

THE NEW HORIZONS AND HUBBLE SPACE TELESCOPE SEARCH FOR RINGS, DUST, AND DEBRIS IN THE PLUTO/CHARON SYSTEM. T. R. Lauer¹, H. B. Throop², M. R. Showalter³, H. A. Weaver⁴, S. Alan Stern⁵, J. R. Spencer⁵, M. W. Buie⁵, D. P. Hamilton⁶, S. B. Porter⁵, A. J. Verbiscer⁵, L. A. Young⁵, C. B. Olkin⁵, K. Ennico⁷, and the New Horizons Science Team. ¹National Optical Astronomy Observatory (Tucson, AZ; lauer@noao.edu), ²PSI (Tucson, AZ), ³SETI (Mountain View, CA), ⁴JHU/APL (Laurel, MD), ⁵SWRI (Boulder, CO), ⁶University of Maryland (College Park, MD), ⁷NASA Ames (Mountain View, CA).

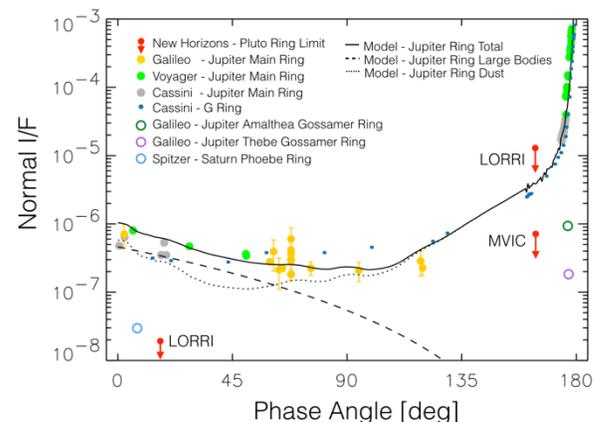
Introduction: We conducted an extensive search for rings, dust clouds, and debris features at all phases of the New Horizons 2015 exploration of the Pluto/Charon system. This program was supplemented with HST imaging searches conducted in advance of the encounter. No features were discovered at I/F limits roughly comparable to those at which faint rings had been detected around other solar system objects. The search is described in detail in [1].

Back Scattering Searches: A dedicated search for rings by back-scattered sunlight was initiated nine weeks prior to the encounter. This approach used repeated sequences of deep imaging with the New Horizons LORRI camera with the primary goal of detecting any aggregates of fine particles within the Pluto/Charon system that might have been hazardous to the spacecraft. The final I/F limits on rings or any other faint dust cloud within 10^5 km of Pluto was resolution dependent, ranging from $I/F \sim 2 \times 10^{-8}$ for 1500 km wide rings, 1×10^{-8} for 6000 km rings, and 7×10^{-9} for 12,000 km rings, all at $\sim 15^\circ$ phase angle. HST imaging conducted in advance of the encounter established limits of $I/F \sim 8 \times 10^{-8}$ for radii $> 10^5$ km from Pluto.

Forward Scattering Searches: Several deep imaging surveys were conducted after the time of closest approach, with New Horizons looking back at Pluto and Charon at $\sim 165^\circ$ phase angle for forward-scattered light from any rings or dust clouds as it departed from the system. Because of the small sun-angle, correcting for light scattered into the camera optics was crucial. The most sensitive searches were thus made with the MVIC instrument, given its markedly superior scattered light performance over LORRI. I/F limits from forward scattering were 8×10^{-7} on 10^4 km scales interior to the 6×10^6 km Hill radius of Pluto.

Occultations and Dust Impacts: Apart from the LORRI and MVIC imaging searches for light scattered by rings, four stars were monitored at closest approach by the Alice instrument to look for occultations by any rings or dust clouds. Again, no events were detected. Exact limits depend on the extent of the occulting object being tested for, but rough limits of optical depths of $\sim 10^{-3}$ are reached on scales of a few km. Lastly, the Student Dust Counter instrument detected no dust impacts over the duration of the encounter that can be attributed to the Pluto/Charon system.

Discussion: The New Horizon ring limits in back-scattered light are at least an order of magnitude stronger than the best limits provided prior to the encounter by HST observations [2], and provide the first constraints on detection by forward scattered light. The red points in the figure below [1] locate the New Horizon ring detection limits in the context of various components of the Jovian ring system and the more diffuse Saturnian rings. The limits on rings in the Pluto/Charon system fall below all known systems except the Jupiter Thebe gossamer ring.



Estimates of the impact gardening of the small satellites of Pluto made prior to the New Horizon mission argued for a substantial possibility that rings would be seen above the limits of the present searches [3]. The paucity of small impact craters on Pluto and Charon seen in New Horizons images [4], however, implies a strong downward revision in the gardening rates assumed by [3]. The complete absence of and dust concentrations in the Pluto/Charon system is also expected as consequence of efficient clearing of the system by solar radiation pressure [5].

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References: [1] Lauer, T. R. (2018) *Icarus*, 301, 155. [2] Steffl, A. J., & Stern, S. A. (2007) *AJ*, 133, 1485. [3] Stern, S. A. et al. (2006) *Nature*, 439, 936. [4] Singer, K. N. et al. (2019) *Science*, 363, 955. [5] Pires dos Santos, P. M. et al. (2013) *MNRAS*, 430, 2761.