Measurement of the Near-Infrared Opposition Surge of Triton Near True Opposition

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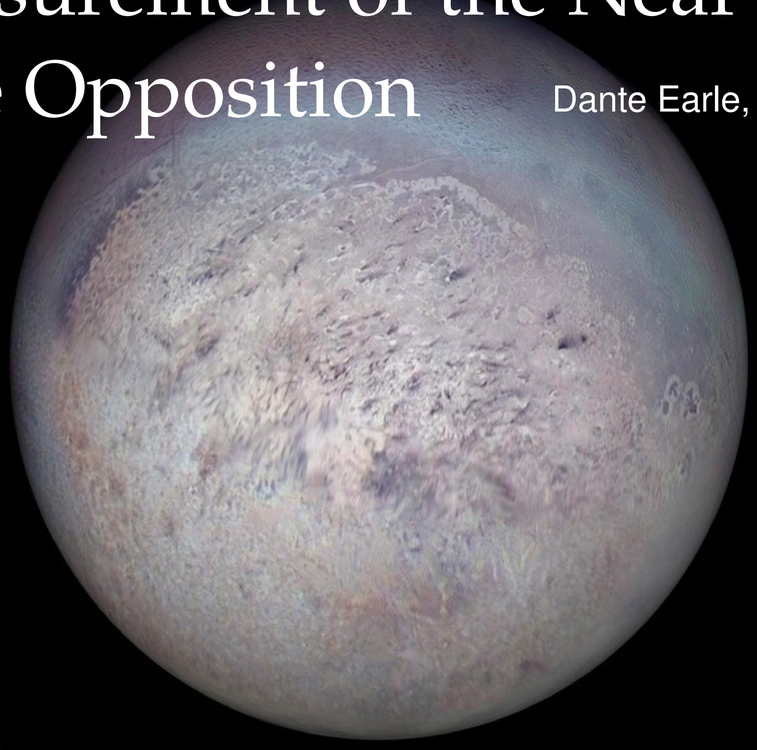
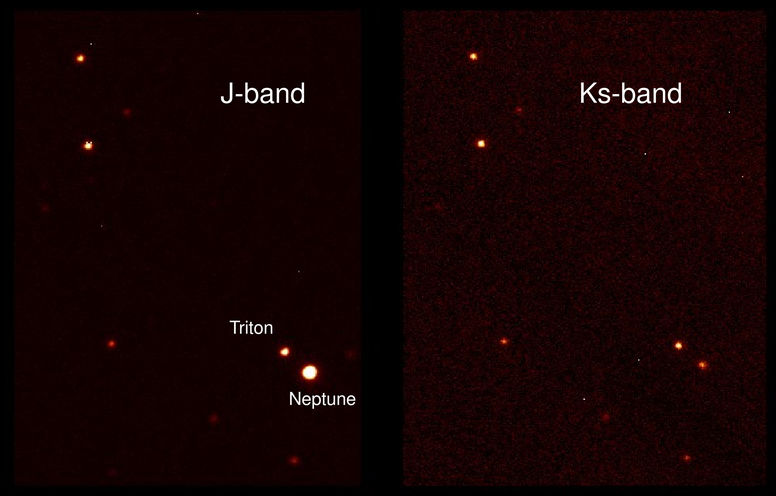
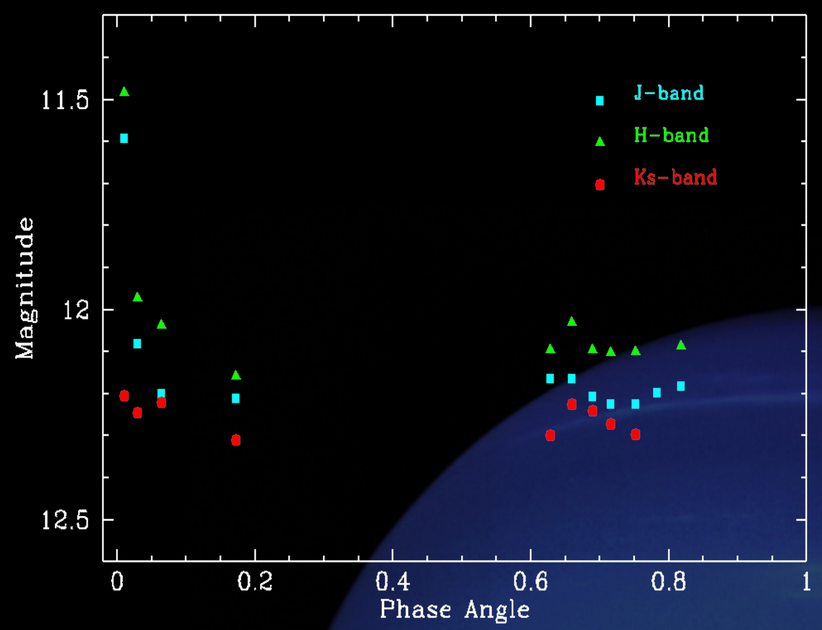


