THE HUBBLE SPACE TELESCOPE EXPLORES THE LIMITS OF ROUNDNESS: CERES AND VESTA.

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Introduction: The *Hubble Space Telescope* (HST) was used to conduct high-resolution imaging of Vesta and Ceres in support of the *Dawn* mission, which will encounter them in 2011 and 2015, respectively. We describe two quite different observational and data processing strategies used to extract as much spatial information as possible for the shape and surface features of these two objects.

Hubble observations: Imaging of Ceres was conducted with the ACS High Resolution Channel (HRC) in 2004 (HST program 9748). Full rotation imaging allowed for analyses of its shape and construction of a global albedo map [1,2]. This program also produced subsampled data for three phase angles 120 degrees apart, with filters F330W and F555W. The 9.1 hour rotational period of Ceres is slow enough to execute a 4-exposure half-pixel dither “box” pointing pattern. This creates a dataset which can be drizzle-combined to enhance the spatial resolution.

Following the failure of ACS in January 2007, the May 2007 observations of Vesta had to be conducted with WFPC2 (HST program 10799). Vesta’s 5.3 hour rotational period was deemed too fast to attempt a subsampling dither pattern. So deconvolution methods were applied to a series of single images with filters F439W, F673N, F953N, and F1042M.

Drizzling Ceres: The four ACS/HRC exposures for each filter were carefully registered using a cross-correlation method which utilizes the available surface features to align the images to within a small fraction of a pixel. Then they were distortion-corrected, combined, and cleaned of cosmic rays and detector artifacts using MultiDrizzle [3]. The subsampled data was drizzled to an output scale of 0.015 arcsec/pixel, or 40% smaller than the input detector pixels (Figure 1).

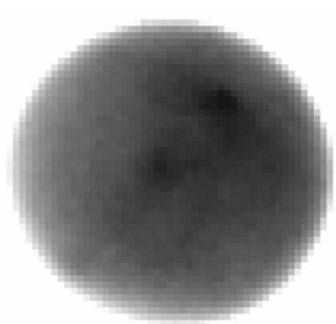

Figure 1: Drizzled ACS/HRC F330W image of Ceres

Deconvolving Vesta: Planetary Camera (PC) images of Vesta were deconvolved using the Maximum Entropy Method (MEM), as implemented in the IRAF/STSDAS *restore* package at STScI [4]. The TinyTIM package [5] was used to make PSFs for each filter. All PSFs were subsampled by a factor of four, to produce images at an output scale of 0.0114 arcsec/pixel (Figure 2).

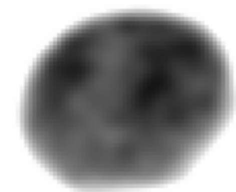

Figure 2: Deconvolved WFPC2 F673N image of Vesta

The WFPC2 camera produces a slight geometric distortion which was not removed from the images, but the effect should be minimal since Vesta is always placed near the PC chip center, where distortion effects are smallest. In preparation for deconvolution, the images were cropped to a small area centered on Vesta, and a simple cosmic ray rejection process was performed on individual images (no image combination) with the disk of Vesta masked to prevent any rejections there. The deconvolution is very sensitive to any CCD defects (e.g. hot pixels) or unrejected cosmic rays, and this may explain some artifacts seen in the output images. Also, MEM deconvolutions of earlier WFPC2 images of Vesta in 1994 and 1997 [6,7] exhibited a ringing effect on the bright sunlit limb of Vesta, and this effect is likely present again. We continue to experiment with independent deconvolution methods, which should provide further leverage to help discern real features from artifacts.

Conclusion: The drizzled and deconvolved output pixel scales were somewhat arbitrarily chosen to extract as much spatial information as possible from the data. The actual improvement in resolution is very difficult to quantify, it varies by wavelength, and some rotational blurring is certainly involved. But the resulting images clearly reveal and define surface features, which exhibit rotational motion, and allows for their physical interpretation.

References: [1] Thomas, P. et al. (2005) *Nature, 437,* 224. [2] Li, J. et al. (2006) *Icarus,* 182, 143. [3] Koekemoer, A. (2002) *HST Calibration Workshop,* 337. [4] Wu, N. (1995) *ADASS IV,* ASP Conf. Series Vol. 77. [5] Krist, J. & Hook, R. (2004) *TinyTIM Users Guide* [6] Zellner, B., et al., (1997) *Icarus,* 128, 83. [7] Thomas, P. et al., (1997) *Science,* 277, 1492