

Measurements of the Interplanetary Dust Population by the Venetia Burney Student Dust Counter on the New Horizons Mission

Andrew R. Poppe^{1,2}, David James¹, Brian Jacobsmeyer^{1,2}, and Mihaly Horányi^{1,2}, ¹Laboratory for Atmospheric and Space Physics, Boulder, CO, and ²Department of Physics, University of Colorado, Boulder, CO, (poppe@lasp.colorado.edu)

Introduction: The Venetia Burney Student Dust Counter (SDC) on the New Horizons mission is an instrument designed to measure the spatial density of interplanetary dust particles with mass, $m > 10^{-12}$ g, on a radial profile throughout the solar system [1]. The instrument consists of fourteen permanently-polarized polyvinylidene fluoride (PVDF) detectors that register a charge when impacted by a hypervelocity ($v > 1$ km/sec) dust particle. PVDF-style dust detectors have previously flown on the Vega 1 and 2 [2] and Cassini spacecraft [3]. The instrument has a total surface area of 0.11 m^2 , a one-second time resolution and a factor of two in mass resolution. When impacted by a hypervelocity dust particle, the instrument records the time, charge, threshold and detector number. SDC is part of the Education and Public Outreach program of New Horizons, and as such, was designed, tested, integrated and is now operated solely by students.

New Horizons was launched on January 19, 2006 and encountered Jupiter on February 28, 2007. Prior to the Jupiter encounter, SDC took measurements in two main periods of the inner solar system: 2.66-3.55 A.U. and 3.99-4.67 A.U. The spacecraft is now on a solar system escape trajectory, with a Pluto-Charon fly-by targeted for July 14, 2015. During the long cruise phase in between Jupiter and Pluto-Charon, SDC routinely takes measurements of the interplanetary dust density. Shown in Figure 1 is the New Horizons flight path up to January 1, 2010.

The scientific goals of SDC are to: (a) measure the interplanetary dust density radially throughout the entire solar; (b) place limits on the dust production rate from the Edgeworth-Kuiper Belt (EKB); and (c) to validate various models of the interplanetary dust distribution [4]. Grains that are produced in the EKB, either as ejecta from cosmic dust impacts or from mutual EKB-object collisions, slowly migrate inwards under the influence of gravity and Poynting-Robertson drag. The particles are gravitationally influenced by the giant planets and are thought to occasionally become trapped in mean-motional resonances (MMR). These MMRs can drastically increase the local interplanetary dust density. Shown in Figure 2, the interplanetary dust density has been predicted to sharply increase near the orbit of Neptune [4], in a region that New Horizons will cross in 2013.

Comparison to Previous Measurements: Previous interplanetary dust density measurements have been

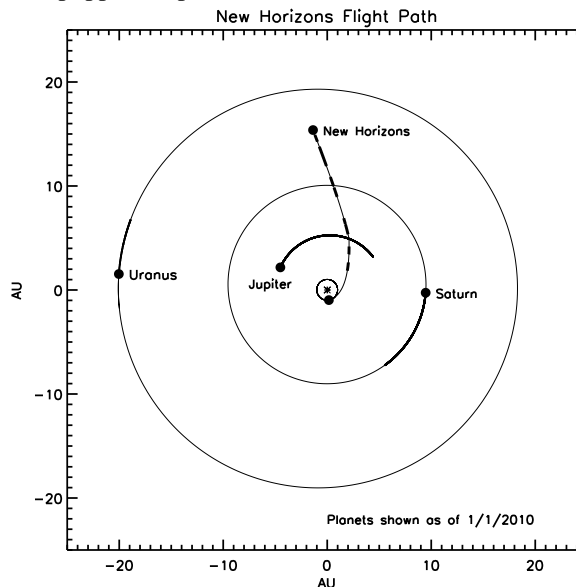


Figure 1: The New Horizons flight path up to January 1, 2010. The spacecraft encountered Jupiter on February 28, 2007 and is on a solar system escape trajectory. Arcs mark the progress of the planets since the New Horizons launch.

made by a variety of instruments, including the Pioneer 10 and 11 meteoroid experiments [5] and the Galileo and Ulysses Dust Detection Systems (DDS) [6, 7]. The Pioneer instruments made measurements out to 18 A.U. for grains greater than approximately 10^{-10} g while the DDS instruments made measurements inside 5 A.U. for grains greater than approximately 10^{-18} g. In order to validate the SDC measurements, we calculate an effective flux for SDC based on the Galileo and Ulysses measurements inside 5 A.U. We first isolate the Galileo and Ulysses data that overlaps with the periods that SDC measured in the inner solar system. Due to the presence of the interstellar dust stream in our solar system, we also characterize each Galileo or Ulysses hit as either interplanetary or interstellar, using the analysis of [8] and [9]. Having identified each grain as either interplanetary or interstellar, we transform the velocity vector of each grain from the Galileo or Ulysses frame into the New Horizons frame in order to determine the grain impact velocity into SDC. With the impact velocity and the

