particles is more difficult to estimate, but is believed to be on the order of 10^{-10} to 10^{-11}g (i.e., in the micron size range), mainly because the impacts have waveforms very similar to those observed near Saturn's ring plane which are thought to be due to micron-sized particles. The absence of significant latitudinal or radial gradients suggests that the particles probably do not originate from planetary rings, moons, or asteroids. Most likely they are of interstellar origin, or possibly from objects orbiting the Sun at great distances, such as comets. Dust originating from Kuiper belt objects, which are confined relatively close to the ecliptic plane, can probably be ruled out because the impact rate does not show any dependence on distance above or below the ecliptic plane out to at least z = 50 AU. We have also looked for evidence of dust streams, such as might be related to comet trails, and none were found. The time interval between impacts has a good fit to a Poisson distribution, indicating a purely random distribution.