A New Ring or Ring Arc of Jupiter? A. F. Cheng[1], H. A. Weaver[2], Lillian Nguyen[3], D. P. Hamilton[4], S. A. Stern[5], H. B. Throop[5]. [1,2,3]The Johns Hopkins University Applied Physics Laboratory, Laurel MD, USA 20723 (andrew.cheng@jhuapl.edu). [4]University of Maryland. [5]SwRI.

Introduction: During the course of instrument commissioning operations for the *New Horizons* mission [1] to Pluto and the Kuiper Belt, the Long Range Reconnaissance Imager (LORRI) made extensive measurements of the Jupiter system several months before Jupiter encounter, where the instrument operated nominally and contributed to 6 reports in *Science* [2-7]. Some observations were targeted to the irregular Jovian satellite Himalia. These observations revealed an unexpected streak-like feature close to Himalia, which is interpreted as a previously unknown, ring or ring arc of Jupiter close to the orbit of Himalia. The streak is not consistent with stray light, which has been characterized in-flight by LORRI observations pointed close to Jupiter and to the Sun. Himalia is the leading member of the Himalia family of prograde, irregular Jovian satellites [8,9]. The possible new ring, or incomplete ring arc, may have formed extremely recently by collisional destruction, e.g., from a km-sized impact onto Himalia.

Observations: LORRI observations of the Jovian system, targeted to Himalia, were obtained on September 22, 2006. LORRI is a 208 mm aperture, 2630 mm focal length reflecting telescope with a panchromatic CCD detector and with 4.95 μr pixels. The field-of-view is 0.29° × 0.29°. A detailed description of the LORRI instrument design and characteristics, with ground calibration and initial in-flight calibration results, can be found in [10]. The streak-like feature is detected in each of six images that were obtained in two groups, separated in time by 3 hr 20 min. The three images in each group were separated from each other by 4 s. This sequence design was designed such that Himalia would move against the background stars, and the stars would shift on the focal plane. Each of the six images was a 1 s exposure and was obtained in 4x4 pixel-binned mode [10]. Himalia was detected (not resolved) in each individual image at about visual magnitude 13. The star images are slightly smeared by pointing jitter.

Figure 1 shows the six images co-added, where the streak runs diagonally across the frame. The observations were obtained while the spacecraft was only about 2° off the orbital plane of Himalia. The spacecraft was 1.737 AU from Jupiter, and Jupiter was 5.392 AU from the Sun. The streak is accurately aligned with the most recent orbital track of Himalia (at the image times; see Fig. 2), but it is not aligned with the direction to Jupiter. Himalia is clearly not within the streak.

Table 1. Himalia images obtained Sept. 22, 2006

LORRI Image Numbers
lorri_0021233012_633_0000_0000_0257_0256_20061003_225500
lorri_0021233016_633_0000_0000_0257_0256_20061003_225506
lorri_0021233020_633_0000_0000_0257_0256_20061003_225511
lorri_0021245002_633_0000_0000_0257_0256_20061014_150609
lorri_0021245006_633_0000_0000_0257_0256_20061014_150637
lorri_0021245010_633_0000_0000_0257_0256_20061014_150705

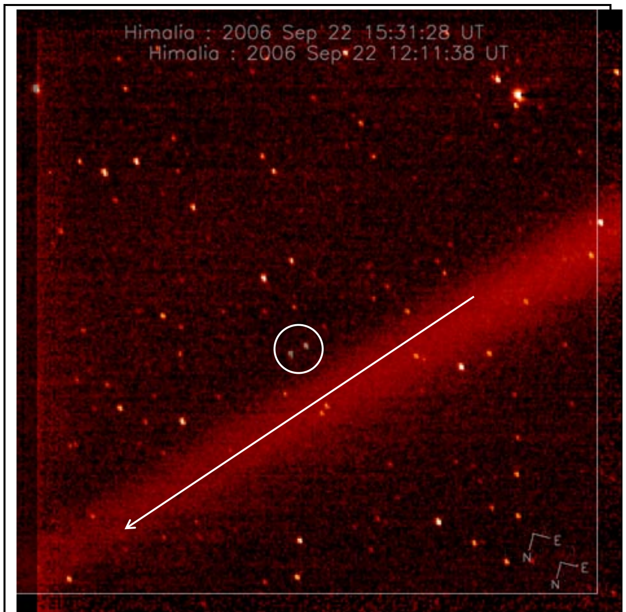

Figure 1. The six images of Table 1 co-added and highly stretched. Himalia is indicated within the white circle; it appears twice because it moved against the background stars between the times of the first three and the last three images. Directions of celestial N and E are indicated at lower right for each group of three images. The streak extends from lower left through middle right. It is parallel to, but not coincident with, the track of Himalia's orbit. Himalia is outside the streak. The long white arrow points to Jupiter.

The streak brightness has, in instrument units of DN [10], a mean value of 2.5 DN/s/px (binned). The streak brightness increases monotonously from left to right, rising from about 1.5 DN/s/px at the left to about 3.5 DN/s/px at the right. The brighter end of the streak is the end farther from Jupiter. The full longitudinal extent of the streak was unobserved and is unknown.

The mean streak brightness, at 2.5 DN/s/px, corresponds to a reflectance of I/F = 3×10^{-7} using the radiometric calibration given by [10].