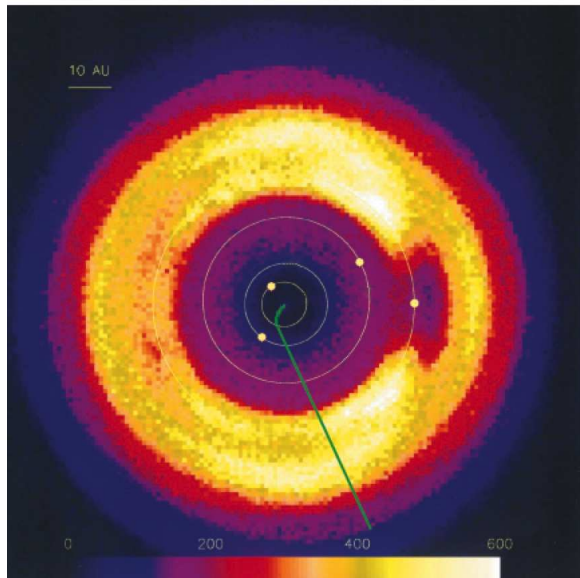


Figure 2: The relative interplanetary dust density as modeled by [4], in a Neptune co-rotating frame. The outer planets are in their July 14, 2015 positions and the New Horizons flightpath is overlaid as the green line.

grain mass, the theoretical charge production by impact into the SDC PVDF detectors for each grain can be calculated. If this charge is greater than the minimum SDC charge detection threshold of 8×10^5 e, then the grain would have registered on SDC. Figure 3 shows the impact velocity and mass of the Galileo and Ulysses hits, as well as the minimum SDC threshold. By taking only the grains with charge greater than the SDC threshold and factoring in the Galileo and Ulysses viewing times and areas, we can calculate the fluxes SDC would have measured flying on Galileo and Ulysses spacecraft.

The SDC fluxes are straightforwardly calculated by subtracting the average impact rate on the reference (noise) detectors from the average impact rate on the science detectors. Events that are coincident within one second of one another are removed from the dataset since the expected impact rate of 1/week implies that these events are extremely unlikely to be dust. The SDC viewing time and area are divided out to obtain the flux. Comparisons between the SDC flux and the Galileo and Ulysses predicted fluxes show good agreement.

Measurements in the Outer Solar System: Since the Jupiter fly-by in February, 2007, New Horizons has been quietly cruising through the outer solar system. During this period, the spacecraft shuts down all instru-

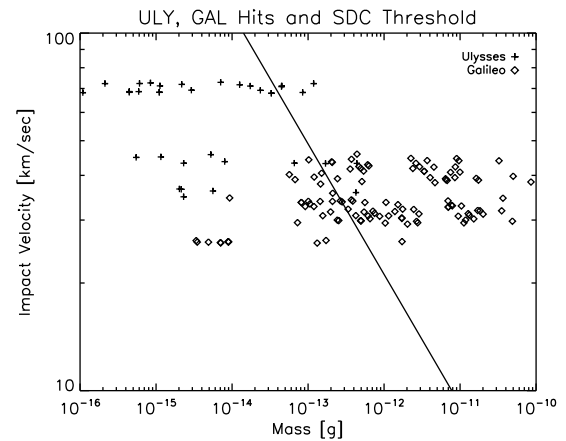


Figure 3: The mass and effective New Horizons impact velocity for Galileo and Ulysses grains. The solid line represents the minimum threshold for SDC.

ments and non-critical systems, with the exception of SDC. To date, SDC has made measurements from: 6.76-7.10 A.U., 9.02-9.91 A.U., 10.01-10.80 A.U., 11.91-13.84 A.U. and 14.29-15.51 A.U. Only the Pioneer detectors and the Cassini Cosmic Dust Analyzer (CDA) have made measurements at these distances from the Sun. The Pioneer measurements were made at a much higher grain size than SDC and the CDA dataset is limited due to instrument pointing and operation and therefore, the SDC data reported here are the first thorough measurements of the sub-micron interplanetary dust distribution in the outer solar system.

References

- [1] M. Horányi *et al.* The Student Dust Counter on the New Horizons Mission. *Space Sci. Rev.*, 2007.
- [2] M. A. Perkins, *et al.* A cometary and interplanetary dust experiment on the Vega spacecraft missions to Halley's Comet. *Nuc. Instr. Meth. Phys. Res.*, A239, 1985.
- [3] R. Srama *et al.* The Cassini Cosmic Dust Analyzer. *Space Sci. Rev.*, 114, 2004.
- [4] J-C. Liou and H. A. Zook. Signatures of the giant planets imprinted on the Edgeworth-Kuiper Belt dust disk. *Astro. Jour.*, 118, July 1999.
- [5] D. H. Humes. Results of Pioneer 10 and 11 Meteoroid Experiments: Interplanetary and Near-Saturn. *J. Geo. Res.*, 85(A11), Nov. 1980.
- [6] E. Grün, *et al.* The Ulysses dust experiment. *Astron. Astrophys. Suppl. Ser.*, 92, 1992.
- [7] E. Grün, *et al.* The Galileo dust detector. *Space Sci. Rev.*, 60, 1992.
- [8] E. Grün, *et al.* Interstellar dust in the heliosphere. *Astron. Astrophys.*, 286, 1994.
- [9] N. Altobelli, *et al.* Interstellar dust flux measurements by the Galileo dust instrument between the orbits of Venus and Mars. *J. Geo. Res.*, 110, 2005.