Abstract

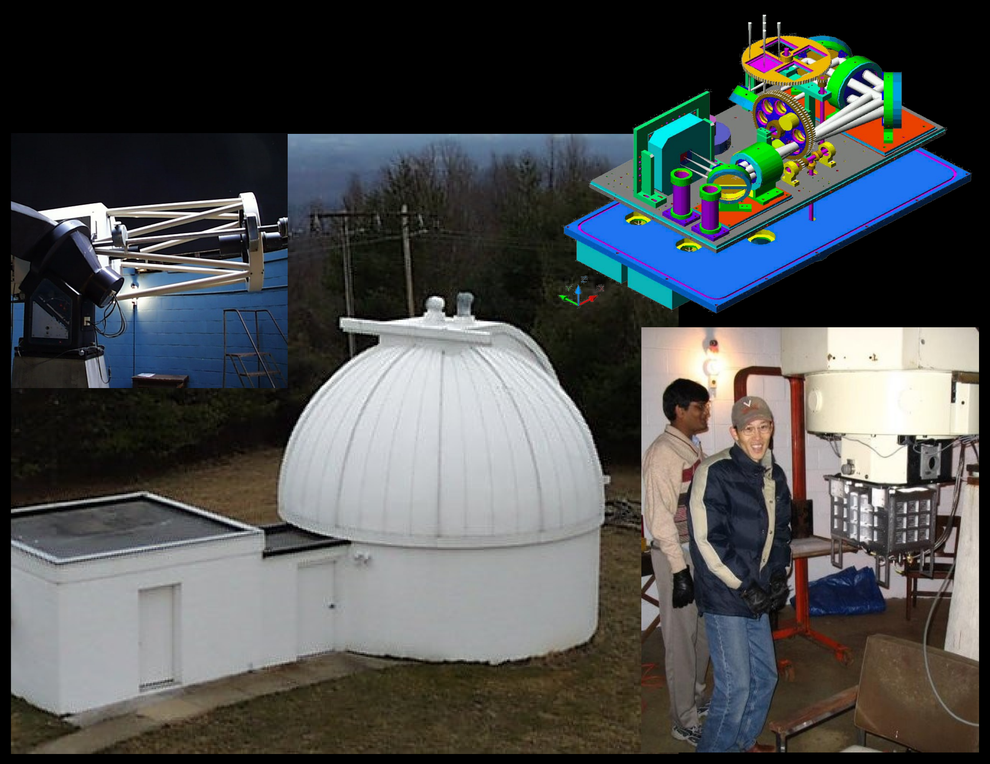
We present near-infrared (J, H, Ks-band) photometry of Triton obtained around the opposition of August 13, 2007 UT. Observations were conducted using a HAWAII-1 infrared camera operating at the University of Virginia's Fan Mountain Observatory's 31-inch reflector. With Neptune near a node crossing, Triton reached solar phase angles as small as 0.009 degrees. Given a heliocentric distance of 30AU, the Sun's angular radius was only 0.008 degrees. The observing campaign took place in two parts - one around opposition, and the other about a month later to characterize the light curve of Triton at these wavelengths while the phase angle was slowly changing. The observations successfully characterize the angular width, amplitude, and wavelength dependence of the near-infrared opposition surge of Triton and provide evidence for a significant contribution from the coherent backscatter effect.