Interpretation: The Himalia observations were obtained at low solar phase angle, with Jupiter about 1° off the LORRI boresight. We have performed extensive ground tests [10], analyses, and observations in-flight to characterize LORRI stray light, using both Jupiter and the Sun as strong sources of light. We have observed no examples of stray light with the features observed in the Himalia streak. The most pertinent in-flight observation was obtained in October, 2008, when the instruments LORRI and Ralph [1] were pointed between 12° and 14° off the Sun, while the spacecraft performed a 360° roll such that the Sun appeared at all clock angles around the LORRI boresight, while images were obtained every 7.5° in clock angle. LORRI is known to form ghost images of sources between about 0.2° and 0.3° off-axis, so there are no ghosts of Jupiter for the Himalia observations.

If the streak is attributed to particles ejected from Himalia, it must have formed extremely recently. Himalia's periapsis precession and nodal precession periods are only 137 and 283 yr, respectively under solar perturbations. The total volume of material in the streak, from the observed I/F and for particle size and albedo of 0.05 mm and 0.05 respectively (the low albedo consistent with the C-type spectra of Himalia family members) would be 0.08 km^3 as a lower limit, if half the total streak is seen in the LORRI FOV. The impact of the lost satellite S/2000 J11 [11] onto Himalia would have produced far more than this rough lower limit volume of ejected material.

Acknowledgements: We thank NASA and the *New Horizons* Project for support. We also thank the LORRI engineering team led by Steve Conard.

References: [1] Stern S. A. (2008) *Spa. Sci. Revs.*, *140*, 3–21. [2] Reuter D. C. et al. (2007) *Science*, *318*, 223-225. [3] Baines K. H. et al. (2007) *Science*, *318*, 226-229. [4] Gladstone G. R. et al. (2007) *Science*, *318*, 229-231. [5] Showalter M. R. et al. (2007) *Science*, *318*, 232-234. [6] Grundy W. M. (2007) *Science*, *318*, 234-237. [7] Spencer J. R. et al. (2007) *Science*, *318*, 240-243. [8] Cuk M. and Burns J. A. (2004) *Icarus*, *167*, 369-381. [9] Christou A. A. (2005) *Icarus*, *174*, 215–229. [10] Cheng A. F. et al. (2008) *Spa. Sci. Revs.*, *140*, 189–215. [11] Sheppard S. S. and Jewitt D. C. (2003) *Nature*, *423*, 261-263.

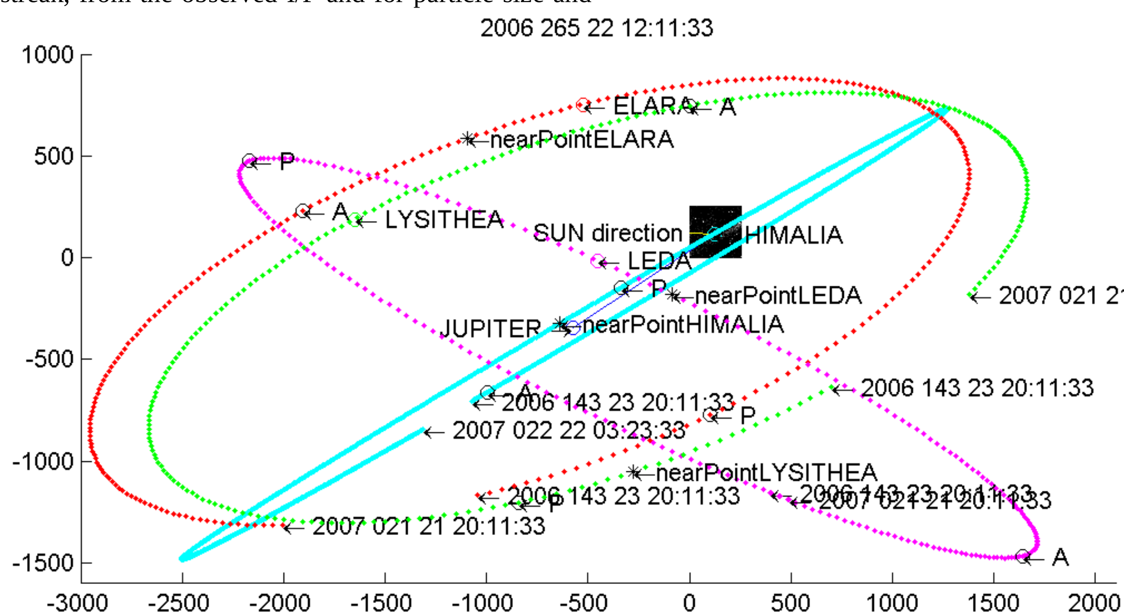

Figure 2. The Himalia family, projected against the plane of the sky from *New Horizons*. Positions of four satellites (Himalia, Elara, Lysithea, Leda) are plotted relative to Jupiter (dark blue octagon), over indicated time spans to trace out orbits. Angular units are LORRI instrument units, such that 1000 on either axis corresponds to 1.13°. Black square is FOV of Figure 1. The projected direction to the Sun is to the left (yellow line from Himalia). The location of each satellite at the time of the first image is shown by colored octagons. The orbit point closest to *New Horizons* is shown by "nearPoint" for each of the satellites, while periapse and apoapse are shown by P and A, respectively.

Himalia's location is close to the center of the FOV. Himalia's orbit track intersects the LORRI FOV twice, because the spacecraft is close to Himalia's orbit plane. The segment of the Himalia orbit closer to the lower right corner of the LORRI FOV is on the other side of Jupiter from *New Horizons*.The streak lies close to the nearer segment of the Himalia orbit, through the middle of the FOV, and it is not detected close to the distant segment. None of the other members of the Himalia family is within the LORRI FOV. The orientation of the streak is not consistent with the orbits of any of the other three members.