Representative J-band (1.25um), and Ks-band (2.16um) 30s exposures showing Triton and Neptune as well as several comparison stars. Neptune is fainter than than Triton at Ks due to methane and molecular hydrogen absorption in Neptune's atmosphere. Each night approximately twenty such exposures were obtained at each of J, H, and Ks-bands and the mean difference between Triton and the 2MASS magnitude of a selected comparison star of comparable brightness was computed. The source position was moved to a different focal plane location for each exposure to mitigate systematic calibration errors. Internal flux/magnitude uncertainties are <1% (0.01 mag). Precision of the final measurements is limited to 2% (0.02 mag) by the uncertainty in the flux of the 2MASS reference star. This uncertainty will be improved in future analysis using all of the reference stars in the field.

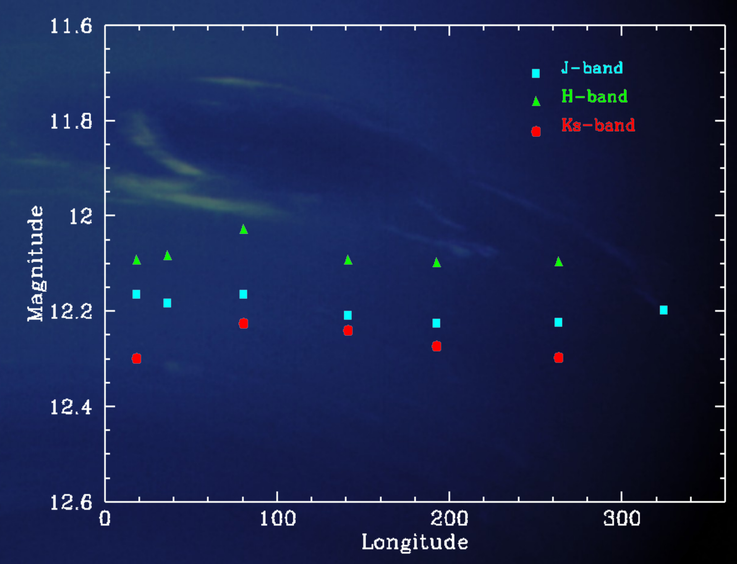


Magnitude of Triton at J, H, and Ks bands as a function of solar phase angle. A significant wavelength-dependent opposition surge is evident at the smallest phase angles (<0.1 degree). The width (FWHM) of the surge increases with wavelength, consistent with the trend predicted by coherent backscatter theory. A particulate surface produces an opposition surge as the result of at least two distinct phenomena: shadow hiding and coherent backscatter. The shadow hiding surge is manifested over a broad range of phase angles (0-20 deg) when particles hide their own shadows as phase angles decrease to zero; it is not wavelength dependent, nor is it evident in the data presented here. However, the coherent backscatter opposition effect, a constructive interference phenomenon, is manifested over a much narrower range of phase angles (0-2 deg). According to theory, the angular width (FWHM) of the surge should increase with wavelength. This trend is evident in the data between solar phase angles of 0 and 0.2 degrees.



The Fan Mountain 31-inch telescope and infrared camera. The camera was designed and fabricated by graduate students Srikrishna Kanneganti and Chan Park (pictured with the system installed on the telescope at lower right). The optics re-image the sky onto a 1024x1024 HgCdTe HAWAII-1 array with a pixel scale of 0.51"/pixel providing an 8.5'x8.5' field of view. Fan Mountain Observatory is located at a dark site 15 miles south of Charlottesville, VA. Ten minutes of on-source integration time yield 10-sigma limiting magnitudes of 18, 17, and 16 at J, H, and Ks-bands respectively. For comparison, Triton is slightly fainter than magnitude 12 in these bands.

Light curve of Triton at J, H, and Ks-bands as a function of magnitude. The plot comprises only the points above at phase angle > 0.5 degrees. Overall, the amplitude of the light curve is small. The leading hemisphere is approximately 0.05mag brighter than the trailing hemisphere in the three bands studied here. Because of this small amplitude the small phase angle points are uncorrected for Triton's infrared light curve.



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